

CONODONTS OF THE MÓJCZA LIMESTONE

JERZY DZIK

Dzik, J. 1994. Conodonts of the Mójcza Limestone. — *In*: J. Dzik, E. Olempska, and A. Pisera 1994. Ordovician carbonate platform ecosystem of the Holy Cross Mountains. *Palaeontologia Polonica* 53, 43–128.

The Ordovician organodetrital limestones and marls studied in outcrops at Mójcza and Międzygórz, Holy Cross Mts, Poland, contains a record of the evolution of local conodont faunas from the latest Arenig (Early Kundan, *Lenodus variabilis* Zone) to the Ashgill (*Amorphognathus ordovicicus* Zone), with a single larger hiatus corresponding to the subzones from *Eoplacognathus pseudoplanus* to *E. reclinatus*. The conodont fauna is Baltic in general appearance but cold water genera, like *Sagittodontina*, *Scabbardella*, and *Hamarodus*, as well as those of Welsh or Chinese affinities, like *Complexodus*, *Phragmodus*, and *Rhodesognathus* are dominant in particular parts of the section while others common in the Baltic region, like *Periodon*, *Eoplacognathus*, and *Scalpellodus* are extremely rare. Most of the lineages continue to occur throughout most of the section enabling quantitative studies on their phyletic evolution. Apparatuses of sixty seven species of thirty six genera are described and illustrated. Phyletic evolution of *Baltoniodus*, *Amorphognathus*, *Complexodus*, and *Pygodus* is biometrically documented. Elements of apparatuses are homologized and the standard notation system is applied to all of them. *Acodontidae* fam. n., *Drepanodus kielcensis* sp. n., and *D. santacrucensis* sp. n. are proposed.

Key words: conodonts, Ordovician, evolution, taxonomy.

Jerzy Dzik, Instytut Paleobiologii PAN, Aleja Żwirki i Wigury 93, 02-089 Warszawa, Poland. Revised version received 5th June, 1993.



CONTENTS

Introduction	45
Acknowledgements	46
Conodont zonation	46
Taxonomic methodology	51
Ranks of taxa	51
Orientation of elements and descriptive terminology	52
Taxonomic descriptions	53
Phylum Chordata, Class Conodonta PANDER, 1856	53
Order Westergaardodinida LINDSTRÖM, 1970	53
Family Westergaardodinidae MÜLLER, 1959	53
Genus <i>Westergaardodina</i> MÜLLER, 1959	53
Order Panderodontida SWEET, 1988	54
Family ?Fryxellodontidae MILLER, 1982	54
Genus <i>Polonodus</i> DZIK, 1976	54
Genus <i>Pseudooneotodus</i> DRYGANT, 1974	54
Family Belodellidae KHODALEVICH <i>et</i> CHERNICH, 1973	55
Genus <i>Scalpellodus</i> DZIK, 1976	55
Genus <i>Walliserodus</i> SERPAGLI, 1967	56
Family Panderodontidae LINDSTRÖM, 1970	58
Genus <i>Panderodus</i> ETHINGTON, 1959	58
<i>Incertae ordinis</i>	60
Family Scolopodontidae BERGSTRÖM, 1982	60
Genus <i>Scolopodus</i> PANDER, 1856	60
Family Strachanognathidae BERGSTRÖM, 1982	60
Genus <i>Cornuodus</i> FÄHRÆUS, 1966	60
Genus <i>Strachanognathus</i> RHODES, 1955	62
Genus <i>Dapsilodus</i> COOPER, 1976	63
Genus <i>Scabbardella</i> ORCHARD, 1980	64
Order Protopanderodontida SWEET, 1988	66
Family Protopanderodontidae LINDSTRÖM, 1970	66
Genus <i>Semiacontiodus</i> MILLER, 1969	66
Genus <i>Drepanodus</i> PANDER, 1856	68
Genus <i>Protopanderodus</i> LINDSTRÖM, 1971	72
Family Distacodontidae BASSLER, 1925	76
Genus <i>Paltodus</i> PANDER, 1856	76
Genus <i>Drepanoistodus</i> LINDSTRÖM, 1971	78
Order Prioniodontida DZIK, 1976	79
Superfamily Prioniodontacea BASSLER, 1925	79
Family Acodontidae fam. n.	79
Genus <i>Tripodus</i> BRADSHAW, 1969	79
Genus <i>Eoneoprioniodus</i> MOUND, 1965	79
Family Balognathidae HASS, 1959	80
Genus <i>Baltoniodus</i> LINDSTRÖM, 1971	80
Genus <i>Lenodus</i> SERGEEVA, 1963	86
Genus <i>Sagittodontina</i> KNÜPFER, 1967	88
Genus <i>Rhodesognathus</i> BERGSTRÖM <i>et</i> SWEET, 1966	89
Genus <i>Amorphognathus</i> BRANSON <i>et</i> MEHL, 1933	91
Genus <i>Eoplacognathus</i> HAMAR, 1966	96
Genus <i>Cahabagnathus</i> BERGSTRÖM, 1983	100
Family Phragmodontidae BERGSTRÖM, 1982	101
Genus <i>Phragmodus</i> BRANSON <i>et</i> MEHL, 1933	101
Family Pygodontidae BERGSTRÖM, 1981	103
Genus <i>Pygodus</i> LAMONT <i>et</i> LINDSTRÖM, 1957	103

Superfamily Icriodontacea MÜLLER <i>et</i> MÜLLER, 1957	106
Family Pterospathodontidae COOPER, 1977	106
Genus <i>Complexodus</i> DZIK, 1976	106
Genus <i>Distomodus</i> BRANSON <i>et</i> BRANSON, 1947	107
Family Icriodontidae MÜLLER <i>et</i> MÜLLER, 1957	109
Genus <i>Icriodella</i> RHODES, 1953	109
Order Ozarkodinida DZIK, 1976	109
Suborder Plectodinina DZIK, 1991	109
Family Oistodontidae LINDSTRÖM, 1970	109
Genus <i>Histiodella</i> HARRIS, 1962	109
Family Periodontidae LINDSTRÖM, 1970	110
Genus <i>Periodon</i> HADDING, 1913	111
Genus <i>Hamarodus</i> VIRA, 1974	111
Family Plectodinidae SWEET, 1988	112
Genus <i>Microzarkodina</i> LINDSTRÖM, 1971	113
Family ?Chirognathidae BRANSON <i>et</i> MEHL, 1944	113
Genus <i>Spinodus</i> DZIK, 1976	113
Suborder Ozarkodinina DZIK, 1976	114
Family Spathognathodontidae HASS, 1959	114
Genus <i>Yaoxianognathus</i> AN, 1985	114
References	115
Tables	118

INTRODUCTION

The Mójcza Limestone does not contain stratigraphically diagnostic macrofossils (see DZIK and PISERA 1994). Conodonts thus represent a key to the subdivision and time correlation of this rock unit. It took some time, however, before these opportunities were appreciated and fully exploited.

The presence of conodonts in the Mójcza Limestone was documented for the first time by SPASSOV and TELLER (1963) who had found rich fauna in Mójcza while sampling the Paleozoic strata in the Holy Cross Mountains. They did not indicate precisely the position and number of their sample(s) in the rock column. Judging from published illustrations of conodont elements, representing 17 form-species, it seems possible that the whole described assemblage comes from a single layer below the discontinuity surface and represents actually 8 biospecies. They concluded that the limestone is of Llandeilo-Caradoc age, which is not contradictory with their taxonomic identifications, although the illustrated specimens seem to be rather Early Kundan in age, being thus close to the Arenig/Llanvirn boundary.

Subsequent conodont study of the Mójcza Limestone in its type locality has been undertaken by BEDNARCZYK (1966). The whole section was sampled but, as the identified specimens have not been illustrated, it is difficult to interpret the 18 listed form-species in modern apparatus terms. He proposed an early Llanvirn age for the basal "Asaphus limestone" in the Mójcza section, basing this determination rather on associated brachiopods and the stratigraphic position below the middle part of the section ("the gray limestone with pink coloration") which was dated late Llanvirn in age on the basis of the presence of *Eoplacognathus robustus* (then *Amorphognathus* n. sp. 3 LINDSTRÖM). Rare conodonts extracted from the top "red-brownish limestone" were not identified specifically. This precluded recognition of the actual degree of stratigraphic condensation, and as a result its earliest Llandeilo age was assumed.

The next step was done by BERGSTRÖM (1971) who identified conodonts of early Caradoc age in a sample sent to him by Dr. Christo SPASSOV. The sample was evidently taken from a different level than those studied by SPASSOV and TELLER (1963).

The presence of Caradoc strata in Mójcza was independently shown also by BEDNARCZYK (1971), who illustrated several conodont species from Mójcza and a few subsurface localities of the Mójcza Limestone, but did unfortunately not give the exact position of the samples in the section. Illustrated specimens represent species which can be judged as coming from below the discontinuity surface (*Baltoniodus parvidentatus* = his *Gothodus costulatus*), from the strata immediately above it (*Eoplacognathus robustus* = his *Ambalodus reclinator*), from just above the bentonite (*Amorphognathus tvaerensis* early form = his *A. ordovicica*), and from about 2 m above the bentonite (*Rhodesognathus polonicus* = his *Holodontus superbus*).

The first twelve samples from Mójcza taken for comparative purposes to study Baltic Ordovician conodont apparatuses (DZIK 1976) presented a surprising stratigraphic completeness of the record in this 8 m thick section, which has been further strengthened after the number of samples was increased to almost thirty (DZIK 1978). The section appeared to represent conodont zones ranging from the latest Arenig to at least latest Caradoc (possibly Ashgill). The only interval of uncertainty that remained is in the Early Llanvirn. Three subzones there (*E. pseudoplanus*, *E. suecicus*, and *E. foliaceus*) have not been documented.

The present study is based on even more complete sampling (Text-fig. 1). Because of continued quarrying of the limestone, the section is rarely exposed completely enough to ensure centimeter precision in identification of sampled beds. Additional series of samples have thus been taken in parts of the section that had not been exposed well enough earlier. A trench of a few meters length was also dug in the topmost part of the section. All together 140 samples were taken from the type locality and several more from outcrops in Międzygórz and Zalesie; 14 of the latter have appeared productive.

Although such a dense sampling resulted in samples being about 10 cm distant from each other, no apparent features of reworking of conodont elements have been identified except for the bed immediately above the discontinuity surface. Abrupt appearances and disappearances of some species (like *Rhodesognathus polonicus*, see Text-fig. 1) shows that the depth of bioturbation was very shallow there, probably not exceeding a few centimeters.

As a result of the restudy of all conodonts from Mójcza (DZIK 1990) specifically diagnostic elements of *Amorphognathus* were recognized in the topmost strata of the section. Their morphology strongly suggests that the Ashgill is also, at least partially, present in Mójcza. Undoubtedly, the Ashgill conodont species *A. ordovicicus*, occurs in lithologically similar strata in Międzygórz and Zalesie, too.

Acknowledgements. — I am very thankful to Anita LÖFGREN (University of Lund) for very thorough review of the manuscript of this paper and for correcting my mistakes and errors in it.

Dr. Wiesław BEDNARCZYK (Institute of Geological Sciences of the Polish Academy of Sciences, Warsaw) has kindly allowed me to examine his documentary collection of conodonts from Bukówka.

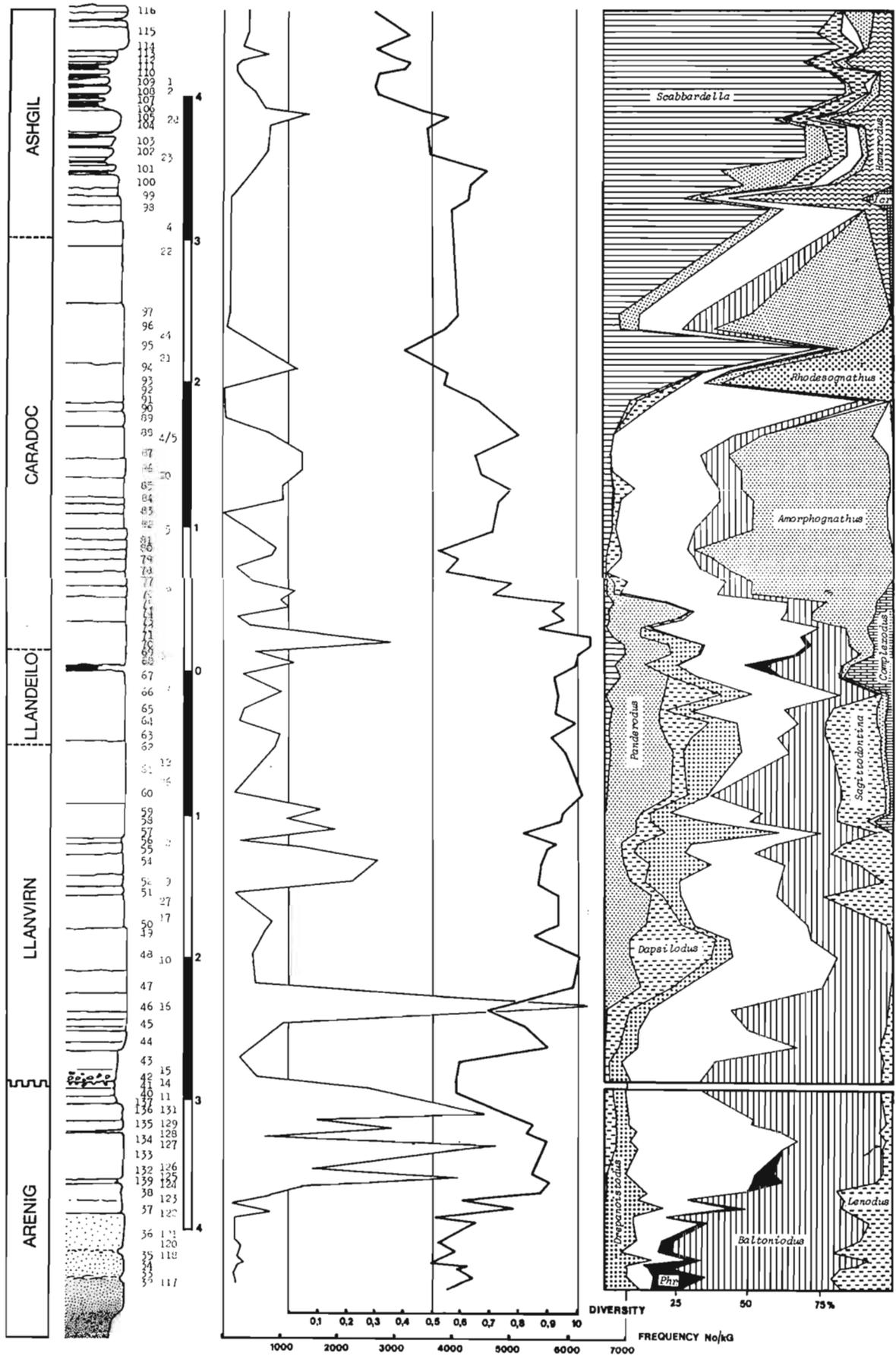
Mr. Wojciech SKARŻYŃSKI assisted in making SEM pictures which were taken at Nencki's Institute of Experimental Biology, Polish Academy of Sciences, Warsaw.

CONODONT ZONATION

Conodonts occurring in the Mójcza Limestone enable application of the scheme of zonation proposed by BERGSTRÖM (1971) for the North Atlantic faunal realm to this section. Most of the units recognized by him are based on phyletic evolutionary, instead of the migration, events usually used in biostratigraphy. In the Mójcza section several of the evolutionary events recognized by BERGSTRÖM (1971) in Baltic and Appalachian sections are more or less directly expressed and morphologies follow in the same order. Nevertheless, the faunal dynamics recorded in the Mójcza Limestone is profoundly

Fig. 1.

Rock column of the Mójcza Limestone outcrop in Mójcza—with the position of conodont samples indicated (left), frequency of conodont elements per kilogram of the rock and the Shannon's index of diversity (center), and a log of percent contribution of dominating lineages (right).



different from the Baltic and Appalachian ones. In result the biostratigraphic units that are not evolutionarily defined are hardly recognizable in Mójcza. This exposes the basic methodological discrepancy between traditional biostratigraphy, based on reported ranges of occurrence of species in rock sections, and the more abstract geochronology based on evolutionary events. I consider these two approaches fundamentally different and prefer not to mix units that are based on each of them (DZIK in press). Accordingly, any inference on time correlation is based here on evolutionary transitions, documented or at least believed to be highly probable.

Despite the faunistic differences between the Mójcza and Baltic sections there are several evolutionary events that enable precise time correlation. At least some of them correspond to established zones or subzones. Below, the most important North Atlantic events are reviewed in stratigraphic order.

(1) The Mójcza section starts with time equivalents of the Volkhovian, for which a few zones were proposed by LINDSTRÖM (1971). Except for two they are clearly based on migrational events rather than evolutionary transformations. These two exceptions refer to the elongation of processes of the **sp** elements in the *Baltoniodus* lineage (*B. "triangularis"* – *B. navis* transition) and to the disappearance of ribs in elements of *Paroistodus* (*P. parallelus* – *P. originalis* transition). A single **tr** element of *Baltoniodus* of rather robust appearance and weak denticulation has been found in a sample collected by Dr. Wiesław BEDNARCZYK from a limestone bed once exposed in the Bukówka quarry. It may represent an early form of *B. navis*, a suspicion supported by its co-occurrence with typical *Drepanodus arcuatus*. Samples from the limestone intercalations within the Bukówka Sandstone, taken by Dr. BEDNARCZYK from the core of the Bukówka IG-1 borehole (depths 83.5–84.0 and 84.0–84.5) contain **sp**, **oz**, **pl**, and **ne** elements of an advanced *Baltoniodus* species, possibly *B. parvidentatus*, associated with robust elements of *Drepanodus*. The limestone intercalations within the Bukówka Sandstone do not differ significantly in age from the base of the Mójcza Limestone, while the bed sampled in the quarry may represent the much older marly intercalation, presumably of early Volkhovian age (reported in older geological literature) that separates the Międzygórz Beds from the Bukówka Sandstone.

(2) The *Baltoniodus* lineage underwent a serious modification during the Late Volkhovian in effect of which the denticulation on some processes of **ke**, **hi**, and **ne** elements has disappeared (*B. navis* – *B. parvidentatus* transition; LINDSTRÖM 1971; DZIK 1976, 1990; LÖFGREN 1978; STOUGE and BAGNOLI 1991). It is not clear which stage of this course of events is represented in the Bukówka Sandstone as no well preserved **ke** element has been found.

(3) Close to the Volkhovian-Kundan boundary the **ne** elements in the *Lenodus* lineage developed V-shaped cristae below the cusp (*L. falodiformis* – *L. variabilis* transition; DZIK 1983; see also STOUGE and BAGNOLI 1991: note that the holotype of *Eoplacognathus pseudoplanus* is of Late Kundan age; it can thus hardly be conspecific with the earliest Kundan populations of *Lenodus* for which the name *L. falodiformis* was chosen). All elements of this type in the Mójcza Limestone have already developed the cristae. The base of the formation is thus within the *Lenodus* ("*Amorphognathus*") *variabilis* Zone. Generally, **ne** elements of *Lenodus* are rare and neither the exact timing of the transition nor the range of the population variability has yet been adequately described.

(4) Much more apparent is the transition following, with some delay, the above discussed transformations in *Lenodus*. This refers to the development of additional denticles in the **sp** and **oz** elements of *Microzarkodina* (*M. flabellum* – *M. ozarkodella* transition; LINDSTRÖM 1971; LÖFGREN 1978; STOUGE and BAGNOLI 1991 proposed a special name *M. hagetiana* for the transitional population) that took place in the early Kundan. Some rare elements found in the basal layers of the Mójcza Limestone resemble *M. hagetiana*. Beginning from 0.7 m below the discontinuity surface typical *M. ozarkodella* occurs.

(5) Of special value for intercontinental correlation is the elongation of external denticles in the **sp** elements of *Histiodela* (*H. tableheadensis* – *H. kristinae* transition; STOUGE 1984) that reached a height taller than the cusp. In Mójcza rare specimens of *H. kristinae* cooccur with *M. ozarkodella*.

(6) The bifurcation and significant elongation of the anterior ("lateral") process in the **sp** elements marks the origin of *Eoplacognathus* from *Lenodus* (*L. variabilis* – *E. zgierzensis* transition; DZIK 1976, 1978). It is present in Mójcza but the poor preservation and rarity of elements in transitional beds

does not allow it to be shown precisely. The early form of *E. zgierzensis* replaces *L. variabilis* 0.5 m below, and occurs up to, the discontinuity surface.

(7) The reduction of the anterior process in the **ke** element of *Baltoniodus* (*B. parvidentatus* – *B. medius* transition; DZIK 1978) is nicely recorded in the Mójcza Limestone, being interrupted by the discontinuity surface prior to reaching the degree typical for *B. medius*. Rare specimens of the latter species have been found reworked in the bed immediately above the discontinuity surface.

(8) The bifurcated process developed further in the *Eoplacognathus* lineage during the late Kundan reaching the size and proportions typical for the genus (*E. zgierzensis* – *E. pseudoplanus* transition; DZIK 1976). Although the species representing the transition are known to occur in proper stratigraphic order in Estonia and the Polish part of the East European Platform, more data is needed, especially concerning the population variability of the diagnostic character, to prove its proposed gradual nature. In Mójcza *E. pseudoplanus* is missing, its range of occurrence being hidden in the hiatus.

(9) The elongation of the external (“anterior”) process in **oz** elements in the Aserian marks the next step in the development of the apparatus organization typical for *Eoplacognathus* (*E. pseudoplanus* – *E. suecicus* transition; VIIRA 1974; DZIK 1978). This transition, although still not described in detail, seems to be a much better marker of the base of the *E. suecicus* Subzone (and, consequently, the base of the *Pygodus serra* Zone) than the appearance of *P. serra*, chosen as such by BERGSTRÖM (1971). The possible transition between *P. anitae* and *P. serra* has not yet been documented and the first known occurrence of *P. serra* is much higher than at the base of its nominal zone. In Mójcza the *E. suecicus* Zone is within the sedimentary hiatus.

(10) The final stage in the reduction of the anterior process in the **ke** elements took place within the Aserian (*Baltoniodus medius* – *B. prevariabilis* transition). Rare reworked specimens of *B. medius* cooccur with typical *B. prevariabilis* in the bed immediately above the discontinuity surface in Mójcza.

(11) Further elongation and the development of asymmetry of the **oz** elements as well as the reduction of a lobe in the **sp** elements permit demarkation of a subzonal boundary well recognized in Sweden and several Baltic localities (*E. suecicus* – *E. foliaceus* transition; BERGSTRÖM 1971). Again this event is not represented in Mójcza because of the hiatus.

(12) Closely similar **oz** elements to those of *E. foliaceus*, but with a discontinuous main row of denticles, occurring above the range of *E. foliaceus* in China and the Baltic area, seem to mark another evolutionary change of potential correlative value (*E. foliaceus* – *Cahabagnathus protoramosus* transition). In South China the latter species occurs in the *E. reclinatus* Subzone (AN 1987: p. 40), in Mójcza and the Lesieniec borehole (NE Poland) in the *E. robustus* Subzone, in the latter locality being abundant also in the *E. lindstroemi* Subzone, when it occurred also in Sweden (BERGSTRÖM 1971, 1983). Some fragmentary specimens from strata immediately above the discontinuity surface may represent either *E. foliaceus* or *C. protoramosus*, the latter species undoubtedly occurs slightly higher in the section. This transition seems to correspond roughly in time to the appearance of *E. reclinatus* in the North Atlantic realm. Although it is generally accepted that *E. reclinatus* is a successor of *E. foliaceus*, the specimens claimed to be transitional (see BERGSTRÖM 1983) decline somewhat from the expected direction of morphologic transformations, and some forms seem to be rather closer to *E. suecicus* (see *Eoplacognathus* sp. of BAUER 1987). The problem requires clarification. It seems possible that the origin of *E. reclinatus* was allopatric in respect to *E. foliaceus* and that the former species appeared in the Baltic area by migration.

(13) Further elongation of the **oz** elements and the widening of their platform (*E. reclinatus* – *E. robustus* transition) was used by BERGSTRÖM (1971) to define another subzonal boundary. In Mójcza the first elements of *Eoplacognathus*, appearing above the discontinuity surface, had processes somewhat shorter than those from slightly higher strata (see Text-fig. 23). It is thus possible that some poorly preserved specimens from the bed immediately above the discontinuity represent *E. reclinatus* and that the transition is recorded in Mójcza, too.

(14) Then, the **oz** elements developed an Y-shaped appearance (*E. robustus* – *E. lindstroemi* transition). Both these species occur in Mójcza but their ranges are separated by a break in the occurrence of the lineage.

(15) The development of the fourth row of tubercles in the **sp** elements of *Pygodus* (*P. serra* – *P. anserinus* transition; BERGSTRÖM 1971) is a one of the most useful evolutionary events for time

correlation. The lineage is best represented in Newfoundland where the transition was described in terms of the vertical concept of chronospecies (FÄHRÆUS 1982). In Mójcza elements of *Pygodus* are rare but still enable quantitative recognition of this evolutionary process (Text-fig. 26) which seems to be quite gradual.

(16) Development of star-shaped **sp** elements characterizes the next step in the evolution of *Eoplacognathus* (*E. lindstroemi* – *E. elongatus* transition). The latter species is extremely rare in Mójcza precluding detailed study of the event.

(17) The typical feature of *Amorphognathus tvaerensis*, as well as species of the same lineage succeeding it, is a bifid posterior (“lateral”) process in the **sp** elements with its external (“anterior”) lobe dominating in size. This feature evidently developed in the Llandeilo (*A. inaequalis* – *A. tvaerensis* transition). In Mójcza the oldest populations of *Amorphognathus*, occurring immediately above the *P. serra* – *P. anserinus* transition, have both lobes of equal size, thus being different from later, typical populations of *A. tvaerensis*. I initially attributed them to *A. inaequalis* (DZIK 1976, 1978) which occurs in approximately coeval strata of Wales. It is now known that in typical *A. inaequalis* the external lobe is variable in shape and usually small. The oldest populations from Mójcza are thus intermediate between these species and could be attributed quite well to any of them. As there is a smooth continuity within the Mójcza record of the evolution of the lineage (Text-fig. 21; DZIK 1990) and as the Welsh species is still inadequately known I hesitate to continue this identification. I am rather inclined to consider the typical population of *A. inaequalis* to be ancestral to the *Rhodesognathus* lineage (see below).

(18) *Baltoniodus*, the most common conodont lineage in the Baltic region, developed a triangular platform in the **sp** elements (*B. prevariabilis* – *B. variabilis* transition) close to the Llandeilo/Caradoc boundary (BERGSTRÖM 1971). This transformation is well known but of limited use in correlation because of the extremely wide population and ontogenetic variability of the diagnostic character. In Mójcza it can be traced (Text-fig. 15) and is used here as a basis for recognition of the zonal boundary, but it is still not certain at what time horizon this process took really place. Unfortunately there is no other time marker, known to me, within this time interval.

(19) Development of *Amorphognathus*-like **sp** elements in *Baltoniodus* is an extremely useful time marker (*B. variabilis* – *B. gerdae* transition; BERGSTRÖM 1971, BERGSTRÖM and CARNES 1976). *B. gerdae*, however, has not been found in Mójcza and alobate *Baltoniodus* with a triangular platform occurs continuously up to the level, where the accessory lobe disappears in the right **sp** elements of *Amorphognathus* (*A. tvaerensis* – *A. superbus* transition; BERGSTRÖM 1971, ORCHARD 1980, BERGSTRÖM *et al.* 1987). It has been suggested that the late populations of *Baltoniodus* in Mójcza were conspecific with Baltic *B. alobatus* and that this species developed in the Mójcza area, allopatrically in respect to *B. gerdae*, from a local population of *B. variabilis* (DZIK 1978). This view is continued to be provisionally accepted also here. *Rhodesognathus* represents another lineage which may be of potential correlation value. Possibly, it developed as a result of a secondary reduction of the platform in the **sp** elements. Welsh Llandeilo *A. inaequalis*, a population identified as *R. polonicus* by BERGSTRÖM *et al.* (1987) from the *Baltoniodus variabilis* Subzone of Britain, the robust specimens from approximately coeval strata in Mójcza (Pl. 21: 13), typical populations of *R. polonicus* from the *A. tvaerensis-superbus* transition, and *R. elegans* from the latest Caradoc and Ashgill are thus proposed to represent subsequent steps in the evolution.

(20) A size domination of the cusp over the few remaining denticles in the **ne** elements of *Amorphognathus* developed in the Ashgill (*A. superbus* – *A. ordovicicus* transition; BERGSTRÖM 1971, ORCHARD 1980). *Amorphognathus* occurs in Mójcza up to the top of the section (marls of the Zalesie Formation) and several **ne** elements have been collected from the topmost strata. The domination of the cusp in these youngest populations seems apparent but the whole process is much obscured by a great population variability that has not been studied in the type areas of any of the two species. Judging from the published illustrations of **ne** elements from England (ORCHARD 1980; SAVAGE and BASSETT 1985) the youngest populations from Mójcza probably represents *A. ordovicicus* although this is not quite certain. Undoubtedly *A. ordovicicus* is represented in Międzygórz, where elements virtually identical with those attributed to the species by BERGSTRÖM (1971) and ORCHARD (1980)

have been found. *Amorphognathus* from the *Dalmanitina* Beds of Zalesie, must also represent the same species; unfortunately the morphology of its **ne** elements remains unknown.

When the evolutionary events reviewed above are superimposed on the vertical distribution and changes in frequency distribution of specimens representing species of particular lineages, there is no correspondence with the faunal dynamics (DZIK 1990). Even if the process of evolution responded to ecological factors controlling the distribution of species, this was evidently done in a more complex and subtle way than is commonly assumed.

TAXONOMIC METHODOLOGY

All the species described below are understood as chronospecies, that is, as being objectively delimited in every time plane but with arbitrarily defined time dimensions. The time-morphologic boundaries of particular species are always understood as being horizontal, separating successive populations, not morphotypes.

Following the above definitions, a type population (the population to which the holotype belongs) represents the reference standard for any species. Selection of the holotype definitely determines the concept of the species. The content of a diagnosis, whether original or emended by subsequent revisers, is irrelevant in respect to particular (bio)species. The only aim of diagnoses remains their usefulness in the identification of a species, especially for beginners in conodont taxonomy. This is why I aim to formulate them in the simplest possible way and to precisely indicate features diagnostic for the species, allowing its differentiation from other cooccurring (sympatric) species and allopatric relatives, as well as from preceding and succeeding stages in the evolution of the lineage.

Regarding the time-morphologic dimension of a chronospecies I feel bound by the decisions of its author or the first reviser, especially when the boundary was indicated in a specified section with documented evolutionary transition from the ancestor and to a successor of the considered species (as in BERGSTRÖM 1971). However, as long as the horizontal concept of chronospecies is accepted here, I do not feel bound by decisions that were made in terms of the vertical concept, except for the cases when the horizon at which the transition between species took place was indicated in a section. The vertical definition is then "translated" into a horizontal one.

Diagnoses are generally (as much as possible) inclusive, i.e. the characters used to produce a generic diagnosis are not repeated in diagnoses of its species.

RANKS OF TAXA

The phylogeny of several Ordovician conodont genera is recognized with a precision rarely reached in paleontology. Together with the development of the conodont taxonomy the split between paleontological and neontological taxonomic rules becomes more and more apparent. Ranges of genera in paleontology are generally restricted to single evolutionary lineages. In effect, genera like *Eoplacognathus*, *Amorphognathus*, *Rhodesognathus*, or *Cahabagnathus* (representing the family Balognathiidae) are actually monospecific in any time plane. There are no coeval species, neither allopatric nor sympatric, in any of them. This makes the paleontological concept of genus closer to the neontological species than genus, where monospecific units are exceptions rather than a rule.

Obviously, this approach is convenient in stratigraphic applications because any generic name unequivocally refers to particular lineage. Having in mind the need for consistency among different areas of biological taxonomy as a general rule, I would prefer to apply the subgeneric rank to these series of chronospecies that are widely used in time correlation. The generic rank should be reserved for groups composed of at least two allopatric lineages unless there is a really profound morphologic

gap separating them or there are reasons to believe that future studies will lead to recognition of more allopatric species within the genus. This approach would still allow the informal use of subgeneric names in biostratigraphic works. Nevertheless, it seems unrealistic to oppose the tendency shared by most conodont specialists. The only purpose of these comments is to make anybody, who is interested in using the taxonomic data presented below for biological analyses, aware that they are basically biased.

I would also prefer to continue the usage of the chronosubspecies rank to these parts of stratigraphically important lineages that are less apparently distinct, especially for inexperienced conodont students. Once again, it appears impractical to introduce such subtleties to biostratigraphy, so I no longer apply this concept to conodonts, invariably using only the species rank for all recognizable units. As it was suggested (DZIK and TRAMMER 1980) the minimum morphologic distance (not necessarily measured but just roughly estimated) acceptable for the type populations of closest chronospecies should be such, that no overlap of standard deviations of diagnostic characters develops (this allows unequivocal distinction without biometrics). If it is necessary to introduce temporal units of lower ranks it seems enough to indicate them by using the terms "early", "typical" and "late forms" (following BERGSTRÖM 1971).

Higher ranked units are defined according to features of the core of the evolutionary branches represented by them. Otherwise numerous homeomorphies would destroy traditionally used schemes of classification, in fact providing no other practical alternative. Decisions concerning ranks of units are based not only on morphologic criteria; but also the number of lineages included is considered. Ranges of units of the same rank are intended to be at least roughly comparable.

The suprageneric classification used here differs slightly from that proposed by SWEET (1988). The objectives for modifications have been discussed elsewhere (DZIK 1991).

ORIENTATION OF ELEMENTS AND DESCRIPTIVE TERMINOLOGY

The three-dimensional organization of the conodont oral apparatuses has become known in more and more detail owing to the analysis of the element orientation in natural assemblages and their possible function has been supported by discoveries of specimens with soft parts preserved (BRIGGS *et al.* 1983). There is thus no longer any need for artificial, arbitrarily chosen orientation of elements, so much that the original assumption that the conodont elements were analogous to fish teeth and scales appears to be definitely wrong.

It is now out of the question that elements in the apparatus had their cusps directed one against the other in every pair (medially), that is, that they were arranged along an oral fissure and transversely to the long axis of the body (DZIK 1976, 1986; DZIK and DRYGANT 1986; ALDRIDGE *et al.* 1987). The surface of any unspecialized element that is gently convex appears thus to be the anterior one (not lateral, as traditionally named) while the opposite side, with the basal cone slightly gaping and swollen, that is the side toward which the cusp is slightly inclined, is the posterior one. Physiologically, the end of any element which was traditionally identified as anterior appears to be actually the ventral one. The process, which tends to be strongly bent is thus the ventral (external, outer) one, while the opposing straight, long process hidden in the mouth should be named the internal (inner, dorsal) process (DZIK 1991). The secondary processes should be renamed accordingly. To avoid the misleading usage of too many adjectives associated with the term "process" I propose to restrict the maximum number of processes to four and to term the additional ramifications as "branches" or "lobes" (see Text-fig. 19).

I thus propose to abandon the traditional terminology of elements (reviewed in SWEET 1982) based on PANDER's assumed orientation, reasonable at the pre-apparatus stage of studies but unsupportable today. To continue to use these artificial coordinates, where even left and right sides are not the physiological ones, would result in too much confusion. I believe that now is the proper, if not the

last, time to change to a physiological orientation and terminology of elements. To fail to do so would become more and more confusing with time.

TAXONOMIC DESCRIPTIONS

Note. — Synonymy lists in the following chapter contain references to the first description of a species or; alternately, the last redescription of the type specimens, the first apparatus reconstructions, all illustrated reports on its occurrences in the Holy Cross Mountains, and their most recent descriptions from elsewhere.

Phylum Chordata

Class Conodonta PANDER, 1856

Diagnosis. — Naked body (lamprey-shaped in Carboniferous forms). Oral apparatus with phosphatic denticles that armed in pairs both sides of a medial oral fissure. Each denticle composed of a conical crown secreted from outside and a (usually poorly developed) basal filling within the basal cavity.

Order Westergaardodinida LINDSTRÖM, 1970

(Paraconodontida MÜLLER, 1962)

Diagnosis. — Distinct from other conodonts in the structure of elements of the oral apparatus. The elements started their growth as minute rods lacking any basal cavity, with the crown tissue secreted from all sides. Subsequent secretion of the crown tissue was restricted to the basal parts of the element surface and to the margin of the basal cavity. The crown tissue contained originally a lot of organic matter, the basal filling tissue, if present, is weakly mineralized (see ANDRES 1988).

Family Westergaardodinidae MÜLLER, 1959

Diagnosis. — Elements with a flat anterior surface separated from strongly convex posterior one by ridges that form more or less pronounced processes.

Genus *Westergaardodina* MÜLLER, 1959

Type species: *W. bicuspidata* MÜLLER, 1959.

Diagnosis. — Flat elements with two long processes gently curved towards the more or less reduced cusp and parallel to it.

Westergaardodina bicuspidata MÜLLER, 1959

[DZIK and PISERA 1994 (this volume): Pl. 9: 13–14]

1959. *Westergaardodina bicuspidata* n. sp.; MÜLLER, p. 468, Pl. 15: 1, 4, 7, 9, 10, 14.

1966. *Westergaardodina bicuspidata* MÜLLER; HAMAR, p. 80, Pl. 6: 1, Text-fig. 2: 3.

1976. *Westergaardodina* ex gr. *bicuspidata* MÜLLER; DZIK, Text-fig. 12a–c.

1982. *Westergaardodina bicuspidata* MÜLLER; LANDING in FORTEY *et al.*, Text-fig. 7d.

Type horizon and locality: Erratic boulder of dark limestone with numerous *Furnishina furnishi* and *Ctenopyge flabellifera*, Pr.-Nr. 836, NE Germany (labelled Mark Brandenburg in old collection of the former Preussische geologische Landesanstalt; see MÜLLER 1959).

Diagnosis. — Completely reduced cusp, strongly thickened processes parallelly arranged, leaving only a narrow fissure in between. Basal cavity restricted only to the distal margins of the processes.

Remarks. — This is a typically Late Cambrian species which has however been repeatedly reported also from the early (FORTEY *et al.* 1982) and even middle Ordovician (HAMAR 1966; DZIK 1976). It seems highly unlikely that the specimens from the Mójcza Limestone had been reworked

from Cambrian strata because the Cambrian in the Kielce area is developed only in a coarse clastic facies. The species is more likely a survivor of its long ranging lineage.

Distribution. — In the Mójcza Limestone found at the level 0.8 m and immediately below the discontinuity surface (*Lenodus variabilis* Zone, Kundan, Arenig/Llanvirn boundary).

Order **Panderodontida** SWEET, 1988

Diagnosis. — Elements of the apparatus forming a single transition series of seven(?) element pairs, the presence of a medial element is uncertain.

Family ?**Fryxellodontidae** MILLER, 1982

Genus *Polonodus* DZIK, 1976

Type species: *Ambalodus clivus* VIIRA, 1974.

Remarks. — Despite the wide geographic distribution of the genus, which is especially well represented in collections from the Table Head Formation of Newfoundland (STOUGE 1984) its relationships remain obscure. Ornamentation and shape of juvenile elements are suggestive of a relationship with cooccurring *Lenodus variabilis* but there are also some morphologically more primitive conodonts similar to *Polonodus*, for instance early species of the *Pygodus* lineage (DZIK 1983) attributed to *Polonodus* by STOUGE and BAGNOLI (1988). Only a single element type has been identified with certainty, although the occurrence of additional types was suggested by BERGSTRÖM (1983). LÖFGREN (1990) proposed a complete apparatus reconstruction with a *Lenodus*-like filtratory basket.

The platform elements of *Polonodus* have a very deep basal cavity and bifurcating processes ornamented with transverse rows of tubercles of variable size. At early ontogenetic stages they are cruciform in occlusal view (DZIK 1976), later in its ontogeny quite complex shapes may develop (STOUGE 1984).

Polonodus sp.

(Pl. 20: 9–10)

1976 *Polonodus clivus* (VIIRA); DZIK, Text-fig. 29c–d.

1978. cf. *Polonodus clivus* (VIIRA); LÖFGREN, p. 77, Pl. 16: 12–13.

1978. *Polonodus?* sp. B.; LÖFGREN, p. 77, Pl. 16: 7–8, Text-fig. 30.

1979. cf. "*Amorphognathus*" n. sp. LINDSTRÖM, 1964 (= ?*Polonodus* sp.); HARRIS *et al.*, Pl. 2: 11, 15.

1984. cf. *Polonodus tablepointensis* n. sp.; STOUGE, p. 72, Pl. 12: 13, Pl. 13: 1–5.

1984. cf. *Polonodus clivus* (VIIRA); STOUGE, p. 73, Pl. 13: 6–13.

1984. cf. *Polonodus? newfoundlandensis* n. sp.; STOUGE, p. 73, Pl. 13: 14–16, Text-fig. 26.

Remarks. — The few fragmentary platform elements from the Mójcza Limestone do not enable reconstruction of the actual shape of adult elements. Judging from known specimens of the genus from Estonia and erratic boulders of Baltic origin they are extremely variable in respect to the ornamentation of the crown. On the other hand the pattern of ontogenetic transformations, expressed mainly in the branching of lobes, seems to be relatively stable and uniform in all known morphotypes. Therefore validity of species introduced by STOUGE (1984) requires additional biometrical support.

Distribution. — Rare in basal parts of the Mójcza Limestone from 0.8 to 0.2 m below the discontinuity surface (*Microzarkodina ozarkodella* Subzone of the Kundan; latest Arenig).

Genus *Pseudooneotodus* DRYGANT, 1974

Type species: *Oneotodus? beckmanni* BISCHOFF *et* SANNEMANN, 1958.

Diagnosis. — Elements are stoutly conical with deep basal cavity, walls thicken apically, surface relatively smooth.

Pseudooneotodus mitratus (MOSKALENKO, 1973)
(Pl. 11: 7)

1973. *Ambalodus mitratus mitratus* MOSKALENKO, sp. nov, subsp. nov.; MOSKALENKO, p. 86, Pl. 17: 9–11.
1976. *Oneotodus mitratus* (MOSKALENKO); DZIK, p. 435, Text-fig. 12e–f.
1980. *Pseudoneotodus mitratus* (MOSKALENKO); ORCHARD, p. 25, Pl. 3: 35, 42.
1983. *Pseudoneotodus mitratus* (MOSKALENKO); NOWLAN, p. 667, Pl. 3: 17, 21.

Type horizon and locality: Sample PT-IV-33, (Baxan stage, Llandeilo), Podkamiennaja Tunguzka river, Siberia.

Diagnosis. — Elements subtriangular in occlusal view with the inner lobe delimited by shallow sinuses. Single cusp.

Comments. — The North Atlantic population of the species slightly differs from the type one in a complete lack of elements with distinctly trilobate contours. Moreover, some younger populations from the Late Caradoc and Ashgill differ from the preceding ones in a more oval shape of the elements. They are replaced in the Silurian by the type species of the genus, elements of which are almost circular. In Siberia another chrono(sub)species, *P. nostras* (MOSKALENKO, 1973) with T-shaped elements having their inner process ornamented with rows of tubercles preceded it in the Chertov stage. This may suggest that *Pseudooneotodus* is actually a secondarily simplified outshoot of the group of platform conodonts widely occurring in the Llanvirn of Siberia and erroneously attributed to *Polyplacognathus* (see MOSKALENKO 1983) but possibly related to *Prattognathus*.

Distribution. — In Mójcza the species occurs sporadically beginning from the level 0.4 m above the discontinuity surface (*E. robustus* Subzone; Late Llanvirn) up to the top of the section. Known also from other outcrops of the Mójcza Limestone and Zalesie Formation in Międzygórz and Zalesie. The species is reported to occur in England and other areas also in the Late Caradoc and Ashgill up to the base of the Hirnantian (ORCHARD 1980).

Pseudooneotodus sp.
(Pl. 11: 6)

1980. *Pseudooneotodus* aff. *beckmanni* (BISCHOFF *et* SANNEMANN); ORCHARD, p. 24, Pl. 3: 30, 34.
1988. *Pseudooneotodus* aff. *P. beckmanni* (BISCHOFF *et* SANNEMANN); NOWLAN *et al.*, p. 34, Pl. 16: 1.

Remarks. — Elements of *Pseudooneotodus* of oval shape from the latest Ordovician are traditionally referred to as *P. beckmanni*. The material at hand (see Tables) is too small to make any taxonomic decision.

Distribution. — In Mójcza the species occurs in the topmost layers of the outcrop (*A. ordovicicus* Zone, Ashgill), elsewhere known from strata of the same age.

Family **Belodellidae** KHODALEVICH *et* CHERNICH, 1973

Diagnosis. — Elements showing prominent size gradient in the apparatus, with the anteriormost elements **ne** being the largest, of knife-like appearance, the following **hi** elements are smooth and laterally twisted, while the remaining elements, with more or less prominent longitudinal ribs, form a separate symmetry transition series.

Genera included.— *Scalpellodus* DZIK, 1976, *Walliserodus* SERPAGLI, 1967, *Belodella* ETHINGTON, 1959, *Drepanodistacodus* MOSKALENKO, 1977, *Dvorakia* KLAPPER *et* BARRICK, 1983.

Genus *Scalpellodus* DZIK, 1976 *emend.* LÖFGREN, 1978

Type species: *Protopanderodus latus* VAN WAMEL, 1974.

Diagnosis. — All the elements in the apparatus ornamented only with a delicate longitudinal striation (**ke–sp**) or almost smooth (**ne–hi**).

Remarks.—The present meaning was given to the genus by LÖFGREN (1978) who identified several chronospecies in the Baltic materials. Originally I erroneously attributed to this genus also **ne** and **hi** elements (they are not diagnostic at the generic level) which actually belong to *Walliserodus*, a more advanced member of the family.

Scalpellodus viruensis LÖFGREN, 1978
(Pls 12: 20, 15: 7)

1978. *Scalpellodus viruensis* sp. n.; LÖFGREN, p. 103, Pl. 5: 1–2, 7–9.

1991. *Scalpellodus? viruensis* LÖFGREN; MCCracken, p. 51, Pl. 3: 32–37.

Type horizon and locality: Sample J69–47, Gärde section, 3 m above the base of the measured section (latest Kundan or earliest Aserian, Early Llanvirn), Jamtland, Sweden .

Remarks. — Few elements of this species, extremely rare in Mójcza, were identified.

Distribution. — In Mójcza the species has been found 0.8 m below and immediately below the bentonite (*P. anserinus* Zone, Llandeilo), significantly higher than in the Baltic region (LÖFGREN 1978).

Genus *Walliserodus* SERPAGLI, 1967

Type species: *Paltodus debolti* REXROAD, 1967 (= *Acodus curvatus* BRANSON et BRANSON, 1947).

Diagnosis. — Except for the two anterior pairs (**ne–hi**) all the remaining elements in the apparatus are armed with a few sharp longitudinal keels.

Walliserodus costatus DZIK, 1976
(Pl. 12: 1–6; Text-fig. 2a)

1976. *Walliserodus costatus* sp. n.; DZIK: p. 421, Pl. 41: 2., Text-fig. 14m, n.

1978. *Walliserodus costatus* DZIK; DZIK: Pl. 15: 7.

1978. *Walliserodus* cf. *ethingtoni* FÄHRÆUS; LÖFGREN: p. 113, Pl. 4: 13–14.

Holotype: ZPAL CVI/307; DZIK 1976, Text-fig. 14m.

Type horizon and locality: Sample MA-14, the layer below the discontinuity surface in the Mójcza Limestone (*L. variabilis* Zone, Kundan; latest Arenig), Mójcza, Holy Cross Mountains, Poland .

Diagnosis. — All the elements of the apparatus with relatively shallow basal cavities (and consequently robust cusps). Longitudinal keels are very low and generally more numerous than in other species of the genus. In the symmetry transition series an almost symmetrical element type with convex external side.

Remarks. — The species differs from *W. ethingtoni* in a shallower basal cavity and less prominent longitudinal ribbing, from *W. nakholmensis* in convex external side of (almost) symmetrical elements. The two largest element types (**ne–hi**) are of a *Scalpellodus* type and this, together with weak and numerous longitudinal keels in the remaining elements, suggests a close relationship or even derivation from the species *Scalpellodus latus* (VAN WAMEL, 1974). The end member of the symmetry transition series may be symmetrical but this remains unclear, as the only strictly symmetrical elements found (in sample MA-127) are of very small size. Their apparent symmetry may be due to the incomplete development of the keels. Morphologically the closest elements from other samples (mainly from MA-128) are slightly asymmetric.

Distribution. — The species appears at the base of the Mójcza limestone and occurs up to the discontinuity surface (*L. variabilis* Zone, Kundan), known also in the latest Latorpian and Volkhovian of the Baltic region (LÖFGREN 1978).

Walliserodus ethingtoni (FÄHRÆUS, 1966)
(Pl. 12: 7–10, 15–19; Text-fig. 2b)

1966. *Panderodus ethingtoni* n. sp.; FÄHRÆUS, p. 26, Pl. 3: 5a–b.

1976. *Scalpellodus cavus* (WEBERS); DZIK, p. 444, Text-fig. 14a–e.

1976. *Walliserodus ethingtoni* (FÄHRÆUS); DZIK, p. 444, Text-fig. 14o–p.

1978. partim *Walliserodus ethingtoni* (FÄHRÆUS); LÖFGREN, p. 114, Pl. 4: 27–35, Text-fig. 33.

1984. *Walliserodus ethingtoni* (FÄHRÆUS); STOUGE, p. 64, Pl. 9: 1–9.

1984. ?*Parapaltodus flexuosus* (BARNES et POPLAWSKI); STOUGE, p. 48, Pl. 1: 19, 22–25.

1984. *Walliserodus ethingtoni* (FÄHRÆUS); CHEN and ZHANG, Pl. 3: 25–26.

1984. *Paltodus? mysticus* LINDSTRÖM; CHEN and ZHANG, Pl. 3: 32–33.

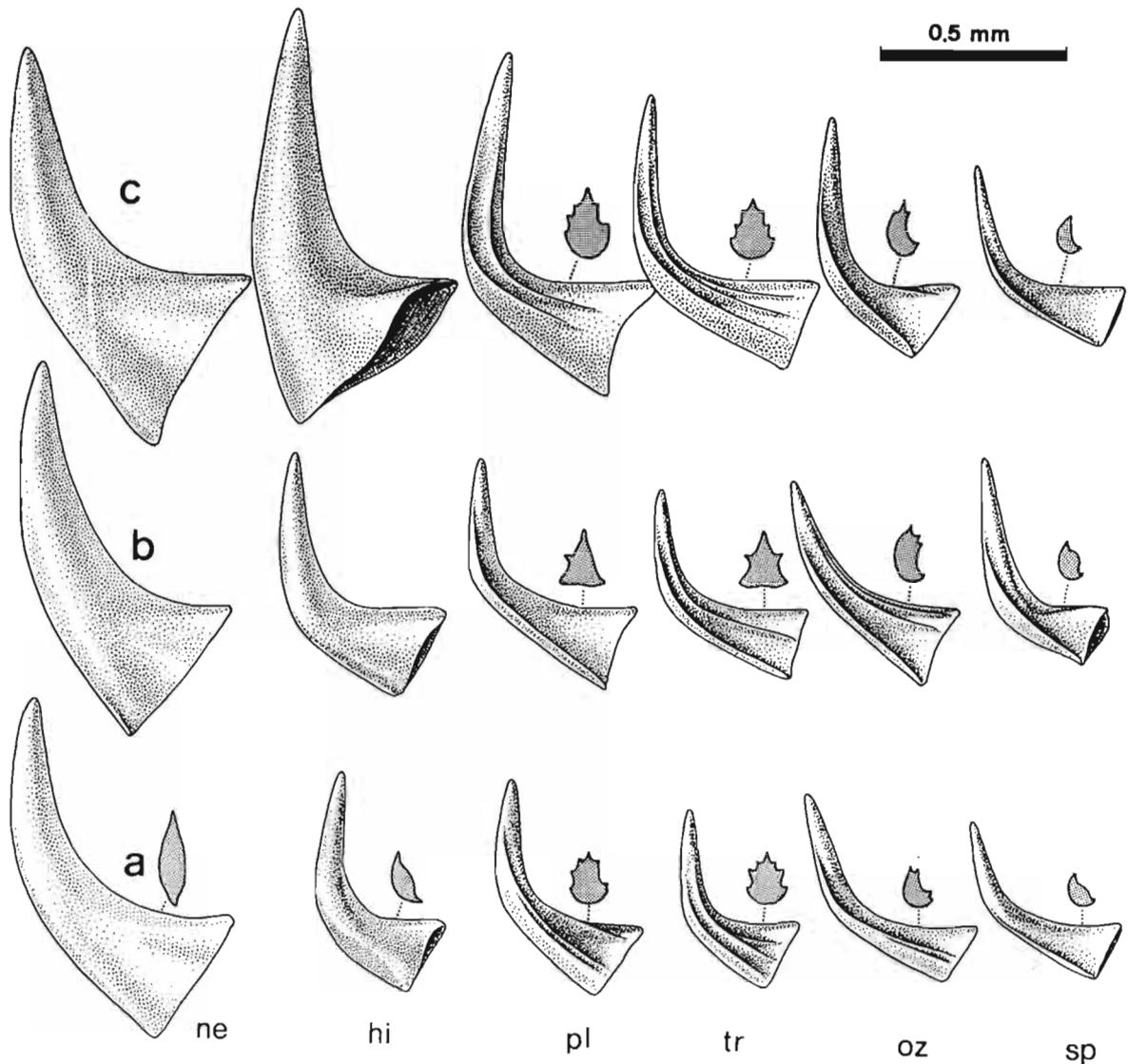


Fig. 2.

Apparatuses of *Walliserodus* species and proposed homology of their elements. a. *W. costatus* DZIK, 1976. b. *W. ethingtoni* (FÄHRÆUS, 1966). c. *W. nakholmensis* (HAMAR, 1966).

1985. *Walliserodus ethingtoni* (FÄHRÆUS); FÄHRÆUS and HUNTER, p. 1180, Text-fig. 6, Pl. 3: 11–16.

1985. *Scalpellodus cavus* (WEBERS); FÄHRÆUS and HUNTER, p. 1178, Pl. 3: 1–7, Text-fig. 4A–E (partim).

Type horizon and locality: Skövde or Vikarby Limestone (not indicated by FÄHRÆUS 1966) (Aserian or Lasnamägian, Llanvim), Gullhögen quarry in Skövde, Västergötland, Sweden.

Diagnosis. — Elements with very deep basal cavities and thin walls. Costate elements (**ke–sp**) with more or less oval cross section at the base, the anteriormost two pairs of elements (**ne–hi**) with wide base, almost alate.

Remarks. — *W. ethingtoni* is probably a successor of *W. costatus*, from which it differs in the elongation of bases in the **ne–hi** elements and stronger costation of the remaining elements. The transition has been described quantitatively by LÖFGREN (1978) in terms of an increasing mean number of keels in the symmetry transition series of **ke–sp** elements. In Mójcza the discontinuity surface cuts across the ranges of these chronospecies making boundaries between them artificially abrupt, but in the Jamtland section the transition seems to be completely smooth. Even in Mójcza specimens from samples MA-44 to MA-50 are exactly transitional between Kundan populations of *W. costatus* and

the very characteristic population of Llandeilo age, identified here as conspecific with *W. ethingtoni*. Although the oldest populations attributed by LÖFGREN (1978) to *W. ethingtoni* are more or less coeval with the type population of *W. costatus*, all her specimens show widely gaping basal cavities. This may suggest an allopatrically overlapping ranges of these species. In the course of subsequent evolution the elements of *W. ethingtoni* become more prominently ornamented and thinner-walled.

Distribution. — In Mójcza the species ranges from 0.4 m above the discontinuity (*E. reclinatus* or *E. robustus* Subzone, Late Llanvirn) up to 0.5 m above the bentonite (*A. tvaerensis*, Early Caradoc). Known occurrences in the Baltic area and Newfoundland range from Aserian (possibly late Kundan) to early Caradoc.

Walliserodus nakholmensis (HAMAR, 1966)
(Pl. 12: 11–14; Text-fig. 2c)

1966. *Panderodus nakholmensis* n. sp.; HAMAR, p. 66, Pl. 7: 22–24, Text-fig. 3: 3.

1967. *Drepanodus amplissimus* n. sp.; SERPAGLI, p. 66, Pl. 15: 1a–5b.

1967. *Walliserodus debolti* (REXROAD); SERPAGLI, p. 104, Pl. 31: 11a–13c.

1976. *Walliserodus nakholmensis* (HAMAR); DZIK, p. 444, Text-fig. 14q–t.

1978. *Walliserodus iniquus* (VIIRA); LÖFGREN, p. 116, Pl. 4: 15–26.

1981. *Walliserodus nakholmensis* (HAMAR); NOWLAN, p. 16, Pl. 3: 1–6, 12.

1985. *Walliserodus nakholmensis* (HAMAR); FÄHRÆUS and HUNTER, p. 1181, Pl. 2: 1–5, Text-fig. 7.

1985. *Scalpellodus cavus* (WEBERS); FÄHRÆUS and HUNTER, p. 1178, Pl. 3: 1–7, Text-fig. 4A–E (partim).

1980. *Walliserodus amplissimus* (SERPAGLI); ORCHARD, p. 26, Pl. 3: 3–7, 12, 13, 17, 18.

1988. *Walliserodus amplissimus* (SERPAGLI); NOWLAN *et al.*, p. 40, Pl. 19: 1–15.

Type horizon and locality: Sample 157, top of the Upper *Chasmops* Limestone (Late Caradoc), Nakholmen in the Oslo district, Norway.

Diagnosis. — Symmetrical elements (**tr**) of the apparatus with flat external side and with only five keels.

Remarks. — Costate elements of *W. nakholmensis* differ from those of related species by having fewer longitudinal keels. The elements of the anteriormost two pairs (**ne–hi**) are morphologically transitional between those of *W. costatus* and *W. ethingtoni* in that they have widened but not alate bases. NOWLAN (1981) was the first who properly recognized the apparatus of the species (and genus) and included in his reconstruction the smooth element types shared also by species of *Scalpellodus*.

Distribution. — The species is widely distributed in North Atlantic faunas of the Middle Ordovician as well as in the Late Ordovician *Hamarodus* fauna. In Mójcza it cooccurs with *W. ethingtoni* in the middle of the section, beginning from the discontinuity surface, and continuing in its occurrence to the top of the section. Occurs also in the Late Ordovician of Międzygórz and Zalesie.

Family **Panderodontidae** LINDSTRÖM, 1970

Diagnosis. — Apparatuses similar to Belodellidae but all elements with the panderodont furrow on the anterior side (or both sides if symmetrical elements are present).

Genera included. — ?*Parapanderodus* STOUGE, 1984, *Panderodus* ETHINGTON, 1959, *Belodina* ETHINGTON, 1959, *Culumbodina* MOSKALENKO, 1973, *Plegagnathus* ETHINGTON *et* FURNISH, 1959, *Pseudobelodina* SWEET, 1979, *Parabelodina* SWEET, 1979, *Neopanderodus* ZIEGLER *et* LINDSTRÖM, 1971.

Genus *Panderodus* ETHINGTON, 1959

Type species: *Paltodus unicosatus* BRANSON *et* MEHL, 1933.

Diagnosis. — Undenticulated (rarely serrated) elements with panderodont furrow always present on the anterior side of the asymmetric elements.

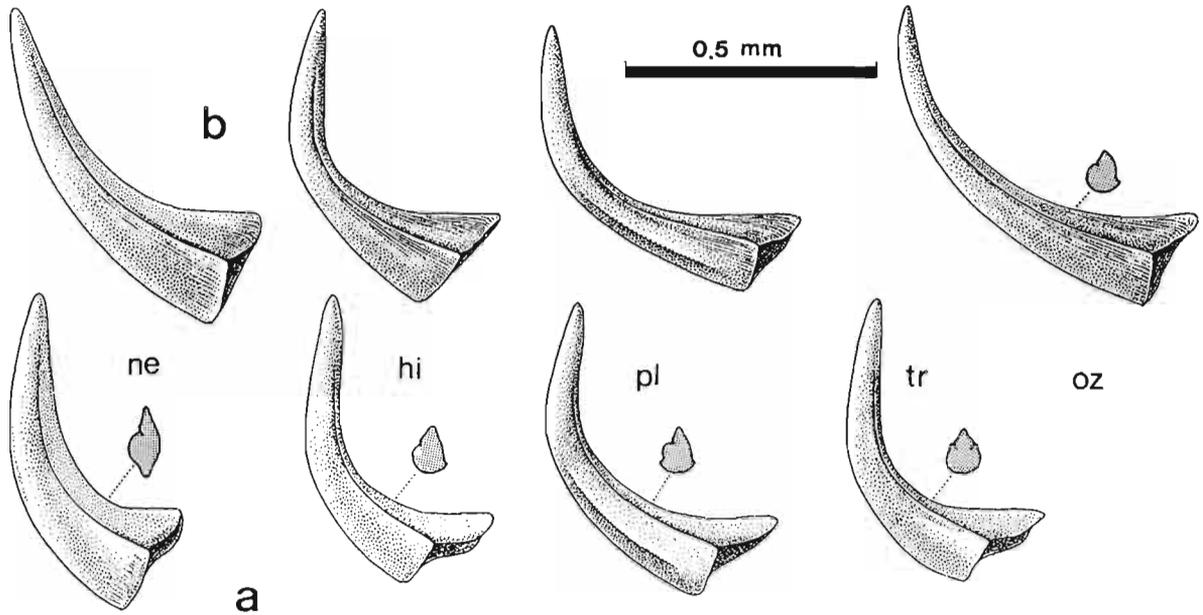


Fig. 3.

Apparatuses of *Panderodus* species and proposed homology of their elements. **a.** *P. sulcatus* (FÅHRÆUS, 1966). **b.** *Panderodus* sp. A.

Panderodus sulcatus (FÅHRÆUS, 1966)
(Pls 12: 21–28; 24: 1; Text-fig. 3a)

1966. *Paltodus sulcatus* n. sp.; FÅHRÆUS, p. 25, Pl. 3: 9a–b.

1976. *Panderodus gracilis* (BRANSON *et* MEHL); DZIK, p. 435, Text-fig 15a–b (non e–f).

1978. *Panderodus sulcatus* (FÅHRÆUS); LÖFGREN, p. 67, Pl. 8: 7–9.

1987. cf. *Panderodus* sp.; BAUER, p. 23, Pl. 4: 12.

Type horizon and locality: Skövde Limestone (*E. reclinatus* Subzone, Llanvirn) at the Gullhögen quarry, Västergötland, Sweden.

Diagnosis. — Relatively robust elements, generalized in shape, the **ne** elements gently curved, wide; a symmetrical element present.

Remarks. — The general apparatus composition has been known since LÖFGREN's (1978) description. The anterior, **ne**, element departs morphologically from the remaining three types that can be easily distinguished from one another owing to the presence or absence of one or two ribs bordering their external sides. The surface of the elements is almost smooth. The symmetrical element has two furrows but sometimes one of them is less complete, which makes the element not quite symmetrical. Undoubtedly symmetrical elements have been found only in older populations of the species (sample MA-52). Higher up they seem to be missing (sample MA-66).

Distribution. — Occurs in Mójcza from 0.4 m above the discontinuity (*E. robustus* Subzone, Llanvirn) at least up to 0.5 m above the bentonite (*A. tvaerensis* Zone, Early Caradoc) and there seems to be an evolutionary continuity to *Panderodus* sp. A. Similarly distributed in Międzygórz. The species is known also from the Llanvirn of the Baltic region.

Panderodus sp. A
(Pl. 12: 29–32; Text-fig. 3b)

Remarks. — Late Ordovician populations of *Panderodus* in the Mójcza section differ from the preceding ones in having more gently curved, slender **ne** elements, more gracile appearance and distinct striation of all elements, as well as in the lack of symmetrical elements in the apparatus.

Distribution. — The lower boundary of the occurrence is difficult to trace because of the rarity and poor preservation of the elements; probably appears 1.2 m above the bentonite (*A. tvaerensis* Zone) but typical forms occur much higher in the marly limestones of the Zalesie Formation (*A. ordovicicus* Zone) in Mójcza, Międzygórz, and Zalesie.

Incertae ordinis

Family **Scolopodontidae** BERGSTRÖM, 1982

Remarks. — The apparatus of *Scolopodus* is still inadequately known and its relationship to the oldest non-westergaardodid conodonts (“euconodonts”) remains unclear.

Genus *Scolopodus* PANDER, 1856

Type species: *Scolopodus sublaevis* PANDER, 1856.

Diagnosis. — Apparatus with low morphologic differentiation of elements that have shallow basal cavities and long, mostly hyaline cusps ornamented with prominent longitudinal ribs.

Scolopodus peselephantis LINDSTRÖM, 1955

(Pl. 11: 1–5)

1955. *Scolopodus? peselephantis* n. sp.; LINDSTRÖM, p. 595, Pl. 2: 19–20, Text-fig. 3Q.

1978. *Scolopodus? peselephantis* LINDSTRÖM; LÖFGREN, p. 108, Pl. 4: 43–47.

1981. “*Scolopodus*” *peselephantis* LINDSTRÖM; NOWLAN, p. 13, Pl. 5: 10–11.

1988. “*Scolopodus*” *peselephantis* LINDSTRÖM; STOUGE and BAGNOLI, p. 139, Pl. 15: 18.

1991. “*Scolopodus*” *peselephantis* LINDSTRÖM; STOUGE and BAGNOLI, p. 25, Pl. 9: 12–13.

Type horizon and locality: Sample 2, base of the Lower Planilimbata Limestone (Arenig) at Latorp, Sweden.

Diagnosis. — Very small elements with almost straight cusps and few strong longitudinal ribs on their inner surface laterally followed by numerous small riblets.

Remarks. — Despite the abundance of elements of the species in my collections I am not able to distinguish discrete element types in the apparatus or to trace any evolutionary change.

Distribution. — The species occurs almost throughout the whole sections in Mójcza, Międzygórz and Zalesie. In Mójcza the first rare specimens occur as low as 1.0 m below the discontinuity surface (*L. variabilis* Zone) and up to 2.0 m above the bentonite (*A. tvaerensis/superbus* transition zone); again in the topmost beds of the Zalesie Formation (*A. ordovicicus* Zone). Elsewhere it is known also from the whole Arenig.

Family **Strachanognathidae** BERGSTRÖM, 1982

(incl. Cornuodontidae STOUGE, 1984)

Diagnosis. — Apparatus composed of elements of approximately uniform size with smooth gradation of shapes, forming a single symmetry transition series (ne elements in advanced forms may be somewhat separated morphologically). Symmetrical elements, if present, of very generalized morphology.

Remarks. — The family differs from the Belodellidae and Panderodontidae in the lack of any prominent size gradient in the apparatus, and from the Protopanderodontidae in having only a single symmetry transition series in the apparatus and in the possible lack of unpaired tr element. The organization of the apparatus resembles closely that of members of the Panderodontida but careful phylogenetic studies are necessary to resolve the question of its relationships.

Genera included. — *Cornuodus* FÄHRÆUS, 1966, *Dapsilodus* COOPER, 1976, *Scabbardella* ORCHARD, 1980, *Decoriconus* COOPER, 1975, *Besselodus* ALDRIDGE, 1982, ?*Strachanognathus* RHODES, 1955.

Genus *Cornuodus* FÄHRÆUS, 1966

Type species: *Cornuodus erectus* FÄHRÆUS, 1966 (= *Drepanodus longibasis* LINDSTRÖM, 1955).

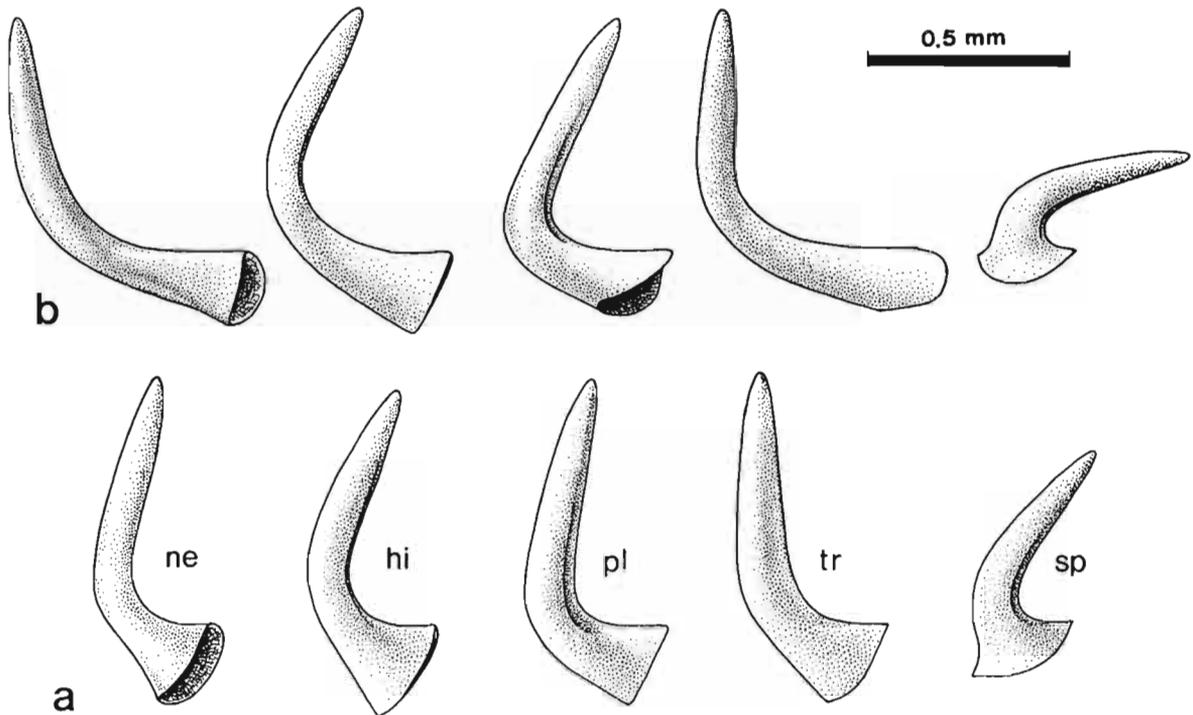


Fig. 4.

Apparatuses of *Cornuodus* species and proposed homology of their elements. **a.** *C. longibasis* (LINDSTRÖM, 1955). **b.** *C. bergstroemi* SERPAGLI, 1967.

Diagnosis. — Elements of the apparatus with deep, conical basal cavities, bases of oval cross section, cusps bent knee-like.

Remarks. — LÖFGREN (1978) first properly identified the main element types of the *Cornuodus* apparatus and distinctions between species. Despite the very generalized morphology of the elements in the apparatus, up to six discrete element types can be distinguished in samples with numerous specimens of the genus. The standard notation of the element types proposed here is, obviously, very tentative and based on some similarity to *Drepanodus*. This does not necessarily mean that these genera are closely related to each other. An alternative interpretation is suggested by the close similarity in the apparatus organization to that of *Dapsilodus*. Especially the elements with widened bases clearly seem homologous in these apparatuses. If *Dapsilodus* is related to *Besselodus*, a genus with the apparatus organization known from a complete cluster (ALDRIDGE 1982), this wide element type would be the **ne** one. There are elements in the apparatus of *Cornuodus* that may be homologous to **tr** elements of higher conodonts but their extremely simple morphology makes any interpretation difficult.

Cornuodus longibasis (LINDSTRÖM, 1955)

(Pl. 11: 8–13; Text-fig. 4a)

1955. *Drepanodus longibasis* n. sp.; LINDSTRÖM a, p. 564, Pl. 3: 31.
 1963. *Paltodus* sp. nov.; SPASSOV and TELLER, p. 80, Pl. 1: 6.
 1966. *Cornuodus erectus* n. sp.; FÄHRÆUS, p. 20, Text-fig. 2B, Pl. 2: 8.
 1976. *Scalpellodus* (?*Cornuodus*) *laevis* sp. n.; DZIK, p. 421, Pl. 41: 1, Text-fig. 13a–c, r–s.
 1984. *Scalpellodus laevis* DZIK; DZIK, p. 336, Pl. 2: 3–4.
 1978 *Cornuodus longibasis* (LINDSTRÖM); LÖFGREN, p. 49, Pl. 4: 36, 38–42, Text-fig. 25A–C.
 1984 *Cornuodus longibasis* (LINDSTRÖM); STOUGE, p. 62, Pl. 8: 1–8.
 1988 *Cornuodus longibasis* (LINDSTRÖM); STOUGE and BAGNOLI, p. 114, Pl. 1: 20–21.
 1991 *Cornuodus longibasis* (LINDSTRÖM); STOUGE and BAGNOLI, p. 14, Pl. 3: 3–7.

Type horizon and locality: Sample 12, top of the Upper Planilimbata Limestone (Arenig) at Lanna near Orebro, Sweden.

Diagnosis. — Elements of generalized shapes, the **sp–oz** ones with funnel-like base, **tr–ne** elements with an oval to round cross-section.

Remarks. — The species differs from its closest relative *C. bergstroemi* in having an almost straight profile of the base in all the element types.

Distribution. — The complete range is difficult to trace because of the similarity of the elements to other generalized species. Probably the species is widespread from the Arenig (Hunnebergian) until Ashgill. In Mójcza, Międzygórz and Zalesie throughout the sections.

Cornuodus bergstroemi SERPAGLI, 1967
(Pl. 11: 14–19; Text-fig. 4b)

1967. *Cornuodus bergstroemi* n. sp.; SERPAGLI, p. 57, Pl. 12: 1a–2c.

1967. *Cornuodus montanaruae* n. sp.; SERPAGLI, p. 58, Pl. 12: 3a–4b.

1967. *Cornuodus erectus* FÄHRÆUS; SERPAGLI, p. 57, Pl. 12: 5a–8b.

1978. *Cornuodus bergstroemi* SERPAGLI; LÖFGREN, p. 51, Pl. 4: 37, Text-fig. 25D.

Type horizon and locality: Sample 1428 (Ashgill) taken at Rifugio Nordio, Carnic Alps, Italy.

Diagnosis. — The **oz** elements with a strongly convex profile of the base, gracile elements with obliquely cut bases and angularly bent cusps.

Remarks. — Elements of the species are generally more gracile than those of *C. longibasis*, the most characteristic feature is the shape of their bases.

Distribution. — Known from the Llanvirn of the Baltic area and Ashgill of the Carnic Alps. Irregularly occurring in Mójcza from 0.5 m above the discontinuity (*E. robustus* Subzone) to 1.2 m above the bentonite (*A. tvaerensis* Zone).

Genus *Strachanognathus* RHODES, 1955

Type species: *Strachanognathus parva* RHODES, 1955.

Diagnosis. — All elements of the apparatus laterally flattened very large denticle on the inner side of the cusp.

Strachanognathus parvus RHODES, 1955
(Pl. 13: 1–6; Text-fig. 5)

1955. *Strachanognathus parvus* sp. n.; RHODES, p. 132, Pl. 8: 1–4.

1962. *Strachanognathus parvus* RHODES; BERGSTRÖM, p. 54, Pl. 3: 1–6.

1971. *Strachanognathus parva* RHODES; BEDNARCZYK, Pl. 3: 6.

1978. *Strachanognathus parvus* RHODES; LÖFGREN, p. 112, Pl. 1: 29.

1979. *Strachanognathus parvus* RHODES; KENNEDY *et al.*, p. 550, Pl. 1: 24.

1980. *Strachanognathus parvus* RHODES; ORCHARD, p. 26, Pl. 4: 34, 35.

1981. *Strachanognathus parvus* RHODES; NOWLAN, p. 13, Pl. 3: 18, 5: 5.

1984. *Strachanognathus parvus* RHODES; STOUGE, p. 57, Pl. 5: 9.

1991. *Strachanognathus parvus* RHODES; MCCracken, p. 52, Pl. 2: 36.

Type horizon and locality: Keysley Limestone at Keysley Bank, Westmoreland, England.

Diagnosis. — As for the genus.

Remarks. — Although all elements of the apparatus are of similar appearance, up to six discrete element types can be distinguished in large samples. They differ in the orientation of the denticles, which are more or less laterally bent, and in the width of their bases. There seems to be only a single symmetry transition series composed of them, with the symmetrical element being the second in width the base. It thus seems reasonable to interpret the element with the widest base to be a homologue of the **sp–oz** platform series while the twisted element at the opposite end of the morphocline is the **ne** element. This is more or less consistent with the interpretation of the *Cornuodus* apparatus proposed here.

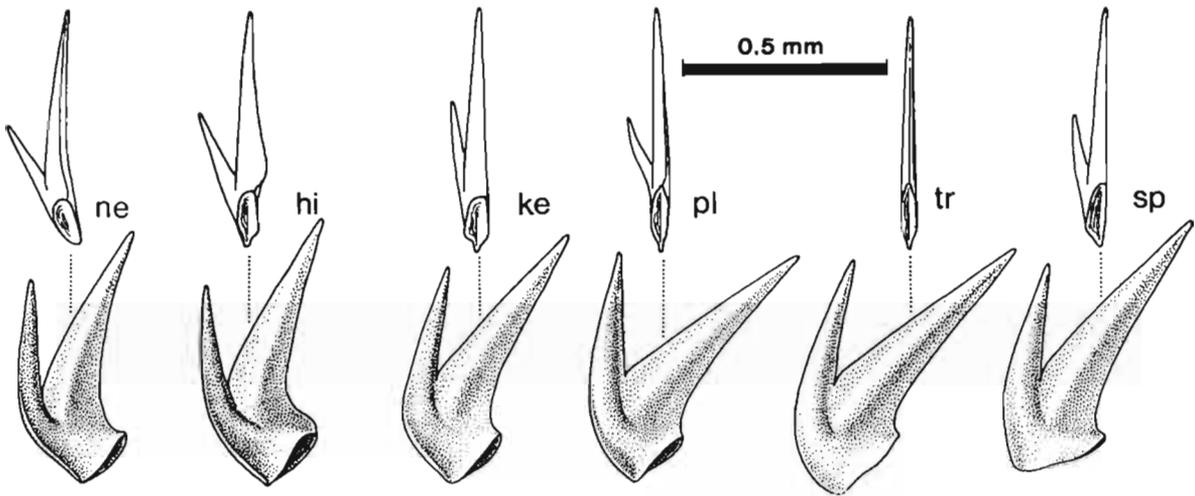


Fig. 5.

Apparatus of *Strachanognathus parvus* RHODES, 1955 and proposed notation of its elements.

There are some ontogenetic changes in the morphology of the elements. Large specimens show a thickening at the postero-internal surface of the cusp; in effect the cusp and the denticle are separated basally by a furrow. Juvenile specimens are completely smooth and very flat.

Distribution. — The species is known to occur from the Volkhovian (LÖFGREN 1978) to Ashgill (SERPAGLI 1967; ORCHARD 1980) without showing any significant evolutionary changes. It thus belongs to one of the evolutionarily most conservative conodont lineages. In Mójcza it almost continuously occurs from 0.4 m above the discontinuity (*E. robustus* Zone) up to 2.2 m above the bentonite (*A. superbus* Zone).

Genus *Dapsilodus* COOPER, 1976

Type species: *Distacodus obliquicostatus* BRANSON *et* MEHL, 1933.

Diagnosis. — Apparatus composed of flattened elements, triangular in lateral outline, all being asymmetric. The *ne* elements with a rounded incision above the base at the inner side and bearing, in common with at least two other element types, the panderodont furrow.

Dapsilodus viruensis (FÄHRÆUS, 1966) (Pl. 11: 20–23, 27–30; Text-fig. 6a–c)

1966. *Acodus viruensis* n. sp.; FÄHRÆUS, p. 12, Pl. 2: 2a–b, Text-fig. 2A.

1966. *Acontiodus sulcatus* n. sp.; FÄHRÆUS, p. 17, Pl. 2: 6a–b, Text-fig. 2F.

1976. *Panderodus (Dapsilodus) mutatus* (BRANSON *et* MEHL); DZIK, Text-fig. 15g–l.

1978. *Acodus? mutatus* (BRANSON *et* MEHL); LÖFGREN, p. 44, Pl. 2: 9–21, Text-fig. 23.

1984. *Dapsilodus striatus* sp. n.; CHEN and ZHANG, p. 134, Pl. 1: 17–20.

1991. *Dapsilodus mutatus* (BRANSON *et* MEHL); STOUGE and BAGNOLI, p. 14, Pl. 9: 19, 26–27.

Type horizon and locality: Vikarby limestone (Llanvirn) at Gullhögen quarry, Västergötland, Sweden.

Diagnosis. — Elements ornamented with longitudinal striae, usually best developed close to the panderodont furrow, external margins smooth.

Remarks. — Apparatus composition presented by DZIK (1976) and LÖFGREN (1978). The size of the elements increases significantly through the Mójcza section from the appearance of the species in sample MA-124 up to typical populations of sample MA-46 and following. The oldest known specimens are more robust than typical ones, with shorter cusps and oval cross-section. In this respect they somewhat resemble *Cornuodus* elements.

Distribution. — From 0.8 m below the discontinuity (*L. variabilis* Zone) up to 1.4 m above the bentonite (*A. tvaerensis* Zone), also in Międzygórz and Zalesie. Reported occurrences in the Baltic area and South China are within this time span.

Dapsilodus mutatus (BRANSON *et* MEHL, 1933)
(Pls 11: 24–26, 31–35, 14: 8–9; Text-fig. 6d)

1933. *Belodus*(?) *mutatus* n. sp.; BRANSON and MEHL, p. 126, Pl. 10: 17.
 1964. *Acodus* [*Belodus*(?)] *mutatus* (BRANSON *et* MEHL); BERGSTRÖM, Text-fig. 2.
 1966. *Acodus jejatus* n. sp.; HAMAR, p. 48, Pl. 1: 10–11, Text-fig. 3: 4.
 1966. *Distacodus bygdoyensis* n. sp.; HAMAR, p. 57, Pl. 1: 12–13, Text-fig. 3: 1.
 1976. *Panderodus (Dapsilodus) mutatus* (BRANSON *et* MEHL); DZIK, p. 435, Text-fig. 15g–i.
 1981. *Dapsilodus? similis* (RHODES); NOWLAN, p. 13, Pl. 5: 1–4.
 1984. *Dapsilodus mutatus* (BRANSON *et* MEHL); CHEN and ZHANG, Pl. 1: 13–16.
 1981. non *Paroistodus? mutatus* (BRANSON *et* MEHL); MCCracken and BARNES, p. 88, Pl. 3: 7–9 (= *Paroistodus? sp.* A NOWLAN *et* MCCracken; NOWLAN *et al.* 1988, p. 24, Pl. 9: 1–22.)
 1992. *Dapsilodus mutatus* (BRANSON *et* MEHL, 1933); BERGSTRÖM and MASSA, p. 1337, Pl. 1: 2.
 Type horizon and locality: Thebes Sandstone, Ozora, Missouri (together with the type of *A. ordovicicus*).

Diagnosis. — Mature elements with sharp smooth lateral ridges and external margins ornamented with oblique striae.

Remarks. — The apparatus of a closely related Silurian species was described by COOPER (1976). The type population of *Belodus*(?) *mutatus* is in need of revision with the application of multielement taxonomy. It is not quite certain whether it is conspecific with the European populations traditionally attributed to the same species. The holotype is an **ne** element, which is diagnostic for the genus leaving no possibility for its species or genus to be identified with *Paltodus? venustus* as suggested by MCCracken and BARNES (1981).

The sample MA-93 departs from the others containing elements of *Dapsilodus* in that its elements are much larger and more prominently ornamented there than in samples below and above. Whether this population represents another species (perhaps *D. obliquicostatus*) or just a fluctuation in the population dynamics is hard to decide with so limited data available.

Distribution. — The range of occurrence of *D. mutatus* in the Mójcza section is separated from its possible ancestor, *D. viruensis*, by a brief gap. The nature of the relationship between them has thus to be recognized in other sections. The species occurs from 1.9 m above the bentonite (*A. tvaerensis/superbus* transition zone) up to the top of the sections in Mójcza, Międzygórz and Zalesie.

Genus *Scabbardella* ORCHARD, 1980

Type species: *Drepanodus? altipes* HENNINGSMOEN, 1948.

Diagnosis. — Apparatus composed of flattened, smooth elements with an elongated triangular outline of the basal part and showing an almost continuous variability in shape within single symmetry transition series; all the elements being asymmetric. The **ne** elements differ from the remaining ones only in their more triangular lateral outline. They bear the panderodont furrow, which occurs also in some other element types.

Remarks. — The genus is very close to *Dapsilodus* being different from it only in the more generalized morphology of the elements. One may even question whether it is necessary to separate these genera.

Scabbardella altipes (HENNINGSMOEN, 1948)
(Pl. 11: 36–39; Text-fig. 6e)

1948. *Drepanodus altipes* n. sp.; HENNINGSMOEN, p. 420, Pl. 25: 14.
 1964. *Drepanodus? altipes* HENNINGSMOEN; BERGSTRÖM, Text-fig. 8.
 1971. *Scandodus inflexus* HAMAR; BEDNARCZYK, Pl. 4: 5.
 1976. *Panderodus (Dapsilodus) similis* (RHODES); DZIK, p. 435, Text-fig. 15c–d, k–m.

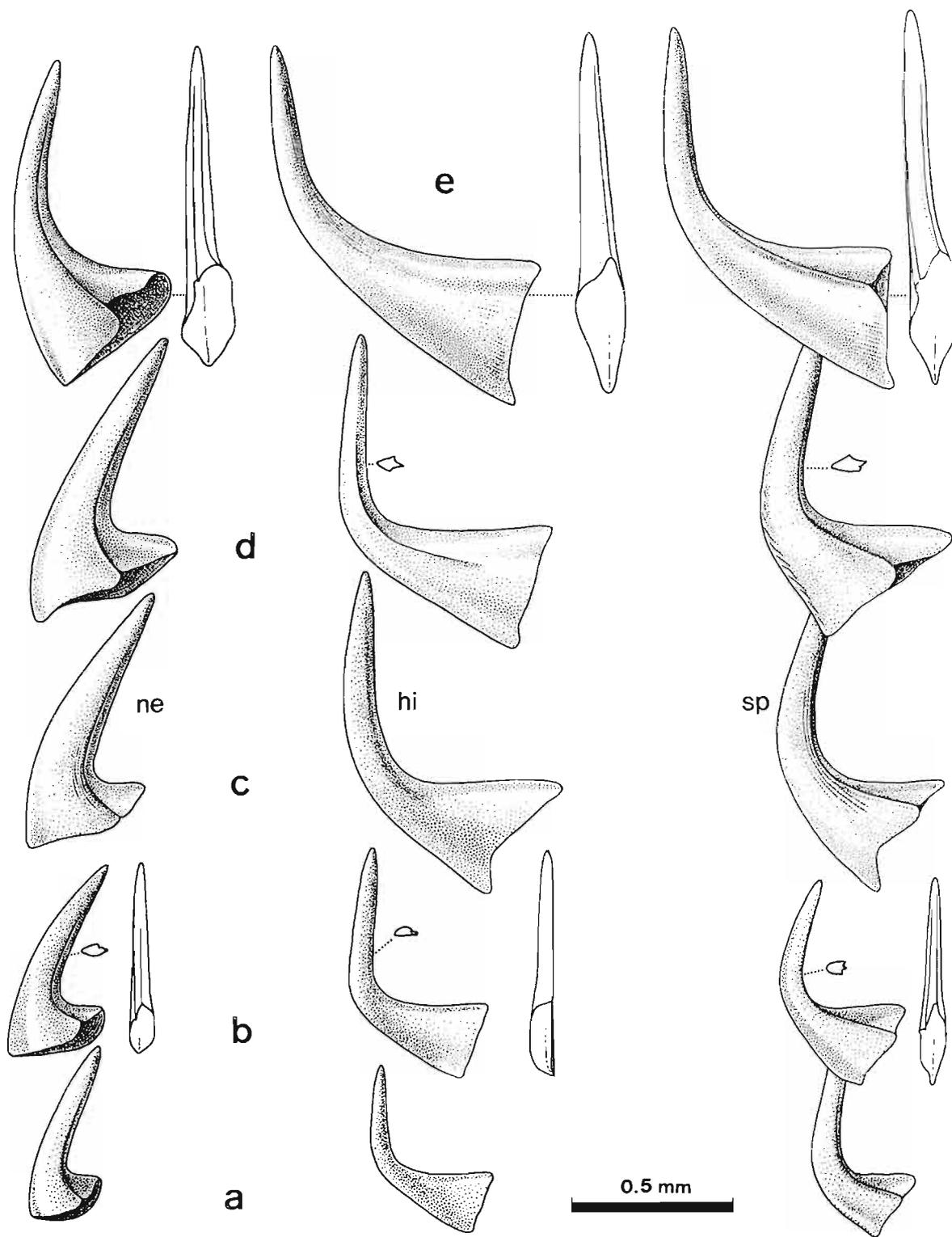


Fig. 6.

Apparatuses of *Dapsilodus* and *Scabbardella* and proposed homology of their elements. a–c. *Dapsilodus viruensis* (FÄHRÆUS, 1966), a, b, early forms, a from sample MA-124, b from MA-128. c, typical form from sample MA-46. d. *D. mutatus* (BRANSON *et* MEHL, 1933). e. *Scabbardella altipes* (HENNINGSMOEN, 1947).

1980. *Scabbardella altipes* (HENNINGSMOEN); ORCHARD, p. 25, Pl. 5: 2–5, 7–8, 12, 14, 18, 20, 23–24, 28, 30, 33, 35.
 1983. *Scabbardella altipes* (HENNINGSMOEN); NOWLAN, p. 668, Pl. 1: 6–7, 11–14.
 1984. *Scabbardella altipes* (HENNINGSMOEN); CHEN and ZHANG, Pl. 2: 29–30.
 1992. *Scabbardella altipes* (HENNINGSMOEN, 1948); BERGSTRÖM and MASSA, p. 1339, Pl. 1: 1, 3, 4.

Type horizon and locality: Fjäckå shale (*Pleurograptus linearis* Zone) at Kinnekulle, Sweden.

Diagnosis. — As for the genus.

Distribution. — A dominant species of the Late Ordovician *Hamarodus* fauna. In Mójcza it appears 0.9 m below the bentonite (*P. anserinus* Zone) and continues to the top of the section in the Zalesie Formation, similarly in Międzygórz and Zalesie.

Order *Protopanderodontida* SWEET, 1988

Diagnosis. — Apparatuses composed of coniform elements with two distinctly differentiated symmetry transition series, that of relatively robust elements of the “platform” series and that of gracile elements including a medial symmetrical element.

Family *Protopanderodontidae* LINDSTRÖM, 1970

Diagnosis. — Apparatuses composed of coniform elements with relatively shallow basal cavities and robust cusps usually armed with ribs on their inner sides.

Genera included. — *Semiacontiodus* MILLER, 1969, *Staufferella* SWEET, THOMPSON *et* SATTERFIELD, 1975, *Drepanodus* PANDER, 1856, *Protopanderodus* LINDSTRÖM, 1971, *Scandodus* LINDSTRÖM, 1955, *Ulrichodina* FURNISH, 1938, ?*Teridontus* MILLER, 1980.

Genus *Semiacontiodus* MILLER, 1969

Type species: *Acontiodus* (*Semiacontiodus*) *nogamii* MILLER, 1969.

Diagnosis. — Apparatus weakly differentiated, elements with relatively shallow basal cavities. The symmetric element robust, with strong lateral ridges; asymmetric elements with more or less oval cross sections of their cusps, bearing distally oblique ridges along their inner side.

Remarks. — *Staufferella* SWEET, THOMPSON *et* SATTERFIELD, 1975 is a generic name commonly used for Late Ordovician species of the same group. Its type species differs from older ones in having incisions at the base of lateral ribs in the **tr** elements; if there is really a need to separate Early and Late Ordovician species into distinct genera I suggest the use of this character as diagnostic for *Staufferella*, species with unmodified ribs being placed in *Semiacontiodus*.

Semiacontiodus cornuformis (SERGEEVA, 1963) (Pl. 13: 7–10; Text-fig. 7a)

1963. *Scolopodus cornuformis* sp. n.; SERGEEVA, p. 93, Pl. 7: 1–3.
 1963. cf. *Scandodus polonicus* sp. nov.; SPASSOV and TELLER, p. 81, Pl. 1: 5.
 1966. *Scolopodus cordis* n. sp. HAMAR, p. 74, Pl. 3: 4–6, Text-fig. 2: 5.
 1976. *Semiacontiodus cornuformis* (SERGEEVA); DZIK, Text-fig. 13g–l, Pl. 41: 4, 7.
 1978. *Scolopodus cornuformis* SERGEEVA; LÖFGREN, p. 105, Pl. 7: 1–6, 12, Pl. 8: 1–2, 4–6; Non Pl. 7: 3–4.
 1991. “*Semiacontiodus*” *cornuformis* (SERGEEVA); STOUGE and BAGNOLI, p. 26, Pl. 9: 14–18, 20–25.

Type horizon and locality: Kundan (Arenig/Llanvirn boundary) at Simonkovo, right bank of the Volchov River, Ingria (St. Petersburg district), northern Russia.

Diagnosis. — The symmetrical element **tr** bears lateral furrows, which separate wide lateral ribs continuously connecting the base with the tip of the cusp. The medial inner rib with a deep medial furrow at its base.

Remarks. — The main element types of the apparatus were identified by DZIK (1976). The most characteristic feature of the species is the robustly alate appearance of the **tr** element, which has a regularly triangular contour in medial view. Identifications of other element types are highly tentative because of their morphologic simplicity and the great population variability.

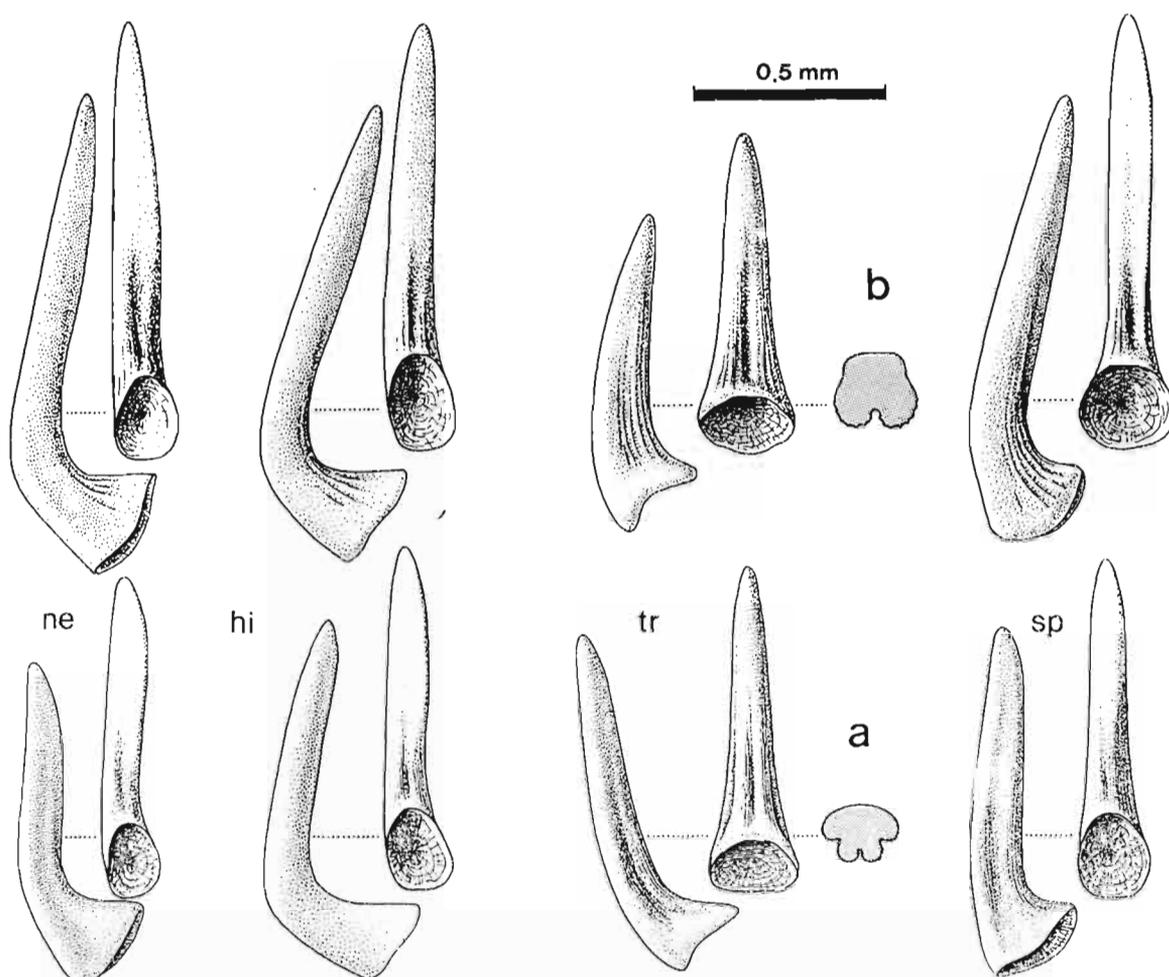


Fig. 7.

Apparatuses of *Semiacontiodus* species and proposed homology of their elements. a. *S. cornuformis* (SERGEEVA, 1963).
b. *S. longicostatus* (DRYGANT, 1974).

Distribution. — Occurs only below the discontinuity surface in Mójcza (the oldest undoubted specimens found 0.8 m below of it) while in the Baltic region it is a long ranging species. Its upper range is difficult to determine in the Baltic sections because it is very rare above the Llanvirn and the diagnostic symmetrical elements are rarely reported.

Semiacontiodus longicostatus (DRYGANT, 1974)
(Pl. 13: 11–13; Text-fig. 7b)

1974. *Scandodus longicostatus* sp. n.; DRYGANT, p. 57, Fig. 9–13.

1976. *Semiacontiodus longicostatus* (DRYGANT); DZIK, p. 443, Text-fig. 13p–q.

1978. cf. *Scolopodus bulbosus* n. sp.; LÖFGREN, p. 107, Pl. 7: 7A–B, 8: 3A–B.

Type horizon and locality: Borehole Piszczka–16 depth 410 m, (Uhakuan, Llandeilo), Volhynia, Ukraine.

Diagnosis. — The symmetrical *tr* element with a subsquare cross section at the base of the cusp and with a wide medial furrow.

Remarks. — The apparatus was identified by DZIK (1976). From its presumed ancestor, *S. cornuformis*, the species differs in the non-alate appearance of the *tr* element and in more prominent ornamentation at the inner side of the cusp base.

Distribution. — Occurs in the Holy Cross Mountains and Volhynia from the Lasnamägian to Kukrusean, probably present also in older (latest Kundan and Aserian) beds in Jämtland, Sweden. In Mójcza it occurs from the discontinuity surface (*E. reclinatus* or *E. robustus* Subzone) up to about 2.0 m above the bentonite (*A. tvaerensis/superbus* transition zone).

Genus *Drepanodus* PANDER, 1856

Type species: *Drepanodus arcuatus* PANDER 1856.

Diagnosis. — Apparatus composed of large, robust (sometimes hyaline) elements distinctly separated into two symmetry transition series. The first one consists of two element types with gaping basal cavities and short cusps, the second is a series of up to five element types with long flattened cusps and with changing curvature of the bending at the base of the cusp. The symmetrical element, which is the end member of the symmetry transition series, has a straight basal margin.

Remarks. — Apparatus reconstruction proposed by DZIK (1990), supported by the cluster described by MCCracken (1989); it testifies that the element types identified here as representing the “platform” series (**sp-oz**) really occupied a marginal position in the apparatus.

Drepanodus arcuatus PANDER, 1856 late form
(Pl. 15: 2–6; Text-fig. 8a–b)

1955. *Drepanodus arcuatus* PANDER; LINDSTRÖM, p. 558, Pl. 2: 30–33, Text-fig. 3J.

1955. *Scandodus pipa* n. sp.; LINDSTRÖM, p. 593, Pl. 4: 39–42 (non 38).

1963. *Acontiodus reclinatus* LINDSTRÖM; SPASSOV and TELLER, p. 77, Pl. 1: 1.

1971. *Drepanodus arcuatus* PANDER; LINDSTRÖM, p. 41, Figs 4, 8.

1971. ?*Drepanodus arcuatus* PANDER; BEDNARCZYK, Pl. 1: 11.

1971. *Drepanodus proteus* LINDSTRÖM; BEDNARCZYK, Pl. 1: 12.

1976. *Drepanodus arcuatus* PANDER; DZIK, Text-fig. 17a, c.

1988. *Drepanodus arcuatus* PANDER; STOUGE and BAGNOLI, p. 115, Pl. 2: 1–6.

1988. cf. *Drepanodus planus* (PANDER); STOUGE and BAGNOLI, p. 116, Pl. 2: 7–10.

Type horizon and locality: The species is generally understood in the way proposed by LINDSTRÖM (1955). His concept of the species has been based on specimens from the Arenig of Sweden, I therefore suggest to consider his most representative sample 10 from the Upper Planilimbata Limestone at Lanna near Örebro to be the standard for the species.

Diagnosis. — The symmetrical **tr** element with smooth lateral surfaces, its inner margin sharp, in juveniles with smooth flanks, but in adults they may bear angulations. The **ne** elements robust, with a deep round incision above the base. All elements hyaline.

Remarks. — Two main element types were identified by LINDSTRÖM (1971), the apparatus reconstruction has been further developed by VAN WAMEL (1974), LÖFGREN (1978), and DZIK (1990). During the evolution of this *Drepanodus* lineage elements become more and more prominently ornamented along their inner edges. In the Arenig some rare specimens (usually large ones) bear three ridges along this edge but I was not able to find any with more elaborated ornamentation, which is typical for later *D. robustus*. Somewhat arbitrarily, I assign to *D. arcuatus* these populations transitional to *D. robustus* that still did not develop five ridges along the inner edge in adult elements. “*Protopanderodus* n. sp. A” MCCracken, 1989 from the *P. serra* Zone of Northern Yukon, Canada, may be a successor of *D. arcuatus*. Oblique bases make it superficially similar to some species of *Protopanderodus* which, however, have quite different “platform” series elements and less elaborated apparatuses.

Distribution. — A few specimens of *Drepanodus*, collected by Dr. Wiesław BEDNARCZYK from the limestone bed once exposed in the Bukówka quarry definitely belong to this species. None of the two large **tr** elements present in the sample has any lateral ridges (Text-fig. 8a). However, a specimen of similar size from the borehole Bukówka IG 1 (depth 83.5–84 m) shows five distinct ridges. This rather exceeds possible population variability and the sample seems thus to be of different age, probably closer to the base of the Mójcza Limestone where similar large elements occur. Somewhat enigmatic is the presence in both Bukówka samples of a few possible **ke** elements with a very convex posterior side and prominent medial rib (Text-fig. 8a). There are too few specimens available to state

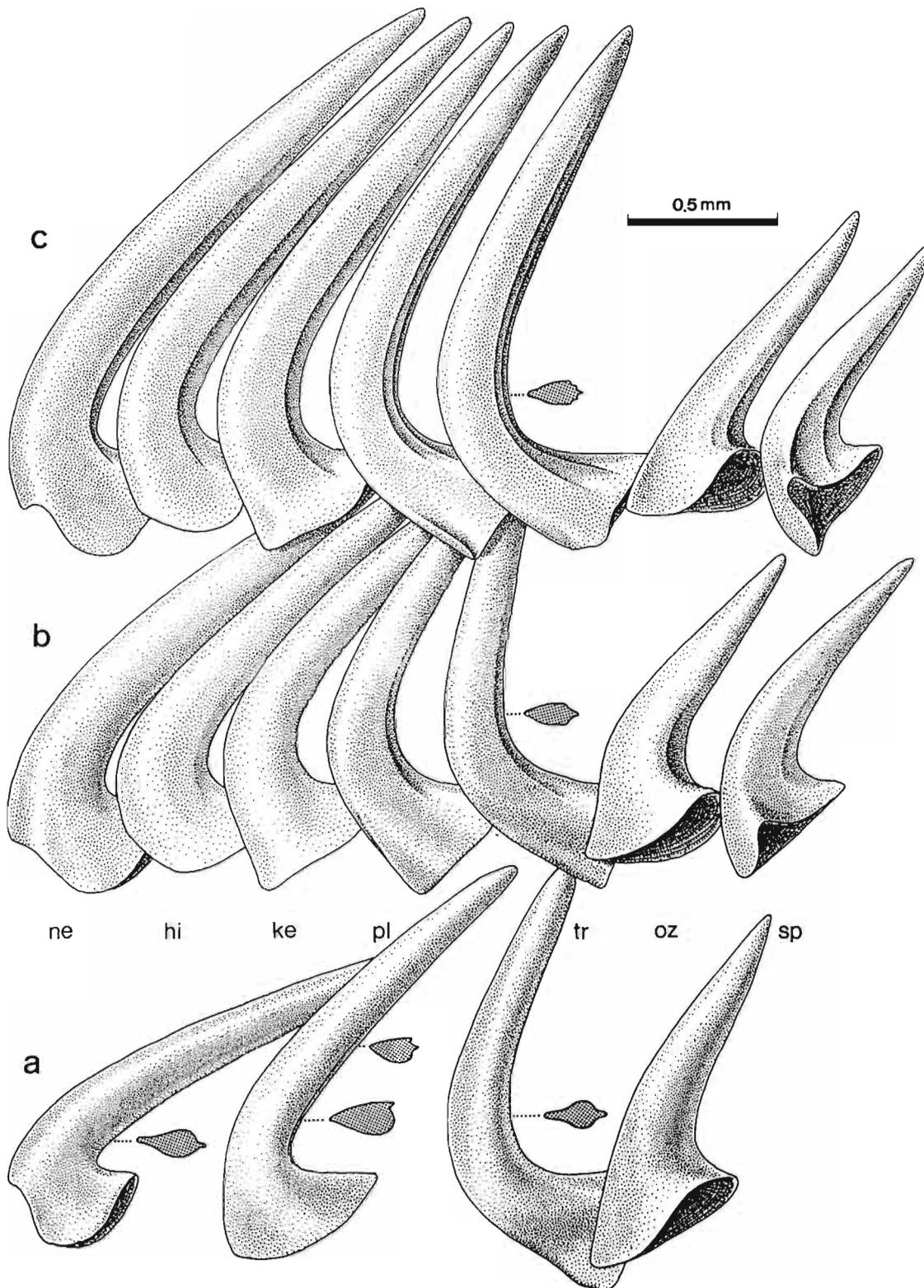


Fig. 8.

Apparatuses of *Drepanodus* species and proposed homology of their elements. **a.** Elements of *D. arcuatus* PANDER, 1856 found in the limestone intercalation in the Bukówka quarry (collected by Dr. Wiesław BEDNARCZYK). **b.** *D. arcuatus* PANDER, 1856, late form from the basal parts of the Mójcza Limestone. **c.** *D. robustus* HADDING, 1913.

with certainty whether they belong to another sympatric species of *Drepanodus* or perhaps they represent **ne** elements of a species of *Protopanderodus*.

To *D. arcuatus* I assign also populations from below the discontinuity surface in Mójcza, with elements usually armed with three sharp ridges. Elsewhere the typical *D. arcuatus* is confined to the Arenig.

Drepanodus kielcensis sp. n.
(Pl. 16: 1–7; Text-fig. 9b)

Holotype: ZPAL CVI/642; Pl. 16: 2.

Type horizon and locality: Sample MA-128, base of the Mójcza Limestone (early Kundan, latest Arenig) at Mójcza, Holy Cross Mountains, Poland.

Diagnosis. — The external crista of the **ne** elements strongly inclined posteriorly above the base, forms a wide furrow. Elements of the main symmetry transition series smooth, their cusps rich in white matter.

Remarks. — Mature elements of *D. kielcensis* are much smaller than those in associated species of the genus. They differ also in a whitish coloration and thicker cusps of the **ne** elements.

Distribution. — In the Mójcza Limestone the species occurs below the discontinuity surface, that is in the Early Kundan *L. variabilis* Zone.

Drepanodus robustus HADDING, 1913
(Pl. 14: 10–14; Text-fig. 8c)

1971. *Drepanodus robustus* HADDING; LINDSTRÖM, p. 41.

1971. *Drepanodus planus* LINDSTRÖM; BEDNARCZYK, Pl. 1: 3.

1976. *Drepanodus robustus* (HADDING); DZIK, p. 432, Text-fig. 17d–g.

1978. partim *Drepanodus arcuatus* PANDER; LÖFGREN, p. 51, Pl. 2: 1, 3, 5, 7–8 (only).

Type horizon and locality: Lower *Dicellograptus* Shale, base of the section E 14a of Fågelsång near Lund, Skåne, Sweden.

Nomenclatorial note. — LINDSTRÖM (1971) proposed to apply this name to costate Middle Ordovician species of *Drepanodus* and I have followed him (DZIK 1976) including additional element types in the apparatus. LÖFGREN (1978) has considered the holotype of *D. robustus* to be a member of *Protopanderodus*. However, the riblets that it bears at the inner side of the base are unknown in any Baltic species of *Protopanderodus* typical for the species under consideration. This is why I am not ready to accept this translocation of the name to another genus.

Diagnosis. — The **ne** elements robust, with almost flat surfaces along the posterior external ridge. Mature elements prominently costate, the **tr** element usually bears five inner ribs (even in some juveniles). All the elements hyaline with rudimentary white matter.

Remarks. — The apparatus of *D. robustus* is of the same organization as that of *D. arcuatus*. The only difference consists in the ornamentation of the inner margins of mature elements. There are populations transitional between these two species but the evolutionary relationships between them are far from being clarified. They probably formed a network of allopatric, independently evolving lineages that occasionally interbred until a complete separation of the lineages at an unknown level of the Llanvirn, when along with the *D. robustus* lineage another line, leading from *D. arcuatus* to *D. santacrucensis* sp. n. was established. Juvenile elements of these species are hardly distinct morphologically. In consequence of a high developmental and population variability it is also not always possible to separate some morphologically close element types within the symmetry transition series.

Distribution. — The species appears in the Mójcza limestone at the discontinuity surface and continues as high above as to 1.8 m above the bentonite (*A. tvaerensis/superbus* transition zone). Rare, specifically unidentifiable elements of *Drepanodus* occur sporadically even higher in the section.

Drepanodus santacrucensis sp. n.
(Pl. 16: 8–13; Text-fig. 9a)

Holotype: ZPAL CVI/640; Pl. 16: 8.

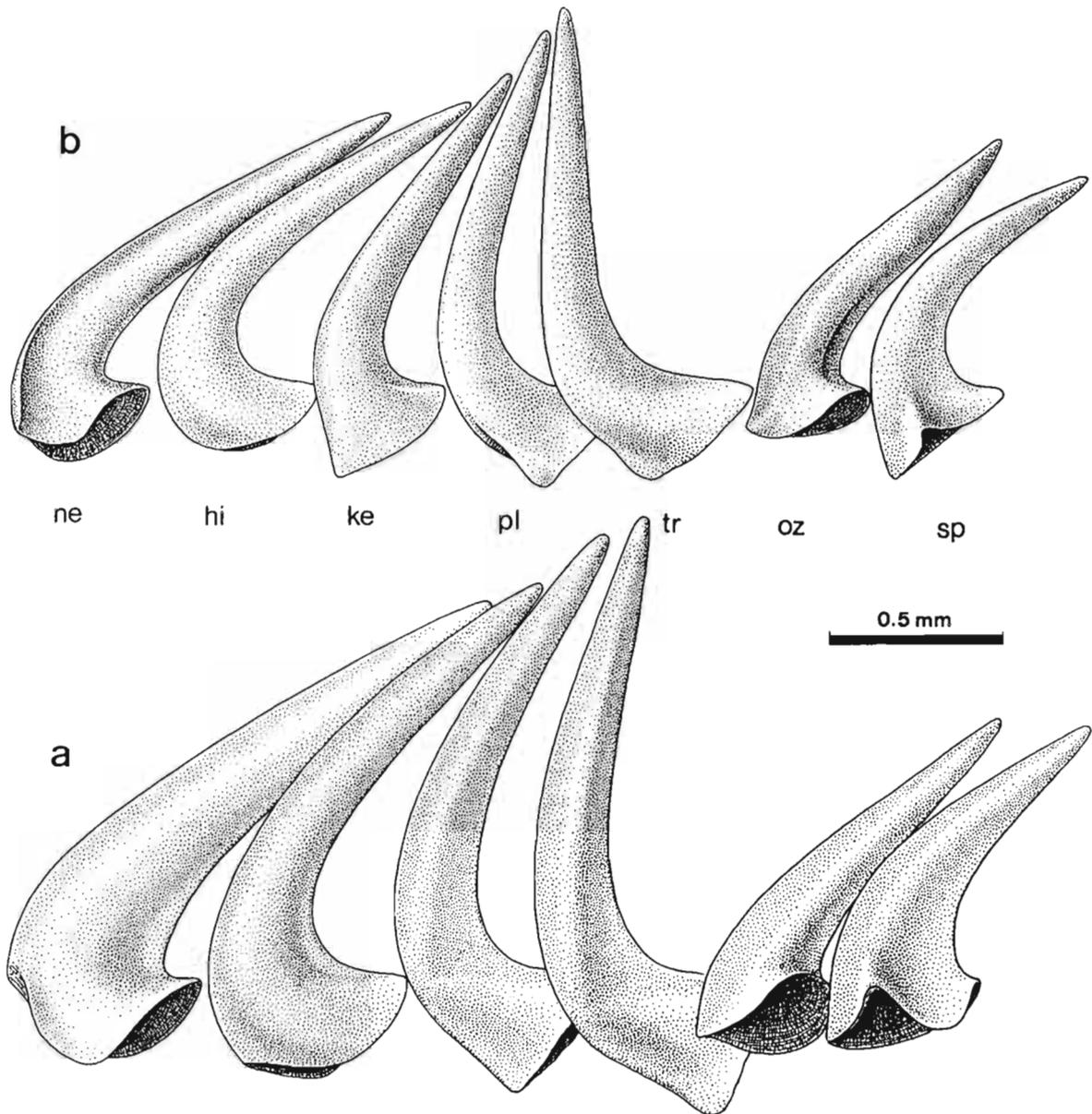


Fig. 9.

Apparatuses of new species of *Drepanodus* and proposed homology of their elements. **a.** *D. santacrucensis* sp. n. **b.** *D. kielcensis* sp. n.

Type horizon and locality: Sample MA-76, Mójcza Limestone (*A. tvaerensis* Zone, Early Caradoc) at Mójcza in the Holy Cross Mountains, Poland.

Diagnosis. — All mature elements with smooth, very flat cusps expanding on both sides into sharp thin cristae.

Remarks. — The most characteristic feature for the species is very flat **ne** elements, unlike those of related species. Although the number of collected specimens is limited and their preservation not good, as a result of the unusual fragility of these thin cristate elements, it seems that the apparatus structure was closely similar to that of its probable ancestor *D. arcuatus*. Their **ke** and **hi** elements are hardly distinguishable.

Distribution. — Rare specimens of the species occur from 1.3 m below (*E. lindstroemi* Subzone) up to 1.9 m above the bentonite (*A. tvaerensis/superbus* transition zone).

Genus *Protopanderodus* LINDSTRÖM, 1971

Type species: *Acontiodus rectus* LINDSTRÖM, 1955.

Diagnosis. — The base of the **ne** elements gapes obliquely to the plane of the wide sharp-edged cusp. Other elements bear three sharp ribs along the inner margin and a variable number of furrows on their sides. Cusps with white matter.

Remarks. — The genus differs from *Drepanodus* in its strongly asymmetric **ne** elements, and generally more regular appearance of robust elements that are not as strongly differentiated morphologically in the apparatus. From *Cornuodus* and *Semiacontiodus* it differs in the externally parabolic, subtriangular cross section of the cusp.

Protopanderodus rectus (LINDSTRÖM, 1955)
(Pl. 13: 27–30; Text-fig. 10a)

1955. *Acontiodus rectus* n. sp.; LINDSTRÖM a, p. 549, Pl. 2: 7–11, Text-figs 2k–m, 3b.
 1963. *Acontiodus rectus* LINDSTRÖM; SPASSOV and TELLER, p. 78, Pl. 1: 4.
 1971. *Protopanderodus rectus* (LINDSTRÖM); LINDSTRÖM, p. 50.
 1971. *Scandodus formosus* FÄHRÆUS; BEDNARCZYK, Pl. 3: 1.
 1971. *Acontiodus rectus* LINDSTRÖM; BEDNARCZYK, Pl. 3: 2.
 1971. *Acontiodus robustus* (HADDING); BEDNARCZYK, Pl. 3: 3.
 1976. partim *Protopanderodus rectus* (LINDSTRÖM); DZIK, Text-fig. 16c, l (only).
 1976. partim *Protopanderodus varicostatus* (SWEET et BERGSTRÖM); DZIK, Text-fig. 16e, g (only).
 1978. *Protopanderodus rectus* (LINDSTRÖM); LÖFGREN, p. 90, Pl. 3: 1–7, 36A–B, Text-fig. 31A–C.
 1984. *Protopanderodus robustus* (HADDING); STOUGE, p. 49, Pl. 2: 3–8.
 1984. *Protopanderodus cooperi* (SWEET et BERGSTRÖM); CHEN and ZHANG, Pl. 3: 34–35.
 1989. cf. *Protopanderodus robustus* (HADDING); MCCracken, p. 20, Pl. 1: 1–10, Text-fig. 3E.
 1991. *Protopanderodus rectus* (LINDSTRÖM); STOUGE and BAGNOLI, p. 23, Pl. 8: 1–5.

Type horizon and locality: Sample 12 from the Upper Planilimbata Limestone (Arenig) of Lanna near Örebro, Sweden.

Diagnosis. — The **ne** elements with smoothly convex postero-internal surface of the cusp.

Remarks. — The apparatus of the species was partially reconstructed by LINDSTRÖM (1971). LÖFGREN (1978) indicated precise distinctions from related species of the genus. There are only four discrete element types in its apparatus. *P. rectus* differs from its closest relative *P. graeai* in the lack of postero-internal ridge in the **ne** element and sinuous profile of bases of all elements and from *P. gradatus* in the lack of posterior furrow in the **ne** element and additional furrows in other element types.

Distribution. — Very common in the Ordovician of the Baltic area and the Holy Cross Mountains where it occurs in the Bukówka Sandstone and in the Mójcza Limestone from its base up to 0.7 m above the bentonite (top of *P. anserinus* Zone). Occasionally it cooccurs sympatrically with two other species of the genus.

Protopanderodus graeai (HAMAR, 1966)
(Pl. 13: 14–22; Text-fig. 10b–c)

1966. *Aodus graeai* n. sp.; HAMAR, p. 47, Pl. 3: 11–14, Text-fig. 3: 5.
 1976. partim *Protopanderodus rectus* (LINDSTRÖM); DZIK, Text-fig. 16a, i (only).
 1978. *Protopanderodus graeai* (HAMAR); LÖFGREN, p. 93, Pl. 3: 19–25, Text-fig. 3I, K–M.
 1991. *Protopanderodus* sp.; STOUGE and BAGNOLI, p. 24, Pl. 8: 6–8.

Type horizon and locality: Sample 187 from a 20 cm thick limestone bed within the uppermost 10 m of the *Ampyx* Limestone at Rødeløkken, Bygdøy peninsula, Oslo, Norway.

Diagnosis. — The **ne** elements with postero-internal surface split by a sharp medial ridge into two concave areas.

Remarks. — Mature elements of the species are much smaller than those of cooccurring species of the genus and have much less sinuous bases. In some samples, the MA-46 being the most

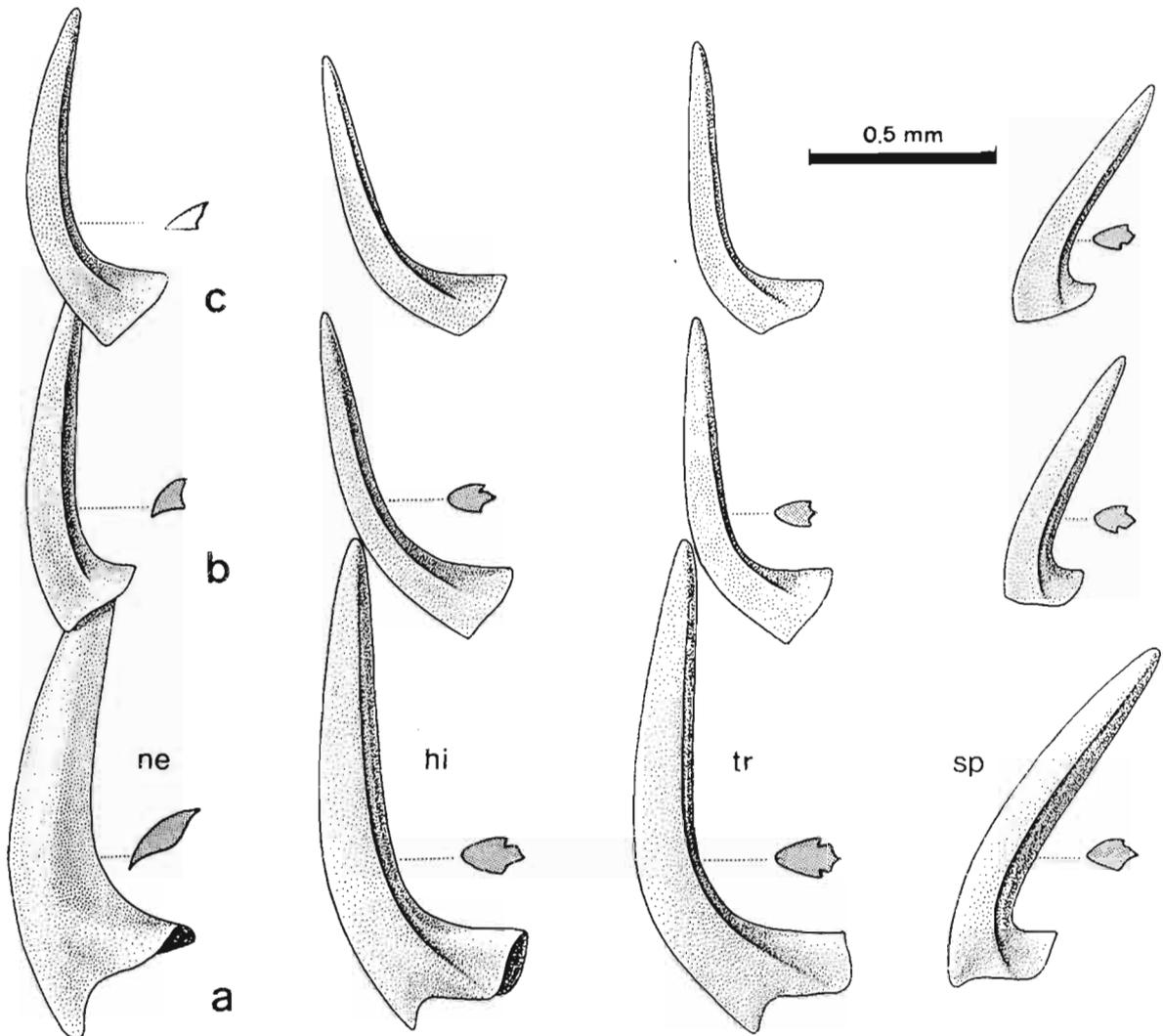


Fig. 10.

Apparatuses of *Protoperododus* species and proposed homology of their elements. **a.** *P. rectus* (LINDSTRÖM, 1955). **b–c.** *P. graeai* (HAMAR, 1966), b from sample MA-128, c from sample MA-46.

conodont-rich of them, there is a complete gradual transition between elements of shapes typical for *P. rectus* and *P. graeai*. All these specimens have similar size (that of *P. graeai*). Above that in the section the typical populations of *P. graeai* reappear. It is unclear whether this was an influx of a distinct species (perhaps *P. robustus* sensu LÖFGREN 1978), temporal interbreeding between *P. graeai* and *P. rectus* or just an irregularity in the course of the evolution.

Distribution. — In Mójcza it occurs from 0.7 m below the discontinuity (*L. variabilis* Zone) and is quite common up to 0.5 m above the bentonite. Rare specimens have been found as high as 1.2 m above the bentonite (*A. tvaerensis* Zone). Occurrences elsewhere are within this time span.

Protoperododus gradatus SERPAGLI, 1974
(Pl. 13: 23–26; Text-fig. 11a)

1974. *Protoperododus gradatus* n. sp.; SERPAGLI, Pl. 15: 5a–8b, Pls 26: 11–15; 30: 1, Text-fig. 17.

1976. partim *Protoperododus rectus* (LINDSTRÖM); DZIK, Text-fig. 16b, d (only).

1978. *Protoperododus* cf. *varicostatus* (SWEET et BERGSTRÖM); LÖFGREN, p. 91, Pl. 3: 26–29, 30–31.

1984. *Protoperododus* cf. *liripipus* KENNEDY, BARNES et UYENO; STOUGE, p. 49, Pl. 2: 9–14, 17.

1984. *Protopanderodus* cf. *varicostatus* (SWEET et BERGSTRÖM), STOUGE, p. 51. Pl. 3: 11–17.

1988. *Protopanderodus gradatus* SERPAGLI; STOUGE and BAGNOLI, p. 136, Pl. 14: 9–12.

1991. *Protopanderodus* cf. *P. varicostatus* (SWEET et BERGSTRÖM); STOUGE and BAGNOLI, p. 23. Pl. 8: 9–12.

Type horizon and locality: Sample 1710 taken from about 80 m below the top of the San Juan Limestone (*Prioniodus navis* Zone, Arenig) near San Juan, Argentina.

Diagnosis. — The *ne* elements have a shallow furrow on the posterior surface along the external margin. In other elements deep furrows split the flanks into rounded ribs.

Remarks. — The type population of the species is the oldest one known (early Volkhovian) and it seems to have primitive morphologic features that are mainly expressed in less sinuous bases of the elements than in younger (early Kundan) populations. Otherwise all the element types in the Argentina population seem to be virtually identical with those in the Baltic and Polish ones. The slide with specimens of the species from the most productive Mójcza sample MA-128 was misplaced in the collection after counting and I am unable to trace it.

Distribution. — Occurs somewhat irregularly in the Mójcza limestone from 0.7 m below the discontinuity surface (*L. variabilis* Zone) up to 1.2 m below the bentonite (*E. lindstroemi* Subzone). In Argentina and Newfoundland known from slightly older strata of Volkhovian age.

Protopanderodus varicostatus (SWEET et BERGSTRÖM, 1962)

(Pl. 14: 1–5; Text-fig. 11b)

1962. *Scolopodus varicostatus* n. sp.; SWEET and BERGSTRÖM, p. 1247, Pl. 168: 4–9, Text-fig. 1: A, C, K.

1976. partim *Protopanderodus varicostatus* (BERGSTRÖM); DZIK, Text-fig. 16f (only).

1983. *Protopanderodus varicostatus* (SWEET et BERGSTRÖM); BURRETT *et al.*, p. 184, Text-fig. 9C–D.

1984. *Protopanderodus varicostatus* (SWEET et BERGSTRÖM); CHEN and ZHANG, Pl. 3: 36–38.

1985. *Protopanderodus varicostatus* (SWEET et BERGSTRÖM); BERGSTRÖM and ORCHARD, Pl. 2.3: 5.

Type horizon and locality: Limestone bed of the Pratt Ferry Formation (*P. anserinus* Zone, Llandeilo) 0.2 mile SW of Pratt Ferry, Alabama.

Diagnosis. — The *ne* elements have a wide shallow furrow in the middle of the posterior side of the cusp. All mature elements with a widened base, their external margins are somewhat alate.

Remarks. — The species differs from its probable ancestor, *P. gradatus*, in the widening of the element bases, which are, however, not transformed into processes as in younger *P. liripipus*. Morphology of elements is very variable.

Distribution. — Rare in the middle part of the Mójcza Limestone from 1.0 m below to just below the bentonite (*P. anserinus* Zone). Widespread in the Llandeilo of the North Atlantic realm (MCCRACKEN 1989)

Protopanderodus liripipus KENNEDY, BARNES et UYENO, 1979

(Pl. 14: 6–7; Text-fig. 11c)

1976. *Protopanderodus insculptus* (BRANSON et MEHL); DZIK, p. 443, Text-fig. 16h, k.

1979. *Protopanderodus liripipus* sp. n.; KENNEDY *et al.*, p. 547, Pl. 1: 9–19.

1979. *Protopanderodus liripipus* KENNEDY *et al.*; AN *et al.*, Pl. 1: 16–17.

1979. *Protopanderodus liripipus* (KENNEDY *et al.*); HARRIS *et al.*, Pl. 5: 4.

1983. *Protopanderodus liripipus* KENNEDY *et al.*; BURRETT *et al.*, p. 184, Text-fig. 9A–B.

1983. *Protopanderodus* cf. *P. liripipus* KENNEDY *et al.*; NOWLAN, p. 667, Pl. 3: 12, 15.

1984. *Protopanderodus liripipus* KENNEDY *et al.*; WANG and LUO, Pl. 8: 6–10.

1984. *Protopanderodus liripipus* KENNEDY *et al.*; CHEN and ZHANG, Pl. 2: 22–24.

1985. *Protopanderodus liripipus* KENNEDY *et al.*; BERGSTRÖM and ORCHARD, Pl. 2.3: 4.

Type horizon and locality: Metabasalt unit of the Tetagouche Group (*Prioniodus alobatus* Zone, Caradoc) at Camel Back Mountain, New Brunswick, Canada.

Diagnosis. — Bases of the elements elongated into internal and external flat processes of parabolic shape.

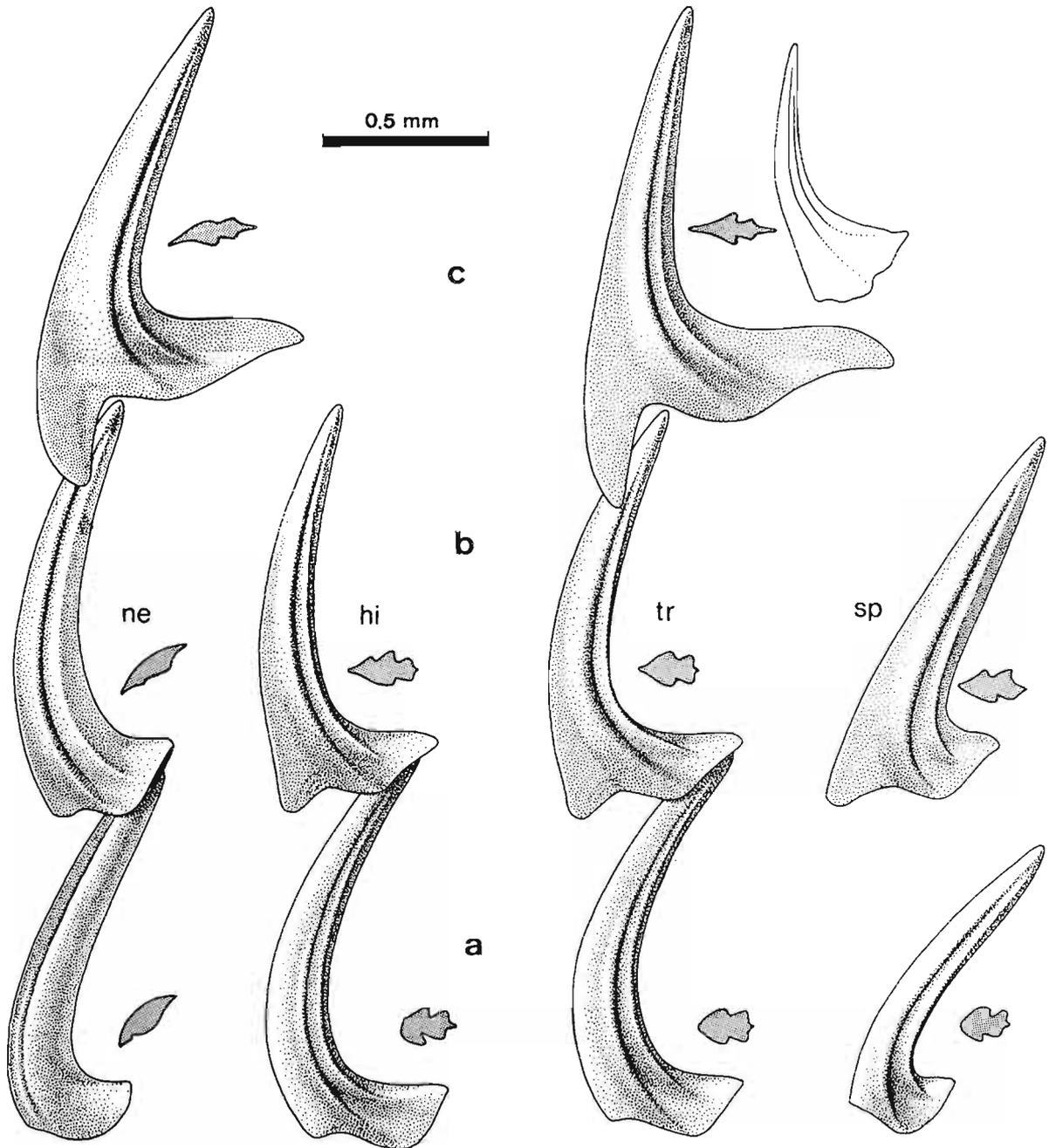


Fig 11.

Apparatuses of *Protopanderodus* species and proposed homology of their elements. a. *P. gradatus* SERPAGLI, 1974 late form. b. *P. varicostatus* (SWEET et BERGSTRÖM, 1962). c. *P. liripipus* KENNEDY, BARNES et UYENO, 1979.

Remarks.— The species differs from its ancestor *P. varicostatus* in a further development of wings at the element bases and from its successor *P. insculptus* in the lack of a denticle on the inner of these wings. Juvenile specimens do not show diagnostic features of the species, being similar to *P. gradatus* in their general shape except for a very deep cavity within a funnel-shaped base. The wings develop gradually during growth of the element. Also the shape of the cusp changes somewhat, in mature specimens being almost straight, which gives specimens the characteristic triangular appearance.

The population described by NOWLAN (1981) is less advanced in the development of external processes while the specimens illustrated by HARRIS *et al.* (1979) seem to be more advanced in the same respect, being on the way to *P. insculptus*.

Distribution. — According to MCCracken (1989) the species ranges from the *P. gerdae* Subzone of the *A. tvaerensis* Zone to the *A. ordovicicus* Zone. In Mójcza it occurs in the marly limestone of the Zalesie Formation (*A. ordovicicus* Zone), being common also in coeval strata in Międzygórz and Zalesie.

Family **Distacodontidae** BASSLER, 1925

Diagnosis. — Apparatuses with geniculate **ne** elements and all remaining elements laterally compressed, with sharp edges of the cusp.

Remarks. — The most primitive conodonts with geniculate **ne** elements are classified in the family. Some forms with geniculate elements are included here into the Strachanognathidae on the basis of overall similarity of elements to more typical members of the family (namely *Besselodus*, which is closely similar to *Dapsilodus*) but it is not clear whether these features really resulted from a convergent evolution.

Genus *Paltodus* PANDER, 1856

Type species: *Paltodus subaequalis* PANDER, 1856 (?= *P. inconstans* LINDSTRÖM, 1955).

Remarks. — The holotype of the type species has been lost and its illustration is specifically undeterminable. Somewhat arbitrarily LINDSTRÖM (1971) suggested that it may be a senior synonym of his *P. inconstans*. It seems reasonable to follow his choice and to consider the type population of the latter species to be the reference standard for the genus. Its apparatus is closely similar to that of *Drepanoistodus* (see BAGNOLI *et al.* 1988) and, actually, separation of these genera seems now rather doubtful. Affinities of the Middle Ordovician species tentatively classified here in *Paltodus* remain uncertain, although some forms transitional in age and morphology (see LÖFGREN 1978: p. 64) may support such attribution.

Paltodus? *semisymmetricus* (HAMAR, 1966) (Pl. 16: 14–15; Text-fig. 12d)

1966. *Acontiodus semisymmetricus* n. sp.; HAMAR, p. 51, Pl. 7: 5–6, Text-fig. 3: 6.

1976. *Paltodus(?) semisymmetricus* (HAMAR); DZIK, p. 435, Text-fig. 18b–f.

Type horizon and locality; Sample 157 from the top of the Upper *Chasmops* Limestone (Late Caradoc) at Nakholmen, Oslo district, Norway.

Remarks. — The apparatus composition was proposed by DZIK (1976) but the species remains only superficially known. Except that the apparatus is composed of an oistodontiform element with long cusp and that elements of the symmetry transition series with two sharp ridges at their sides have characteristically internally expanding bases, little can be said about it. The morphology of elements of the species is closely similar to that of *Besselodus arcticus* ALDRIDGE, 1982 and it is a matter of dispute whether this is an effect of a secondary development of geniculation of the **ne** elements in the *Dapsilodus* lineage or a development of peculiar oblique striation in elements of the symmetry transition series of *Paltodus*, making them identical with respective elements of *Dapsilodus*. I am rather inclined to the first interpretation.

Distribution. — Rare in the Mójcza Limestone from 0.4 above up to 1.4 m above the discontinuity (*E. robustus* – *E. lindstroemi* Subzones) and in coeval strata of the Baltic region.

Paltodus? *venustus* (STAUFFER, 1935) (Text-fig. 12c)

1935. *Oistodus venustus* n. sp.; STAUFFER, p. 146, Pl. 12: 12.

1963. *Oistodus venustus* STAUFFER; SPASSOV and TELLER, p. 79, Pl. 1: 10.

1971. *Oistodus forceps* LINDSTRÖM; BEDNARCZYK, Pl. 1: 1.

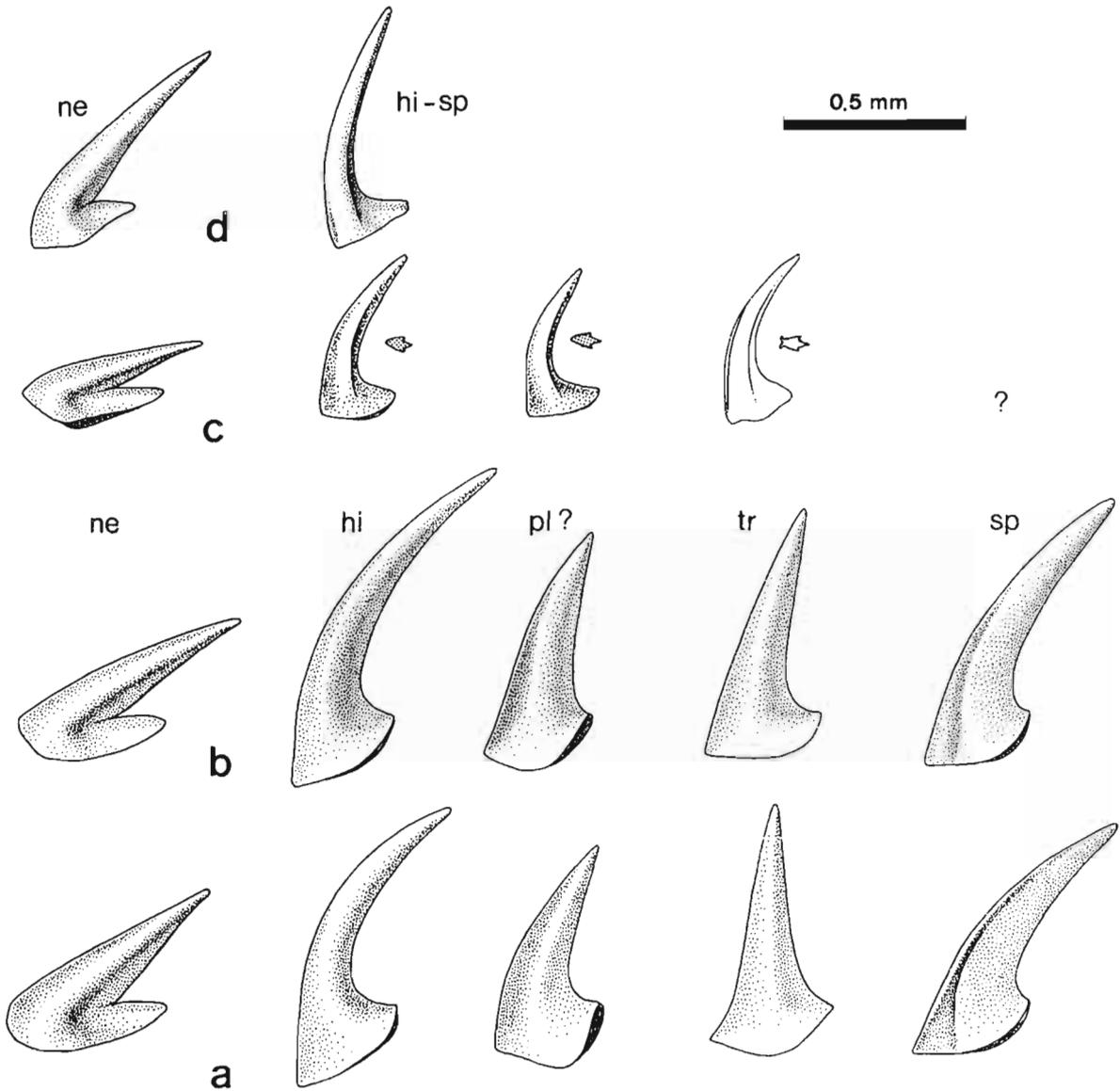


Fig. 12.

Apparatuses of the Distacodontidae and proposed homology of their elements. **a.** *Drepanoistodus basiovalis* (SERGEEVA, 1963). **b.** *D. suberectus* (BRANSON *et* MEHL, 1933) early form. **c.** *Paltodus? venustus* (STAUFFER, 1935); symmetrical element not found in Mójcza. **d.** *P.? semisymmetricus* (HAMAR, 1966).

1978. *Drepanoistodus? venustus* (STAUFFER); LÖFGREN, p. 57, Pl. 1: 9–10.

1988. *Paroistodus? sp.* A NOWLAN *et* MCCRACKEN; NOWLAN *et al.*, p. 24, Pl. 9: 1–22.

Type horizon and locality: Glenwood Formation.

Diagnosis. — The **ne** elements with cusps of almost the same length as the base, **tr** element with sharp flat ribs along the external margin.

Remarks. — Like in all other known occurrences of the oistodontiform elements of this species there are no other elements in the Mójcza Limestone that could be easily matched with them on the basis of common occurrence with expected frequency (that is dominating in numbers over the **ne** elements). However, in two samples, MA-70 and MA-87, singular minute elements have been found that are identical with those proposed by NOWLAN *et al.* (1988) to belong to its apparatus. This reconstruction seems more probable than the alternative one that the rest of the apparatus of the species

is identical with *Drepanoistodus*. The unusually high abundance of **ne** elements may result from their small size and special hydrodynamic properties.

As there is no inversion of the basal cavity in elements of *P.?* *venustus*, the species cannot be included in the genus *Paroistodus*, as provisionally chosen by NOWLAN *et al.* (1988). The strong ribs arming element flanks and short lateral keels in symmetrical elements are highly primitive traits in the Distacodontidae. This is suggestive of a relationship with Early Ordovician *Paltodus* species.

Distribution. — In Mójcza the species occurs from the level immediately below the bentonite (*P. anserinus* Zone) up to the top of the section. It may possibly occur also below the discontinuity but there the **ne** elements of this morphology are difficult to separate from associated *Drepanoistodus* species. In the North American Midcontinent the species is common in the Late Ordovician while in the North Atlantic realm it seems to range from Arenig to Ashgill.

Genus *Drepanoistodus* LINDSTRÖM, 1971

Type species: *Oistodus forceps* LINDSTRÖM, 1955.

Diagnosis. — The **tr** element with an erect cusp; all the elements in the apparatus with smooth or weakly ribbed flanks.

Remarks. — The genus differs from its closest relative *Paroistodus* in the characteristic shape of the **tr** element and in lack of inversion of the basal cavity in all elements.

Drepanoistodus basiovalis (SERGEEVA, 1963) (Pl. 16: 16–20; Text-fig. 12a)

1963. *Oistodus basiovalis* sp. nov.; SERGEEVA, p. 96, Pl. 7: 6–7.

1971. *Oistodus basiovalis* SERGEEVA; BEDNARCZYK, Pl. 1: 2.

1978. *Drepanoistodus basiovalis* (SERGEEVA); LÖFGREN, p. 55, Pl. 1: 11–17, Text-fig. 26B–C.

1984. *Drepanoistodus forceps* (LINDSTRÖM)?; DZIK, p. 337, Pl. 3: 1–4.

Type horizon and locality: Late Volkhovian (Late Arenig) at Simonkovo, right bank of the Volkhov river, Ingria (St. Petersburg district), northern Russia.

Diagnosis. — The **sp** elements with an angulation at the anterior flank separating an external triangular area, which slightly deviates backward from the plane of the element, the **pl** elements with a sinuous profile of the base, the **ne** elements with their cusps significantly longer than the base.

Remarks. — The species differs from the older *D. forceps* in having a generally longer cusp of the **ne** element (see DZIK 1984 for a biometric evaluation), and from the succeeding *D. suberectus* in a less simplified morphology of the **sp** and **pl** elements. Elements of *Drepanoistodus* are extremely variable within samples but there seem to be five discrete types of elements with possibly a sixth one morphologically intermediate between these interpreted here as **pl** and **hi**.

Distribution. — Abundant below the discontinuity surface (*L. variabilis* Zone).

Drepanoistodus suberectus (BRANSON *et* MEHL, 1933) (Pl. 17: 2–6; Text-fig. 12b)

1933. *Oistodus suberectus* n. sp.; BRANSON and MEHL, p. 111, Pl. 9: 7.

1966. *Drepanodus suberectus* (BRANSON *et* MEHL); BERGSTRÖM and SWEET, p. 330, Pl. 35: 22–27.

1971. *Drepanodus homocurvatus* LINDSTRÖM; BEDNARCZYK, Pl. 3: 9.

1988. *Drepanoistodus suberectus* (BRANSON *et* MEHL); NOWLAN *et al.*, p. 16, Pl. 3: 19–22.

Type horizon and locality: Plattin (Late Caradoc), Salt River, Missouri.

Diagnosis. — The **sp** elements with a weakly separated external area, **pl** elements flat with a somewhat elongated external tip of the base and a concave posterior side.

Remarks. — The apparatus composition was recognized by BERGSTRÖM and SWEET (1966). Distinctions between the species and its predecessor, *D. basiovalis*, are somewhat problematic and additional biometric studies are necessary to clarify the issue. It remains far from clear whether the Late Ordovician populations from the North American Midcontinent are conspecific with the European

ones. Somewhat arbitrarily I assign to the species late populations of *Drepanoistodus* in the Mójcza section, starting from the discontinuity surface.

Distribution. — Abundant in the Llanvirn and Llandeilo but sparse in the Caradoc of the Holy Cross Mountains

Order *Prioniodontida* DZIK, 1976

Diagnosis. — Apparatuses composed of ramiform elements. Elements of the platform series (**sp-oz**), as well as the **tr** and **ke** elements, tend to develop three processes, the **pl** elements with four processes.

Superfamily *Prioniodontacea* BASSLER, 1925

Diagnosis. — All four processes of the **pl** (tetraprioniodontiform) elements well developed, elements of the symmetry transition series with long, usually denticulated processes.

Family *Acodontidae* fam. n.

Diagnosis. — Elements of the apparatus with blade-like, adenticulated processes.

Remarks. — Morphologically similar elements occur also in the ozarkodinid family Oistodontidae. Nevertheless, the **sp-oz** locations in the oistodontids are occupied by biramous elements while the **pl** elements are triramous (instead of tetramorous in the new prioniodontid family *Acodontidae*), at the best a fourth rudimentary crest develops.

Genera included. — *Acodus* PANDER, 1856, *Tripodus* BRADSHAW, 1969, *Eoneoprioniodus* MOUND, 1965.

Genus *Tripodus* BRADSHAW, 1969

Type species: *Tripodus laevis* BRADSHAW, 1969.

Tripodus? sp. indet.
(Pl. 24: 26–27)

Remarks. — A few albid, minute elements from the sample MA-128 may represent this genus. This is far from being certain, however, as no tetramorous element is present in the collection. Similar albid elements are known also among primitive Ozarkodinina (see DZIK 1983, Fig. 5).

Distribution. — Only in a single sample 0.5 m below the discontinuity surface (*L. variabilis* Zone).

Genus *Eoneoprioniodus* MOUND, 1965

Type species: *Eoneoprioniodus cryptodens* MOUND, 1965.

Diagnosis. — Elements of the apparatus with long, gently curved cusps and more or less alate processes, hyaline, generally of large mature size.

Eoneoprioniodus alatus (DZIK, 1976)
(Pl. 17: 1)

1976. *Triangulodus(?) alatus* sp. n.; DZIK, p. 422, Text-fig. 20f–k, Pl. 41: 2–5.

1987. *Triangulodus alatus* DZIK; BAUER, p. 31, Pl. 5: 3–4, 6, 9–10.

Type horizon and locality: Erratic boulder of Baltic origin E-149 (*E. reclinatus* Zone, Lasnamägian, Late Llanvirn) from Międzyzdroje, Poland.

Remarks. — Only a single specimen, probably representing an **oz** element has been found in the sample MA-42. It closely resembles *E. alatus* occurring widely in coeval and younger strata of the Baltic region and North American Midcontinent (see DZIK 1983; BAUER 1987). With no other element found any interpretation must remain tentative, however.

Distribution. — Only in the bed immediately above the discontinuity. The specimen may be reworked from slightly older strata.

Family **Balognathidae** HASS, 1959

Diagnosis. — The **sp** elements are morphologically clearly distinct from the **oz** elements, with at least a tendency to develop platform and a ramified anterior process.

Genera included. — *Baltoniodus* LINDSTRÖM, 1971, *Lenodus* SERGEEVA, 1963, *Amorphognathus* BRANSON *et* MEHL, 1933, *Rhodesognathus* BERGSTRÖM *et* SWEET, 1966, *Eoplacognathus* HAMAR, 1966, *Cahabagnathus* BERGSTRÖM, 1983, *Polyplacognathus* STAUFFER, 1935, *Sagittodontina* KNÜPFER, 1967.

Genus *Baltoniodus* LINDSTRÖM, 1971

Type species: *Prioniodus navis* LINDSTRÖM, 1955.

Diagnosis. — The **sp** elements with a weakly denticulated or adenticulated anterior process, **ne** elements with weakly denticulated external process.

Remarks. — The relationship between *Baltoniodus* and *Prioniodus* still requires clarification. It is generally believed that these genera, characterized by denticulated elements, derived independently from adenticulate species of *Acodus* (VAN WAMEL, 1974), which has been convincingly documented in the case of *Prioniodus* (STOUGE and BAGNOLI 1988) but the supposed transition to *Baltoniodus* has not yet been described in detail. Another possibility still remains; that the *Baltoniodus* lineage appeared in the Baltic region as an effect of migration from an unknown area after the transition from early *Prioniodus* to *Baltoniodus* had taken place. This is suggested by a rather complex migration pattern in the early evolution of *Prioniodus* as shown by STOUGE and BAGNOLI (1988). Generally the *Baltoniodus* lineage was cold-water and its range seems to be wider in the “Mediterranean” than North Atlantic realm (DZIK 1984).

Late species of *Baltoniodus* can have a lobate platform, which makes them similar to the balognathids but their anterior process is never ramified.

Baltoniodus parvidentatus (SERGEEVA, 1963)

(Pl. 18: 8–14; Text-figs 13, 14a)

1963. *Falodus parvidentatus* n. sp.; SERGEEVA, p. 103, Pl. 8: 4–7.

1963. *Prioniodus alatus* HADDING; SPASSOV and TELLER, p. 80, Pl. 1: 3.

1963. *Falodus* sp.; SPASSOV and TELLER, p. 78, Pl. 1: 8–9.

1963. *Prioniodus* sp. n. 1 LINDSTRÖM; SPASSOV and TELLER, p. 81, Pl. 1: 11.

1963. *Oepikodus smithensis* LINDSTRÖM; SPASSOV and TELLER, p. 78, Pl. 1: 15.

1963. *Prioniodus navis* LINDSTRÖM; SPASSOV and TELLER, p. 80, Pl. 1: 16–17.

1963. *Tetraprioniodus superbus* (RHODES); SPASSOV and TELLER, p. 82, Pl. 1: 18.

1963. *Trapezognathus lindstroemi* sp. n.; SPASSOV and TELLER, p. 82, Pl. 1: 19.

1963. *Tetraprioniodus* sp. LINDSTRÖM; SPASSOV and TELLER, p. 82, Pl. 1: 20–21.

1971. *Gothodus* cf. *costulatus* LINDSTRÖM; BEDNARCZYK, Pl. 2: 3.

1971. *Oistodus brevibasis* SERGEEVA; BEDNARCZYK, Pl. 2: 4.

1976. *Prioniodus alatus parvidentatus* (SERGEEVA); DZIK, p. 437, Text-fig. 22k–r.

1978. *Prioniodus (Baltoniodus) praevariabilis norrlandicus* n. ssp.; LÖFGREN, p. 84, Pls 10: 3A–E; 12: 17–26; 14: 2A–B.

1991. *Baltoniodus norrlandicus* LÖFGREN; STOUGE and BAGNOLI, p. 11, Pl. 1: 11–20.

1991. *Baltoniodus clavatus* n. sp; STOUGE and BAGNOLI, p. 12, Pls 2: 1–12; 3: 1–2.

1991. *Baltoniodus medius* (DZIK); RASMUSSEN, p. 274, Text-fig. 5D–H, J–K.

Type horizon and locality: Kundan (Arenig/Llanvirm boundary) at Simonkovo, right bank of the Volkhov river, Ingria (St. Petersburg district), northern Russia.

Nomenclatorial note: The species is widespread in the early Kundan of the Baltic region but none of the available species names is based on morphologically diagnostic elements. Among the names attached to holotypes presumably belonging to populations of the species, the first proposed are those of SERGEEVA (1963): *Falodus parvidentatus* and *Tetraprioniodus minax*. I chose (DZIK 1976) the first name for the apparatus because its holotype is an **ne** element. Its

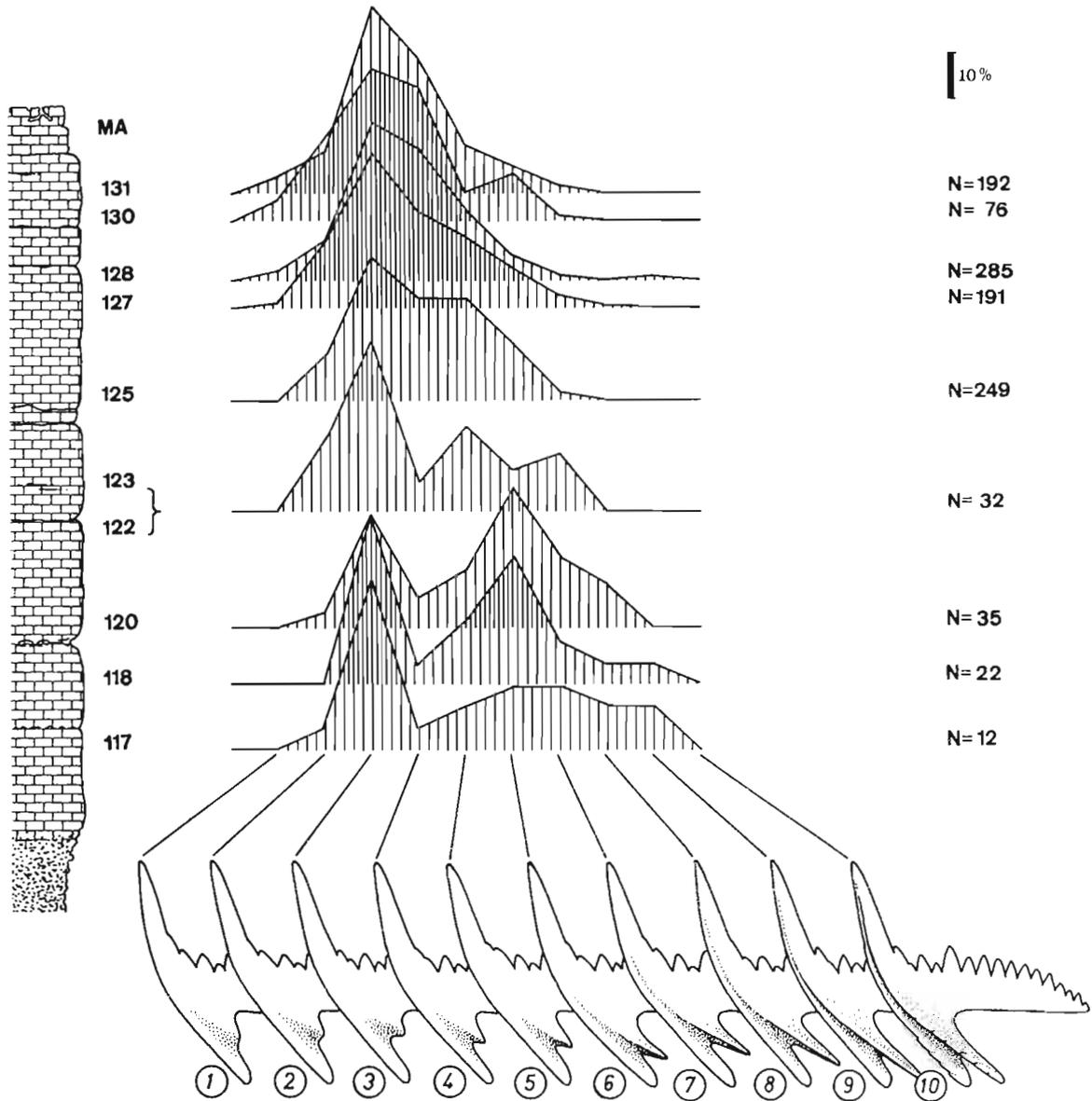


Fig. 13.

Changes in frequency distribution in classes of length of the anterior process in **hi-ke** elements of *Baltoniodus parvidentatus* (SERGEEVA, 1963) in the Mójcza Limestone.

morphology allows us to distinguish the species from the preceding *B. navis*, while I am not able to detect any clear difference in the **pl** element. LÖFGREN's *Prioniodus norrlandicus* also has a **pl** element as its holotype. Unfortunately SERGEEVA (1963) did not indicate the exact position of her samples, which makes this identification somewhat uncertain and in need of testing by additional sampling in the type section.

Diagnosis. — The anterior process of the **ke** elements usually long but undenticulated.

Remarks. — There is a profound ontogenetic transformation in the shape of the **sp** elements in the species, much more apparent than in other species of the genus. Juvenile elements are characterized by a much shorter inner process than in mature ones (which is actually a recapitulation of phylogeny in ontogeny) and by a weakly developed posterior expansion of the basal cavity. Also the length of the anterior process is extremely variable character in the **ke** element (Text-fig. 13). This was a subject

of highly directional evolution resulting in a gradual disappearance of the distinction between the **ke** and **hi** elements. Because of the population variability it seems impractical to recognize more chronospecies in the lineage, and to split this particular segment into two units as proposed by STOUGE and BAGNOLI (1991; actually, they applied the vertical concept of chronospecies).

Distribution. — A few specimens of *Baltoniodus* found by Dr. Wiesław BEDNARCZYK in the limestone exposed in the Bukówka quarry seem to belong to an early form of *B. navis*. Although the most diagnostic **ke** elements are not present in his collection, this is strongly suggested by the appearance of the **tr** element. Its successor, *B. parvidentatus*, seems to occur in the limestone intercalations in the Bukówka Sandstone recovered by the Bukówka IG 1 borehole, as suggested by long processes in the **sp** elements, and remains abundant up to the discontinuity surface in the Mójcza Limestone.

Baltoniodus medius (DZIK, 1976)

1976. *Prioniodus alatus medius* ssp. n.; DZIK, p. 423, Pl. 42: 1, Text-fig. 23a-l.

1978. *Prioniodus (Baltoniodus) prevariabilis medius* DZIK; LÖFGREN, p. 86, Pls 12: 27–36; 13: 1A–B, 3, 6A–D.

1984. non *Baltoniodus? prevariabilis medius* (DZIK); STOUGE, p. 77, Pl. 15: 1–6.

1991. *Baltoniodus* n. sp. A; STOUGE and BAGNOLI, p. 13, Pl. 2: 13–21.

1991. non *Baltoniodus medius* (DZIK); RASMUSSEN, p. 274, Fig. 5D–H, J–K.

Holotype: ZPAL CVI/139; DZIK 1976, Text-fig. 23f.

Type horizon and locality: Erratic boulder E-079 of a glauconitic limestone (*Eoplacognathus pseudoplanus* Subzone, latest Kundan, early Llanvirn) of Baltic origin, Mochty near Zakroczym, Poland.

Diagnosis. — The **ke** elements with the anterior process short but sharply pointed.

Remarks. — The type population of the species is Late Kundan in age but originally also Aserian populations were included, with the diagnostic pointing of the anterior process in the **ke** elements less apparent. RASMUSSEN (1991) proposed to restrict the range of *B. medius* to the Kundan but his identification of the species in the Early Kundan is based on misidentification of **ke** elements in his samples. The illustrated specimen (RASMUSSEN 1991: Fig. 5G) is actually a **hi** element of *B. parvidentatus*.

Distribution. — Being widespread in the Late Kundan and Aserian of the Baltic region this species occurs in the Mójcza Limestone only as rare reworked large specimens in the layer immediately above the discontinuity surface.

Baltoniodus prevariabilis (FÅHRÆUS, 1966)

(Pl. 18: 17–22; Text-fig. 14b)

1966. *Prioniodus prevariabilis* n. sp.; FÅHRÆUS, p. 29, Pl. 4: 5a–b.

1971. *Prioniodus prevariabilis* FÅHRÆUS; BERGSTRÖM; P. 146, Pl. 2: 1.

1971. *Prioniodus alatus* HADDING; BEDNARCZYK, Pl. 2: 7.

1971. *Prioniodus prevariabilis* FÅHRÆUS; BEDNARCZYK, Pl. 3: 8.

1971. *Paracordylodus lindstroemi* BERGSTRÖM; BEDNARCZYK, Pl. 3: 7.

1971. *Prioniodus navis* LINDSTRÖM; BEDNARCZYK, Pl. 3: 11.

1976. *Prioniodus alatus alatus* HADDING; DZIK, p. 436, Text-fig. 24a–g.

1978. *Prioniodus (Baltoniodus) prevariabilis prevariabilis* FÅHRÆUS; LÖFGREN, p. 87, Pl. 12: 37–43.

Type horizon and locality: Vikarby or Skövde Limestone (not indicated precisely) (Llanvirn) at Gullhögen quarry, Skövde, Västergötland, Sweden.

Diagnosis. — The **ke** and **hi** elements almost indistinguishable from each other, both having rudimentary anterior process, **sp** elements with a thin-walled triangular expansion at the base of the inner process.

Remarks. — The species was reinterpreted as multielement by BERGSTRÖM (1971) and illustrations of all elements were given by DZIK (1976) and LÖFGREN (1978). Juvenile **sp** elements of this species have considerably longer processes than those of *B. parvidentatus*. The shape of the expansion of the base is highly variable within populations. The **ke** and **hi** elements, although closely similar in outline, can be distinguished owing to a different profile of the rudiment of the anterior process. In

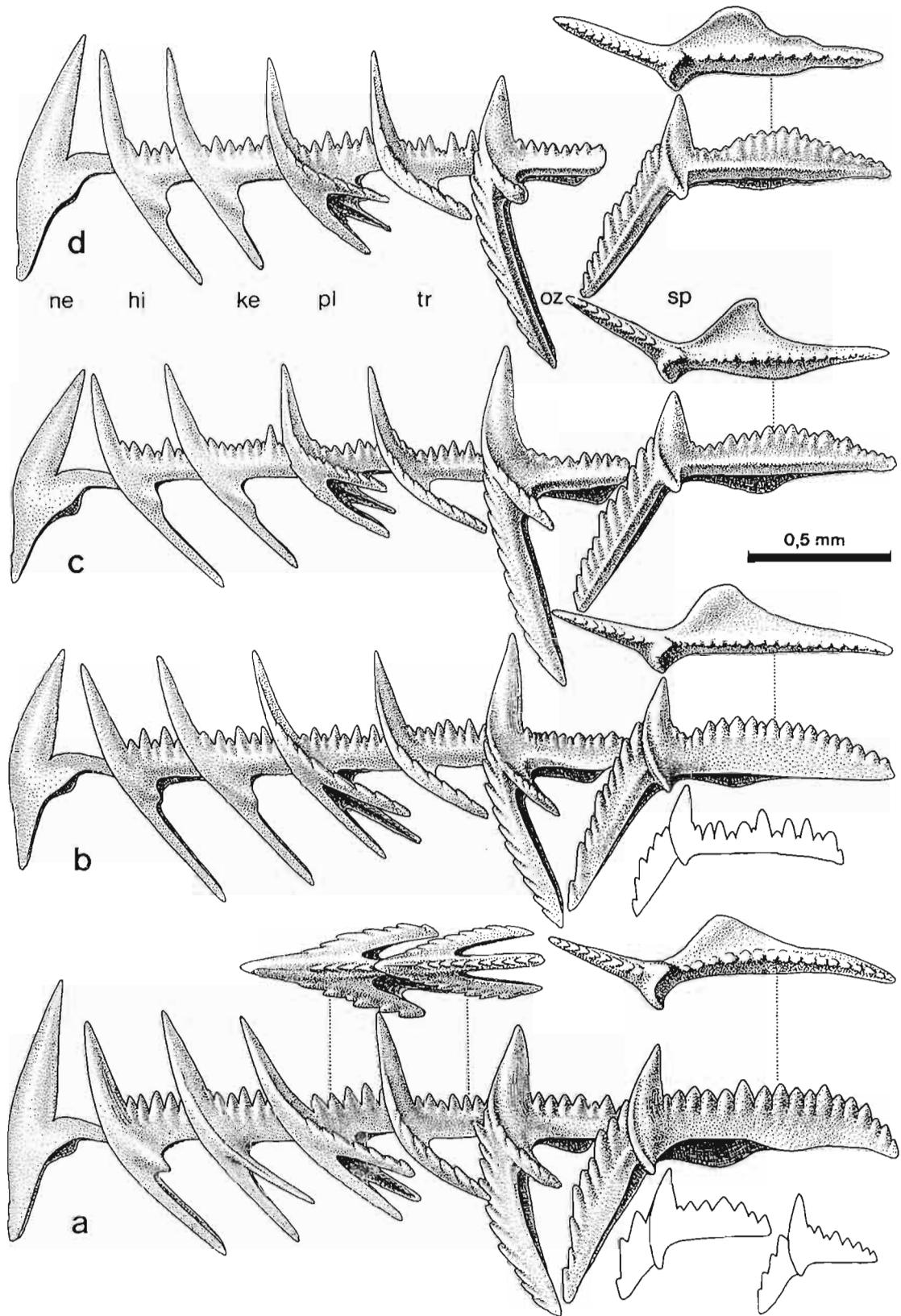


Fig. 14.

Apparatuses of *Baltoniodus* species and proposed homology of their elements. a. *B. parvidentatus* (SERGEEVA, 1963). b. *B. prevariabilis* (FÄHRÆUS, 1966). c. *B. variabilis* (BERGSTRÖM, 1962). d. *B. alobatus* (BERGSTRÖM, 1971).

the **ke** elements the rudiment of the anterior process is unified with the inner margin of the external process and its surface is somewhat angular. In the **hi** elements the process is more or less parabolic in outline and located in between the remaining processes.

Distribution. — In Mójcza the species occurs from the discontinuity surface up to 0.2 m above the bentonite; elsewhere in the Late Llanvirn and Llandeilo.

Baltoniodus variabilis (BERGSTRÖM, 1962)
(Pl. 19: 1–9; Text-figs 14c, 15)

1962. *Prioniodus variabilis* sp. n.; BERGSTRÖM, p. 51, Pl. 2: 1–7.

1971. *Prioniodus variabilis* BERGSTRÖM; BERGSTRÖM, p. 147, Pl. 2: 2.

1971. *Keislognathus gracilis* RHODES; BEDNARCZYK, Pl. 4: 1.

1976. *Prioniodus variabilis* BERGSTRÖM; DZIK, Text-fig. 24h–l.

1981. *Prioniodus variabilis* BERGSTRÖM; NOWLAN, p. 12, Pl. 4: 10–12, 14–17.

1984. *Baltoniodus variabilis* (BERGSTRÖM); CHEN and ZHANG, Pl. 2: 8–15.

1985. *Baltoniodus variabilis* (BERGSTRÖM); BERGSTRÖM *et al.*, Pl. 23: 2.

1985. *Baltoniodus variabilis* (BERGSTRÖM); BERGSTRÖM and ORCHARD, Pl. 2.3: 2.

Type horizon and locality: Not specified precisely, a boulder of the Ludibundus limestone (Early Caradoc) from the Tvären area, Sweden.

Diagnosis. — The **sp** elements with a triangular platform developed along the posterior margin of the inner process (at least in adult specimens).

Remarks. — An apparatus reinterpretation of the species was given by BERGSTRÖM (1971), all its elements were also illustrated by DZIK (1976). The shape of the platform in the **sp** elements of this species is subject to great population variability, which practically precludes its taxonomic identification unless adult robust specimens are preserved in a sample. Juveniles do not have any platform; they exhibit a more or less low triangular shape of the posterior margin of the process. Mature specimens usually show a shelf-like margin of this triangular area which has a distinctly triangular outline, but some specimens can always be found that depart from the mode. The thickened margin (platform) is actually the only feature that allows the distinction of the species from its predecessor, *P. prevariabilis*. Unfortunately, in older samples this feature can be detected only in large, adult specimens. Probably the modification took place somewhere at the level of 0.2 m above the bentonite (samples MA-70 and 71). Adult specimens present in both of these samples seem to differ slightly in this respect (with the platform already developed in some elements in the sample MA-70) enabling the recognition of the evolutionary change. This demarcation of the boundary between these two chronospecies has to be taken with some caution, however, because of rather small sample size. Contributions of elements lacking a platform decrease slowly upwards, and the evolutionary process seems to be connected with an ontogenetic acceleration. Even much higher in the section juveniles may still lack a platform. As most specimens in the samples from MA-72 to MA-85 are small this does not make them especially useful in time correlation. A rudimentary platform develops also in large **oz** elements. Other element types do not seem to differ from related species within the lineage. I am also unable to trace any discontinuity in the population variability of the **hi–ke** elements. They are virtually identical and if there are any differences between these element in the apparatus, they are completely obscured by the variability.

Distribution. — Populations occurring higher than 0.2 m above the bentonite in Mójcza are, somewhat arbitrarily, assigned to the species. It is widely distributed in the North Atlantic province (BERGSTRÖM 1971). BERGSTRÖM *et al.* (1987) give the lower range of the species well within the *P. anserinus* Zone, thus much below that chosen here. Without thorough biometrical studies of the **sp** elements this apparent discrepancy cannot be resolved.

Baltoniodus alobatus (BERGSTRÖM 1971)
(Pl. 19: 10–15; Text-figs 14d, 15)

1971. *Prioniodus alobatus* n. sp.; BERGSTRÖM, p. 145, Pl. 2: 4.

1978. *Prioniodus* sp. (cf. *P. alobatus* BERGSTRÖM); DZIK, Pl. 13: 3.

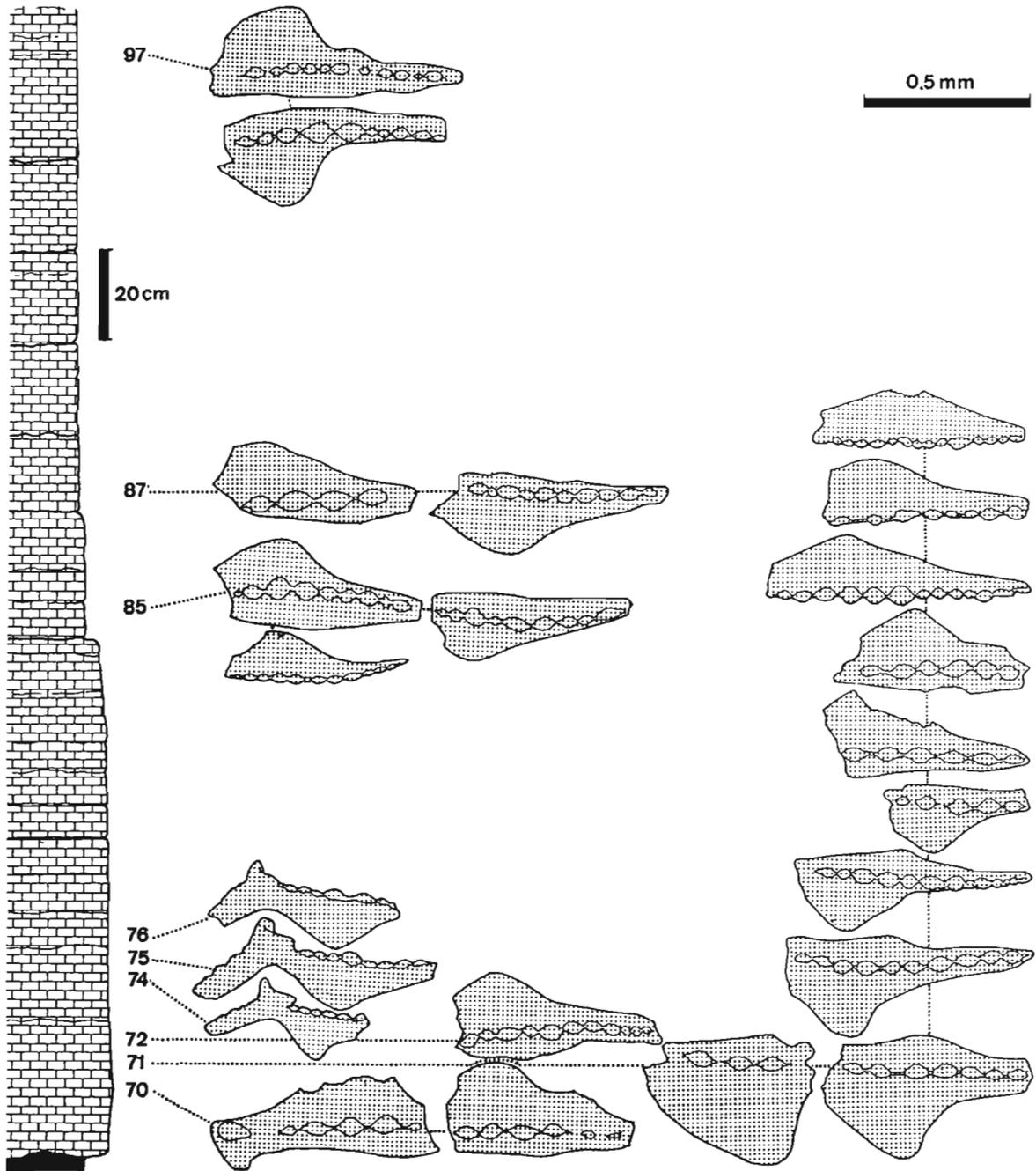


Fig. 15.

Shape of platform in *sp* elements of *Baltoniodus* in the Mójcza Limestone above the bentonite.

1980. *Prioniodus* sp. nov. A; ORCHARD, p. 24, Pl. 6: 5, 9, 11–12.

1981. *Prioniodus alobatus* BERGSTRÖM; NOWLAN, p. 12, Pl. 5: 9, 15, 17–22.

Type horizon and locality: Sample D60–160 taken 15.30–15.35 m above base of the Dalby Limestone (Late Caradoc), Fjäckå, Dalarna, Sweden.

Diagnosis. — The *sp* elements develop a thick, smooth platform with slightly raised edges, of variable shape, usually rather narrow and somewhat irregular.

Remarks. — The species was proposed by BERGSTRÖM (1971) as a multielement one; complete illustration was given by NOWLAN (1981). In typical North Atlantic sections *B. variabilis* evolves into its successor *B. gerdae* (BERGSTRÖM, 1971), having an additional process developed by a widening of the platform of the **sp** element (BERGSTRÖM 1971; BERGSTRÖM and CARNES 1976). In Mójcza *B. gerdae* has not been identified, while populations of *B. variabilis* continue to occur in strata presumably coeval with these including *B. gerdae* and even younger beds. The youngest populations of the lineage in Mójcza are clearly different from typical *B. variabilis*. Some shallowing of the sinuosity in the platform contour can be identified in sample MA-85 and above it. This is mostly a result of increasing population variability of this character. Even as high as in the sample MA-22 an element was found (DZIK 1978: Pl. 13: 3) with the platform being generally of the *B. variabilis* morphology, except for its sharp upper edge. Examinations of specimens of *Baltoniodus alobatus* from Estonia, in the collection of Dr. Viive VIIRA, Tallinn, led me to suggest that the populations from Mójcza and Estonia were conspecific (DZIK 1978). If this is really the case, they represent the chronospecies, which in the Baltic region and other North Atlantic localities occurs above the range of *B. gerdae*. Practically the only feature that enables identification of *B. alobatus*, if such a wide range of variability in the shape of the platform is accepted (see also KENNEDY *et al.* 1979, p. 546, and ORCHARD 1980, p. 24), is a sharp upper edge of the platform and its generally higher thickness. The proposed gradual pattern of the transition between *B. variabilis* and *B. alobatus* diminishes their value as zonal fossils.

Distribution. — Populations from about 1.5 m (late *A. tvaerensis*) up to 2.5 m above the bentonite (*A. tvaerensis/superbus* transition zone) are attributed to this species.

Genus *Lenodus* SERGEEVA, 1963

Type species: *Lenodus clarus* SERGEEVA, 1963 (= *Amorphognathus variabilis* SERGEEVA, 1963).

Diagnosis. — The posterior process of the **sp** elements uniramous, elements **ne** with a thick prominent cusp, elements of the symmetry transition series robust with small, low denticles.

Lenodus variabilis (SERGEEVA, 1963) (Pls 19: 16–23; 20: 1–8; Text-fig. 16a)

1963. *Amorphognathus variabilis* sp. n.; SERGEEVA, p. 106, Pl. 8: 15–17.

1978. *Eoplacognathus variabilis* (SERGEEVA); TIPNIS *et al.*, Pl. 8: 1, 1–6.

1979. *Prioniodus prevariabilis* FÄHRÆUS; NI, Pl. 1: 27.

1979. *Lenodus clarus* SERGEEVA; NI, Pl. 2: 36.

1984. cf. ?*Amorphognathus*? sp. A; STOUGE, p. 71, Pl. 12: 8–12, 14.

1987. *Eoplacognathus suecicus* BERGSTRÖM; HÜNICKEN and ORTEGA, p. 139, Pl. 7.1: 4–13.

1988. *Eoplacognathus suecicus* BERGSTRÖM; WATSON, p. 112, Pls 6: 28, 32–33; 7: 3, 5.

1988. *Eoplacognathus foliaceus*? (FÄHRÆUS); WATSON, p. 112, Pls 6: 29; 7: 2.

Type horizon and locality: Presumably Early Kundan (Arenig/Llanvirn boundary) of the right bank of the Popovka river, Ingria (St. Petersburg district), northern Russia.

Diagnosis. — The anterior process of the **sp** elements with a short bifurcation appearing relatively late in the ontogeny, the **oz** elements with processes widely flaring and with thick and prominently ornamented platform. Strongly asymmetric **ne** elements weakly denticulated with posterior rib without denticles.

Remarks. — Large platform elements of the species (especially **oz**) show tuberculation, which makes them remotely similar to cooccurring elements of *Polonodus*. Whether this is a feature of phylogenetic significance or not, remains on open question.

The **oz** elements do not form a mirror-image pair but the difference is not profound. The anterior and inner processes in the dextral element are linearly arranged while in the sinistral element the anterior process is strongly curved, the remaining processes forming a line. No apparent asymmetry was identified in the **sp** pair.

Distribution. — Volkhovian populations of *Lenodus* are still inadequately known but it seems that the lack of bifurcation of the anterior process in the **sp** elements as well as the presence of an inner-posterior rib in the **ne** elements (the feature diagnostic of *L. falodiformis* SERGEEVA), reported

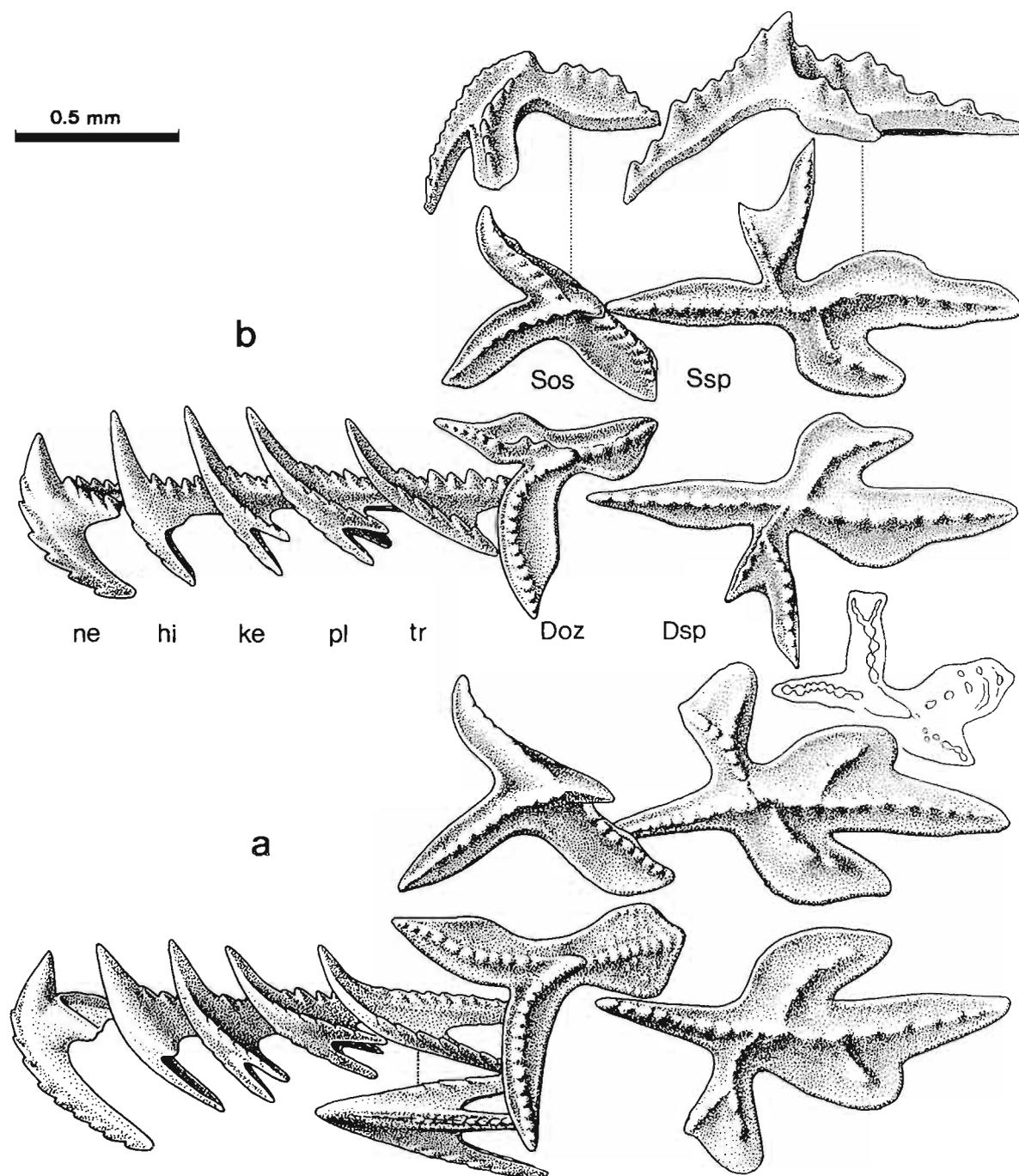


Fig. 16.

Apparatuses of *Lenodus* and earliest *Eoplacognathus* and proposed homology of their elements. **a.** *L. variabilis* (SERGEEVA, 1963). **b.** *E. zgierzensis* DZIK, 1976 early form.

in few known, poorly preserved specimens from the latest Volkhovian, is typical for them. The exact level of transition between *L. falodiformis* and *L. variabilis* has not been identified yet. Although it was hypothesized that in the Hälludden section, Öland, this took place somewhere close to the boundary between the Volkhovian and Kundan (DZIK 1983) the data of STOUGE and BAGNOLI (1991) from the Högudden section suggests that it was well within the Early Kundan. In the Lesieniec 1 borehole, in the Polish part of the East European platform, *Lenodus* occurs even earlier, together with

typical *Baltoniodus navis* and *Paroistodus originalis*, and this may be the ancestral species of the lineage. The upper range of *L. variabilis* has not been precisely traced, either. In Mójca it is replaced 0.5 m below the discontinuity surface (between samples MA-125 and MA-127) with *Eoplacognathus zgierzensis* and *Sagittodontina kielcensis*. Both these species are probable successors of *Lenodus* but the available material is too incomplete to show the transition. A direct connection between *L. variabilis* and *E. zgierzensis* seems very probable. These two species differ almost exclusively in the degree of elongation of the anterior process in the **sp** element. *S. kielcensis* is more derived and may represent an immigrant lineage.

Genus *Sagittodontina* KNÜPFER, 1967

Type species: *Sagittodontina robusta* KNÜPFER, 1967 (= *S. bifurcata* KNÜPFER, 1967).

Diagnosis. — Long denticles developed in all elements of the apparatus, especially in the symmetry transition series, a deep basal cavity and thin crown characterize the platform elements. The anterior process in the **oz** elements short.

Sagittodontina kielcensis (DZIK, 1976)

(Pl. 22: 1–6; Text-fig. 17)

1976. *Amorphognathus kielcensis* sp. n.; DZIK, p. 423, Text-fig. 26h–l, Pl. 44: 1.

1976. partim *Amorphognathus variabilis* SERGEEVA; DZIK: Text-fig. 26a–c (only).

1978. *Amorphognathus kielcensis* DZIK; DZIK, Pl. 13: 1–2, 5.

1979. *Amorphognathus kielcensis* DZIK; AN *et al.*, Pl. 1: 24.

1985. *Prioniodus deani* sp. nov.; SAVAGE and BASSETT, p. 707, Pl. 80: 23–29, 38 (erroneously labelled 33), 39 (non 30–37 which are elements of *Amorphognathus*).

Holotype: ZPAL CVI/176; DZIK 1976, Text-fig. 26h.

Type horizon and locality: Sample MA-18 from 0.65 m below the bentonite in the Mójca Limestone (Uhakuan, Llandeilo) at Mójca, Holy Cross Mountains, Poland.

Diagnosis. — The **sp** elements with a short but still bifurcating anterior process and with the posterior process long and oriented almost parallel to the inner one, external margins of these processes strongly flaring. The **oz** elements with the main processes in the same vertical plane, forming an almost right angle, the base of the external process with a sinuous profile.

Remarks. — Except for the sample MA-46, I am not able to find any strictly symmetrical elements in the symmetry transition series. It thus cannot be excluded that the **tr** location was occupied by a slightly asymmetrical element. Early populations of the species are, to some degree, similar to *Lenodus* but can be easily distinguished by the reduced anterior process of the **oz** elements (like in *Baltoniodus*) and prominently denticulated **ne** elements.

Distribution. — The transition between *Lenodus* and *Sagittodontina* cannot be traced in Mójca and it seems that the introduction of the latter lineage, represented by some primitive populations 0.7 m below and up to the discontinuity (samples MA-125 and MA-41), was migrational rather than evolutionary. The species gradually disappears in Mójca, being represented up to 0.5 m above the bentonite (*B. variabilis* Subzone), later possibly replaced by an early *Amorphognathus*. Again, this is not an evolutionarily meaningful process. Rare specimens of the species occur at some levels in the Llanvirn of the Baltic area and south China. In Wales it is known from the early Caradoc.

Sagittodontina bifurcata KNÜPFER, 1967

(Pl. 22: 7)

1967. *Sagittodontina bifurcata* n. sp.; KNÜPFER, p. 39, Pl. 7: 5a–b (a full list of synonyms from KNÜPFER 1967 in DZIK 1990).

1982. *Noixodontus girardeauensis* (SATTERFIELD); MCCracken and BARNES, p. 1480, Pl. 2: 5–12.

1983. *Sagittodontina bifurcata* KNÜPFER; BERGSTRÖM, p. 46, Fig. 4.

1990. *Sagittodontina bifurcata* KNÜPFER; DZIK, p. 6, Fig. 2, 3C.

1992. *Sagittodontina robusta* KNÜPFER; BERGSTRÖM and MASSA, p. 1338, Pl. 1: 6–14.

1992. *Istorinus erectus* KNÜPFER; BERGSTRÖM and MASSA, p. 1338, Pl. 1: 15–16.

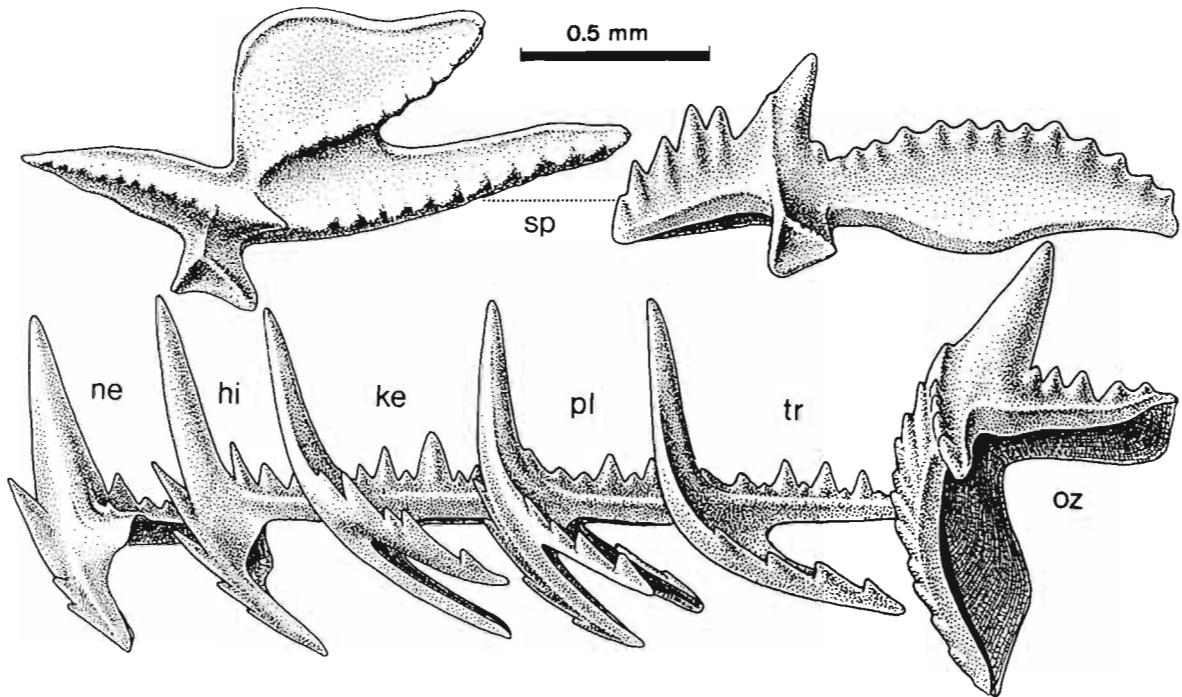


Fig. 17.
Apparatus of *Sagittodontina kielcensis* (DZIK, 1976).

Holotype: BF Nr. 45/1051; KNÜPFER 1967, Pl. 7: 5a–b.

Type horizon and locality: Limestone bed (Kalkbank) topping the upper iron ore horizon (late *A. superbus* or *A. ordovicicus* Zone, late Caradoc or Ashgill) at the mine Gebersdorf, Thuringia.

Diagnosis. — A flat *oz* element with angular profile of the base of the external process. Elements of the symmetry transition series with wide basal cavities; showing a tendency to dismember denticles on poorly mineralized processes.

Remarks. — The apparatus was reconstructed and the name for it was chosen by BERGSTRÖM (1983). The species is represented in Mójcza by an early population and this is probably the reason for the appearance of the rare and poorly preserved elements of the symmetry transition series, still similar to those in *S. kielcensis*. Only fragments of the *sp* elements have been found which do not allow any reliable reconstruction.

Distribution. — In Mójcza the species occurs from 1.8 above the bentonite (*A. tvaerensis/superbus* transition zone) to the top of the massive Mójcza Limestone (*A. superbus* Zone). Known also from the *A. superbus* (or *A. ordovicicus*) Zone of Thuringia, coeval strata in Libya and the topmost beds of the Ordovician in the North American Midcontinent.

Genus *Rhodesognathus* BERGSTRÖM *et* SWEET, 1966

Type species: *Ambalodus elegans* RHODES, 1953.

Diagnosis. — A weakly developed platform (with variably developed accessory lobes) in the *sp* and *oz* elements. The symmetry transition series similar to that in coeval species of *Amorphognathus*, but with strongly bent cusp in the *ne* elements.

Remarks. — The platform elements of the genus are similar to those of *Baltoniodus*. Except for the symmetry transition series, which is distinctly balognathid, the most significant difference concerns the position of branching of the anterior process in the platform elements. In *Rhodesognathus*, like other balognathids, it is connected with the external denticle of the cusp, while in *Baltoniodus* a rib connects the process directly with the cusp.

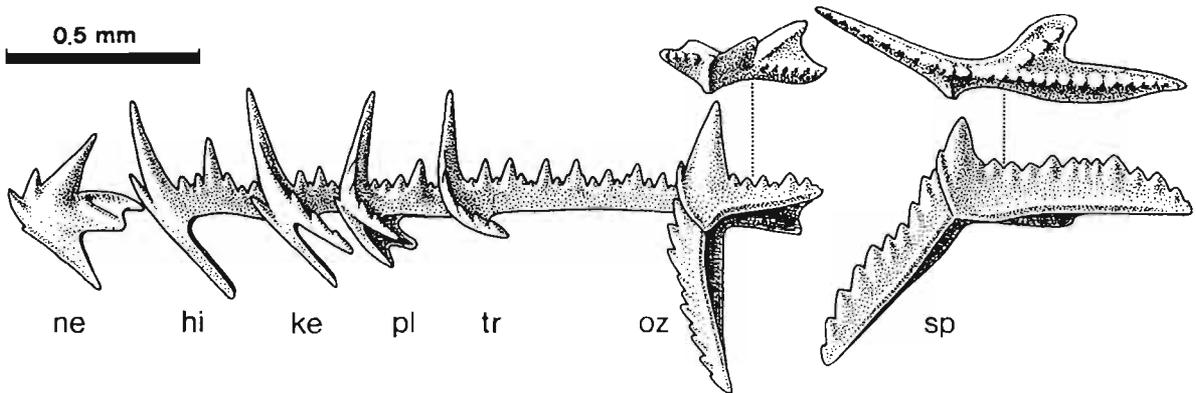


Fig. 18.
Apparatus of *Rhodesognathus polonicus* (DZIK, 1976).

Rhodesognathus inaequalis RHODES, 1953
(Pl. 21: 13)

1953. *Amorphognathus inaequalis* n. sp.; RHODES, p. 284, Pl. 22: 204.

1974. *Amorphognathus inaequalis* RHODES; LINDSTRÖM *et al.*, p. 16, Pls 1: 8–11; 2: 1–2, 7.

1987. *Amorphognathus inaequalis* RHODES; BERGSTRÖM *et al.*, Fig. 18.5.

1988. *Amorphognathus inaequalis* RHODES; BERGSTRÖM and ORCHARD, Pl. 2.2: 14

Type horizon and locality: Llandeilo Limestone, Llandeilo, Wales.

Diagnosis. — The *sp* elements with a small external lobe of the posterior process, *ne* elements well denticulated, with a low cusp.

Remarks. — A few specimens found in samples MA-74 and MA-76, although incomplete, well fit characters of the species despite their evidently younger age than the type population. They occur for above the first appearance of *A. tvaerensis*, the supposed successor of the Welsh *A. inaequalis*. The interpretation of this stratigraphic discrepancy that appeals most to me is an allopatric evolution of the *Rhodesognathus* and *Amorphognathus* lineages during Llandeilo and Early Caradoc.

Distribution. — Typical populations of the species are confined to the Llandeilo of Wales and Armorica. The Mójcza specimens occur 0.4–0.5 m above the bentonite (*B. variabilis* Subzone).

Rhodesognathus polonicus (DZIK, 1976)
(Pl. 21: 14–25; Text-fig. 18)

1971. *Holodontus superbus* RHODES; BEDNARCZYK, Pl. 4: 3.

1971. *Ligonodina delicata* (BRANSON *et* MEHL); BEDNARCZYK, Pl. 4: 4.

1971. *Ambalodus pulcher* RHODES; BEDNARCZYK, Pl. 4: 6.

1971. *Tetraprioniodus delicatus* (BRANSON *et* MEHL); BEDNARCZYK, Pl. 4: 7.

1976. *Rhodesognathus elegans polonicus* ssp. n.; DZIK, p. 424, Pl. 44: 3–4, Text-fig. 25g–h.

1976. partim *Amorphognathus tvaerensis* BERGSTRÖM; DZIK, Text-fig. 27l–n (only).

1978. *Rhodesognathus elegans polonicus* DZIK; DZIK, Pl. 13: 4–7.

Holotype: ZPAL CVI/136, DZIK 1976, Text-fig. 25g.

Type horizon and locality: Sample MA-21 from 2.1 m above the bentonite (Late Caradoc) in the Mójcza Limestone at Mójcza, Holy Cross Mountains, Poland.

Diagnosis. — The *oz* elements with a bifurcated inner process, *sp* elements with a small, usually denticulated posterior process, *ne* elements with sharp, strongly inclined cusp.

Remarks. — The species seems to be a successor of Welsh *Rhodesognathus inaequalis*, from which it differs mostly in having a smaller and always undivided posterior process of the *sp* elements. The most widespread species of the genus, *R. elegans* has, as is documented by samples from the Lesieniec borehole, a very similar appearance of the *ne* and other elements of the symmetry transition

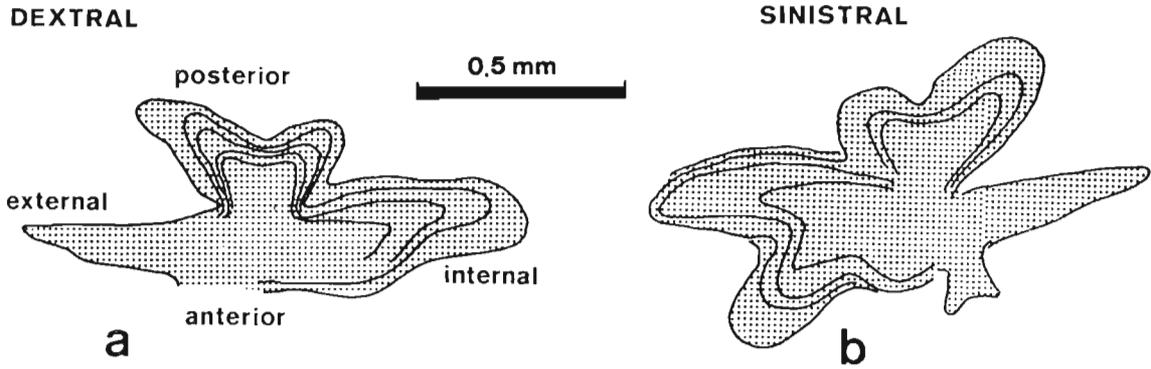


Fig. 19.

Growth changes in platform shape in the **sp** element of *Amorphognathus tvaerensis* BERGSTRÖM, 1962 and descriptives for its processes and lobes, contours of right (a) and left (b) elements in occlusal view.

series. Their close similarity to cooccurring elements of *Amorphognathus* is the reason for the late recognition of the apparatus composition in the genus (see BERGSTRÖM and SWEET 1966). *R. elegans* differs from *R. polonicus* in lacking additional processes in the **sp** and **oz** elements.

The development of the platform in the **sp** elements is extremely variable in the species. It is remarkable that the specimens of the species preceding this one stratigraphically in the section (Pl. 21: 13) show more prominent platform lobes. Specimens of typical populations of the species usually bear two or three denticles on the posterior process but sometimes the process is completely missing. This is suggestive of a very weak selection pressure controlling the morphology of the platform elements. Probably this resulted in the evolutionary reduction of the platform in the lineage. Also the morphology of the **ne** elements is variable. Usually they lack an inner-posterior crest but sometimes a rudimentary rib occurs there, which makes it difficult to distinguish these elements from homologous element of *A. tvaerensis*.

Distribution. — In Mójcza the species occurs from 1.8 to 2.4 m above the bentonite (*A. tvaerensis*/*superbus* transition zone).

Genus *Amorphognathus* BRANSON *et* MEHL, 1933

Type species: *Amorphognathus ordovicica* BRANSON *et* MEHL, 1933.

Diagnosis. — The anterior and posterior processes of the **sp** elements bifid, the former with lobes of almost equal length. The **ne** elements with prominent denticulation.

Amorphognathus tvaerensis BERGSTRÖM, 1962

[Pls 22: 8–22; 23: 1–2; Text-figs 19–20, 21a, 22 (lower part)]

Early form:

1976. *Amorphognathus inaequalis* RHODES; DZIK, p. 425, Text-fig. 27a–f.

Late form:

1962. *Amorphognathus tvaerensis* n. sp.; BERGSTRÖM, p. 37, Pl. 4: 7–10.

1971. *Amorphognathus tvaerensis* BERGSTRÖM; BERGSTRÖM, p. 135, Pl. 2: 10–11, Text-fig. 13M–T.

1971. *Amorphognathus ordovicica* BRANSON *et* MEHL; BEDNARCZYK, Pl. 4: 8.

1971. *Ambalodus frognoeyensis* HAMAR; BEDNARCZYK, Pl. 4: 9.

1971. *Ambalodus triangularis* BRANSON *et* MEHL; BEDNARCZYK, Pl. 4: 10.

1976. *Amorphognathus tvaerensis* BERGSTRÖM; DZIK, p. 432, Text-fig. 27g–k, o–q (non l–n which represent *Rhodesognathus*).

1981. *Amorphognathus tvaerensis* BERGSTRÖM; NOWLAN, p. 11, Pl. 5: 13–14, 16.

1983. *Amorphognathus tvaerensis* BERGSTRÖM; BURRETT *et al.*, p. 181, Text-fig. 4.

1985. *Amorphognathus tvaerensis* BERGSTRÖM; BERGSTRÖM and ORCHARD, Pl. 2.3: 8–9, 11, 16.

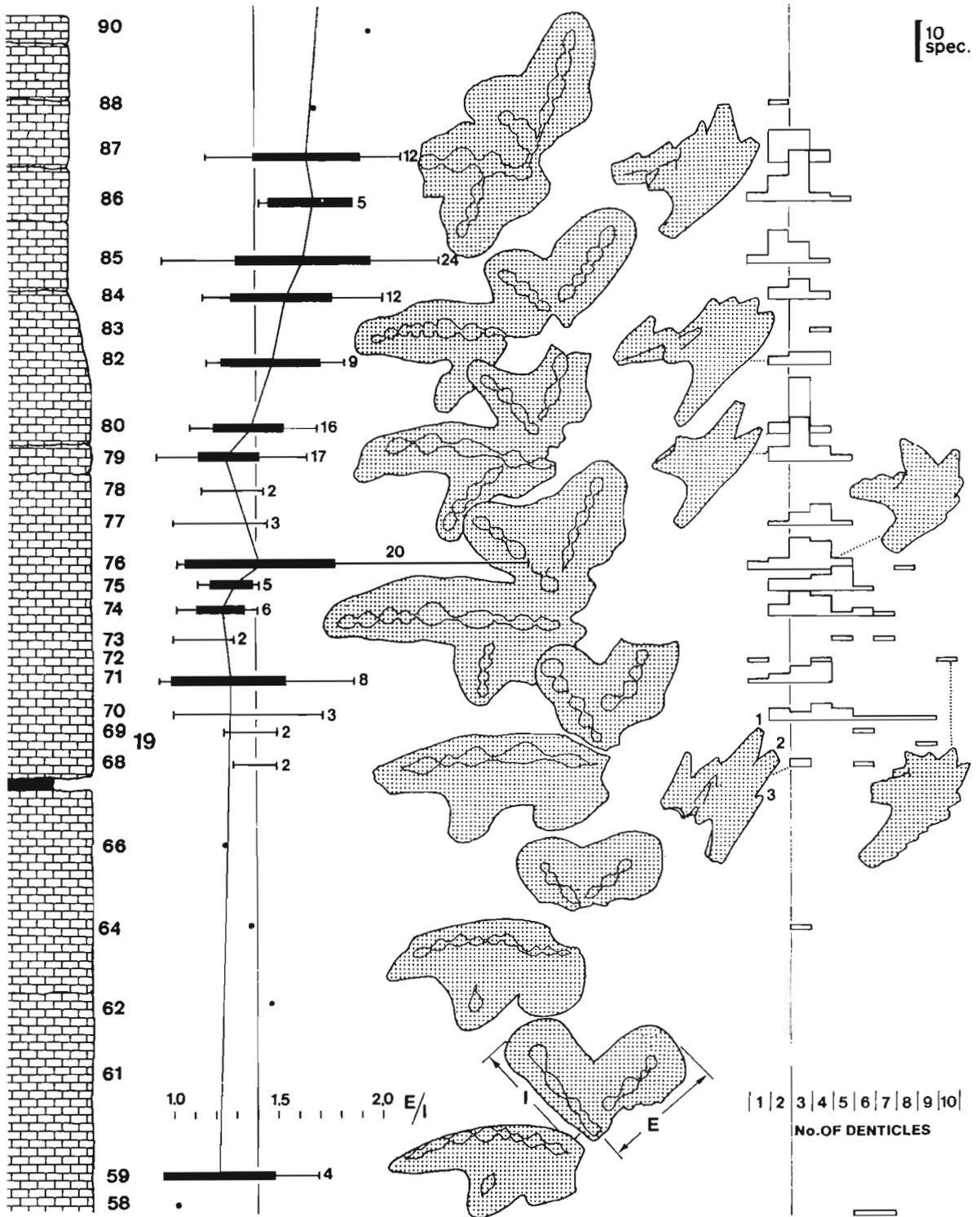


Fig. 20.

Changes in ratios between lengths of inner and outer lobes of the posterior process in right **sp** element and in number of denticles (including cusp) in the **ne** element of *Amorphognathus* in the middle part of the Mójcza section.

Type horizon and locality: Not specified precisely, a boulder of the Ludibundus limestone (early Caradoc) from the Tvären area, Sweden.

Diagnosis. — The **sp** elements do not form a mirror-image pair, the sinistral one being more highly arched and bears an additional antero-internal lobe; branches of the posterior process of similar length, the external one being somewhat longer. The elements **ne** with a low cusp that usually does not differ in size from neighbouring denticles.

Remarks. — BERGSTRÖM (1971) proposed the first complete reconstruction of the apparatus and homologized elements with the prioniodontids. He used the presence of the antero-internal lobe in the left **sp** element as the diagnostic feature. The lobe is usually armed with a single denticle in the earliest populations of the lineage in Mójcza. Gradually it becomes larger and larger and armed with a row of up to four denticles. It branches relatively late in ontogeny but in the course of evolution the branching developed earlier and earlier in histogeny as indicated by a migration of the point of branching towards the cusp (Text-fig. 21). There is thus an acceleration of the ontogeny which also concerns the bifurcation of the posterior process. Its external lobe becomes more and more elongated in the course of evolution.

The right **sp** element is flat, with a wide platform and lacks any additional lobes on its inner process. However, in some rare specimens a denticle corresponding to that in the left element is present. Single elements of this morphology were found in samples MA-76, 86, and 88; the sample MA-82 contains two such elements associated with four undenticulated ones. Even if the denticle is present the left elements remain flat and clearly different from their right counterparts.

The denticulation in the **ne** elements is extremely variable (Text-fig. 20), usually with a group of 3–5 radially arranged denticles; the posterior process remains undenticulated or bears very small denticles. In early populations the external process is prominently denticulated. In the course of evolution this denticulation gradually disappears and the process itself becomes smaller and smaller.

Distribution. — The lineage immigrated to the Holy Cross Mountains area already in the Llandeilo. The early populations in Mójcza (1.0 m below the bentonite – the base of the *P. anserinus* Zone) are thus at least partially coeval with the Welsh populations of *Rhodesognathus inaequalis*, possibly being conspecific with them. Although in *R. inaequalis* the lobes of the posterior process in the **sp** elements are variably developed (see BERGSTRÖM *et al.* 1985) the external lobe is usually smaller than the remaining one, which is a state more primitive than in any of the Mójcza populations. It seems probable that both the Polish-Baltic lineage of *A. tvaerensis* and the Welsh lineage of *Rhodesognathus* developed from *R. inaequalis*, the former by further development of the external lobe, the latter by a secondary reduction of the platform. As there is at least a possibility of an allopatrically divergent evolution of these lineages I prefer to provisionally attribute the early Mójcza populations to *A. tvaerensis*, as its early form, instead of assigning them to *R. inaequalis*. Being intermediate between typical populations of these species they still do not deserve separation into a new subspecies because the overlap of the population variabilities seems too large. To solve the problem more data on the evolution of *Rhodesognathus* in its type area is required.

Both the lower boundary of the typical (late) form of *A. tvaerensis* and its transition into the succeeding *A. superbis* is very unclear due to a great population variability of all the diagnostic characters (Text-fig. 22). The first **sp** elements without accessory lobes on their inner lobes appear 2.0 m above the bentonite, the last with the lobe occur 2.5 m above the bentonite (see DZIK 1989). This makes zonal boundaries based on these species rather fuzzy unless they coincide with immigrations in some areas, which was evidently the case with the lower boundary of the *A. tvaerensis* Zone in the Baltic area. As evidenced by the much earlier appearance of the lineage in the Holy Cross Mountains there is a possibility that a boundary so defined may prove to be significantly heterochronous.

Amorphognathus superbis (RHODES, 1953)
[Pl. 23: 3–5; Text-figs 21b, 22 (middle)]

1964. *Holodontus superbis* RHODES; BERGSTRÖM, p. 26, Text-fig. 11.

1976. *Amorphognathus superbis* (RHODES); DZIK, Text-fig. 28a–c.

1980. *Amorphognathus complicatus* RHODES; MERRILL, Text-fig. 4: 2–23.
 1984. *Amorphognathus superbus* (RHODES); CHEN and ZHANG, Pl. 1: 1–7.
 1985. *Amorphognathus superbus* (RHODES); SAVAGE and BASSETT, p. 692, Pl. 83: 1–19.
 1985. *Amorphognathus superbus* (RHODES); BERGSTRÖM and ORCHARD, Pl. 2.4: 1–4, 8.
 Type horizon and locality: Gelli-grin Limestone (Late Caradoc), Wales.

Diagnosis. — The sinistral **sp** element without any lobe on its inner process (if present in some specimens of early populations the point of branching is near the cusp). The **ne** elements with a few robust denticles of similar length and an undenticulated external process.

Remarks. — BERGSTRÖM (1971), supporting earlier suggestions in BERGSTRÖM and SWEET (1966), presented the first complete reconstruction of the apparatus composition. He defined the boundary between *A. tvaerensis* and *A. superbus* at the point of disappearance of the accessory lobe of the inner process of the left **sp** element. In Mójcza there is a significant zone of overlap in the occurrence of lobed and unlobed sinistral **sp** elements. In the course of evolution the point of bifurcation of the lobe was closer and closer to the cusp and finally it disappeared. As the lobe is very small in those specimens that possess it, and associated **ne** elements are of the *A. superbus* morphology I consider these populations to represent *A. superbus*.

The **ne** elements have denticulation distinct from that in the succeeding *A. ordovicicus*. However, they are very variable within the population, and their usefulness in the demarcation of the boundaries of the species is rather limited, especially in the case of the lower boundary. Elements identical with the holotype of *A. superbus* can be found well within the range of *A. tvaerensis*.

There is a barren interval within the range of *A. superbus* in the Mójcza Limestone. Well preserved left **sp** elements have been found only in the oldest populations of the species and such a lobate specimen, not typical for the species is included in the reconstruction of its apparatus (Text-fig. 21b; also DZIK 1989: Text-figs. 16, 17). This prevents a biometrical study of the transition between the species and the succeeding *A. ordovicicus*. Actually I am not able to indicate precisely the boundary between them.

Distribution. — The transition from *A. tvaerensis* to *A. superbus* took place in the interval 2.0–2.5 m above the bentonite, the transition to *A. ordovicicus* is even more difficult to indicate precisely but the dominance of the cusp over the denticles in the **ne** elements develops somewhere within the basal parts of the marly limestones of the Zalesie Formation in the topmost parts of the section in Mójcza.

Amorphognathus ordovicicus BRANSON *et* MEHL, 1933
 [Pls 23: 6–12; ?24: 20; Text-figs 21c, 22 (upper part)]

1933. *Amorphognathus ordovicica* n. sp.; BRANSON and MEHL, p. 127, Pl. 10: 38.
 1971. *Amorphognathus ordovicicus* BRANSON *et* MEHL; BERGSTRÖM, p. 134, Pl. 2: 6–7.
 1978. *Amorphognathus ordovicicus* BRANSON *et* MEHL; BERGSTRÖM, Pl. 80: 1–11.
 1980. *Amorphognathus ordovicicus* BRANSON *et* MEHL; ORCHARD, p. 16, Pl. 4: 1–13, 17–18.
 1983. *Amorphognathus ordovicicus* BRANSON *et* MEHL; NOWLAN, p. 660, Pl. 2: 16–17, 22, 25–27.
 1985. *Amorphognathus ordovicicus* BRANSON *et* MEHL; SAVAGE and BASSETT, p. 691, Pls 84: 1–21, 85: 1–26; 86: 1–13.
 1991. *Amorphognathus ordovicicus* BRANSON *et* MEHL; FERRETTI and SERPAGLI, Pl. 1: 1–9.
 1992. *Amorphognathus* sp. cf. *A. ordovicicus* (BRANSON *et* MEHL); BERGSTRÖM and MASSA, p. 1337, Pl. 1: 18–24.
 Type horizon and locality: Thebes Sandstone, Ozora, Missouri.

Diagnosis. — The **ne** elements with a long cusp dominating over the denticles, which occur in very low numbers, usually a single one on each process.

Remarks. — Only platform and **hi** elements were described by BRANSON and MEHL (1933) from the type locality. The identification of the species is based on the assumed conspecificity with populations studied by BERGSTRÖM (1971) and ORCHARD (1980). Some of the **sp** elements from the uppermost part (Zalesie Formation) of the Mójcza section have an unbranched anterior process associated with a very wide platform. This seems to be characteristic of the species although there are several other associated specimens which differ from the older ones of *A. superbus* only in a slightly less developed inner lobe of the posterior process and a shorter, slightly more twisted inner process. The difference is not great and is much obscured by the great population variability. All the

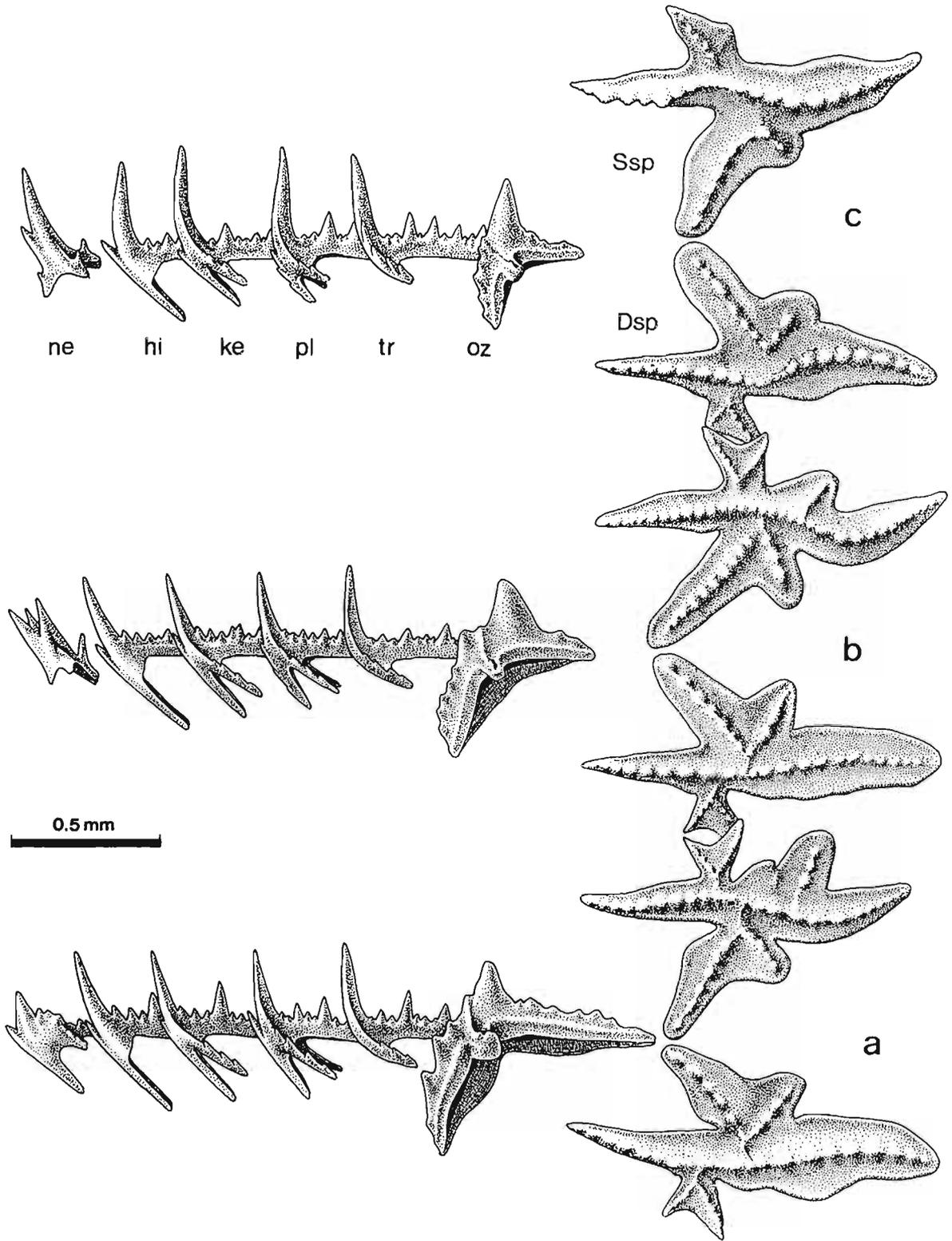


Fig. 21.

Apparatuses of *Amorphognathus* species and proposed homology of their elements. a. *A. tvaerensis* BERGSTRÖM, 1962.
 b. *A. superbus* (RHODES, 1953) early form. c. *A. ordovicicus* BRANSON et MEHL, 1933, early form.

associated **ne** elements from the marly part of the section have the cusp strongly dominating over a few associated denticles, which is the diagnostic feature of the species (BERGSTRÖM 1971; ORCHARD 1980; SAVAGE and BASSETT 1985). Still some doubts remain whether this is enough to consider these Mójcza populations conspecific with the British ones and the zonal boundaries based on the evolution of *Amorphognathus* must remain tentative. The main reason for this uncertainty is the very limited evidence on the population and ontogenetic variability of the **ne** elements. It is clear from the available material that **ne** elements in late *Amorphognathus* species changed significantly in their histogeny (note the difference between the illustrated elements of *A. superbis* and *A. ordovicicus* on Pl. 23: 3, 6 that mostly results from differences in ontogenetic advancement).

Distribution. — Populations from the marly limestones of the Zalesie Formation in Mójcza are assigned to the species with some hesitation. Undoubtedly conspecific with British ones are the populations from the Zalesie Formation in Zalesie and in Międzygórz (in the latter locality well preserved **ne** elements were found).

Genus *Eoplacognathus* HAMAR, 1966

Type species: *Ambalodus lindstroemi* HAMAR, 1966.

Diagnosis. — The **sp** elements with a long inner lobe of the bifurcated anterior process, posterior process undivided. A strong asymmetry in the **oz** pair, with both elements having the anterior(?) process much elongated.

Remarks. — It is rather difficult to indicate any fundamental distinctions between *Eoplacognathus* and *Polyplacognathus*. They seem to differ only in the further development of the robustly ornamented platform in the youngest form, *P. ramosus*.

Ramiform elements have not been identified in most of the species of the genus but sparse data strongly suggest a presence of small elements similar to those of *Lenodus*.

Eoplacognathus zgierzensis DZIK, 1976 (Pl. 20: 11–17; Text-fig. 16b)

1963. cf. *Prioniodus* sp.; SPASSOV and TELLER, p. 81, Pl. 1: 2.

1963. cf. *Prioniodus mojczensis* sp. nov.; SPASSOV and TELLER, p. 81, Pl. 1: 12.

1963. cf. *Ambalodus* sp.; SPASSOV and TELLER, p. 78, Pl. 1: 13–14.

1976. *Eoplacognathus zgierzensis* sp. n.; DZIK, p. 424, Text-fig. 30a–f, Pl. 43: 2.

1976. partim *Amorphognathus variabilis* SERGEEVA; DZIK, Text-fig. 26d–g (only).

1978. *Eoplacognathus? variabilis* (SERGEEVA); LÖFGREN, p. 57, Pl. 15: 15, 22–25.

Holotype: ZPAL CVI/223; DZIK 1976, Text-fig. 30d.

Type horizon and locality: Erratic boulder E-096 of a red *Orthoceras* limestone (Middle Kundan, Arenig/Llanvirn boundary) of Baltic origin, Zgierz, Poland.

Diagnosis. — The elements **sp** with the inner lobe of the anterior process approximately two times longer than the remaining lobe; the anterior process in dextral **oz** element shorter than the remaining ones.

Remarks. — This is the oldest species of the genus, different from its predecessor *Lenodus variabilis* solely in an elongation of the inner lobe of the anterior process (the diagnostic feature of *Eoplacognathus*) and in a denticulated internal process in the **ne** element. Its successor, *E. pseudo-planus* (VIIRA, 1974), has the inner lobe of the anterior process elongated even further, to a degree typical for most species of the genus, while the elongation of the anterior process in the **oz** elements starts from still younger *E. suecicus* BERGSTRÖM, 1971.

The degree of development in denticulation of the **ne** elements vary rather randomly among samples. This, together with a generally incomplete preservation of the **sp** elements, hampers any biometrical study, thus not allowing clarification of the relationship with *Lenodus*, which precedes the species stratigraphically in Mójcza and the Baltic sections.

Distribution. — In Mójcza the species appears 0.5 m below the discontinuity (sample MA-127), where it cooccurs with *Sagittodontina kielcensis*. The transition to *E. pseudo-planus* cannot be traced

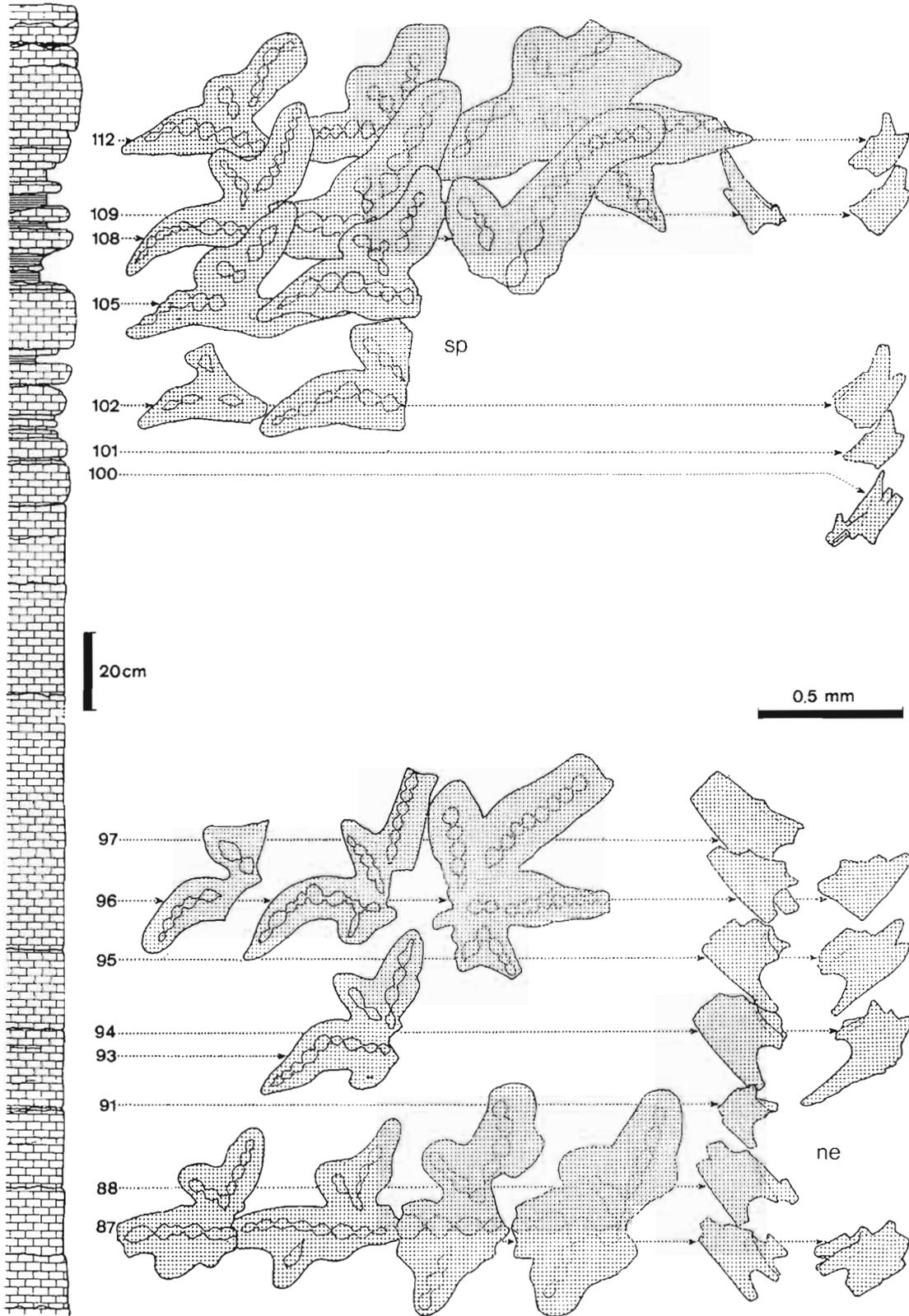


Fig. 22.

Shapes of right *sp* elements (left) and denticulation of *ne* elements of *Amorphognathus* in the upper part of the Mójcza section.

in Mójcza because it corresponds to the hiatus, which covers also the range of *E. pseudoplanus*, *E. suecicus*, at least partially *E. foliaceus*, and probably a major part of the range of *E. reclinatus*.

Eoplacognathus robustus BERGSTRÖM, 1971

(Pl. 21: 3–5; Text-fig. 23)

1971. *Amorphognathus* sp. 3 LINDSTRÖM; BEDNARCZYK, Pl. 2: 2.

1971. *Amorphognathus complicata* RHODES; BEDNARCZYK, Pl. 2: 6.

1971. *Ambalodus reclinatus* FÄHRÆUS; BEDNARCZYK, Pl. 3: 4.

1971. *Eoplacognathus robustus* n. sp.; BERGSTRÖM, p. 140, Pl. 1: 14–16.

1976. *Eoplacognathus lindstroemi robustus* BERGSTRÖM; DZIK, Text-fig. 32a–c.

1985. *Eoplacognathus robustus* BERGSTRÖM; BERGSTRÖM and ORCHARD, Pl. 2.2: 8, 12.

Type horizon and locality: 4 m above the base of the Gullhögen Formation (Llanvim) at Gullhögen quarry, Skövde, Västergötland, Sweden.

Diagnosis. — Flat **oz** elements with a wide platform, left one T-shaped, right Y-shaped, the external process at least two times as long as the remaining ones.

Remarks. — The platform part of the apparatus was reconstructed by BERGSTRÖM (1971). The stratigraphically preceding species of the lineage, *E. reclinatus* (FÄHRÆUS, 1966) can be distinguished by shorter external processes, narrower platform (at similar stages of histogeny) and more elevated cusp in the **oz** elements. The morphology of the platform elements is highly variable making identification of single elements difficult. It is unclear whether the generally large size and robust platform of the elements is a result of some particular dynamics of its Baltic and Polish populations or a stable character.

Distribution. — The lowermost sample, in which well preserved specimens were found, is MA-43 about 0.2 m above the discontinuity. The oldest populations still resemble *E. reclinatus* in that the external process is somewhat shorter in the **oz** elements than is typical for *E. robustus* and may belong to *E. reclinatus*. It is thus unclear whether the bed immediately above the discontinuity surface with fragmentary specimens represents the *E. robustus* or *E. reclinatus* Subzone. The species ranges at least as high as to 0.8 m above the discontinuity.

Eoplacognathus lindstroemi (HAMAR, 1964)

(Pl. 21: 6–9; Text-fig. 23)

1964. *Ambalodus lindstroemi* n. sp.; HAMAR, p. 258, Pl. 5: 1, 4, 7–8, 10–11, Text-fig. 5: 1, 3, 4.

1971. *Eoplacognathus lindstroemi* (HAMAR); BERGSTRÖM, p. 139, Pl. 2: 15–18.

1985. *Eoplacognathus lindstroemi* (HAMAR); BERGSTRÖM and ORCHARD, Pl. 2.2: 11, 13.

Type horizon and locality: Not specified precisely, *Ampyx* limestone, Kellerud or Gomnaes in Ringerike area, Norway.

Diagnosis. — In both elements of the **oz** pair the inner and anterior processes meet approximately at a right angle. In the **sp** elements the inner and outer processes are arranged almost linearly.

Remarks. — The platform part of the apparatus was reconstructed by BERGSTRÖM (1971). In Mójcza only a few elements have been found, so it is impossible to establish if there is a continuum with the preceding species of the lineage. A short barren interval separates these two species, each represented by rather few specimens.

Distribution. — Specimens definitely belonging to the species occur from 1.5 m to 1.2 m below the bentonite.

Eoplacognathus elongatus (BERGSTRÖM, 1962)

(Pl. 21: 10–12; Text-fig. 23)

1962. *Amorphognathus elongata* n. sp.; BERGSTRÖM, p. 31, Pl. 5: 1–3.

1971. *Eoplacognathus elongatus* (BERGSTRÖM); BERGSTRÖM, p. 137, Pl. 2: 12–14.

1976. *Eoplacognathus elongatus* (BERGSTRÖM); DZIK, Text-fig. 33d.

1983. *Eoplacognathus elongatus* (BERGSTRÖM); BARRETT *et al.*, p. 182, Text-figs 6, 7.

1985. *Eoplacognathus elongatus* (BERGSTRÖM); BERGSTRÖM and ORCHARD, Pl. 2.3: 15.

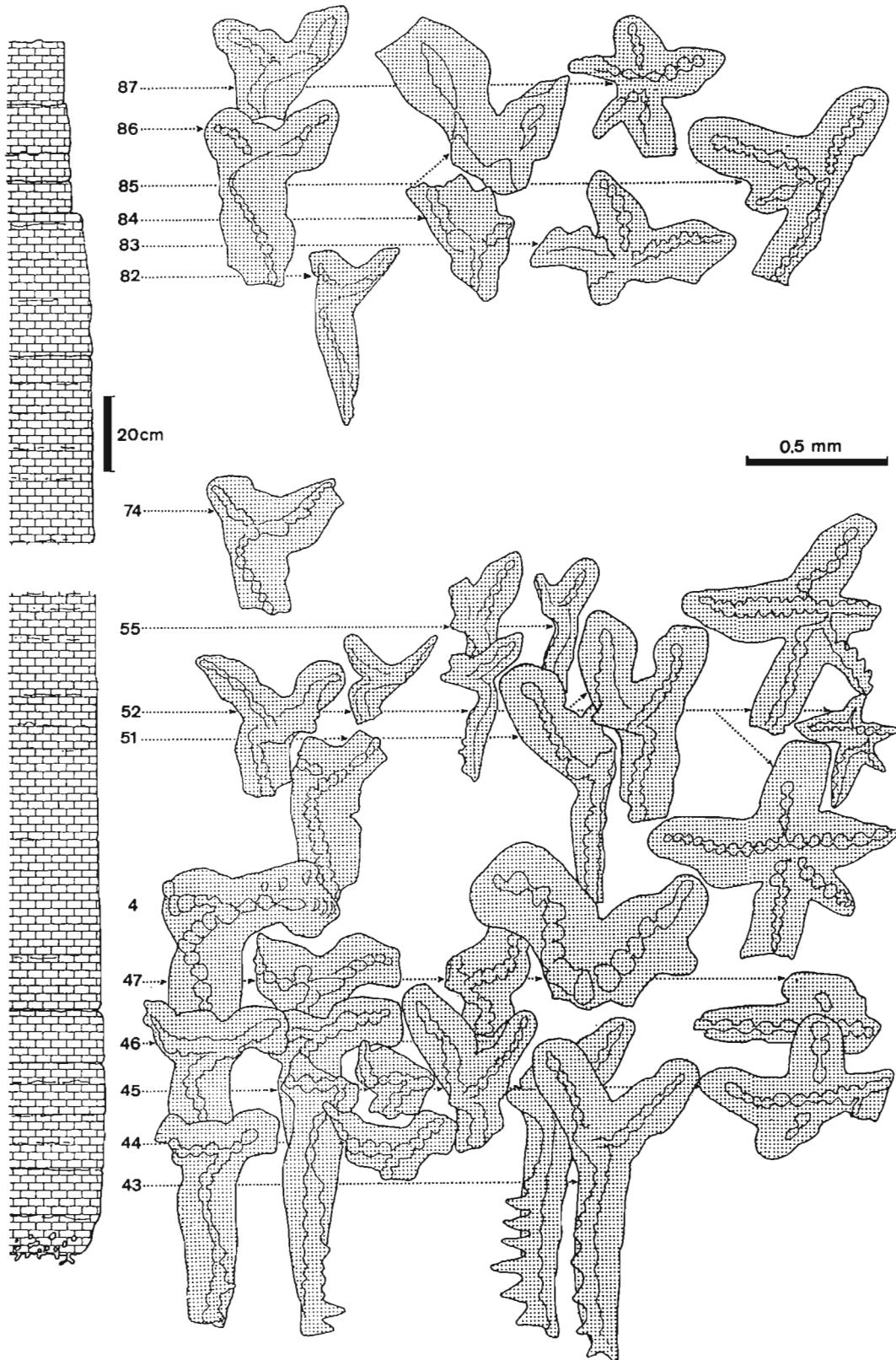


Fig. 23.

Shapes of *oz* (left) and *sp* (right) elements of *Eoplacognathus* in the Mójcza section (lower part from the discontinuity surface to 1 m below the bentonite, upper part from 0.4 to 1.5 m above the bentonite).

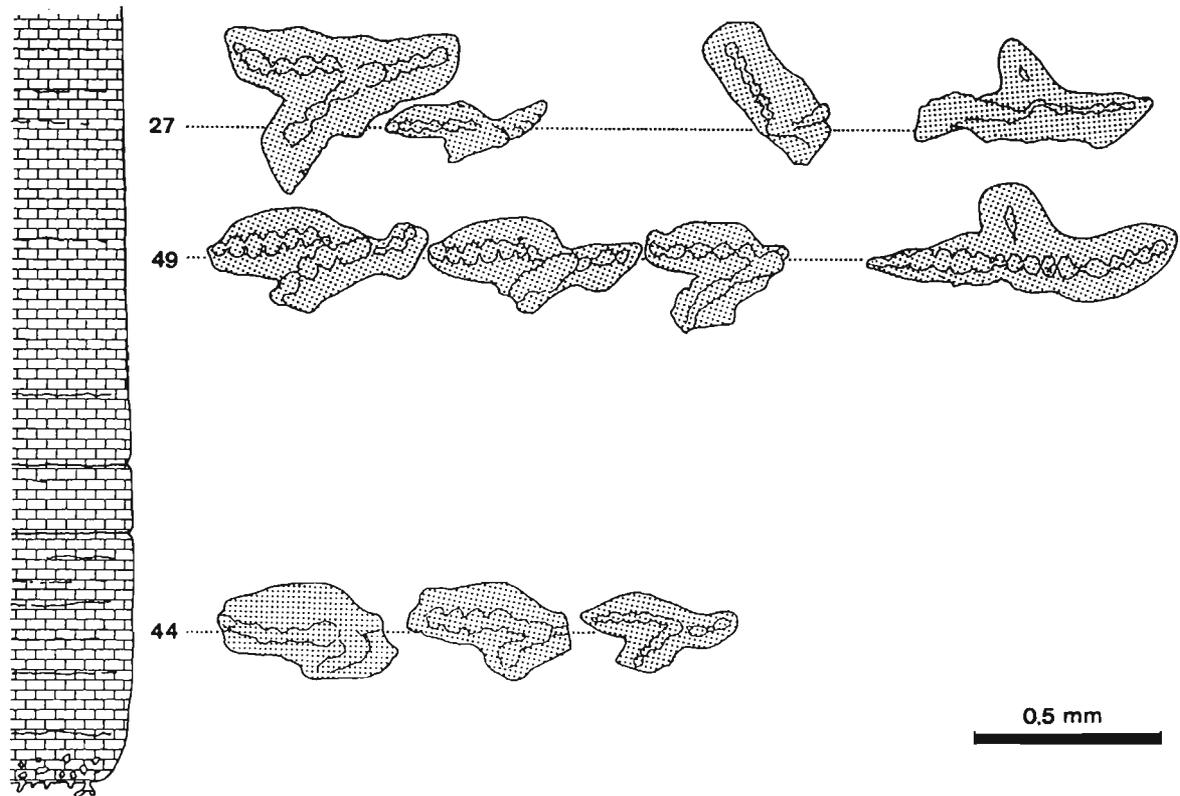


Fig. 24.

Shapes of **oz** (left) and **sp** (right) elements of *Cahabagnathus protoramosus* (CHEN, CHEN *et* ZHANG, 1983) in the Mójcza section above the discontinuity surface.

Type horizon and locality: Not specified precisely, boulder 4 or 6 of the Ludibundus limestone (early Caradoc) from the Tvären area, Sweden.

Diagnosis. — The **sp** elements with the outer and inner processes meeting at an angle in the center of the elements, which results in a star-shaped appearance. The **oz** elements Y-shaped, with a wide platform.

Distribution. — The presumably oldest specimen from Mójcza has been found in sample MA-74, 0.7 m above the bentonite, but undisputable occurrences are from 1.0 to 1.5 m above the bentonite.

Genus *Cahabagnathus* BERGSTRÖM, 1983

Type species: *Polyplacognathus sweeti* BERGSTRÖM, 1971.

Diagnosis. — The **oz** elements with a discontinuous and displaced denticle row on the external process, usually developing a kind of bifurcation. The anterior process of the **sp** elements with its external lobe tending to be reduced.

Cahabagnathus protoramosus (CHEN, CHEN *et* ZHANG, 1983)

(Pl. 21: 1–2; Text-fig. 24)

1971. *Eoplacognathus* n. sp. A.; BERGSTRÖM, Pl. 2: 19

1979. *Eoplacognathus* cf. *reclinatus* (FÄHRÆUS); NI, Pl. 1: 32a–b.

1983. *Eoplacognathus* n. sp. A BERGSTRÖM; BERGSTRÖM, Text-fig. 2.

1983. *Eoplacognathus protoramosus* sp. n.; CHEN *et al.*, p. 135, Pl. 1: 7–10.

1987. *Eoplacognathus protoramosus* CHEN, CHEN *et al.*; AN, p. 149, Pl. 27, 11–13, 17–18.

Type horizon and locality: Lower Tatanba Formation, Tangshan Hills near Nanjing, China.

Diagnosis. — The platform elements of the apparatus are similar in outline to those of *Eoplacognathus foliaceus* but in both **oz** elements the row of denticles on the external process is split into two straight segments, the proximal one continuing somewhat further than the point at which it meets the distal one.

Remarks. — All the specimens from the Mójcza Limestone are fragmentary but they are clearly conspecific with the one illustrated by BERGSTRÖM (1971). A much more numerous collection of the species has been derived from coeval strata of the borehole Lesieniec 1, where the species also cooccurs with *E. reclinatus*. All the platform elements of the apparatus show a striking similarity to *E. foliaceus*, which is certainly the ancestor of the species. The only difference is in the angular bending of the denticle row in the external process of the **oz** elements with a tendency to develop a disruption in their course. These features strongly suggests a phylogenetic proximity to "*E.*" *jianyensis* (AN *et* DING) from the Llandeilo of Tatiambu Formation, Tangshan Hills near Nanjin, China, which connects it with more typical American species of *Cahabagnathus*.

Distribution. — In South China the species occurs in the *E. reclinatus* Subzone (see AN 1987: p. 40), in the Lesieniec borehole, NE Poland in the *E. robustus* and *E. lindstroemi* Subzones. The occurrences in the Baltic area are of the latter age. In Mójcza it occurs from 0.3 to 1.1 m above the discontinuity (*E. robustus* Subzone).

Family Phragmodontidae BERGSTRÖM, 1982

Diagnosis. — The elements of the platform series with a very short anterior process (sometimes missing in the **sp** elements). Elements of the symmetry transition series with all processes but the inner one more or less reduced.

Genera included. — *Phragmodus* BRANSON and MEHL, 1933, *Paraprioniodus* ETHINGTON *et* CLARK, 1981, *Acanthocordylodus* MOSKALENKO, 1973.

Genus *Phragmodus* BRANSON *et* MEHL, 1933

Type species: *Phragmodus primus* BRANSON *et* MEHL, 1933.

Diagnosis. — The inner process of the **tr** and **pl** elements with long denticles, laterally undulating in their orientation, the **sp** elements compressed, with a more or less reduced anterior process.

Phragmodus? sp. aff. "*Baltoniodus*" *crassulus* (LINDSTRÖM, 1955)
(Pl. 17: 13–18; Text-fig. 25a)

Remarks. — The species is represented in the basal beds of the Mójcza Limestone by poorly preserved specimens. A similarity to cooccurring *Baltoniodus* makes separation sometimes, at such a state of preservation, difficult. Especially the **pl** and **tr** elements are not easy to assign properly to a species unless their internal processes are well preserved. They differ, however, from *Baltoniodus* in a less prominent denticulation of the remaining processes. Some morphologically transitional elements have been found (for instance Pl. 17: 14) that are hard to classify. Like the ramiform elements in typical populations of "*B.*" *crassulus* the elements from Mójcza also have very long, gently curved cusps. This makes identification of the species rather easy even if the processes are broken.

The population from the Mójcza Limestone differs from older populations of "*B.*" *crassulus* (see DZIK 1984; BAGNOLI *et al.* 1988) in the more robust appearance of the elements, which may be a result of taphonomic selection during sedimentation of the coarse sandy limestone.

Distribution. — Typical "*B.*" *crassulus* occurs in the topmost Latorpian of the Baltic area, being later replaced by species of the *Baltoniodus* lineage. In Mójcza and the Myszków borehole (Upper Silesian Massif) it seems to occur as high as in the basal Kundan (up to 0.3 m above the base of the limestone in Mójcza), being replaced here by an early form of *P. polonicus*. These species are so close morphologically that an evolutionary connection seems possible. Because of stratigraphic condensation of the section and the rarity of specimens in the transitional strata this cannot however, be precisely documented.

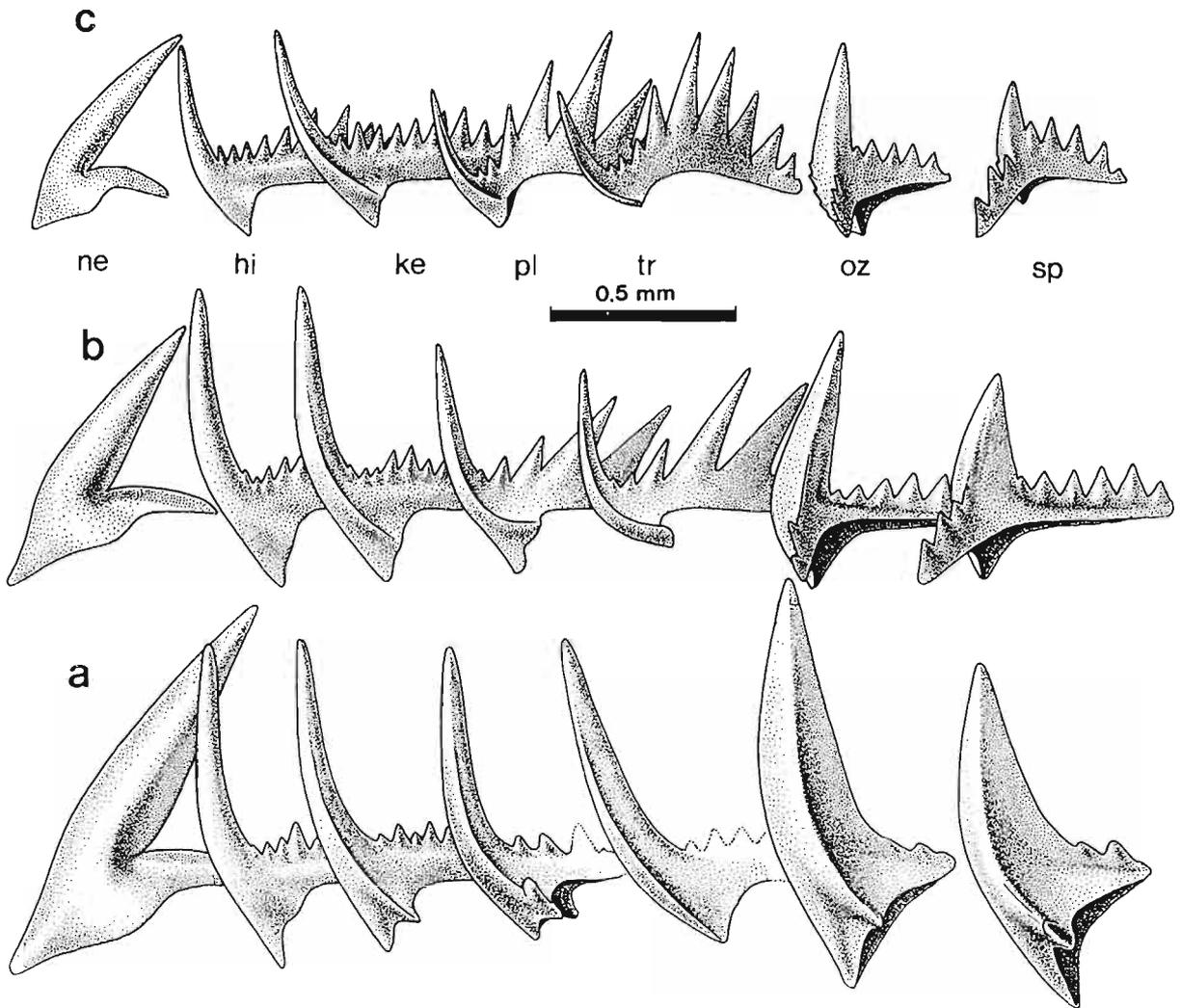


Fig. 25.

Apparatuses of *Phragmodus* species and proposed homology of their elements. a. *P.?* sp. aff. "*Baltoniodus*" *crassulus* (LINDSTRÖM, 1955). b–c. *P. polonicus* DZIK, 1978. b – early form from below the discontinuity surface.

Phragmodus polonicus DZIK, 1978
(Pls 17: 19–25; 18: 1–7; Text-fig. 25b–c)

1976. *Phragmodus* sp.; DZIK, Text-fig. 35m, n (not o).

1978. *Phragmodus polonicus* sp. n.; DZIK, p. 63, Pl. 14: 1–5, Text-fig. 5 (non Pl. 14: 3, Text-fig. 5e).

1981. ?*Phragmodus flexuosus* MOSKALENKO; ETHINGTON and CLARK, p. 79, Pl. 9: 2–7.

1988. *Phragmodus polystrophos* sp. nov.; WATSON, p. 121, Pls 6: 20–21, 24–27; 7: 10, 12–16.

1989. *Phragmodus harrisi* n. sp. (correctly should be: *harrisae*); BAUER, p. 103, Text-fig. 7: 1–8.

Holotype: ZPAL CVI/348; DZIK 1978, Pl. 14: 1.

Type horizon and locality: Sample MA-27. 1.6 m below the bentonite layer in the Mójcza Limestone (*E. lindstroemi* Zone, Llanvirn) at Mójcza, Holy Cross Mountains, Poland.

Diagnosis. — The external process of juvenile **sp** elements serrate, at older stages of histogeny smooth. The **ne** elements undenticulated, geniculate (oistodontiform).

Remarks. — The species differs from these species of the genus that also have an oistodontiform **ne** elements (*P. undatus*) in having a more primitive appearance in the remaining elements. Other species of *Phragmodus* have denticulated (cyrtionodontiform) **ne** elements.

The **tr** element tentatively attributed to this species in the original description (DZIK 1976, 1978) belongs to *Complexodus pugionifer*. This wrong identification resulted in much confusion in respect to the phylogenetic interpretation of the species (DZIK 1978).

Range. — In the Canning Basin, Australia, the species cooccurs with early representatives of the *Eoplacognathus* lineage, thus being coeval with the early Mójcza populations, but another species of the genus precedes it there and in the Ordos Platform, China. In the Chinese species, *P. paraundatus* WANG and LUO, 1984 (possibly conspecific with Australian *P. spicatus* WATSON, 1989) the **sp-oz** locations are occupied by cyrtionodontiform elements (**ne** is oistodontiform). The cooccurrence with *Histiodellella holodentata* ETHINGTON *et* CLARK, 1981, definitely shows that these strata are older than the base of the Mójcza Limestone where a more advanced species of the *Histiodellella* lineage occurs. This means that the proposed transition from *P.?* *crassulus* to *P. polonicus* (and/or *P. spicatus*) either took place somewhat earlier than the first appearance of the latter species in Mójcza, or the *Phragmodus* lineage derived from early *Periodon*.

Distribution. — The species is known almost worldwide, being present in the North American Midcontinent (BAUER 1989), Siberia, and Australia (WATSON 1988). It ranges from the *Histiodellella kristinae* Zone (early Kundan, Late Arenig) to the *A. tvaerensis* Zone. In equatorial regions it was replaced by *P. flexuosus* (in Siberia being sympatric for a brief time in some regions) but in the Baltic region and the Holy Cross Mountains continues up to the Early Caradoc. Rare specimens are known from the Llanvirn and Llandeilo of the Lesieniec 1 borehole (Polish part of the East European Platform), from Estonia (BERGSTRÖM *et al.* 1987), and from the Myszków borehole (Upper Silesian Massif). The oldest population of *P. polonicus* from the sample MA-120 in Mójcza (0.5 m above the base of the limestone) is different from later populations by still showing a tetraprionodontiform appearance of the **pl** elements, which is much less apparent higher in the section. Also the distinction between the **hi-ke** and **pl-tr** groups within the symmetry transition series seems to be less pronounced in this oldest population. The populations of the species from strata up to 0.7 m above the discontinuity surface (*E. robustus* – *B. variabilis* Subzones) are mostly represented by minute, probably juvenile specimens.

Family **Pygodontidae** BERGSTRÖM, 1981

Diagnosis. — The **sp** elements with a reduced inner process but developing instead an additional externally oriented process connected by a thin sheet into a triangular unit. The remaining elements of the symmetry transition series with obliquely oriented minute denticles.

Genus *Pygodus* LAMONT *et* LINDSTRÖM, 1957

Type species: *Pygodus anserinus* LAMONT *et* LINDSTRÖM, 1957.

Diagnosis. — As for the family.

Pygodus serra (HADDING, 1913) (Pl. 17: 9–12; Text-fig. 26)

1955. *Pygodus serra* (HADDING); LINDSTRÖM b, p. 110, Pl. 22: 17, 20–25.
 1971. *Pygodus serrus* (HADDING); BERGSTRÖM, p. 149, Pl. 2: 22–23.
 1976. *Pygodus serrus* (HADDING); DZIK, Text-fig. 29a–b, e.
 1978. *Pygodus serra* (HADDING); LÖFGREN, p. 98, Text-fig. 32D–F.
 1984. *Pygodus serrus* (HADDING); CHEN and ZHANG, Pl. 2: 16–19.
 1979. *Pygodus serrus* (HADDING); NI, Pl. 1: 28–29.
 1991. *Pygodus serra* (HADDING); MCCracken, p. 51, Pl. 2: 4, 6, 7, 9, 11–12, 14–18, 20–13, 28–30.
 1991. *Pygodus* sp. cf. *serra* (HADDING); MCCracken, p. 51, Pl. 2: 1–3, 5, 8, 10, 13, 19.

Type horizon and locality: Upper part of the Lower *Dicellograptus* Shale at section E 15, Fågelsång near Lund, Skåne, Sweden.

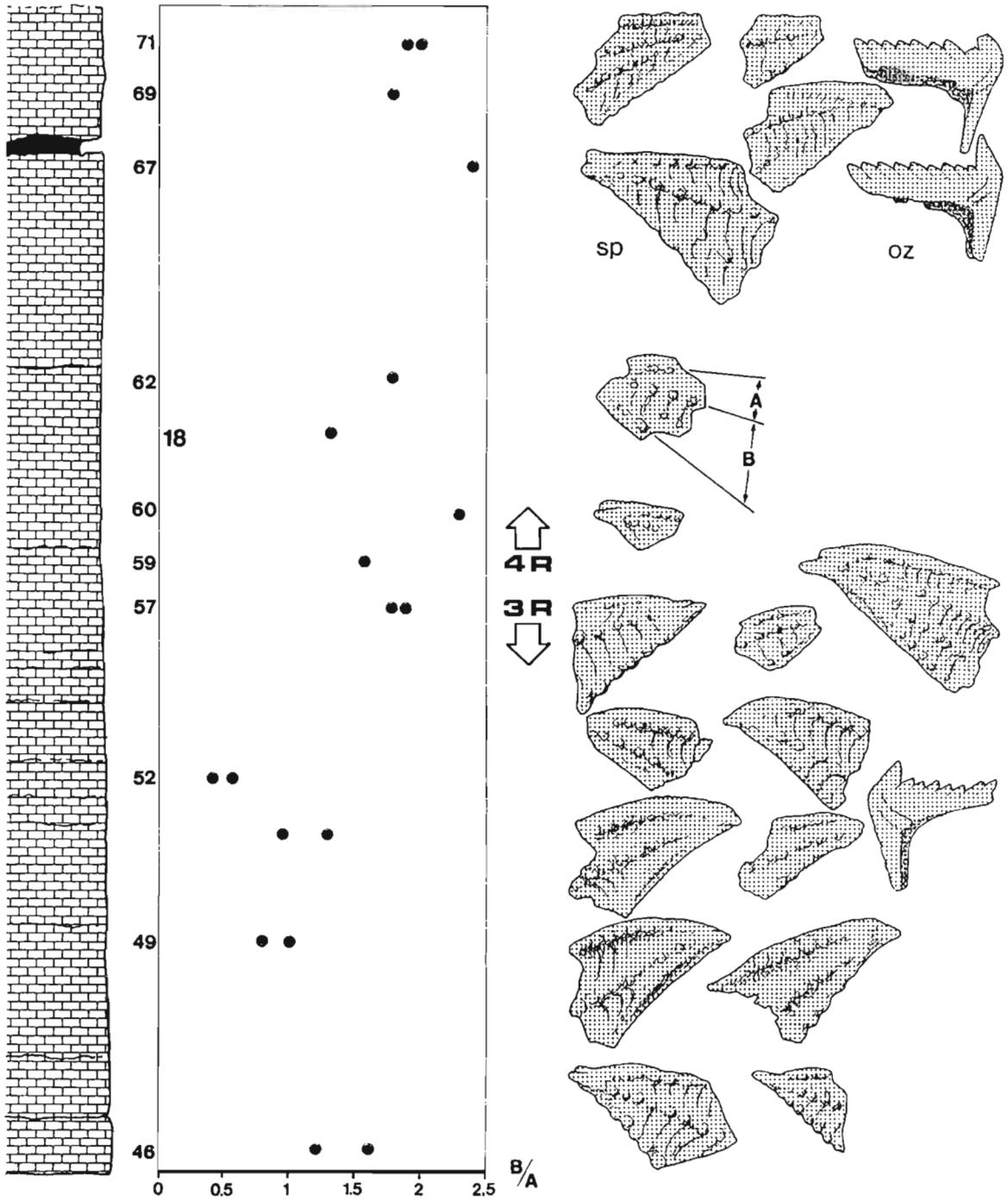


Fig. 26.

Changes in morphology of *sp* elements of *Pygodus* in the Mójcza section expressed as the ratio between widths of the fields separated by the medial row of tubercles; contours of *sp* and *oz* elements to the right.

Diagnosis. — The *sp* elements with three rows of tubercles connected by a wide sheet with transverse wrinkles. The *oz* elements with an external process merging at almost right angle the internal one.

Remarks. — The apparatus of *Pygodus* was interpreted by BERGSTRÖM (1971) and its evolution discussed by BERGSTRÖM (1983). Along with two well known element types the apparatus of *Pygodus*

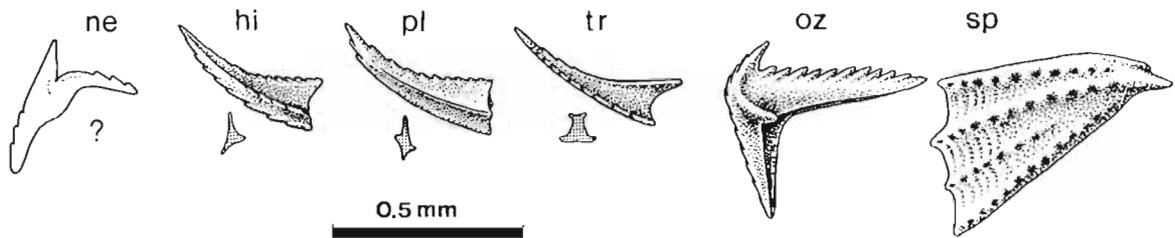


Fig. 27.

Apparatus of *Pygodus* (sp element of *P. anserinus* LAMONT *et* LINDSTRÖM, 1957; tentative identification of ne element based on materials from the borehole Lesieniec 1, NE Poland).

consists also of several minute ramiform elements that form a symmetry transition series (MCCRACKEN 1991). Of special interest is the morphology of the symmetrical element, which has its medial process weakly denticulated but split into two parallel ridges (Pl. 17: 10). All of the few ramiform elements in my collection, as well as those illustrated by other authors, have at least three processes, which may make a distinction from other prioniodontids among which at least the **hi** element is biramous. In a sample from the Lesieniec 1 borehole, located in the Polish part of the East European Platform, two oistodontiform elements have been found which, being unlikely to belong to any other conodont species, seem to represent the **ne** elements of *Pygodus*. If this identification is correct it would support a derivation of *Pygodus* from the prioniodontids (DZIK 1983) rather than from *Polonodus* (BERGSTRÖM 1983) unless the latter genus is also a prioniodontid as proposed by LÖFGREN (1990).

Distribution. — In Mójcza the species occurs from 0.5 m above the discontinuity to 1.5 m below the bentonite. An interesting reversal in the course of evolution seems to have taken place within the range of *P. serra*. The lineage seems to evolve towards more and more narrow posterior area between the two posterior rows of tubercles. Beginning from the sample MA-57 this area again becomes wider, thus making room for the fourth row of tubercles diagnostic for the succeeding species. Such a morphotype, transitional morphologically to *P. anserinus* but cooccurring with typical elements of *P. serra*, has been identified as a separate species by MCCRACKEN (1991).

Pygodus anserinus LAMONT *et* LINDSTRÖM, 1957
(Pl. 17: 7–8; Text-figs 26–27)

1971. *Pygodus anserinus* LAMONT *et* LINDSTRÖM; BERGSTRÖM, p. 149, Pl. 2: 20–21.

1976. *Pygodus anserinus* LAMONT *et* LINDSTRÖM; DZIK, Text-fig. 29f.

1984. *Pygodus anserinus* LAMONT *et* LINDSTRÖM; CHEN and ZHANG, Pl. 2: 18–21.

Type horizon and locality: Cherts at Crawford (Llandeilo), Normangill Burn, Scotland.

Diagnosis. — The elements **sp** with four rows of tubercles, the **oz** elements with the angle between processes slightly smaller than right.

Remarks. — Relationships between these two species are the subject of some controversy. FÄHRÆUS (1982) claimed that there is an overlap in time ranges of *P. serra* and *P. anserinus*. He evidently defined these species vertically, all specimens with three rows of tubercles classified as *P. serra* while those with four as *P. anserinus*. One may argue, however, that in populations transitional between these chronospecies both these morphotypes must occur together. The overlap in their ranges would then be an artifact resulting from the application of the typologic, instead of population, species concept. No population study on *Pygodus* has been performed yet and this precludes a more precise recognition of the evolutionary process. The material from the Mójcza Limestone is too scarce to solve the problem. Nevertheless, it is evident that the evolutionary introduction of the fourth row of tubercles was rather smooth, with widening of the area between two neighbouring rows preceding insertion of the new one (Text-fig. 26). Initially the tubercles of the fourth row developed quite late in the histogeny of the element and in the course of evolution they started to develop closer and closer to the cusp. Although there are some differences in the orientation of processes in the **oz** elements of these two species of *Pygodus* (BERGSTRÖM 1971) this is far from being apparent in the Mójcza

material. The great population variability makes this feature useful taxonomically only if numerous *oz* elements are available.

Distribution. — In Mójcza the species occurs from 1.0 m below to 0.2 m above the bentonite (with the first *Baltoniodus variabilis*)

Superfamily *Icriodontacea* MÜLLER *et* MÜLLER, 1957

Diagnosis. — The *sp* elements tend to develop a complex molar-like appearance by means of widening tips of denticles (icrion), rarely by thickening margins of the base (platform). The elements of the symmetry transition series minute, more or less simplified morphologically.

Family *Pterospathodontidae* COOPER, 1977

Diagnosis. — The *sp* elements multiramous, the elements of the symmetry transition series with densely distributed, long and sharp denticles.

Genus *Complexodus* DZIK, 1976

Type species: *Balognathus pugionifer* DRYGANT, 1974.

Diagnosis. — Flat elements with sharp denticulation and deep basal cavities. The *sp* elements with a bifurcated posterior process tending to develop a robust shape (icrion) by widening of the denticle tips.

Remarks. — The *sp* elements of the genus can be distinguished from those of superficially similar balognathids by the undivided anterior process, which branches directly from the cusp.

Complexodus originalis CHEN *et* ZHANG, 1984

(Pl. 23: 13–19; Text-figs 28a, 29)

1984. *Complexodus originalis* sp. n.; CHEN and ZHANG, p. 133, Pl. 1: 11–12.

Type horizon and locality: Lower Tatanba Formation, Tangshan Hills near Nanjing, China.

Diagnosis. — An almost straight external branch of the posterior process of the *sp* elements, which have denticles with sharp tips.

Distribution. — In China the species occurs from the *E. reclinatus* Subzone to the *P. anserinus* Zone (CHEN and ZHANG 1984); according to AN (1987) its ancestor is *Amorphognathus complexoides* AN. In Mójcza it appears 1.1 m below the bentonite (*E. lindstroemi* Subzone), 0.2 m below the bentonite it is replaced by *C. pugionifer* but seems to reappear 1.0 m above and continue up to 1.7 m above the bentonite (*A. tvaerensis* Zone) (Text-fig. 29).

Complexodus pugionifer (DRYGANT, 1974)

(Pl. 23: 20–26; Text-figs 28b, 29)

1974. *Balognathus pugionifer* sp. n.; DRYGANT, p. 56, Pl. 1: 4–8.

1976. *Complexodus pugionifer* (DRYGANT); DZIK, p. 423, Text-fig. 25i, Pl. 44: 2.

1978. *Complexodus pugionifer* (DRYGANT); DZIK, Pl. 13: 6.

1981. *Complexodus pugionifer* (DRYGANT); AN, Pl. 4: 4

1985. *Complexodus pugionifer* (DRYGANT); BERGSTRÖM and ORCHARD, Pl. 2.3: 6.

1987. *Complexodus pugionifer* (DRYGANT); AN, p. 122, Pls 25: 21–22, 25, 28; 29: 13.

Holotype: IGGI 29226, DRYGANT 1974, Pl. 1: 4.

Type horizon and locality: Borehole Piszczka-16, depth 405–407 m (Uhakuan), Volhynia, Ukraine.

Diagnosis. — The posterior process of the *sp* elements with an external lobe that is very sinuous, immediately after branching curving towards the remaining lobe. Distal denticles of the inner and posterior processes with more or less transversely widened tips.

Remarks. — The type population seems to be located close to the lower range of the species. Later the diagnostic lobe of the posterior process has become more and more strongly bent (Text-fig. 29).

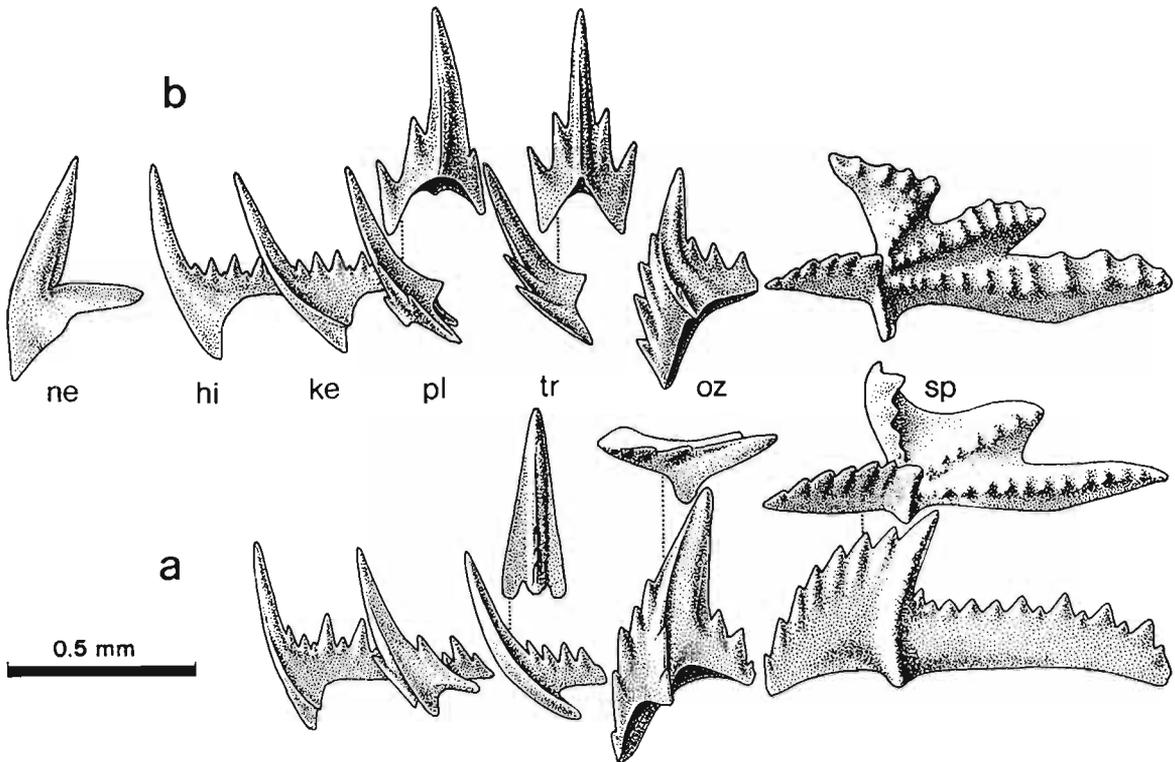


Fig. 28.

Apparatuses of *Complexodus* species and proposed homology of their elements. **a.** *C. originalis* CHEN and ZHANG, 1984. **b.** *C. pugionifer* (DRYGANT, 1974).

Distribution. — Known from the Llandeilo of Ukraine, South China and Wales. In Mójcza it appears 0.1 m below the bentonite and continues up to 0.5 m above (*P. anserinus* – basal *A. tvaerensis* Zones).

Complexodus sp. A
(Pl. 23: 27; Text-fig. 29)

Remarks. — Unlike *C. pugionifer*, which precedes this species stratigraphically in the Mójcza section, the external lobe of the posterior process develops a sinuosity not before a late stages in histogeny. The general appearance of the **sp** elements is thus similar rather to *C. originalis* although adult elements are rather robust (Pl. 23: 27). It is unclear whether the reappearance of such primitive morphologies is a result of an evolutionary reversal or a second immigration of *C. originalis* to the Mójcza area from a region of its permanent occurrence and evolutionary stasis. A slight shift in frequency distribution of the diagnostic character (Text-fig. 29) suggests rather the reversal.

Distribution. — Occurs in Mójcza from 1.0 to 1.7 m above the bentonite. The range of the species is separated from that of *C. pugionifer* by a gap.

Genus *Distomodus* BRANSON *et* BRANSON, 1947

Type species: *Distomodus kentuckyensis* BRANSON *et* BRANSON, 1947.

Distomodus sp.
(Pl. 18: 15–16)

Remarks. — A few fragmentary specimens of this enigmatic species have been found in the sample MA-92. The best preserved represent **ne** elements (Pl. 18: 16) and **pl** elements (Pl. 18: 15), which are morphologically close to Silurian species of the genus.

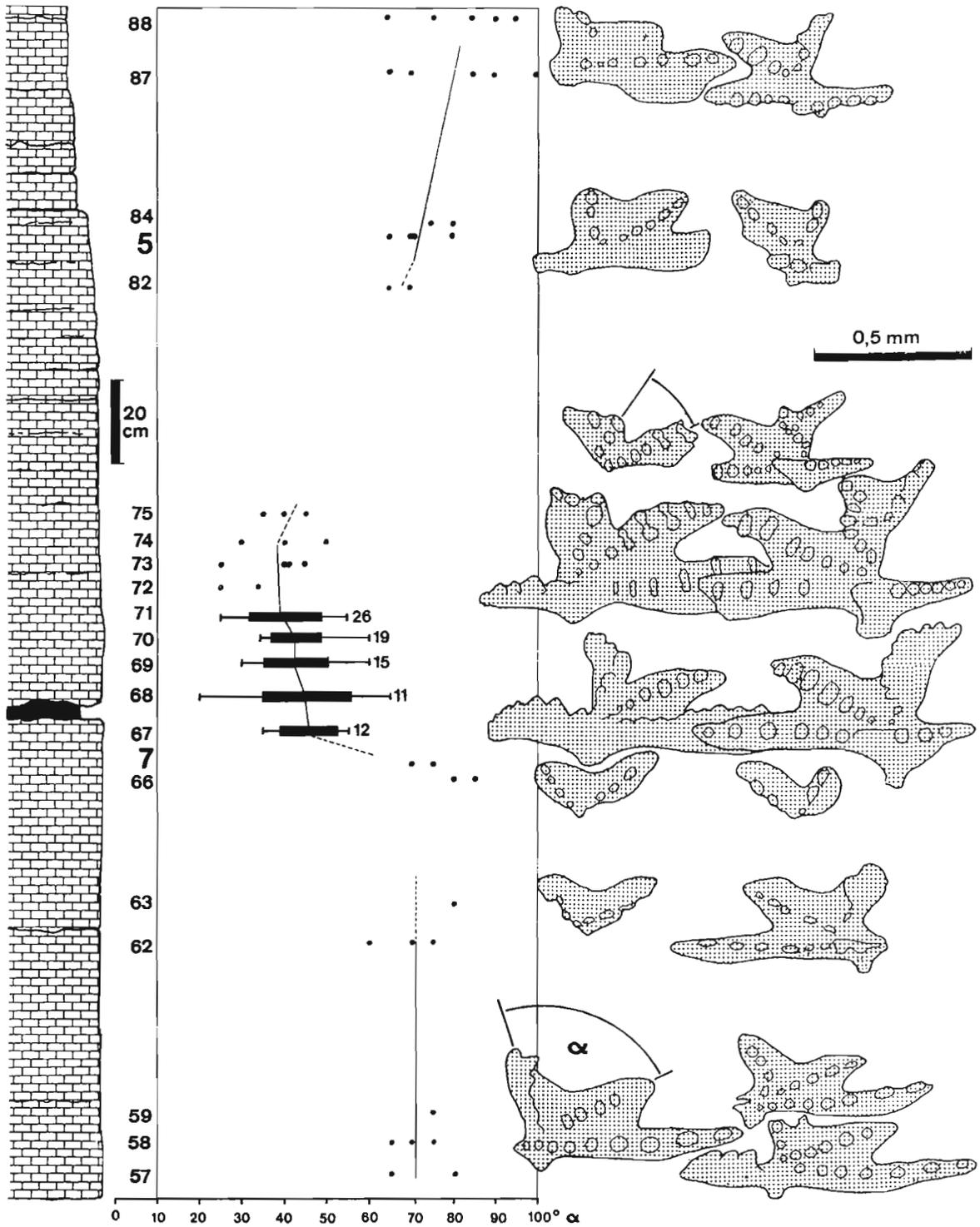


Fig. 29.

Changes in orientation of lobes of the posterior process in *sp* elements of *Complexodus* in the Mójcza section.

Distribution. — In Mójcza found 1.9 m above the bentonite (*A. tvaerensis/superbus* transition zone).

Family **Icriodontidae** MÜLLER *et* MÜLLER, 1957

Diagnosis. — Symmetry transition series and **oz** elements show a tendency to simplification, in later forms mimicking coniforms. The **sp** elements have a strong external process usually with tips of its denticles transversely widened to form triple rows (icrion), the inner process with a tendency to reduction, although, secondarily, in some genera a complex star-like shape of the element may develop.

Genus *Icriodella* RHODES, 1953

Type species: *Icriodella superba* RHODES, 1953.

Diagnosis. — The elements of the symmetry transition series with deep basal cavities and, except for the **ne** ones, with well developed denticulation. The **sp** elements with a well developed, denticulated inner process.

Icriodella n. sp. A NOWLAN, 1983
(Pl. 24: 3–4)

1983. *Icriodella* n. sp. A; NOWLAN, p. 666, Pl. 1: 1–5.

Remarks. — The species is represented in the Mójcza collection by a few fragmentary **sp** elements with variably, but generally weakly, developed molarization of the outer process. The elements **oz** do not differ in shape from other Late Ordovician species of the genus.

Distribution. — Rare in samples MA-98 and MA-99 (top of the Mójcza Limestone, *A. superbus* Zone).

Icriodella prominens ORCHARD, 1980
(Pl. 24: 2)

1980. *Icriodella prominens* sp. nov.; ORCHARD, p. 22, Pl. 1: 19–21, ?22, 25, ?27, 28.

1983. *Icriodella prominens* ORCHARD; NOWLAN, p. 666, Pl. 1: 8–10.

Type horizon and locality: Sample K3, Lower Keysley Limestone, Keysley Quarry, Cross Fell, England.

Diagnosis. — The **sp** elements with a molarized part “which tapers progressively from its proximal end which bears relatively discrete nodes; the subcentral cusp is long and sharp” (modified after ORCHARD 1980).

Distribution. — Seems to be widespread in the Ashgill. Rare in the Zalesie Formation of the Mójcza section.

Order **Ozarkodinida** DZIK, 1976

Diagnosis. — The platform series in the apparatus originally and typically represented by biramous elements. The **tr** and **pl** elements originally triramous with repeated tendency to reduce the inner process.

Suborder **Plectodinina** DZIK, 1991

Diagnosis. — The **ne** elements with a proclined cusp.

Family **Oistodontidae** LINDSTRÖM, 1970

Diagnosis. — Flattened undenticulated elements, their processes armed with high cristae; in some advanced forms denticulation develops in all elements except the **ne** ones.

Genus *Histiodela* HARRIS, 1962

Type species: *Histiodela altifrons* HARRIS, 1962.

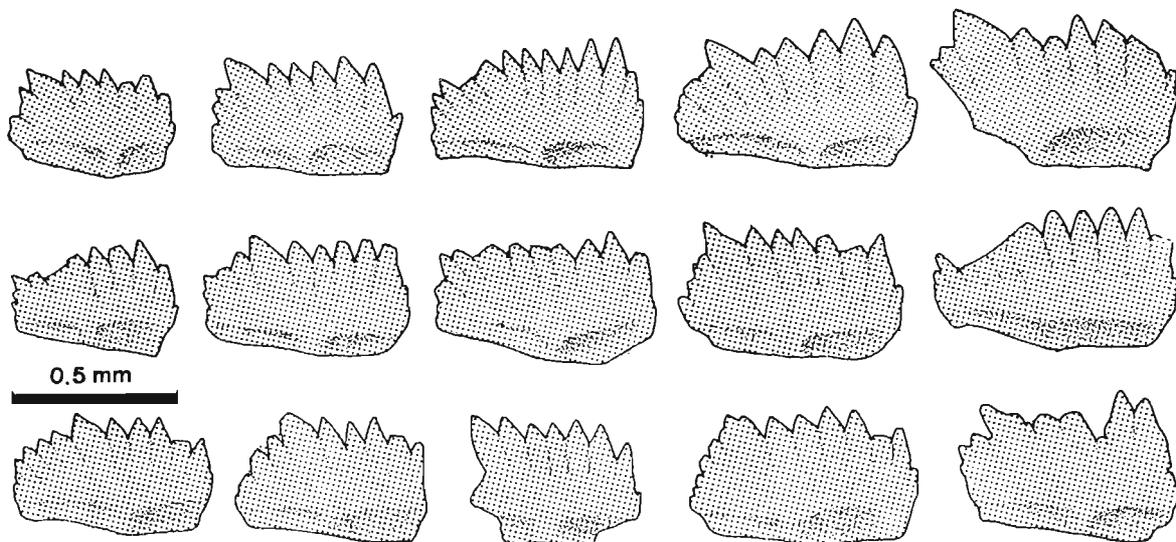


Fig. 30.

Contours of **sp** elements of *Histiodella kristinae* STOUGE, 1984 from the basal part of the Mójcza Limestone (samples MA-127, 128, 130, 131).

Diagnosis. — Elements albid, of pentagonal outline with microserrate or denticulated carinae, except for the **ne** ones, which are geniculate (oistodontiform). The **tr-pl** elements with a short medial process.

Histiodella kristinae STOUGE, 1984

(Pl. 24: 28–30; Text-fig. 30)

1976. *Histiodella serrata* HARRIS; DZIK, Text-fig. 12d.

1978. *Histiodella serrata* HARRIS; DZIK, Pl. 14: 7.

1979. *Histiodella* (sp. nov); NI, Pl. 1: 26

1979. *Histiodella miaopoensis* sp. nov.; AN *et al.*, Pl. 1: 20.

1979. *Histiodella* n. sp. 1 (= *Histiodella* sp. A SWEET *et al.*); HARRIS *et al.*, Pl. 1: 9.

1984. *Histiodella serrata* HARRIS; WANG and LUO, Pl. 11: 6–7.

1984. *Histiodella kristinae* n. sp.; STOUGE, p. 87, Pl. 18: 1–7, 9–11, Text-fig. 17.

Type horizon and locality: Middle Table Head Formation, sample TP 68, Table Point, Newfoundland.

Diagnosis. — The **sp** elements with denticles at the end of the external process taller than the cusp (modified after STOUGE 1984).

Remarks. — The evolution of the lineage of *Histiodella* is well known owing to descriptions by MCHARGUE (1982) of its earlier part and by STOUGE (1984) of the later stages in the evolutionary development of denticulation. This allows very precise across-Iapetus correlation of the Late Arenig strata containing this species. In Mójcza only the **sp** elements have been found but the apparatus was reconstructed by STOUGE (1984) on the basis of a rich Newfoundland material.

Distribution. — The species occurs in the early-middle Kundan of the Baltic region and the Holy Cross Mountains, and in corresponding strata of the Yangtze region of China and in Newfoundland. In Mójcza 0.5–0, 2 m below the discontinuity.

Family **Periodontidae** LINDSTRÖM, 1970

Diagnosis. — Sharply denticulated elements, the **pl** and **tr** ones with all their processes reduced, except for the medial one, the **ne** element oistodontiform.

Genera included. — *Periodon* HADDING, 1913, ?*Hamarodus* VIIRA, 1974.

Genus *Periodon* HADDING, 1913

Type species: *Periodon aculeatus* HADDING, 1913.

Diagnosis. — The elements of the symmetry transition and the “platform” series with very long, sharp denticles oriented fan-like. The **ne** elements with a weakly denticulated, very short external process and undenticulated long inner one.

Periodon aculeatus HADDING, 1913 late form
(Pl. 24: 10–13; Text-fig. 31b)

1955. *Periodon aculeatus* HADDING; LINDSTRÖM b, p. 110, Pl. 22: 10–11, 14–16, 35.

1976. *Periodon aculeatus aculeatus* HADDING; DZIK, p. 435, Text-fig. 341–r.

1984. *Periodon aculeatus* (HADDING); CHEN and ZHANG, Pl. II, 1–7.

1985. *Periodon aculeatus* (HADDING); BURRETT *et al.*, p. 183, Text-fig. 8.

1985. *Periodon aculeatus* (HADDING); BERGSTRÖM and ORCHARD, Pl. 2.2: 6–7.

Type horizon and locality: Lower *Dicellograptus* shale, Fågelsång section E 15, upper part; Skåne, Sweden.

Diagnosis. — External processes in the symmetry transition series and the **ne** elements reduced, with very small denticles.

Remarks. — The species is extremely rare in Mójcza and little can be added to the reconstruction of its apparatus in DZIK (1976). In the course of the evolution of the *Periodon* lineage non-inner processes in the elements of the symmetry transition series gradually disappeared (see DZIK 1976, 1983; STOUGE and BAGNOLI 1988). This can be recognized also within the chronospecies *P. aculeatus*, in its present mening. Early forms (see DZIK 1976; LÖFGREN 1978) have rudimentary processes of **tr** and **pl** elements more prominently denticulated.

Distribution. — Cosmopolitan species. In Mójcza from 2.2 m to 1.2 below the bentonite (*E. robustus* – *E. lindstroemi* Subzones).

Genus *Hamarodus* VIIRA, 1974

Type species: *Distomodus europaeus* SERPAGLI, 1967 (= *Neoprioniodus brevirameus* WALLISER, 1964).

Diagnosis. — The elements **sp–oz** with a very deep basal cavity and rudimentarily denticulated processes; inner processes of the elements of the symmetry transition series denticulated with minute, sharp alternating denticles, remaining processes being more or less reduced.

Hamarodus brevirameus (WALLISER, 1964)
(Pl. 24: 14–19; Text-fig. 31a)

1964. *Neoprioniodus brevirameus* n. sp.; WALLISER, Pl. 4: 5, 29: 5–10.

1964. cf. *Roundya prima* n. sp.; WALLISER, Pl. 4: 6, 31: 1–2.

1967. *Distomodus europaeus* n. sp.; SERPAGLI, p. 64, Pl. 14: 1–6 (other synonyms from SERPAGLI 1967 in SWEET and BERGSTRÖM 1984).

1976. *Hamarodus europaeus* (SERPAGLI); DZIK, p. 435, Text-fig. 36a–g.

1978. *Hamarodus europaeus* (SERPAGLI); DZIK, Text-fig. 2.

1980. *Hamarodus europaeus* (SERPAGLI); ORCHARD, p. 21, Pl. 4: 22, 25, 29–31.

1979. *Hamarodus europaeus* SERPAGLI; NI, Pl. 1: 33.

1983. *Hamarodus* sp. cf. *H. europaeus* (SERPAGLI); NOWLAN, p. 664, Pl. 2: 1–12.

1991. *Hamarodus europaeus* (SERPAGLI); FERRETTI and SERPAGLI, Pl. 2: 1–6.

Type horizon and locality: Bereich 1, Schicht 2A (Ashgill) at Cellon, Carnic Alps, Austria,

Diagnosis. — As for the genus.

Remarks. — The apparatus reconstruction proposed by DZIK (1976, 1978) has been proven by subsequent studies (ORCHARD 1980) and additional collecting in the Holy Cross Mountains, Baltic region, and Carnic Alps. The elements of the “platform” series are very variable and it is not quite certain whether differences in their shape and denticulation really represents a distinction between element types and not just population variability. There seems to be some ontogenetic change in the

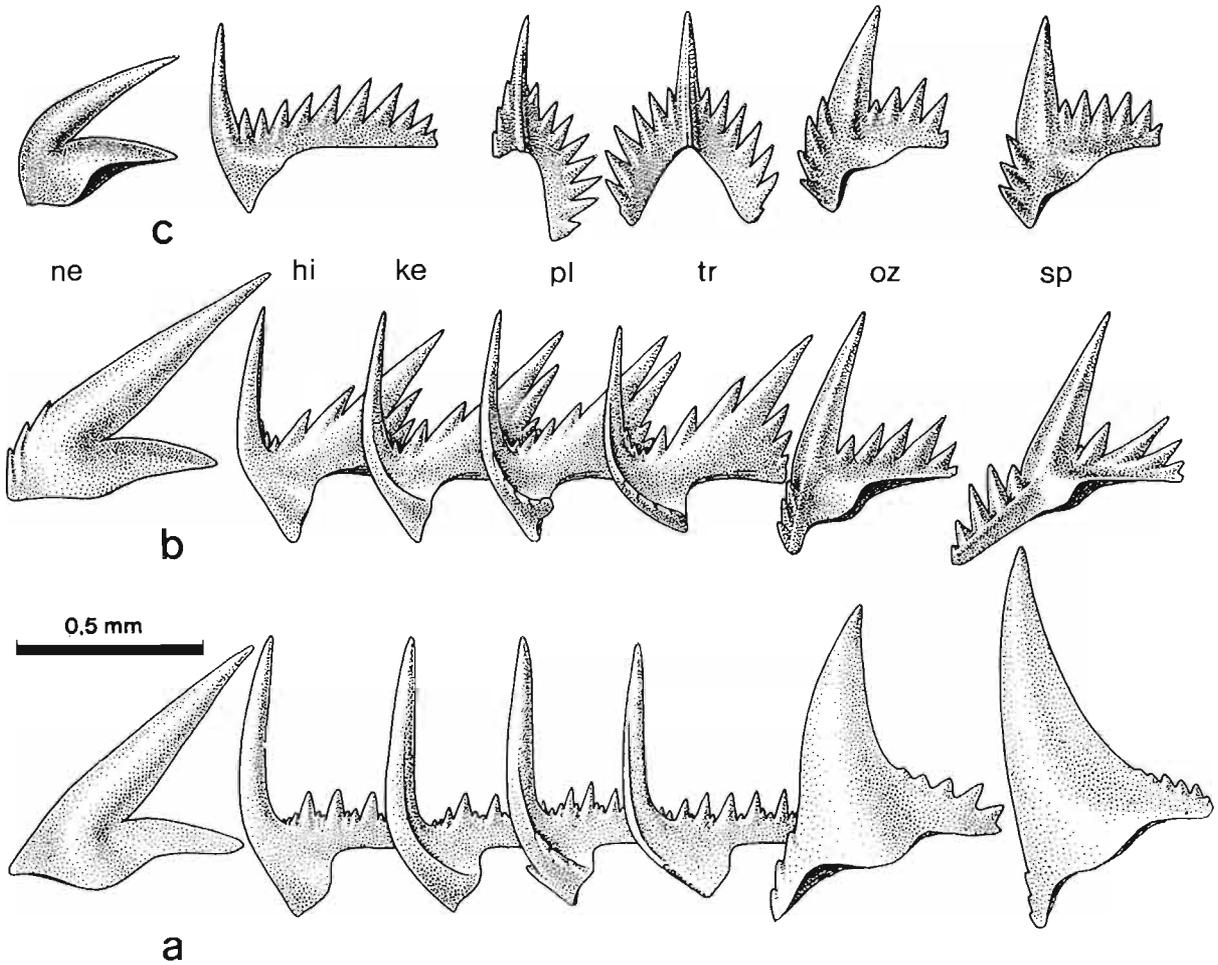


Fig. 31.

Apparatuses of *Hamarodus*, *Periodon*, and *Microzarkodina* and proposed homology of their elements. **a.** *H. brevirameus* (WALLISER, 1964). **b.** *P. aculeatus* HADDING, 1913 late form. **c.** *M. ozarkodella* LINDSTRÖM, 1971.

denticulation of the reduced processes in the symmetry transition series elements. Denticles disappear during element growth, and are being replaced with robust ridges.

There is now a good reason to believe that only a single lineage of the genus was represented in the Late Ordovician of Europe. It thus seems unavoidable to synonymize the names introduced by WALLISER (1964) for the topmost Ordovician representatives of the species from the Cellon Section in the Austrian part of the Carnic Alps with those for specimens from almost coeval strata of the Monte Zermula on the Italian side of the boundary (SERPAGLI 1967). This involves a somewhat unfortunate change of widely used name of the species.

Distribution. — This is a species characteristic of cold-water seas of the Late Ordovician, known from the whole Mediterranean Realm as well as from the Baltic area and South China. In Mójcza it appears by migration 0.2 m below the top of the massive limestone (*A. superbustordovicicus* transition).

Family Plectodinidae SWEET, 1988

Diagnosis. — The **tr** and **pl** elements with a reduced inner process, all the elements sharply denticulated, the **ne** ones having a straight, usually denticulate inner process and long cusp, inclined to it (cyrtodontiform, rarely oistodontiform).

Genera included. — *Microzarkodina* LINDSTRÖM, 1971, *Plectodina* STAUFFER, 1935, *Aphelognathus* BRANSON, MEHL *et* BRANSON, 1951, *Bryantodina* STAUFFER, 1935, *Scyphiodus* STAUFFER, 1935, *Oulodus* BRANSON *et* MEHL, 1935.

Genus *Microzarkodina* LINDSTRÖM, 1971

Type species: *Prioniodina flabellum* LINDSTRÖM, 1955.

Diagnosis. — Minute, flat, sharply denticulated elements with radial orientation of denticles with a low contribution of the white matter. The **ne** element undenticulated, with a proclined cusp shorter or similar in length to the inner process; the **tr-pl** elements with a short undenticulated internal process.

Microzarkodina ozarkodella LINDSTRÖM, 1971

(Pl. 24: 5–9; Text-fig. 31c)

1971. *Microzarkodina ozarkodella* sp. n.; LINDSTRÖM, p. 59, Pl. 1: 15–17.

1963. *Ozarkodina* sp.; SPASSOV and TELLER, p. 79, Pl. 1: 7.

1976. *Microzarkodina ozarkodella* LINDSTRÖM; DZIK, Text-fig. 35i–l.

1978. *Microzarkodina ozarkodella* LINDSTRÖM; LÖFGREN, p. 62, Pl. 11: 37–47, Text-fig. 27C–G.

Type horizon and locality: Boda Hamn drilling core 27.74–27.79 m (Kundan, Arenig/Llanvirn boundary), Sweden.

Diagnosis. — The **sp** and **oz** elements with typically two to four denticles on their external processes, the denticles decrease in size in distal direction from the cusp (modified after LINDSTRÖM 1971).

Remarks. — The apparatus of the species does not differ from other species of the genus (DZIK 1976), and the most diagnostic is the denticulation of elements of the “platform” series.

Distribution. — Stratigraphic and geographic distribution of the species in the Baltic region was presented by LÖFGREN (1978). In the lowermost part of the Mójcza Limestone (1.2–0.9 m below the discontinuity) the ancestor of *M. ozarkodella*, that is *M. hagetiana* STOUGE *et* BAGNOLI, 1991, may be present. This is suggested by more acute external bases in rare **ne** elements. Regrettably only a single juvenile element **sp** was found at this level (sample MA-122) which makes identification not certain. Undoubted *M. ozarkodella* appears 0.7 m below the discontinuity and occurs up to it. Specifically undeterminable specimens of *Microzarkodina* appear again 2 m above the discontinuity (*E. robustus* Subzone). They do not seem to be reworked.

Family ?**Chirognathidae** BRANSON *et* MEHL, 1944

Genus *Spinodus* DZIK, 1976

Type species: *Cordylodus spinatus* HADDING, 1913.

Diagnosis. — All the elements of the apparatus with few, but very long denticles with rounded cross sections, their size and shape being similar to the cusp.

Remarks. — The relationships of *Spinodus* still remain obscure. Its most probable ancestor is *Erraticodon*, which shows a similar shape of the elements and organization of the apparatus. Some forms from the Marathon section of Texas may appear transitional between these genera.

Spinodus spinatus (HADDING, 1913)

(Pl. 24: 22–25; Text-fig. 32)

1964. *Cordylodus spinatus* HADDING; LINDSTRÖM, Fig. 27A–D.

1976. *Spinodus spinatus* (HADDING); DZIK, p. 424, Text-fig. 21c.

1981. *Spinodus ramosus* (HADDING); NOWLAN, p. 15, Pl. 4: 18–19.

1987. *Spinodus spinatus* (HADDING); BERGSTRÖM and ORCHARD, Pl. 2.2: 1, 4.

Type horizon and locality: Lower *Dicellograptus* shale, upper part of the section Fågelsång E15, Skåne, Sweden.

Diagnosis. — As for the genus.

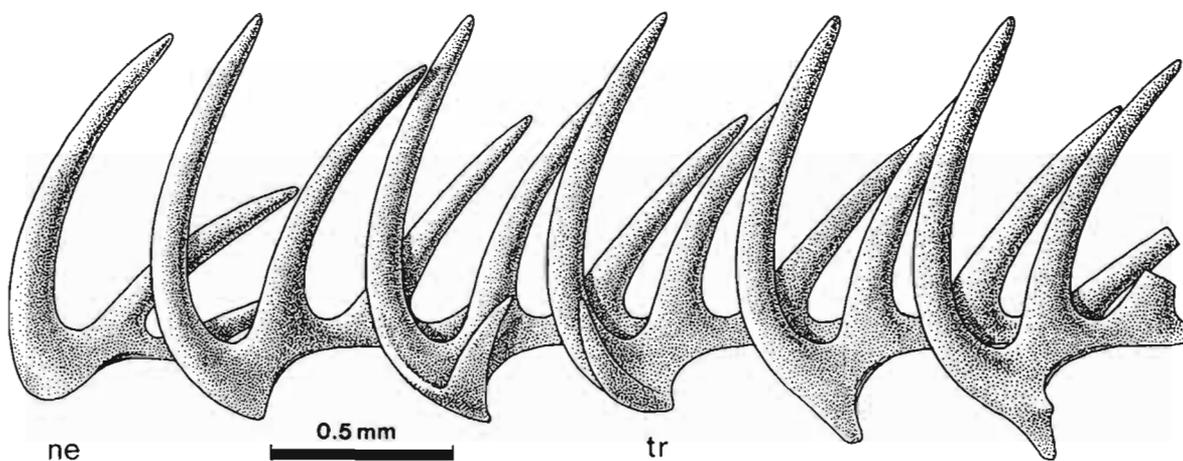


Fig. 32.

Apparatus of *Spinodus spinatus* (HADDING, 1913).

Remarks. — LINDSTRÖM (1964) proposing his apparatus reconstruction made it clear that HADDING's *Cordylodus spinatus* and *C. ramosus* represent the same species. The former name was chosen by LINDSTRÖM (1964) as valid for the apparatus species and myself (DZIK 1976) for the type species of the genus. There is thus no need to replace it with the latter one, as proposed by NOWLAN (1981).

Among broken specimens from Mójcza no **tr** one have been found. In an attempt to reconstruct its apparatus (Text-fig. 32) I used also data from the Baltic Ordovician and from the literature.

Distribution. — Distribution and range similar to *Periodon aculeatus*. Occurs sparsely in Mójcza from the discontinuity up to 1.0 m above the bentonite (*A. tvaerensis*).

Suborder Ozarkodinina DZIK, 1976

Diagnosis. — Erect cusp and arched inner process of the **ne** elements.

Family Spathognathodontidae HASS, 1959

Diagnosis. — The **sp**, **oz**, and **pl** elements blade-like, the **tr** element biramous.

Remarks. — All the post-Ordovician Ozarkodinina are characterized by the uniform morphology of the **ne** elements, basically different from that in their Ordovician relatives. I consider any independent acquisition of this character by the spathognathodontid and hibbardellid lineages highly unlikely; this is why *Oulodus* is here included in the Plectodinidae.

Genus *Yaoxianognathus* AN, 1985

Type species: *Y. yaoxianensis* AN, 1985.

Diagnosis. — The **ne** elements with internal process strongly denticulated, denticles orientation parallel to that of the cusp.

Yaoxianognathus? sp. (Pl. 24: 21, ?20)

Remarks. — A single **hi** element of an ozarkodinid morphology was found in the topmost strata of the Mójcza section. Another enigmatic specimen from the same part of the section (DZIK 1978: Pl. 15: 4; here Pl. 24: 20) may possibly belong here, although it may quite well be an **ne** element of *A. ordovicicus* preserved more completely than usual.

Distribution. — The Zalesie Formation at Mójcza, Ashgill.

REFERENCES

- ALDRIDGE, R.J. 1982. A fused cluster of coniform conodont elements from the Late Ordovician of Washington Land, western North Greenland. — *Palaeontology* **25**, 425–430.
- ALDRIDGE, R.J., SMITH, M.P., NORBY, R.D., and BRIGGS, D.E.G. 1987. The architecture and function of Carboniferous polygnathacean conodont apparatuses. — In: R.J. Aldridge (ed.) *Palaeobiology of Conodonts*, 63–75. Ellis Horwood Ltd, Chichester.
- AN, T-x. 1981. Recent progress in Cambrian and Ordovician conodont biostratigraphy of China. — *Geological Society of America Special Paper* **187**, 209–225.
- AN, T-x. 1987. *The Lower Paleozoic conodonts of South China*. 238 pp.
- AN, T-x., DU, G., GAO, Q., CHEN, Q., and LI, W. 1979. Conodont biostratigraphy of the Ordovician system of Yichang, Hubei. — *1st Convention of the Micropaleontological Society of China, Selected Papers*, 105–113.
- ANDRES, D. 1988. Strukturen, Apparate und Phylogenie primitiver Conodonten. — *Palaeontographica* **200A**, 105–152.
- BAGNOLI, G., STOUGE, S., and TONGIORGI, M. 1988. Acritarchs and conodonts from the Cambro-Ordovician Furuhall (Kopingsklint) section (Öland, Sweden). — *Rivista Italiana di Paleontologia e Stratigrafia* **94**, 2, 163–248.
- BAUER, J.A. 1987. Conodonts and conodont biostratigraphy of the McLish and Tulip Creek Formations (Middle Ordovician), south-central Oklahoma. — *Oklahoma Geological Survey Bulletin* **141**, 1–53.
- BAUER, J.A. 1989. Conodont biostratigraphy and paleoecology of Middle Ordovician rocks in eastern Oklahoma. — *Journal of Paleontology* **63**, 1, 92–107.
- BEDNARCZYK, W. 1966. Stratygrafia wapieni z Mójczy pod Kielcami (Góry Świętokrzyskie). — *Acta Geologica Polonica* **16**, 1, 107–126.
- BEDNARCZYK, W. 1971. Stratigraphy and palaeogeography of the Ordovician in the Holy Cross Mts. — *Acta Geologica Polonica* **21**, 4, 573–616.
- BERGSTRÖM, S.M. 1962. Conodonts from the Ludibundus Limestone (Middle Ordovician) of the Tvären area (S.E. Sweden). — *Arkiv för Mineralogi och Geologi* **3**, 1, 1–61.
- BERGSTRÖM, S.M. 1964. Remarks on some Ordovician conodont faunas from Wales. — *Acta Universitatis Lundensis Sectio II* **1964**, 1–67.
- BERGSTRÖM, S.M. 1971. Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America. — *Geological Society of America Memoir* **127**, 83–157.
- BERGSTRÖM, S.M. 1978. Middle and Upper Ordovician conodont and graptolite biostratigraphy of the Marathon, Texas graptolite zone reference standard. — *Palaeontology* **21**, 4, 723–758.
- BERGSTRÖM, S.M. 1983. Biogeography, evolutionary relationships, and biostratigraphic significance of Ordovician platform conodonts. — *Fossils and Strata* **15**, 35–58.
- BERGSTRÖM, S.M. and CARNES, J.B. 1976. Conodont biostratigraphy and paleoecology of the Holston Formation (Middle Ordovician) and associated strata in eastern Tennessee. — *Geological Association of Canada Special Paper* **15**, 27–57.
- BERGSTRÖM, S.M. and MASSA, D. 1992. Stratigraphic and Biogeographic significance of Upper Ordovician conodonts from northwestern Libya. — In: M.J. Salem, O.S. Hammuda, and B.A. Eliagoubi (eds) *The Geology of Libya, Vol. 4*. 1323–1342. Elsevier, Amsterdam.
- BERGSTRÖM, S.M. and ORCHARD, M.J. 1985. Conodonts of the Cambrian and Ordovician Systems from the British Isles. — In: A.C. Higgins and R.L. Austin (eds) *A Stratigraphical Index of Conodonts*, 32–67. Ellis Horwood Ltd., Chichester.
- BERGSTRÖM, S.M., RHODES, F.H.T., and LINDSTRÖM, M. 1987. Conodont biostratigraphy of the Llanvirn-Llandeilo and Llandeilo-Caradoc Series boundaries in the Ordovician System of Wales and the Welsh Borderland. — In: R.L. Austin (ed.) *Conodonts: Investigative Techniques and Applications*, 294–315. Ellis Horwood Ltd., Chichester.
- BERGSTRÖM, S.M. and SWEET, W.C. 1966. Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its lateral equivalents in Ohio and Indiana. — *Bulletins of American Paleontology* **50**, 229, 271–441.
- BRANSON, E.B. and MEHL, M.G. 1933. Conodonts from the Plattin (Middle Ordovician) of Missouri. Conodonts from the Maquoketa-Thebes (Upper Ordovician) of Missouri. — *University of Missouri Studies* **8**, 2, 101–131.
- BRIGGS, D.E.G., CLARKSON, E.N.K., and ALDRIDGE, R.J. 1983. The conodont animal. — *Lethaia* **16**, 1–14.
- BURRETT, C., STAIT, B., and LAURIE, J. 1983. Trilobites and microfossils from the Middle Ordovician of Surprise Bay, southern Tasmania, Australia. — *Memoirs of the Association of Australasian Palaeontologists* **1**, 177–193.
- CHEN, M.-j., CHEN, Y-t., and ZHANG, J.-h. 1983. Ordovician conodont sequence in Nanjing Hills. — *Journal of Nanjing University* **1**, 129–139 (in Chinese).
- CHEN, M.-j. and ZHANG, J.-h. 1984. Middle Ordovician conodonts from Tangshan, Nanjing. — *Acta Micropalaeontologica Sinica* **1**, 2, 120–137.
- COOPER, B.J. 1976. Multielement conodonts from the St.-Clair Limestone (Silurian) of southern Ohio. — *Journal of Paleontology* **50**, 205–217.

- DRYGANT, D.M. (Дригант, Д.М.) 1974. Новые среднеордовикские конодонты северо-западной Волыни (New Middle Ordovician Conodonts from the North-Western Volhynia). — *Палеонтологический сборник* **11**, 1, 54–58.
- DZIK, J. 1976. Remarks on the evolution of Ordovician conodonts. — *Acta Palaeontologica Polonica* **21**, 4, 395–455.
- DZIK, J. 1978. Conodont biostratigraphy and paleogeographical relations of the Ordovician Mójcza Limestone (Holy Cross Mts, Poland). — *Acta Palaeontologica Polonica* **23**, 1, 51–72.
- DZIK, J. 1983. Relationships between Ordovician Baltic and North American Midcontinent conodont faunas. — *Fossils and Strata* **15**, 59–86.
- DZIK, J. 1984. Early Ordovician conodonts from the Barrandian and Bohemian-Baltic faunal relationships. — *Acta Palaeontologica Polonica* **28**, 3–4, 327–368.
- DZIK, J. 1986. Chordate affinities of the conodonts. — In: A. Hoffman and M.H. Nitecki (eds) *Problematic Fossil Taxa*, 240–254. Oxford University Press, New York.
- DZIK, J. 1990. Conodont evolution in high latitudes of the Ordovician. — *Courier der Forschungsinstitut Senckenberg* **117**, 1–28.
- DZIK, J. 1991. Evolution of oral apparatuses in the conodont chordates. — *Acta Palaeontologica Polonica* **36**, 3, 265–323.
- DZIK, J. (in press) Range-based biostratigraphy and evolutionary chronology. — In: Pallini, G. (ed.) *Fossili, Evoluzione, Ambiente*.
- DZIK, J. and DRYGANT, D. 1986. The apparatus of panderodontid conodonts. — *Lethaia* **19**, 133–141.
- DZIK, J. and PISERA, A. 1994. Sedimentation and fossils of the Mójcza Limestone. — In: J. Dzik, E. Olempska, and A. Pisera. Ordovician carbonate platform ecosystem of the Holy Cross Mountains. *Palaeontologia Polonica* **53**, 5–41.
- DZIK, J. and TRAMMER, J. 1980. Gradual evolution of conodontophorids in the Polish Triassic. — *Acta Palaeontologica Polonica* **25**, 1, 55–89.
- ETHINGTON, R.L. and CLARK, D.L. 1981. Lower and Middle Ordovician conodonts from the Ibx area, Western Millard County, Utah. — *Brigham Young University Geology Studies* **28**, 2, 1–160.
- FÄHRÆUS, L.E. 1966. Lower Viruan (Middle Ordovician) conodonts from the Güllhögen quarry, Southern Central Sweden. — *Sveriges Geologiska Undersökning Avhandlingar* **60**, 5, 1–40.
- FÄHRÆUS, L.E. 1982. Allopatric speciation and lineage zonation exemplified by the *Pygodus serrus* – *P. anserinus* transition (Conodontophorida, Ordovician). — *Newsletter on Stratigraphy* **11**, 1–7.
- FÄHRÆUS, L.E. and HUNTER, D.R. 1985. Simple-cone conodont taxa from the Cobbs Arm Limestone (Middle Ordovician), New World Island, Newfoundland. — *Canadian Journal of Earth Sciences* **22**, 8, 1171–1182.
- FORTEY, R.A., LANDING, E., and SKEVINGTON, D. 1982. Cambrian-Ordovician boundary sections in the Cow Head Group, western Newfoundland. — In: M.G. Bassett and W.T. Dean (eds) *The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations*, 95–129. National Museum of Wales, Cardiff.
- HAMAR, G. 1964. The Middle Ordovician of the Oslo Region, Norway. 17. Conodonts from the lower Middle Ordovician of Ringerike. — *Norsk Geologisk Tidsskrift* **44**, 2, 243–292.
- HAMAR, G. 1966. The Middle Ordovician of the Oslo Region, Norway. 22. Preliminary report on conodonts from the Oslo -Asker and Ringerike districts. — *Norsk Geologisk Tidsskrift* **46**, 1, 27–83.
- HARRIS, A.G., BERGSTRÖM, S.M., ETHINGTON, R.L., and ROSS, R.J.jr. 1979. Aspects of Middle and Upper Ordovician conodont biostratigraphy of carbonate facies in Nevada and southeast California and comparison with some Appalachian successions. — *Brigham Young University Geology Studies* **26**, 3, 7–33.
- HUNICKEN, M. and ORTEGA, G.C. 1987. Lower Llanvirn-Lower Caradoc (Ordovician) conodonts and graptolites from the Argentine central Precordillera. — In: R.L. Austin (ed.) *Conodonts: Investigative Techniques and Applications*. 136–145. Ellis Horwood Ltd., Chichester.
- KENNEDY, D.J., BARNES, C.R., and UYENO, T.T. 1979. A Middle Ordovician conodont faunule from the Tetagouche Group, Camel Back Mountain, New Brunswick. — *Canadian Journal of Earth Sciences* **16**, 3, 540–551.
- KNÜPFER, J. 1967. Zur Fauna und Biostratigraphie des Ordoviziums (Gräfenhaler Schichten) in Thüringen. — *Freiberger Forschungshefte* **C220**, 1–119.
- LAMONT, A. and LINDSTRÖM, M. 1957. Arenigian and Llandeilian cherts identified in the Southern Uplands of Scotland by means of conodonts, etc. — *Transactions of the Edinburgh Geological Society* **17**, 1, 60–70 (not seen).
- LINDSTRÖM, M. 1955a. Conodonts from the lowermost Ordovician strata of south-central Sweden. — *Geologiska Föreningens i Stockholm Förhandlingar* **76**, 4, 517–604.
- LINDSTRÖM, M. 1955b. The conodonts described by A.R. Hadding, 1913. — *Journal of Paleontology* **29**, 1, 105–111.
- LINDSTRÖM, M. 1964. *Conodonts*. 196 pp. Elsevier, Amsterdam.
- LINDSTRÖM, M. 1971. Lower Ordovician conodonts of Europe. — *Geological Society of America Memoir* **127**, 21–61.
- LINDSTRÖM, M., RACHEBOEUF, P.R., and HENRY, J.-L. 1974. Ordovician conodonts from the Postolonnec Formation (Crozon peninsula, Massif Armorica) and their stratigraphic significance. — *Geologica et Palaeontologica* **8**, 15–28.
- LÖFGREN, A. 1978. Arenigian and Llanvirnian conodonts from Jämtland, northern Sweden. — *Fossils and Strata* **13**, 1–129.

- LÖFGREN, A. 1985. Early Ordovician conodont biozonation at Finngrundet, south Bothnian Bay, Sweden. — *Bulletin of the Geological Institute of the University of Uppsala N.S.* **10**, 115–128.
- LÖFGREN, A. 1990. Non-platform elements of the Ordovician conodont genus *Polorodus*. — *Paläontologische Zeitschrift* **64**, 3/4, 245–259.
- MCCRACKEN, A.D. 1989. *Protopanderodus* (Conodontata) from the Ordovician Foad River Group, Northern Yukon Territory, and the evolution of the genus. — *Geological Survey of Canada Bulletin* **388**, 1–39.
- MCCRACKEN, A.D. 1991. Middle Ordovician conodonts from the Cordilleran Roac River Group, northern Yukon Territory, Canada. — *Geological Survey of Canada Bulletin* **417**, 41–63.
- MCCRACKEN, A.D. and BARNES, C.R. 1981. Conodont biostratigraphy and paleoecology of the Ellis Bay Formation, Anticosti Island, Quebec, with special reference to Late Ordovician–Early Silurian chronostratigraphy and systemic boundary. — *Geological Survey of Canada Bulletin* **329**, 51–134.
- MCCRACKEN, A.D. and BARNES, C.R. 1982. Restudy of conodonts (Late Ordovician – Early Silurian) from the Edgewood Group, Clarksville, Missouri. — *Canadian Journal of Earth Sciences* **19**, 7, 1474–1485.
- MCHARGUE, T.R. 1982. Ontogeny, phylogeny, and apparatus reconstruction of the conodont genus *Histiodelia*, Joins Fm., Arbuckle Mountains, Oklahoma. — *Journal of Paleontology* **56**, 1410–1433.
- MERRILL, G.K. 1980: Ordovician conodonts from the Åland Islands, Finland. — *Geologiska Föreningens i Stockholm Forhandlingar* **101**, 4, 329–341.
- MOSKALENKO, T.A. (Москаленко, Т.А.) 1973. Конодонты среднего и верхнего ордовика Сибирской Платформы (Conodonts from the Middle and Upper Ordovician of the Siberian Platform). — *Труды Института Геологии и Геофизики СОАН СССР* **137**, 1–143.
- MOSKALENKO, T.A. 1983. Conodonts and biostratigraphy in the Ordovician of the Siberian Platform. — *Fossils and Strata* **15**, 87–94.
- MÜLLER, K.J. 1959. Kambrische Conodonten. — *Zeitschrift der Deutsche Geologische Gesellschaft* **111**, 434–485.
- NI, S. 1979. Discussion of some problems of Ordovician stratigraphy by means of conodonts in eastern part of Yangtze Gorges region. — *1st Convention of the Micropaleontological Society of China, Selected papers*, 127–134.
- NOWLAN, G.S. 1981. Some Ordovician conodont faunules from the Miramichi Anticlinorium, New Brunswick. — *Geological Survey of Canada Bulletin* **345**, 1–335.
- NOWLAN, G.S. 1983. Biostratigraphic, paleogeographic, and tectonic implications of Late Ordovician conodonts from the Grog Brook Group, northwestern New Brunswick. — *Canadian Journal of Earth Sciences* **20**, 4, 651–671.
- NOWLAN, G.S., MCCRACKEN, A.D., and CHATTERTON, B.D.E. 1988: Conodonts from Ordovician–Silurian boundary strata, Whittaker Formation, Mackenzie Mountains, Northwest Territories. — *Geological Survey of Canada Bulletin* **373**, 1–99.
- ORCHARD, M.J. 1980. Upper Ordovician conodonts from England and Wales. — *Geologica et Paleontologica* **14**, 9–44.
- RASMUSSEN, J.A. 1991. Conodont stratigraphy of the Lower Ordovician Huk Formation of Slemmestad, southern Norway. — *Norsk Geologisk Tidsskrift* **71**, 265–288.
- RHODES, F.H.T. 1953. Some British Lower Palaeozoic conodont faunas. — *Philosophical Transaction of the Royal Society London* **237B**, 261–334.
- RHODES, F.H.T. 1955. The conodont fauna of the Keysley Limestone. — *Quarterly Journal of the Geological Society London* **111**, 117–142.
- SAVAGE, N.M. and BASSETT, M.G. 1985. Caradoc-Ashgill conodont faunas from Wales and the Welsh Borderland. — *Palaeontology* **28**, 4, 679–713.
- SERGEEVA, S.P. (Сергеева, С.П.) 1963. Конодонты из нижнего ордовика Ленинградской области (Conodont from the Lower Ordovician of the Leningrad region). — *Палеонтологический журнал* **1963**, 2, 93–108.
- SERPAGLI, E. 1967. I conodonti dell'Ordoviciano superiore (Ashgiliano) delle Alpi Carniche. — *Bolletino della Societa Paleontologica Italiana* **6**, 1, 30–111.
- SERPAGLI, E. 1974. Lower Ordovician conodonts from precordilleran Argentina (Province of San Juan). — *Bolletino della Societa Paleontologica Italiana* **13**, 1–2, 17–98.
- SERPAGLI, E. and GRECO, A. 1964. Osservazioni preliminari sur alcuni conodonti ordoviciani e siluriani della Alpi Carniche italiane. — *Bolletino della Societa Paleontologica Italiana* **3**, 2, 192–211.
- SPASSOV, C. and TELLER, L. (Спасов, Х. и Теллер, Л.) 1963. Конодонты от ордовикските варовици при с. Муйча в Górach Świątokrzyskich, Польша. — *Трудове вькхы геологские на България* **5**, 75–83.
- STAUFFER, C.R. 1935. Conodonts of the Glenwood beds. — *Geological Society of America Bulletin* **46**, 125–168.
- STOUGE, S. 1984. Conodonts of the Middle Ordovician Table Head Formation, western Newfoundland. — *Fossils and Strata* **16**, 1–145.
- STOUGE, S. and BAGNOLI, G. 1988. Early Ordovician conodonts from Cow Head Peninsula, western Newfoundland. — *Palaeontographia Italica* **75**, 89–179.
- STOUGE, S. and BAGNOLI, G. 1991. Lower Ordovician (Volkhovian–Kundan) conodonts from Hägudden, northern Öland, Sweden. — *Palaeontographia Italica* **77** (1990), 1–54.
- SWEET, W.C. 1982. Micromorphology of elements and apparatuses. — *In*: R.A. Robison (ed.) *Treatise on Invertebrate Paleontology, Part W, Suppl. 2 Conodonta*, 5–16. Geological Society of America, Boulder.

- SWEET, W.C. 1988. *The Conodonta: Morphology, Taxonomy, Paleocology and Evolutionary History of a Long-Extinct Animal Phylum*. 212 pp. Oxford University Press, New York.
- SWEET, W.C. and BERGSTRÖM, S.M. 1962. Conodonts from the Pratt Ferry Formation (Middle Ordovician) of Alabama. — *Journal of Paleontology* **36**, 6, 1214–1252.
- SWEET, W.C. and BERGSTRÖM, S.M. 1984. Conodont provinces and biofacies of the Late Ordovician. — *Geological Society of America Special Paper* **196**, 69–87.
- TIPNIS, R.S., CHATTERTON, B.D.E., and LUDVIGSEN, R. 1978. Ordovician conodont biostratigraphy of the southern District of Mackenzie, Canada. — *Geological Association of Canada Special Paper* **18**, 39–91.
- VAN WAMEL, W.A. 1974. Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of north-western Öland, south-eastern Sweden. — *Utrecht Micropalaeontological Bulletin* **10**, 1–125.
- VIIRA, V. (Ви́ира, В.) 1974. *Конодонты ордовика Прибалтики* (Conodonts from the Ordovician of the East Baltic). 140 pp. Valgus, Tallinn.
- WALLISER, O.H. 1964. Conodonten des Silurs. — *Abhandlungen der Hessischen Landesamtes Bodenforschung* **41**, 1–106.
- WANG, Z-z. and LUO, K-q. 1984. Late Cambrian and Ordovician conodonts from the marginal areas of the Ordos Platform, China. — *Bulletin of the Nanjing Institute of Geology and Paleontology, Academia Sinica* **8**, 237–304.
- WATSON, S.T. 1988. Ordovician conodonts from the Canning Basin (W. Australia). — *Palaeontographica* **203A**, 91–147.

TABLES

Frequencies of conodont elements in samples from outcrops of the Ordovician in Mójcza (MA), Międzygórz (MG) and Zalesie near Łągów (ZA) and from the borehole Zalesie 1.

	A. tvaerensis Zone					A. ordovicicus Zone							
	Zalesie 1: 217.5m 215.5m	215.1m	MG-1	2	3	4	5	6	8	9	10	11	ZA-2
<i>Pseudooneotodus</i>			1						2	1		1	2
<i>S. peselephantis</i>	10	9	1	2									
<i>Cornuodus</i>	3	8	3						5				
<i>Dapsilodus mutatus</i>	3	5	11						25	20	26	84	29
<i>Scabbardella aitipes</i>		3	3	2	4	2		1	115	46	40	163	374
<i>Strachanognathus parvus</i>		3											
<i>Walliserodus nakholmensis</i>				2	1	1			27	2	1	7	8
<i>Panderodus</i> sp.			10		1	1		5	4	13	4	14	6
<i>Semiacontiodus longicostatus</i>			1	8				1					
<i>D. robustus</i>	3	2	10								?		?
<i>P. graei</i>	2		2	3									
<i>Protopanderodus liripipus</i>									2	13		1	6
<i>Paltodus? venustus</i>									2				1
<i>Drepanoistodus suberectus</i>				3				1					1
<i>Baltoniodus</i>	?	1	4	7			1						
<i>Amorphognathus</i>	8	36	2	3	158		7	2	35	43	4	33	76
<i>Rhodesognathus</i>						1	1						
<i>Complexodus pugionifer</i>	?	?						6					
<i>Hamarodus brevirameus</i>									27		1		13

		<i>Lenodus variabilis</i> Zone																			
		MA -117	33	34	118	35	120	122	36	37	123	38	124	125	126	127	128	129	130	131	14	41
<i>Westergaardodina bicuspidata</i>		1																			
<i>Scolopodus peselephantis</i>		2																			
<i>Polonodus</i>		1																			
<i>Cornuodus longibasis</i>	ne	2 1 1																			
	hi	1 1																			
	ke-sp	4 1 2 12 2 2 5																			
<i>Dapsilodus viruensis</i>	ne	2 3 35 41 16 13 27 5 16																			
	hi-sp	5 5 3 32 148 56 19 35 8 28																			
<i>Walliserodus costatus</i>	ne	1 1 2 3 4 1 12 4 30																			
	hi	1 1 1 3 2																			
	ke-sp	1 3																			
<i>Semiacontiodus cornuiformis</i>	hi	1																			
	tr	20 574 71 74 19 18 9 27 20 8																			
<i>Drepanodus kielcensis</i>	ne	1 1 1																			
	pl-tr	1 1 1 4 7 4																			
	sp-oz ke-hi	1 2 1 3 1 6																			
<i>Drepanodus arcuatus</i>	ne	1 2 3 1 1 2 1 1 6 1																			
	pl-tr	2 1 1 5 1 7 4 1 7 2 10																			
	sp-oz ke-hi	6 5 4 14 5 10 13 20 14 6 7																			
<i>Protopanderodus rectus</i>	sne	1 1 1 3 1 1 2 5																			
	hi-tr	2 1 2 5 1 4 2 4 6 10 9																			
	sp-oz	2 2																			
<i>Protopanderodus graei</i>	ne	1 9 11 7 2 5 7																			
	hi-tr	6 27 92 63 13 10 24 12																			
	sp-oz	4 6 1 10 1 2 ?																			
<i>Protopanderodus gradatus</i>	ne	6 7 1 74																			
	hi-tr	4 19 552																			
	sp-oz	2 ? 30																			
<i>Drepanoistodus basiovalis</i>	ne	12 3 3 5 3 2 4 6 9 10 11																			
	hi-sp	11 3 3 11 9 9 16 23 41 21 26																			
	tr	13 41 10 22 15 10 5 18 3 9																			
<i>Paltodus ? venustus</i>		4 2																			
<i>Tripodus?</i>		3																			
<i>Phragmodus ? crassulus</i> <i>Phragmodus polonicus</i>	ne	3 5 3 2 3 3 5 4 5 ?																			
	hi	1 1 1																			
	ke	4 2 2 1 1 1																			
	pl	8 1 1 6 1 6 1																			
	tr	1 2 3 3 2																			
	oz-sp	11 8 4 15 1 2 2 7 1																			

		<i>Lenodus variabilis</i> Zone																					
		MA -117	33	34	118	35	120	122	36	37	123	38	124	125	126	127	128	129	130	131	14	41	
<i>Baltoniodus parvidentatus</i>	ne	17	5	16	21	13	23	27	46	83	12	46	55	561	195	395	434	167	132	372	58	194	
	hi	24	8	21	23	9	18	16	38	38	6	15	36	168	72	48	172	94	53	163	72	102	
	ke	16	4	7	7	6	8	4	9	26	1	13	13	37	17	25	29	13	14	30	12	50	
	pl	28	5	26	23	14	38	30	35	59	16	26	60	250	89	234	316	150	110	254	46	97	
	tr	5	3	1	6	2	7	10	15	24	7	12	22	64	40	72	73	45	35	101	3	45	
	oz	36	9	12	27	7	48	26	40	107	8	66	50	189	162	339	365	147	77	206	111	363	
	sp	10	8	8	15	6	16	4	15	32	4	35	22	33	20	76	116	85	39	142	22	209	
	<i>Lenodus variabilis</i> <i>Eoplacognathus zgierzensis</i>	ne					1			1	1	?	5	6	14	1	2	3		1	9	1	1
hi							2	3		1		2	2	15	3	1	2	2	2	4	1	3	
ke							1			1		1	3	8	3	12	5	2	4	10	?	2	
pl		5			2		3	1		1	1		1	6	4	5	3	3		2	?		
tr		1	1								1			4	?	1	3	1	1	1	?		
oz		30	12	25	22	7	44	11	26	62	19	56	100	111	26	37	55	10	17	47	14	64	
sp		6	8	4	5		7	2	7	2	8	5	51	62	15	22	31	13	4	31	3	6	
<i>Sagittodontina kielcensis</i>	ne																	2	2				
	hi																	4		1	1		
	ke												1					1	3		1		
	pl																	1					
	tr																		1		1		
	oz																	3	3	6	37	6	24
	sp																		2	4	4	17	18
<i>Histiodela kristinae</i>																		1	1		1	14	2
<i>Microzarkodina ozarkodella</i>	ne					1		2					8	155	20	41	11	6	7	38	3		
	hi							1						4	1						1		
	pl												1										
	tr																		2		1		
	sp-oz							1						3	27	10	18	5	1	4	26	4	1

	<i>Eoplacognathus robustus</i> Subzone											<i>Eoplacognathus lindstroemi</i> Subzone												
	MA	42	15	43	44	45	16	46	47	48	10	49	50	17	27	51	52	54	55	56	8	57		
<i>Phragmodus polonicus</i>	ne							4		?		5	4	1			2							
	hi												2				2						1	
	ke																							
	pl																	3	1					
	tr																	3						
	sp-oz								1	2			6	4				8		2	1			2
<i>Baltoniodus prevariabilis ke-ni</i>	ne	28	23	5	21	84	8	463	37	19	47	58	20	14	16	4	151	63	25	8	13	61		
	hi	39	31	21	18	96	4	659	23	8	62	32	14	16	29	3	122	55	29	7	5	30		
	pl	55	23	16	29	75		633	41	6	83	33	11	6	14	7	133	56	37	6	14	33		
	tr	14	9	5	3	36	3	206	10	4	32	13	3	2	7	1	47	29	27	3	4	15		
	oz	21	20	17	16	133	8	742	25	16	190	43	21	20	48	7	168	59	55	17	21	26		
	sp	10	7	9	1	96		522	23	10	72	34	14	13	21	4	130	34	41	20	8	20		
<i>Sagittodontina kielcensis</i>	ne	3		2	1	3	2	11				3	?	1			2	8	22	24	2	5	7	
	hi		5	1	4	3	1	8				4	1	2	1		1	11	16	16	1	6	2	
	ke		1		3	5		16						1			2	12	15	12	1	?	1	
	pl							4				1		2	3	1	4	8	5	1	5	4		
	tr					11		7				?	1	4			2		6	2	6	1		
	oz	3	2		3	2		22	2		9	3	2	2	3	11	13	31	46	10	18	15		
sp	5	2	1	5	4		43				8	1	1	1	2	21	26	41	66	29	14	23		
<i>Cahabagnathus protoramosus</i>	oz				3							3												
	sp				?							?												
<i>Eoplacognathus robustus lindstroemi</i>	oz	1	1	4	1	30		8	39	6	5	3	2	22	2		50	8	6	2	4	3		
	sp	2	1	1	2	21		7	69	15	4	4	7	31	3		71	2	5	8	6	6		
<i>Pygodus serra</i>	hi-tr							1																
	oz							2				1		2	1						1			
	sp							2	1			3				4								
<i>Spinodus spinatus</i>		1	2		3	2		7	?		1		1	1	1		1	1					1	
<i>Microzarkodina</i>	ne											2												
	pl											1												
<i>Periodon aculeatus</i>									1								1					1		
<i>Complexodus</i>	sp																						2	
																							<i>originalis</i>	

	<i>Pygodus anserinus</i> Zone															<i>A. tvaerensis</i> Zone								
	MA -	58	59	60	26	18	62	63	64	65	66	7	67	68	19	69	70	71	72	73	74	75		
<i>Phragmodus polonicus</i>	ne						1	2				2		30	2	2	4	9						
	hi							2						12	1	4	6							
	ke													3										
	pl							1	3	2	?				10	7	1	5	1					
	tr											2			2	3		2						
	sp-oz							3	2		2		1		4	9	3	12	1					
<i>Baltoniodus prevariabilis variabilis</i>	ne	56	58	2	6	12	31	11	7	10	32	17	12	50	79	16	53	39	8	2	19	20		
	ke-hi	53	54	3	6	13	20	11	2	4	5	5	9	35	72	13	54	40	8	4	11	12		
	pl	36	41		5	16	16	8	2	8	14	8	7	42	42	20	56	49	2	5	13	17		
	tr	19	19		5	7	9	1	2		4	3	3	12	16	11	24	25	1	2	15	10		
	oz	54	58	3	7	21	44	9	5	16	14	16	15	42	86	23	63	37	4	6	10	16		
	sp	32	28		6	7	18	9	1	4	9	6	8	24	48	14	20	34	7	3	3	8		
<i>Sagittodontina kielcensis</i>	ne	6	13	3	4	20	16	5	5	6		7												
	hi	3	17	3	6	11	22	4	3	3	1	1												
	ke	12	21	3		21	22	9	3	4	3	2	1											
	pl	6	12	1	6	5	4	6	5	1		2												
	tr				8	22	23					2												
	oz	11	40	7	10	38	25	10	7	6	2	6	1	1								2		
sp	45	58	5	5	45	62	21	12	23	2	29										2			
<i>Amorphognathus tvaerensis</i>	ne	3			1				1			1		4	10	1	35	15	4	3	24	13		
	hi		1											8	2		13	8	2	6	11	9		
	ke	2					1							1	8	1	13	6	2	1	7	6		
	pl														?	2	6	3		4	6	10		
	tr						1								7						3	?		
	oz	6	5	1	1	3	10	2	2	7	7	2	1	12	34	8	52	36	9	11	61	30		
sp	7	9	2	1	3	6	1	2	3	5	2		5	25	7	55	39	7	17	50	42			
<i>Eoplacognathus elongatus</i>	oz	4	1	1					?													1		
	sp	5	4				?																	
<i>Pygodus anserinus</i>	hi	1														2								
	oz		1								2	1	3		1	1	1							
	sp		1	1		1	1						1		1	1	3	2						
<i>Spinodus spinatus</i>																2	1	2	2	2	2	1		
<i>Periodon aculeatus</i>																1	2	1						
<i>Complexodus originalis</i>	ne				?									4							3	1		
	hi													1	2		2	6	1			1		
	ke																9	7	1					
	pl						1	?				1		6	1		2				1			
	tr										1						1							
	oz	2	1	3			2	?				2	2	2	18	3	19	7	3		3	11		
sp	54	9	3	1	2	21	7	6	5	8	23	38	103	126	28	88	85	23	14	34	19			

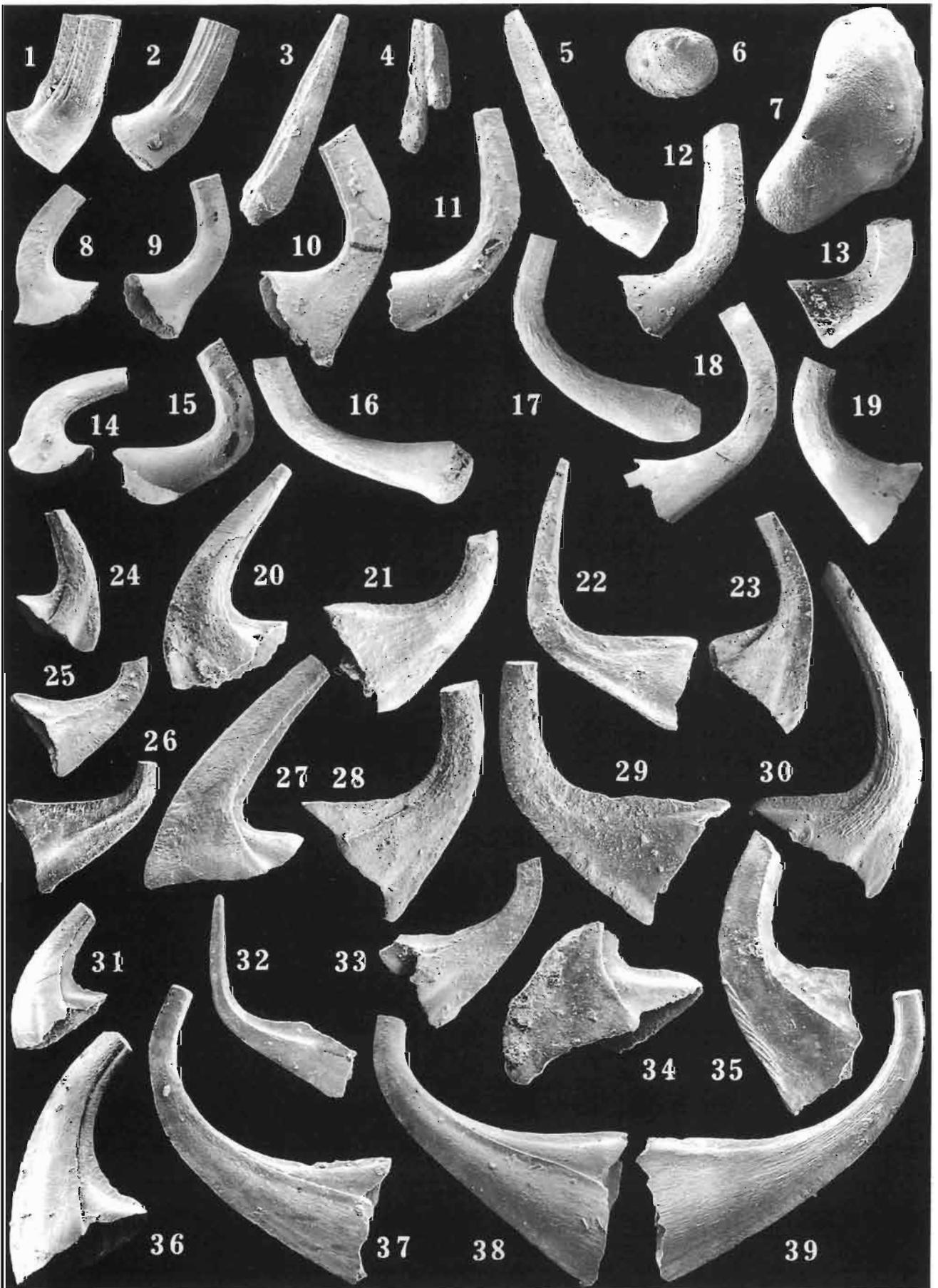
	Amorphognathus superbus Zone												Amorphognathus ordovicicus Zone													
	MA	93	24	94	95	25	96	22	97	98	99	4	100	101	102	23	104	105	106	2d	108	2				
<i>Scolopodus peselephantis</i>													2 ?													
<i>Pseudooneotodus</i>													3 2 3 6 ? 2													
<i>Cornuodus longibasis</i>	ne	7	1	3	2																					
	hi	43	1	17	4											1										
	ke-sp	2											1	1	1	1	3	?	?							
<i>Dapsilodus mutatus</i>	ne	6				1																				
	hi-sp	8	1				1	36	29	21			2	8	1				3							
<i>Scabbarbella</i>	465 16 302 504 188 5 14 5 56 39 15												150 133 342 156 171 510 434 168 520 294													
<i>Walliserodus nakholmensis</i>	ne	14	1	14	4			2	6	9	2	4	1	3	3	1				4						
	hi	7			12	2			5	3	2	5	1			1	5	1	2	2	2	3	2			
	ke-sp	25	3	24	4			3	9	6	15	7	3	5	9	7	1	6	2				2	3		
<i>Panderodus sp.</i>	21 1 7 6 2 5 3 6 1 5 1												33 39 42 4 15 21 17 13 1													
<i>Semiacontiodus</i>	1																									
<i>Drepanodus sp.</i>													1													
<i>Strachanognathus</i>	19 4 1																									
<i>Protopanderodus liripipus</i>													2 2 1 9 1													
	hi-sp													3 1 4 2 2 14 10 14 3 3												
<i>Drepanoistodus suberectus</i>	ne	6	2	4	2	1			1	1	2															
	hi-sp	25	2	10	2			3			1	1	1			2	7	4			1	1				
	tr	1	1	1					1			1														
<i>P? venustus</i>	1												2 1 1													
<i>Baltoniodus alobatus</i>	ne	8			4	1	1	5	2	6																
	ke-hi	1			3	3			1	4	3															
	pl	2								1	5	3														
	tr	1				1	2																			
	oz	4			2	5	1	2	6	2																
	sp	1			1	2				1	2															
<i>Sagittodontina robusta</i>	oz											1			2	1										
	sp											2														
<i>Rhodesognathus polonicus</i>	ne	171	7	68	9			2																		
	hi	58	4	19	10																					
	ke	54	3	12	4																					
	pl	45	1	19	4																					
	tr	52	3	26	4																					
	oz	508	20	270	40	10			1																	
	sp	236	19	40	22	3			1																	
<i>Amorphognathus superbus ordovicicus</i>	ne	4			4	3	2	2	4	2																
	hi	1				2			1	1	1	2														
	ke	1			1	1	1	5	3	4																
	pl	1				1	2	4	2																	
	tr					1	3	1	2																	
	oz	38	2	24	19	3	17	17	13																	
	sp	63			17	16	4	18	16	19																
														1 1 1 1 1 5 3 2 2 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1												

		A <i>superbus</i> Zone				Amorphognathus <i>ordovicicus</i> Zone																													
		MA	98	99	4	100	101	102	23	104	105	106	2d	108	2	109	110	111	112	113	114	115	116												
<i>Icriodella prominens</i>		2	12																	2	1														
<i>Hanarodus brevirameus</i>		ne	3	30	5	15	22	18	6	10	82	29	1	9	12	6	6	17	28	59	24	31	26												
		hi	3	7	3	15	4	16	2	5	45	15		12	4	4	4	15	18	31	5	6	7												
		pl			2	4	1			2	3		1			1	2	1	12	2	2	3													
		tr		1	1	1	1			2	3	2							2	5			2												
		sp-oz	?	6	2	17	5	6	1	7	57	16	2	6	1	9	4	14	13	68	5	19	15												
<i>Ozarkodina? sp.</i>																		1																	
																						2	32												
																						1	3	1											
																						1	1	1	1										
																						11	5	3	3	12	2	6							
																						11	48	16	27	153	17	53	18						
																						367	283	246	265	1059	310	558	692						
																						2		1	2										
																						2				1	1	3	2						
																						3	2	3	2	5	1	6	2						
																						6		4	2	10	2								
																						1													
																																2			
																																1			
																																1			
																						3				1			3						
																						1		1	2	2	1	3	3						
																						3		1	1	1		1	3						
																								2		1		1	5						
																										1	2	1	3	11					
																						2	1	1	5	6	1	16	34						
																						4	1	3	9	8	2	10	27						

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 11

<i>Scolopodus peselephantis</i> LINDSTRÖM, 1955 . . . . .	.60
Fig. 1. Specimen ZPAL CVI/679, sample MA-128.	
Fig. 2. Specimen ZPAL CVI/680, sample MA-128.	
Fig. 3. Specimen ZPAL CVI/682 with dissolved basal parts, sample MA-86.	
Fig. 4. Specimen ZPAL CVI/683, sample MA-87.	
Fig. 5. Specimen ZPAL CVI/681, sample MA-86	
<i>Pseudooneotodus</i> sp. . . . .	.55
Fig. 6. Specimen ZPAL CVI/678, sample MA-113.	
<i>Pseudooneotodus mitratus</i> (MOSKALENKO, 1973) . . . . .	.55
Fig. 7. Specimen ZPAL CVI/677, sample MA-54.	
<i>Cornuodus longibasis</i> (LINDSTRÖM, 1955) . . . . .	.61
Fig. 8. Element ne ZPAL CVI/618, sample MA-128.	
Fig. 9. Element hi ZPAL CVI/617, sample MA-128.	
Fig. 10. Element pl ZPAL CVI/620, sample MA-128.	
Fig. 11. Element tr ZPAL CVI/621, sample MA-128.	
Fig. 12. Element oz ZPAL CVI/622, sample MA-128.	
Fig. 13. Element sp ZPAL CVI/623, sample MA-128.	
<i>Cornuodus bergstroemi</i> SERPAGLI, 1967 . . . . .	.62
Fig. 14. Element ne ZPAL CVI/630, sample MA-46.	
Fig. 15. Element hi ZPAL CVI/629, sample MA-46.	
Fig. 16. Element pl ZPAL CVI/631, sample MA-46.	
Fig. 17. Element tr ZPAL CVI/633, sample MA-46.	
Fig. 18. Element oz ZPAL CVI/632, sample MA-46.	
Fig. 19. Element sp ZPAL CVI/634, sample MA-46.	
<i>Dapsilodus viruensis</i> (FÄHRÆUS, 1966) . . . . .	.63
early form:	
Fig. 20. Element ne ZPAL CVI/549, sample MA-41.	
Fig. 21. Element hi ZPAL CVI/548, sample MA-41.	
Fig. 22. Element pl ZPAL CVI/547, sample MA-41.	
Fig. 23. Element oz ZPAL CVI/546, sample MA-41.	
late form:	
Fig. 27. Element ne ZPAL CVI/551, sample MA-46.	
Fig. 28. Element hi ZPAL CVI/550, sample MA-46.	
Fig. 29. Element pl ZPAL CVI/553, sample MA-46.	
Fig. 30. Element oz ZPAL CVI/552, sample MA-46.	
<i>Dapsilodus mutatus</i> (BRANSON <i>et</i> MEHL, 1933) . . . . .	.64
Fig. 24. Element ne ZPAL CVI/555, sample MA-91.	
Fig. 25. Element hi ZPAL CVI/556, sample MA-91.	
Fig. 26. Element pl ZPAL CVI/554, sample MA-91.	
Fig. 31. Element ne ZPAL CVI/561, sample MA-100.	
Fig. 32. Element pl ZPAL CVI/560, sample MA-100.	
Fig. 33. Element hi ZPAL CVI/559, sample MA-100.	
Fig. 34. Element ne ZPAL CVI/557, sample MA-93.	
Fig. 35. Element pl ZPAL CVI/558, sample MA-93.	
<i>Scabbardella altipes</i> (HENNINGSMOEN, 1947) . . . . .	.64
Fig. 36. Element ne ZPAL CVI/562, sample MA-93.	
Fig. 37. Element hi ZPAL CVI/564, sample MA-93.	
Fig. 38. Element oz ZPAL CVI/563, sample MA-93.	
Fig. 39. Element pl ZPAL CVI/565, sample MA-93.	
All illustrations × 80, except when otherwise stated.	

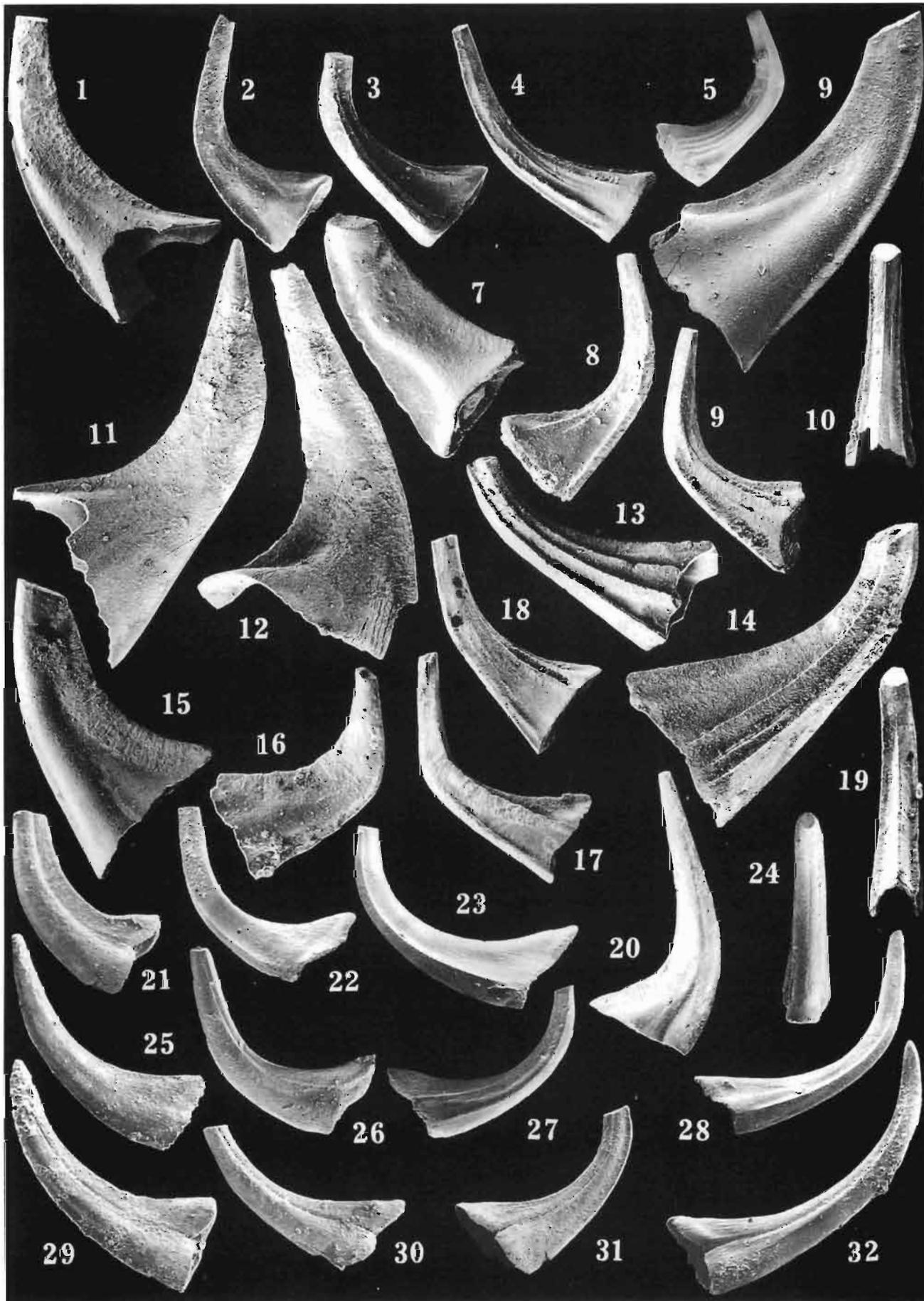


DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 12

<i>Walliserodus costatus</i> DZIK, 1976 . . . . .	.56
Fig. 1. Element ne ZPAL CVI/600, sample MA-128.	
Fig. 2. Element hi ZPAL CVI/599, sample MA-128.	
Fig. 3. Element pl ZPAL CVI/597, sample MA-128.	
Fig. 4. Element oz ZPAL CVI/598, sample MA-128.	
Fig. 5. Element pl ZPAL CVI/342, sample MA-14.	
Fig. 6. Element ne ZPAL CVI/601, sample MA-131.	
<i>Walliserodus ethingtoni</i> (FÅHRÆUS, 1966) . . . . .	.56
Fig. 7. Element hi ZPAL CVI/615, sample MA-52.	
Fig. 8. Element pl ZPAL CVI/614, sample MA-52.	
Fig. 9. Element oz? (or ke?) ZPAL CVI/612, sample MA-42.	
Fig. 10. Element tr ZPAL CVI/613, sample MA-44.	
Fig. 15. Element ne ZPAL CVI/604, sample MA-93.	
Fig. 16. Element hi ZPAL CVI/605, sample MA-94.	
Fig. 17. Element pl? ZPAL CVI/603, sample MA-93.	
Fig. 18. Element ke? ZPAL CVI/602, sample MA-93.	
Fig. 19. Element tr ZPAL CVI/606, sample MA-94.	
<i>Walliserodus nakholmensis</i> (HAMAR, 1966) . . . . .	.58
Fig. 11. Element ne ZPAL CVI/608, sample MA-70.	
Fig. 12. Element hi ZPAL CVI/607, sample MA-2.	
Fig. 13. Element ke? (or oz?) ZPAL CVI/610, sample MA-69.	
Fig. 14. Element pl? ZPAL CVI/609, sample MA-72.	
<i>Scalpellodus viruensis</i> LÖFGREN, 1978 . . . . .	.56
Fig. 20. Element hi ZPAL CVI/611, sample MA-60 (see also Pl. 15: 7).	
<i>Panderodus sulcatus</i> (FÅHRÆUS, 1966) early form . . . . .	.59
Fig. 21. Element ne ZPAL CVI/569, sample MA-520.	
Fig. 22. Element hi ZPAL CVI/568, sample MA-52.	
Fig. 23. Element pl ZPAL CVI/567, sample MA-52.	
Fig. 24. Element tr ZPAL CVI/566, sample MA-52 (see also Pl. 24: 1).	
<i>Panderodus sulcatus</i> (FÅHRÆUS, 1966) late form . . . . .	.59
Fig. 25. Element ne ZPAL CVI/570, sample MA-62.	
Fig. 26. Element hi ZPAL CVI/574, sample MA-62.	
Fig. 27. Element pl ZPAL CVI/575, sample MA-70.	
Fig. 28. Element ke-sp ZPAL CVI/573, sample MA-62.	
<i>Panderodus</i> sp. A . . . . .	.59
Fig. 29. Element ne ZPAL CVI/577, sample MA-101.	
Fig. 30. Element hi ZPAL CVI/579, sample MA-101.	
Fig. 31. Element pl ZPAL CVI/578, sample MA-101.	
Fig. 32. Element ke-sp ZPAL CVI/576, sample MA-101.	
All illustrations × 80, except when otherwise stated.	



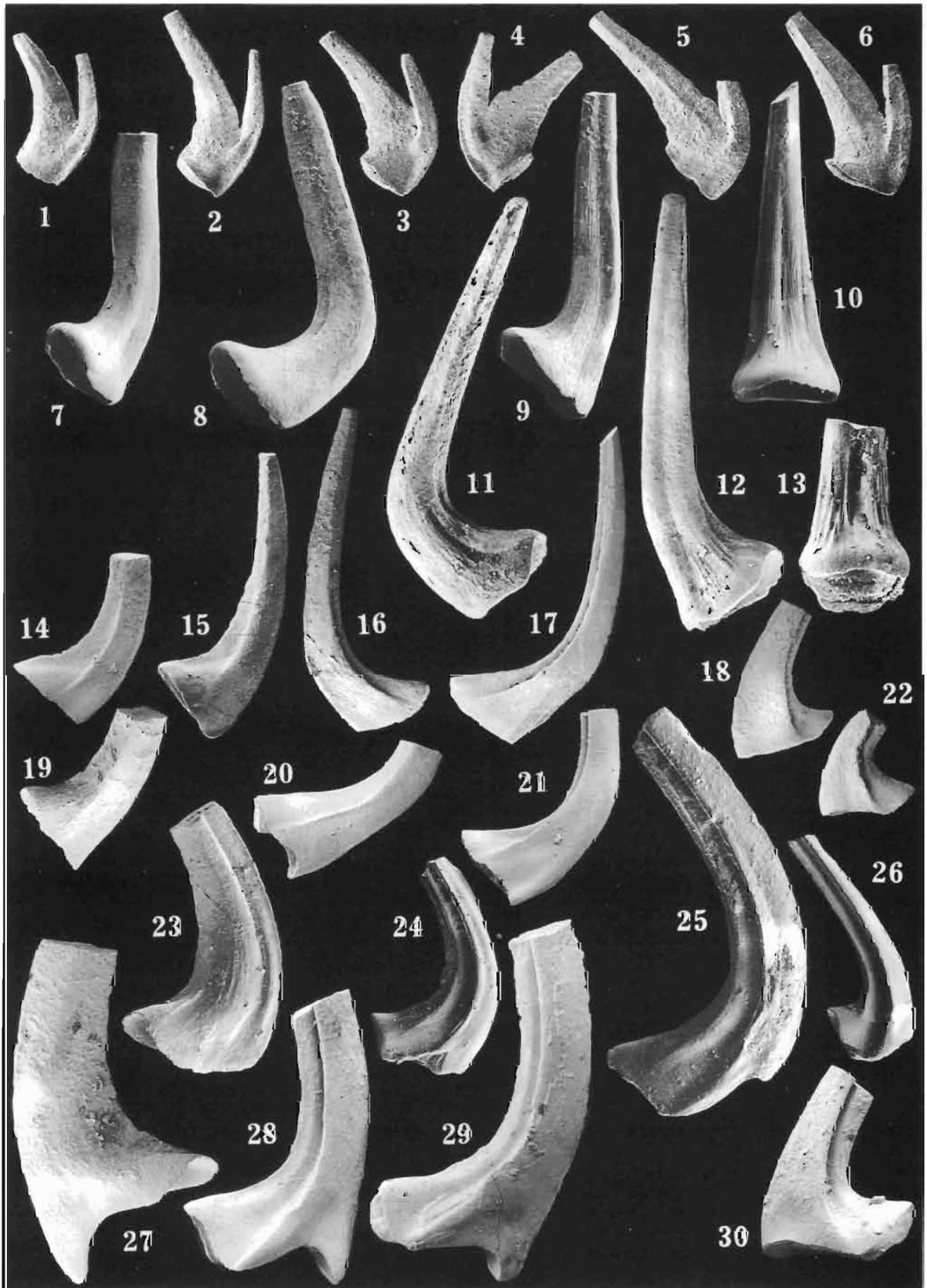
DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 13

<i>Strachanognathus parvus</i> RHODES, 1955 . . . . .	.62
Fig. 1. Element ne ZPAL CVI/690, sample MA-46.	
Fig. 2. Element hie ZPAL CVI/689, sample MA-46.	
Fig. 3. Element ke ZPAL CVI/688, sample MA-46.	
Fig. 4. Element pl ZPAL CVI/684, sample MA-46.	
Fig. 5. Element tr ZPAL CVI/685, sample MA-46.	
Fig. 6. Element oz-sp ZPAL CVI/687, sample MA-46.	
<i>Semiacontiodus cornuformis</i> (SERGEEVA, 1963) . . . . .	.66
Fig. 7. Element ne ZPAL CVI/586, sample MA-125.	
Fig. 8. Element hi ZPAL CVI/587, sample MA-125.	
Fig. 9. Element pl ZPAL CVI/588, sample MA-125.	
Fig. 10. Element tr ZPAL CVI/589, sample MA-125.	
<i>Semiacontiodus longicostatus</i> (DRYGANT, 1974) . . . . .	.67
Fig. 11. Element ne ZPAL CVI/595, sample MA-59.	
Fig. 12. Element pl ZPAL CVI/594, sample MA-58.	
Fig. 13. Element ne ZPAL CVI/596, sample MA-19.	
<i>Protopanderodus graei</i> (HAMAR, 1966) . . . . .	.72
Fig. 14. Element ne ZPAL CVI/660, sample MA-46.	
Fig. 15. Extremely acostate element ne ZPAL CVI/657, sample MA-46.	
Fig. 16. Element hi-pl ZPAL CVI/656, sample MA-46.	
Fig. 17. Element tr ZPAL CVI/658, sample MA-46.	
Fig. 18. Element oz-sp ZPAL CVI/659, sample MA-46.	
Fig. 19. Element ne ZPAL CVI/654, sample MA-128.	
Fig. 20. Element hi-pl ZPAL CVI/653, sample MA-128.	
Fig. 21. Element tr ZPAL CVI/652, sample MA-128.	
Fig. 22. Element oz-sp ZPAL CVI/655, sample MA-128.	
<i>Protopanderodus gradatus</i> SERPAGLI, 1974 late form . . . . .	.73
Fig. 23. Element ne ZPAL CVI/581, sample MA-124.	
Fig. 24. Element hi-pl ZPAL CVI/582, sample MA-125.	
Fig. 25. Element tr ZPAL CVI/580, sample MA-124.	
Fig. 26. Element oz-sp ZPAL CVI/583, sample MA-125.	
<i>Protopanderodus rectus</i> (LINDSTRÖM, 1955) . . . . .	.72
Fig. 27. Element ne ZPAL CVI/648, sample MA-128.	
Fig. 28. Element hi-pl ZPAL CVI/650, sample MA-128.	
Fig. 29. Element tr ZPAL CVI/649, sample MA-128.	
Fig. 30. Element oz-sp ZPAL CVI/651, sample MA-128.	

All illustrations × 80, except when otherwise stated.



DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 14

Protopanderodus varicostatus (SWEET *et* BERGSTRÖM, 1962)74

- Fig. 1. Element **ne** ZPAL CVI/590, sample MA-46.
- Fig. 2. Element **hi-ke** ZPAL CVI/589, sample MA-46.
- Fig. 3. Element **pl** ZPAL CVI/592, sample MA-17.
- Fig. 4. Element **tr** ZPAL CVI/593, sample MA-52.
- Fig. 5. Element **oz-sp** ZPAL CVI/591, sample MA-48.

Protopanderodus liripipus KENNEDY, BARNES *et* UYENO, 197974

- Fig. 6. Element **ne** ZPAL CVI/584, sample MA-2.
- Fig. 7. Element **hi-sp** ZPAL CVI/585, sample MA-105.

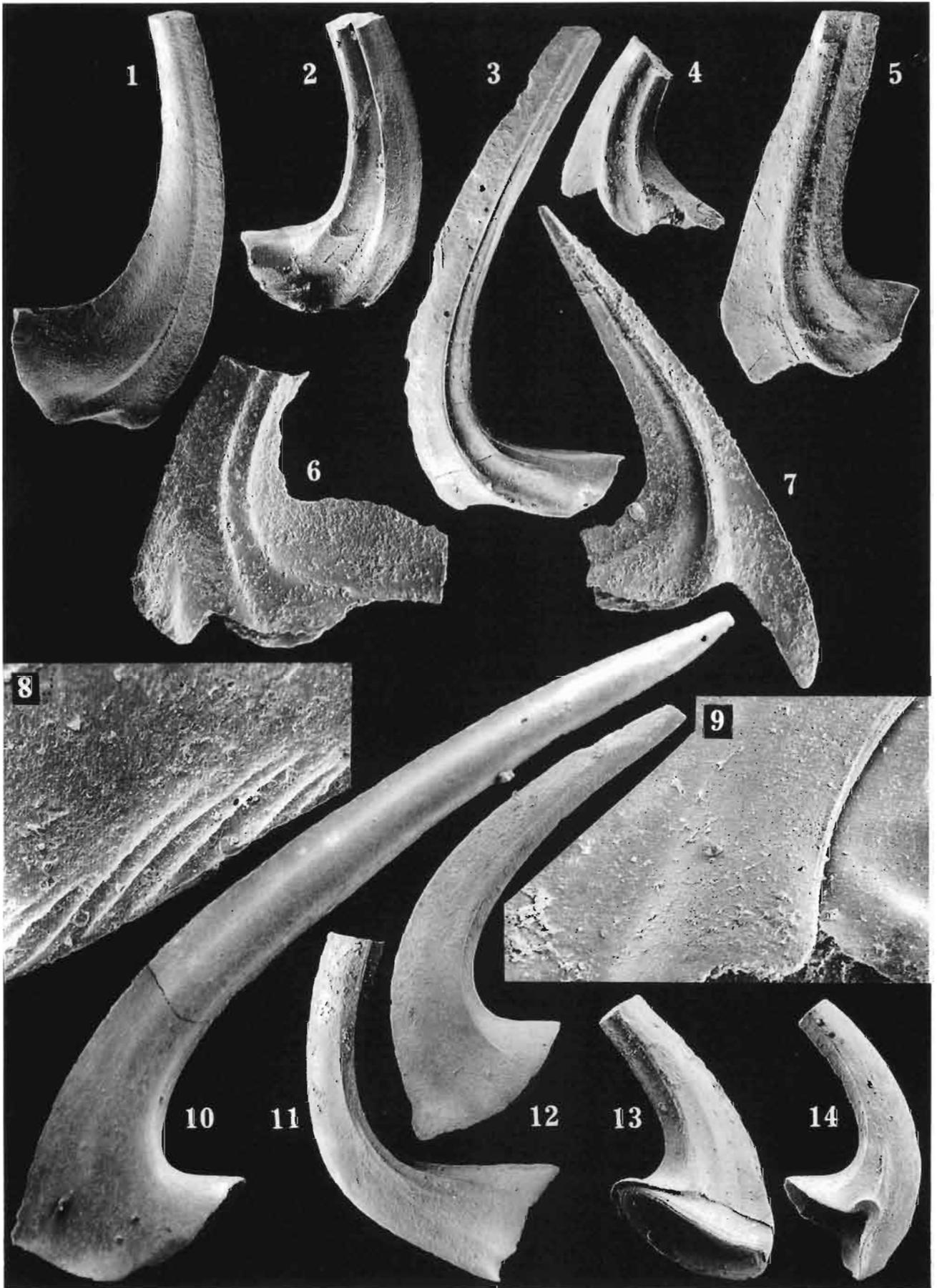
Dapsilodus mutatus (BRANSON *et* MEHL, 1933)64

- Fig. 8. External margin of element **pl?** ZPAL CVI/558, sample MA-93 (see also Pl. 11: 35) × 400.
- Fig. 9. Panderodont furrow of element **ne** ZPAL CVI/561, sample MA-100 (see also Pl. 11: 31) × 400.

Drepanodus robustus HADDING 191370

- Fig. 10. Element **ne** ZPAL CVI/625, sample MA-66.
- Fig. 11. Element **tr** ZPAL CVI/626, sample MA-54.
- Fig. 12. Element **hi-pl** ZPAL CVI/624, sample MA-65.
- Fig. 13. Element **oz** ZPAL CVI/628, sample MA-74.
- Fig. 14. Element **sp** ZPAL CVI/627, sample MA-76.

All illustrations × 80, except when otherwise stated.



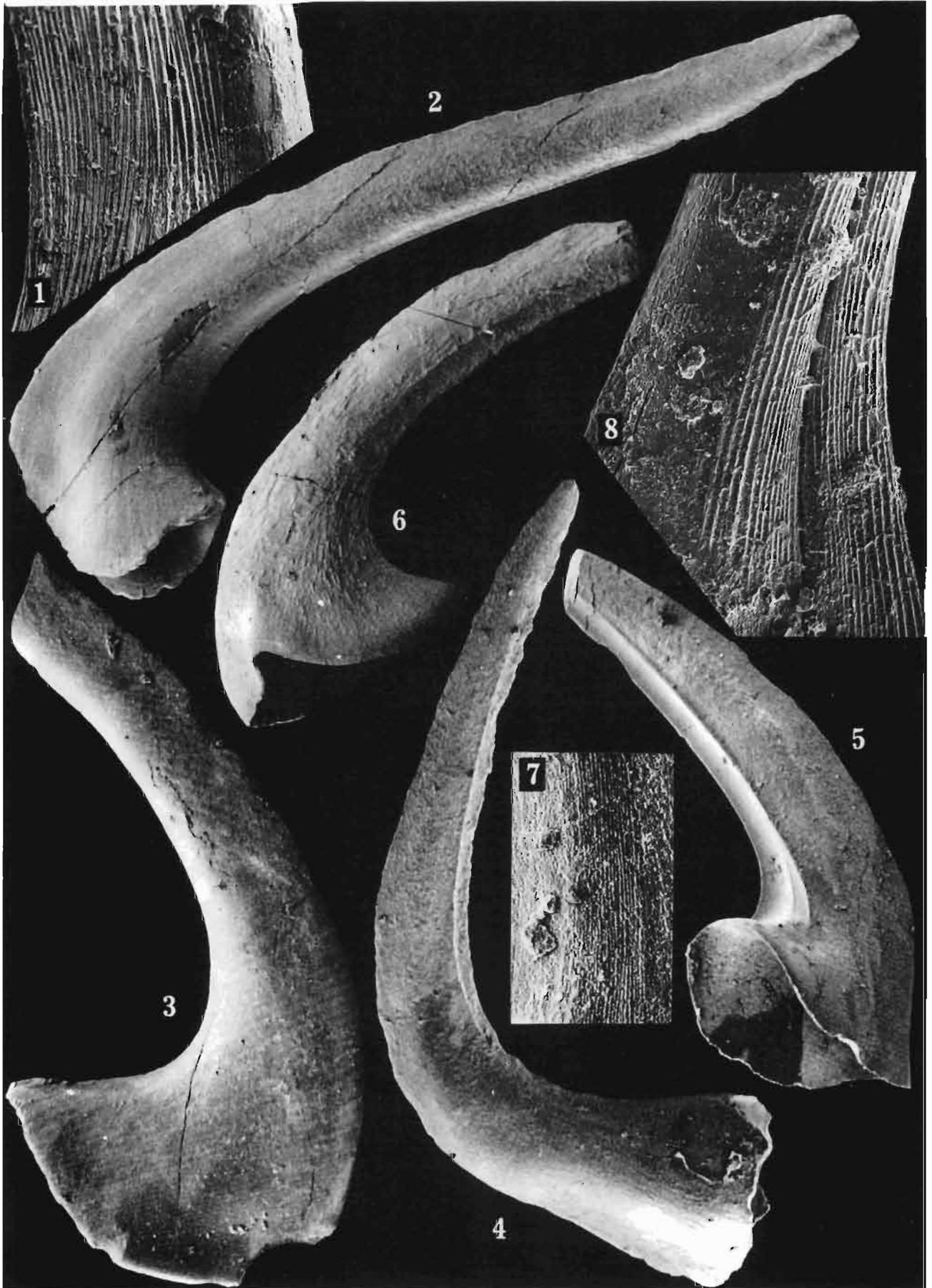
DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 15

<i>Semiacontiodus cornuformis</i> (SERGEEVA, 1963) . . . . .	.66
Fig. 1. Microornamentation of element pl ZPAL CVI/588, sample MA-125 (see also Pl. 13: 9) × 400.	
<i>Drepanodus arcuatus</i> PANDER, 1856 late form . . . . .	.68
Fig. 2. Element ne ZPAL CVI/691, sample MA-128.	
Fig. 3. Element hi ZPAL CVI/695, sample MA-128.	
Fig. 4. Element tr ZPAL CVI/692, sample MA-127.	
Fig. 5. Element oz ZPAL CVI/693, sample MA-131.	
Fig. 6. Element sp ZPAL CVI/694, sample MA-131.	
<i>Scalpellodus viruensis</i> LÖFGREN, 1978 . . . . .	.56
Fig. 7. Microornamentation of element ne ZPAL CVI/611, sample MA-60 (see also Pl. 12: 20) × 400.	
<i>Panderodus</i> sp. A. . . . .	.59
Fig. 8. Microornamentation of element hi ZPAL CVI/579, sample MA-101 (see also Pl. 12: 30) × 400.	

All illustrations × 80, except when otherwise stated.



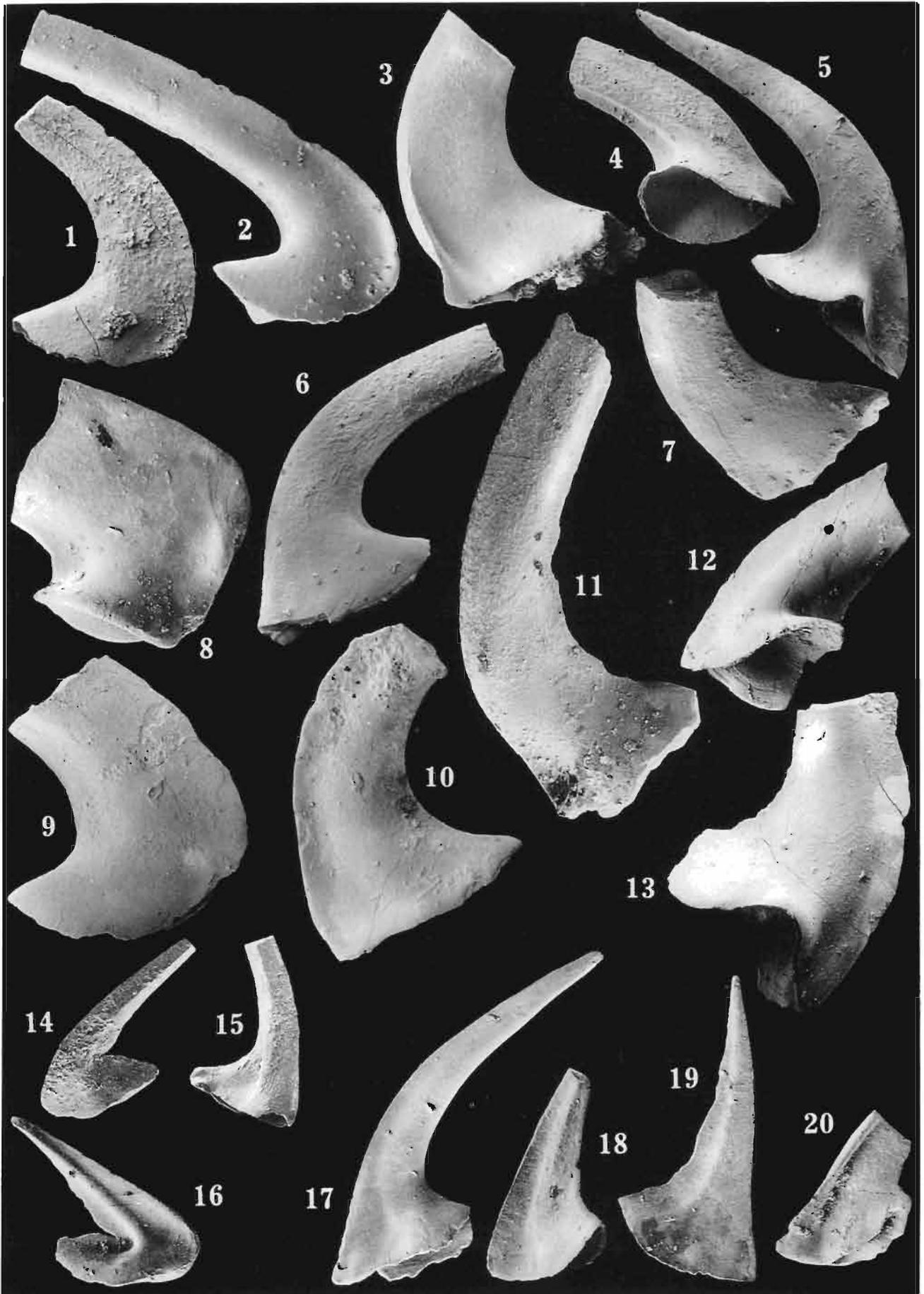
DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 16

<i>Drepanodus kielcensis</i> sp. n. . . . .	.70
Fig. 1. Element hi ZPAL CVI/644, sample MA-129.	
Fig. 2. Holotype, element ne ZPAL CVI/642, sample MA-128.	
Fig. 3. Element pl ZPAL CVI/641, sample MA-128.	
Fig. 4. Element oz ZPAL CVI/647, sample MA-131.	
Fig. 5. Element sp ZPAL CVI/646, sample MA-41.	
Fig. 6. Element ke ZPAL CVI/643, sample MA-128.	
Fig. 7. Element tr ZPAL CVI/645, sample MA-129.	
<i>Drepanodus santacrucensis</i> sp. n. . . . .	.70
Fig. 8. Holotype, element ne ZPAL CVI/640, sample MA-76.	
Fig. 9. Element hi ZPAL CVI/635, sample MA-75.	
Fig. 10. Element ke ZPAL CVI/636, sample MA-58.	
Fig. 11. Element pl? ZPAL CVI/639, sample MA-74.	
Fig. 12. Element oz ZPAL CVI/638, sample MA-74.	
Fig. 13. Element sp ZPAL CVI/637, sample MA-74.	
<i>Paltodus? semisymmetricus</i> (HAMAR, 1966) . . . . .	.76
Fig. 14. Element ne ZPAL CVI/662, sample MA-46.	
Fig. 15. Element hi-sp ZPAL CVI/661, sample MA-46.	
<i>Drepanoistodus basiovalis</i> (SERGEEVA, 1963) . . . . .	.78
Fig. 16. Element ne ZPAL CVI/670, sample MA-125.	
Fig. 17. Element hi ZPAL CVI/669, sample MA-37.	
Fig. 18. Element pl ZPAL CVI/668, sample MA-38.	
Fig. 19. Element tr ZPAL CVI/667, sample MA-38.	
Fig. 20. Element oz-sp ZPAL CVI/666, sample MA-125.	

All illustrations × 80, except when otherwise stated.



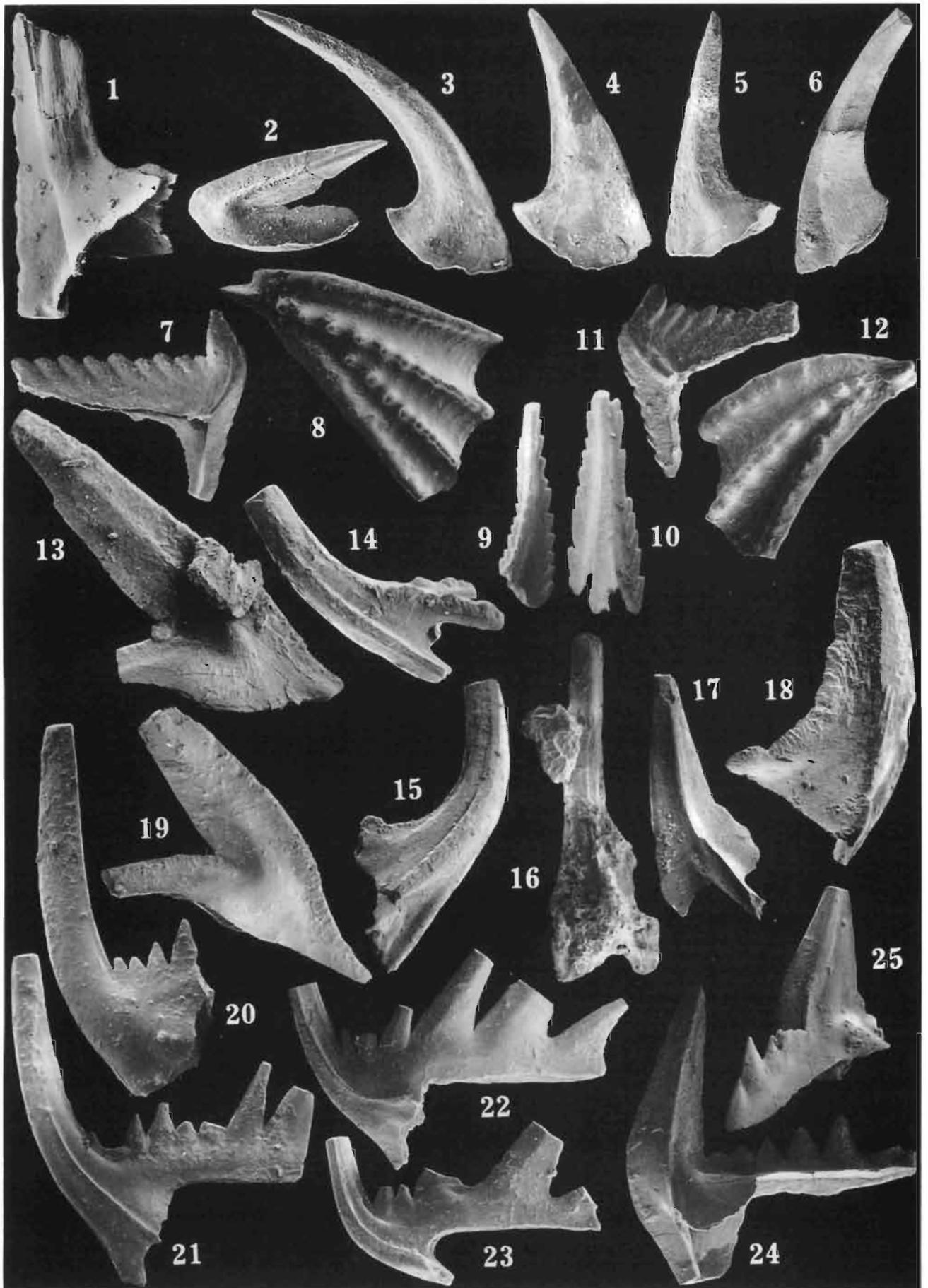
DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 17

<i>Eoneoprioniodus alatus</i> (DZIK, 1976)	79
Fig. 1. Element oz ? ZPAL CVI/663, sample MA-42.	
<i>Drepanoistodus suberectus</i> (BRANSON <i>et</i> MEHL, 1933) early form	78
Fig. 2. Element ne ZPAL CVI/675 with extremely short cusp, may quite well belong to <i>Paltodus? venustus</i> , sample MA-46.	
Fig. 3. Element hi ZPAL CVI/674, sample MA-46.	
Fig. 4. Element pl ZPAL CVI/673, sample MA-46.	
Fig. 5. Element tr ZPAL CVI/672, sample MA-46.	
Fig. 6. Element oz-sp ZPAL CVI/671, sample MA-46.	
<i>Pygodus anserinus</i> LAMONT <i>et</i> LINDSTRÖM, 1957	105
Fig. 7. Element oz ZPAL CVI/537, sample MA-67.	
Fig. 8. Element sp ZPAL CVI/536, sample MA-59.	
<i>Pygodus serra</i> (HADDING, 1913)	103
Fig. 9. Element ke ? ZPAL CVI/535, sample MA-58.	
Fig. 10. Element tr ZPAL CVI/534, sample MA-46.	
Fig. 11. Element oz ZPAL CVI/533, sample MA-52.	
Fig. 12. Element sp ZPAL CVI/532, sample MA-49.	
<i>Phragmodus?</i> sp. aff. " <i>Baltoniodus</i> " <i>crassulus</i> (LINDSTRÖM, 1955)	101
Fig. 13. Element ne ZPAL CVI/386, sample MA-118.	
Fig. 14. Element pl ZPAL CVI/385, sample MA-117.	
Fig. 15. Element ke ZPAL CVI/388, sample MA-117.	
Fig. 16. Element tr ZPAL CVI/384, sample MA-117.	
Fig. 17. Element sp ZPAL CVI/384, sample MA-117.	
Fig. 18. Element oz ZPAL CVI/383, sample MA-117.	
<i>Phragmodus polonicus</i> DZIK, 1978	102
Fig. 19. Element ne ZPAL CVI/499, sample MA-125.	
Fig. 20. Element hi ZPAL CVI/498, sample MA-125.	
Fig. 21. Element ke ZPAL CVI/497, sample MA-125.	
Fig. 22. Element tr ZPAL CVI/495, sample MA-125.	
Fig. 23. Element pl ZPAL CVI/496, sample MA-125.	
Fig. 24. Element oz ZPAL CVI/494, sample MA-125.	
Fig. 25. Element sp ZPAL CVI/493, sample MA-125.	

All illustrations × 80, except when otherwise stated.



DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 18

<i>Phragmodus polonicus</i> DZIK, 1978	102
Fig. 1. Element ke ZPAL CVI/502, sample MA-68.	
Fig. 2. Element tr ZPAL CVI/504, sample MA-68.	
Fig. 3. Element oz ZPAL CVI/501, sample MA-68.	
Fig. 4. Element sp ZPAL CVI/500, sample MA-52.	
Fig. 5. Element ne ZPAL CVI/505, sample MA-68.	
Fig. 6. Element pl ZPAL CVI/503, sample MA-68.	
Fig. 7. Element hi ZPAL CVI/506, sample MA-52.	
<i>Baltoniodus parvidentatus</i> (SERGEEVA, 1963)	80
Fig. 8. Element ne ZPAL CVI/403, sample MA-120.	
Fig. 9. Element tr ZPAL CVI/404, sample MA-120.	
Fig. 10. Element pl ZPAL CVI/400, sample MA-120.	
Fig. 11. Element oz ZPAL CVI/401, sample MA-120.	
Fig. 12. Element sp ZPAL CVI/402, sample MA-120.	
Fig. 13. Element ke ZPAL CVI/398, sample MA-120.	
Fig. 14. Element hi ZPAL CVI/399, sample MA-120.	
<i>Distomodus</i> sp.	107
Fig. 15. Element pl ZPAL CVI/717, sample MA-93.	
Fig. 16. Element ne ZPAL CVI/716, sample MA-93.	
<i>Baltoniodus prevariabilis</i> (FÅHRÆUS, 1966)	82
Fig. 17. Element oz ZPAL CVI/513, sample MA-46.	
Fig. 18. Element hi ZPAL CVI/516, sample MA-46.	
Fig. 19. Element tr ZPAL CVI/514, sample MA-46.	
Fig. 20. Element ne ZPAL CVI/517, sample MA-46.	
Fig. 21. Element sp ZPAL CVI/512, sample MA-46.	
Fig. 22. Element ke ZPAL CVI/515, sample MA-46.	

All illustrations × 80, except when otherwise stated.



DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 19

Baltoniodus variabilis (BERGSTRÖM, 1963)84

- Fig. 1. Element **ne** ZPAL CVI/525, sample MA-71.
- Fig. 2. Element **hi** ZPAL CVI/523, sample MA-71.
- Fig. 3. Element **pl** ZPAL CVI/522, sample MA-71.
- Fig. 4. Element **sp** ZPAL CVI/519, sample MA-70.
- Fig. 5. Element **ke** ZPAL CVI/524, sample MA-71.
- Fig. 6. Element **tr** ZPAL CVI/521, sample MA-71.
- Fig. 7. Element **sp** ZPAL CVI/518, sample MA-71.
- Fig. 8. Element **oz** ZPAL CVI/520, sample MA-78.
- Fig. 9. Element **sp** ZPAL CVI/360, sample MA-22, from population transitional to *B. alobatus*.

Baltoniodus alobatus (BERGSTRÖM, 1971)84

- Fig. 10. Element **ne** ZPAL CVI/531, sample MA-93.
- Fig. 11. Element **hi-ke** ZPAL CVI/530, sample MA-97.
- Fig. 12. Element **sp** ZPAL CVI/526, sample MA-97.
- Fig. 13. Element **tr** ZPAL CVI/528, sample MA-93.
- Fig. 14. Element **pl** ZPAL CVI/529, sample MA-96.
- Fig. 15. Element **oz** ZPAL CVI/527, sample MA-93.

Lenodus variabilis (SERGEEVA, 1963) late form86

- Fig. 16. Extremely robust element **ne** ZPAL CVI/410, sample MA-125.
- Fig. 17. Dextral element **oz** ZPAL CVI/412, sample MA-125.
- Fig. 18. Sinistral element **oz** ZPAL CVI/405, sample MA-124.
- Fig. 19. Element **hi** ZPAL CVI/409, sample MA-125.
- Fig. 20. Element **ke** ZPAL CVI/408, sample MA-125.
- Fig. 21. Element **pl** ZPAL CVI/407, sample MA-125.
- Fig. 22. Element **sp** ZPAL CVI/411, sample MA-125.
- Fig. 23. Element **tr** ZPAL CVI/406, sample MA-125.

All illustrations × 80, except when otherwise stated.



DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 20

Lenodus variabilis (SERGEEVA, 1963)86

- Fig. 1. Element **ne** ZPAL CVI/395, sample MA-35.
- Fig. 2. Dextral element **oz** ZPAL CVI/367, sample MA-118.
- Fig. 3. Element **sp** ZPAL CVI/391, sample MA-118.
- Fig. 4. Element **tr** ZPAL CVI/392, sample MA-33.
- Fig. 5. Sinistral element **oz** ZPAL CVI/396, sample MA-35.
- Fig. 6. Anterior process of element **sp** ZPAL CVI/397, sample MA-33.
- Fig. 7. Element **pl** ZPAL CVI/394, sample MA-33.
- Fig. 8. Element **ke** ZPAL CVI/393, sample MA-33.

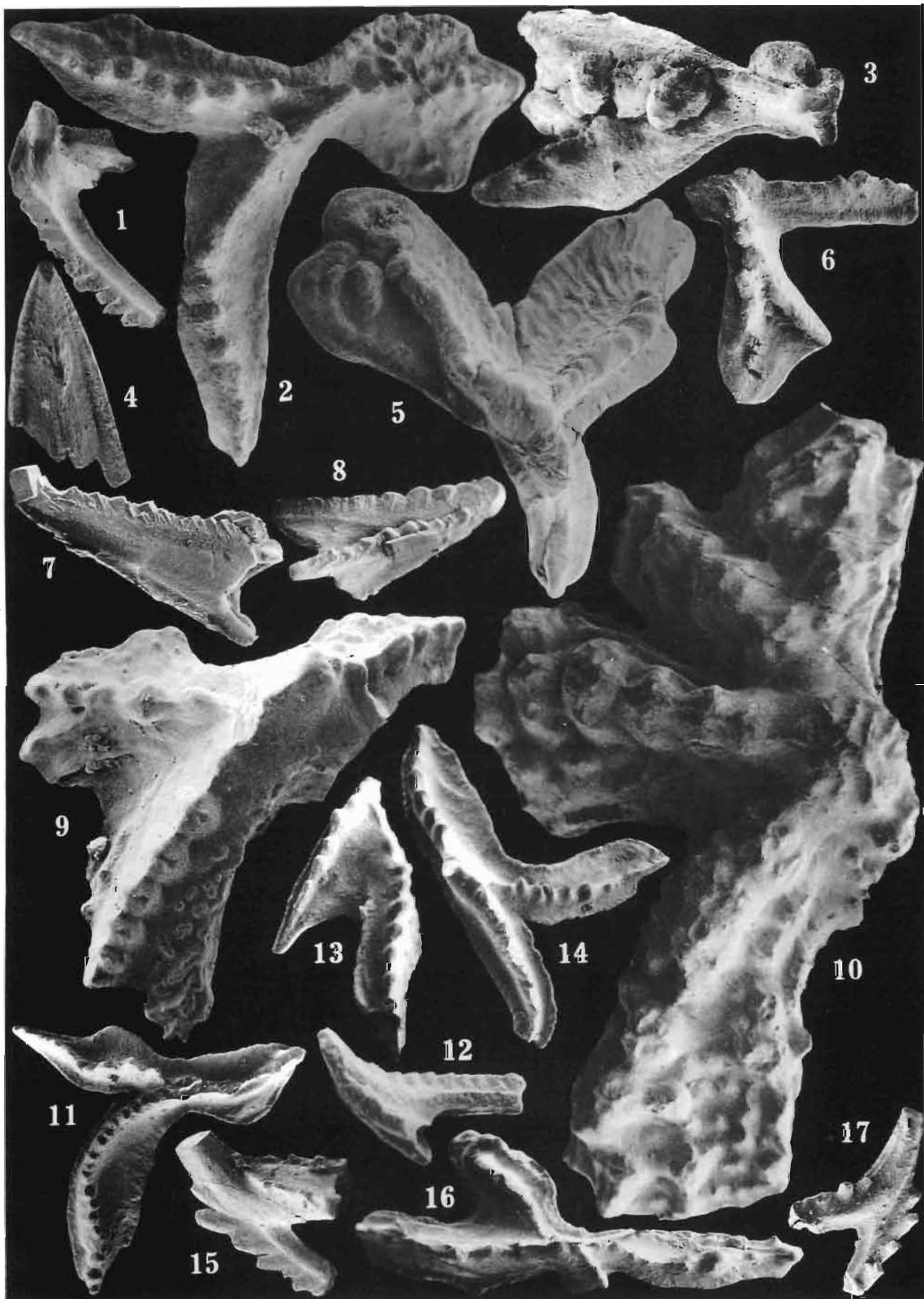
Polonodus sp.54

- Fig. 9. Specimen ZPAL CVI/715, sample MA-125,
- Fig. 10. Specimen ZPAL CVI/714, sample MA-128.

Eoplacognathus zgierzensis DZIK, 1976 early form96

- Fig. 11. Dextral element **oz** ZPAL CVI/418, sample MA-131.
- Fig. 12. Element **tr** ZPAL CVI/421, sample MA-131.
- Fig. 13. Anterior process of element **sp** ZPAL CVI/417, sample MA-131.
- Fig. 14. Sinistral element **oz** ZPAL CVI/419, sample MA-131.
- Fig. 15. Element **ne** ZPAL CVI/423, sample MA-131.
- Fig. 16. Element **sp** ZPAL CVI/416, sample MA-131.
- Fig. 17. Element **hi** ZPAL CVI/422, sample MA-131.

All illustrations × 80, except when otherwise stated.



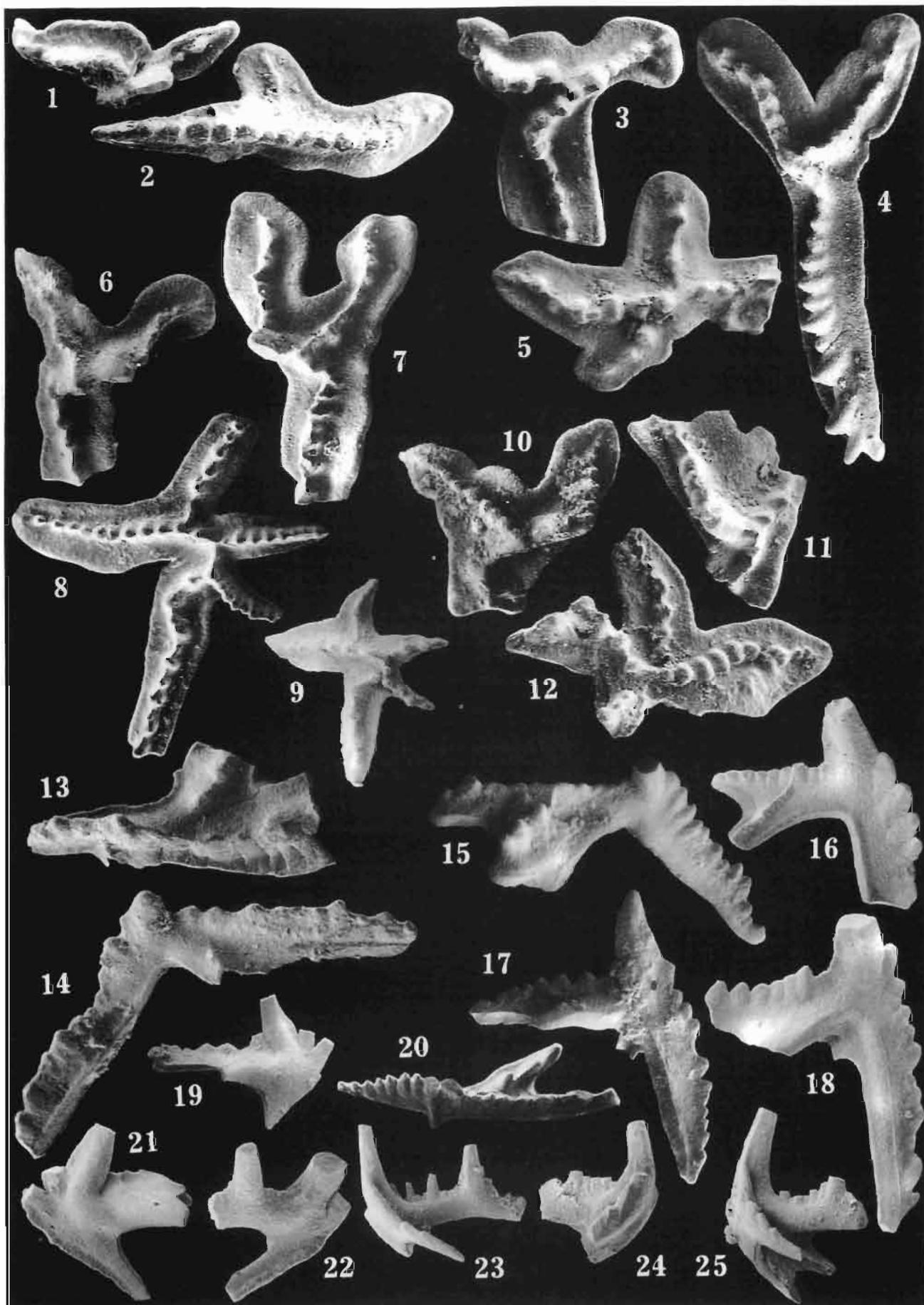
DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 21

<i>Cahabagnathus protoramosus</i> (CHEN, CHEN <i>et</i> ZHANG, 1983)	100
Fig. 1. Dextral element oz ZPAL CVI/432, sample MA-49.	
Fig. 2. Element sp ZPAL CVI/431, sample MA-49.	
<i>Eoplacognathus robustus</i> BERGSTRÖM, 1971 . . . . .	.98
Fig. 3. Dextral element oz ZPAL CVI/429, sample MA-46.	
Fig. 4. Sinistral element oz ZPAL CVI/428, sample MA-43, × 60.	
Fig. 5. Element sp ZPAL CVI/430, sample MA-45.	
<i>Eoplacognathus lindstroemi</i> (HAMAR, 1964) . . . . .	.98
Fig. 6. Dextral element oz ZPAL CVI/434, sample MA-52.	
Fig. 7. Sinistral element oz ZPAL CVI/435, sample MA-52.	
Fig. 8. Element sp ZPAL CVI/433, sample MA-52.	
Fig. 9. Juvenile element sp ZPAL CVI/436, sample MA-52.	
<i>Eoplacognathus elongatus</i> (BERGSTRÖM, 1962) . . . . .	.98
Fig. 10. Dextral element oz ZPAL CVI/439, sample MA-87.	
Fig. 11. Sinistral element oz ZPAL CVI/438, sample MA-84.	
Fig. 12. Element sp ZPAL CVI/437, sample MA-83.	
<i>Rhodesognathus inaequalis</i> (RHODES, 1953) . . . . .	.90
Fig. 13. Element sp ZPAL CVI/478, sample MA-74.	
<i>Rhodesognathus polonicus</i> (DZIK, 1976) . . . . .	.90
Fig. 14. Element sp ZPAL CVI/470, sample MA-93.	
Fig. 15. Element sp ZPAL CVI/126, sample MA-22.	
Fig. 16. Element oz ZPAL CVI/, sample MA-93.	
Fig. 17. Element oz ZPAL CVI/337, sample MA-22.	
Fig. 18. Element oz ZPAL CVI/471, sample MA-93.	
Fig. 19. Element ne ZPAL CVI/477, sample MA-93.	
Fig. 20. Element sp ZPAL CVI/468, sample MA-93.	
Fig. 21. Element ne ZPAL CVI/476, sample MA-93.	
Fig. 22. Element hi ZPAL CVI/475, sample MA-93.	
Fig. 23. Element ke ZPAL CVI/474, sample MA-93.	
Fig. 24. Element tr ZPAL CVI/472, sample MA-93.	
Fig. 25. Element pl ZPAL CVI/473, sample MA-93.	

All illustrations × 80, except when otherwise stated.



DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 22

<i>Sagittodontina kielcensis</i> (DZIK, 1976) . . . . .	.88
Fig. 1. Element ne ZPAL CVI/414, sample MA-63.	
Fig. 2. Element hi ZPAL CVI/425, sample MA-54.	
Fig. 3. Element ke ZPAL CVI/415, sample MA-63.	
Fig. 4. Element pl ZPAL CVI/426, sample MA-54.	
Fig. 5. Element oz ZPAL CVI/425, sample MA-45.	
Fig. 6. Element sp ZPAL CVI/413, sample MA-60.	
<i>Sagittodontina bifurcata</i> KNÜPFER, 1967 . . . . .	.88
Fig. 7. Element oz ZPAL CVI/427, sample MA-91.	
<i>Amorphognathus tvaerensis</i> BERGSTRÖM, 1962 early form . . . . .	.91
Fig. 8. Element ne ZPAL CVI/445, sample MA-68.	
Fig. 9. Element hi ZPAL CVI/446, sample MA-68.	
Fig. 10. Element ke ZPAL CVI/443, sample MA-62.	
Fig. 11. Element pl ZPAL CVI/447, sample MA-69.	
Fig. 12. Element oz ZPAL CVI/438, sample MA-59.	
Fig. 13. Posterior process of element sp ZPAL CVI/440, sample MA-59.	
Fig. 14. Internal process element sp ZPAL CVI/439, sample MA-59.	
Fig. 15. Dextral element sp ZPAL CVI/444, sample MA-68.	
<i>Amorphognathus tvaerensis</i> BERGSTRÖM, 1962 . . . . .	.91
Fig. 16. Element ne ZPAL CVI/452, sample MA-86.	
Fig. 17. Element hi ZPAL CVI/457, sample MA-86.	
Fig. 18. Element ke ZPAL CVI/455, sample MA-86.	
Fig. 19. Element pl ZPAL CVI/453, sample MA-86.	
Fig. 20. Element tr ZPAL CVI/454, sample MA-86.	
Fig. 21. Dextral element sp ZPAL CVI/448, sample MA-85.	
Fig. 22. Sinistral element sp ZPAL CVI/449, sample MA-85.	

All illustrations × 80, except when otherwise stated.



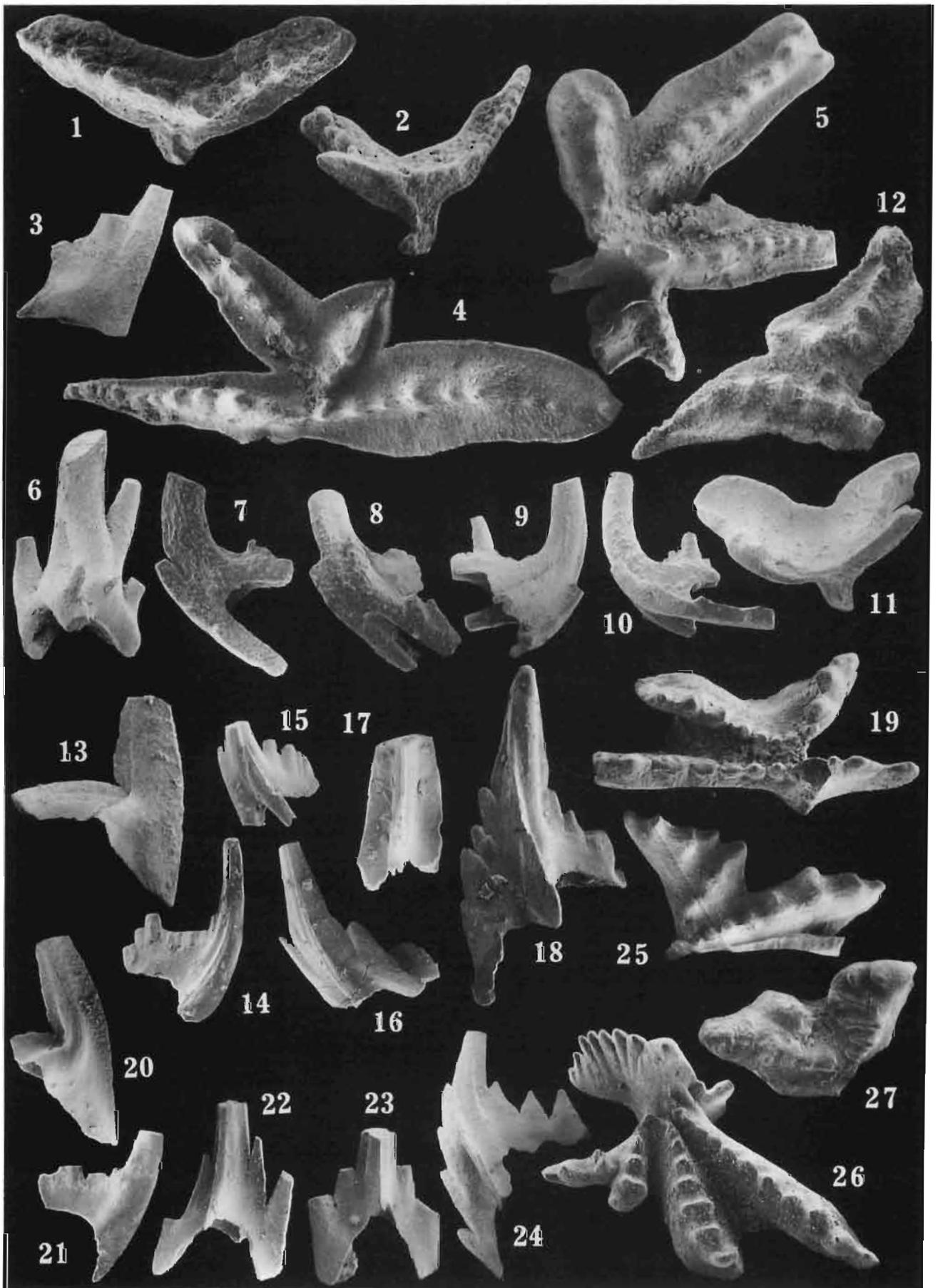
DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 23

<i>Amorphognathus tvaerensis</i> BERGSTRÖM, 1962 . . . . .	.91
Fig. 1. Dextral element oz ZPAL CVI/451, sample MA-85.	
Fig. 2. Sinistral element oz ZPAL CVI/450, sample MA-85.	
<i>Amorphognathus superbus</i> (RHODES, 1953) early form . . . . .	.93
Fig. 3. Element ne ZPAL CVI/467, sample MA-96.	
Fig. 4. Dextral element sp ZPAL CVI/458, sample MA-95.	
Fig. 5. Sinistral element sp ZPAL CVI/466, sample MA-96.	
<i>Amorphognathus ordovicicus</i> BRANSON <i>et</i> MEHL, 1933 . . . . .	.94
Fig. 6. Element ne ZPAL CVI/460, sample MA-109.	
Fig. 7. Element hi ZPAL CVI/459, sample MA-113.	
Fig. 8. Element ke ZPAL CVI/461, sample MA-109.	
Fig. 9. Element pl ZPAL CVI/462, sample MA-105.	
Fig. 10. Element tr ZPAL CVI/463, sample MA-105.	
Fig. 11. Element oz ZPAL CVI/464, sample MA-105.	
Fig. 12. Dextral element sp ZPAL CVI/465, sample MA-105.	
<i>Complexodus originalis</i> CHEN <i>et</i> ZHANG, 1984	106
Fig. 13. Element ne ZPAL CVI/485, sample MA-67.	
Fig. 14. Element hi ? ZPAL CVI/481, sample MA-62.	
Fig. 15. Element ke ? ZPAL CVI/482, sample MA-66.	
Fig. 16. Element pl ZPAL CVI/483, sample MA-66.	
Fig. 17. Element tr ZPAL CVI/484, sample MA-66.	
Fig. 18. Element oz ZPAL CVI/479, sample MA-59.	
Fig. 19. Element sp ZPAL CVI/480, sample MA-59.	
<i>Complexodus pugionifer</i> (DRYGANT, 1974)	106
Fig. 20. Element ne ZPAL CVI/490, sample MA-70.	
Fig. 21. Element hi ZPAL CVI/489, sample MA-70.	
Fig. 22. Element pl ZPAL CVI/486, sample MA-70.	
Fig. 23. Element tr ZPAL CVI/481, sample MA-70, × 110.	
Fig. 24. Element oz ZPAL CVI/488, sample MA-70.	
Fig. 25. Posterior process of element sp ZPAL CVI/491, sample MA-71.	
Fig. 26. Element sp ZPAL CVI/335, sample MA-21.	
<i>Complexodus</i> sp. A	107
Fig. 27. Posterior process of element sp ZPAL CVI/492, sample MA-87.	

All illustrations × 80, except when otherwise stated.

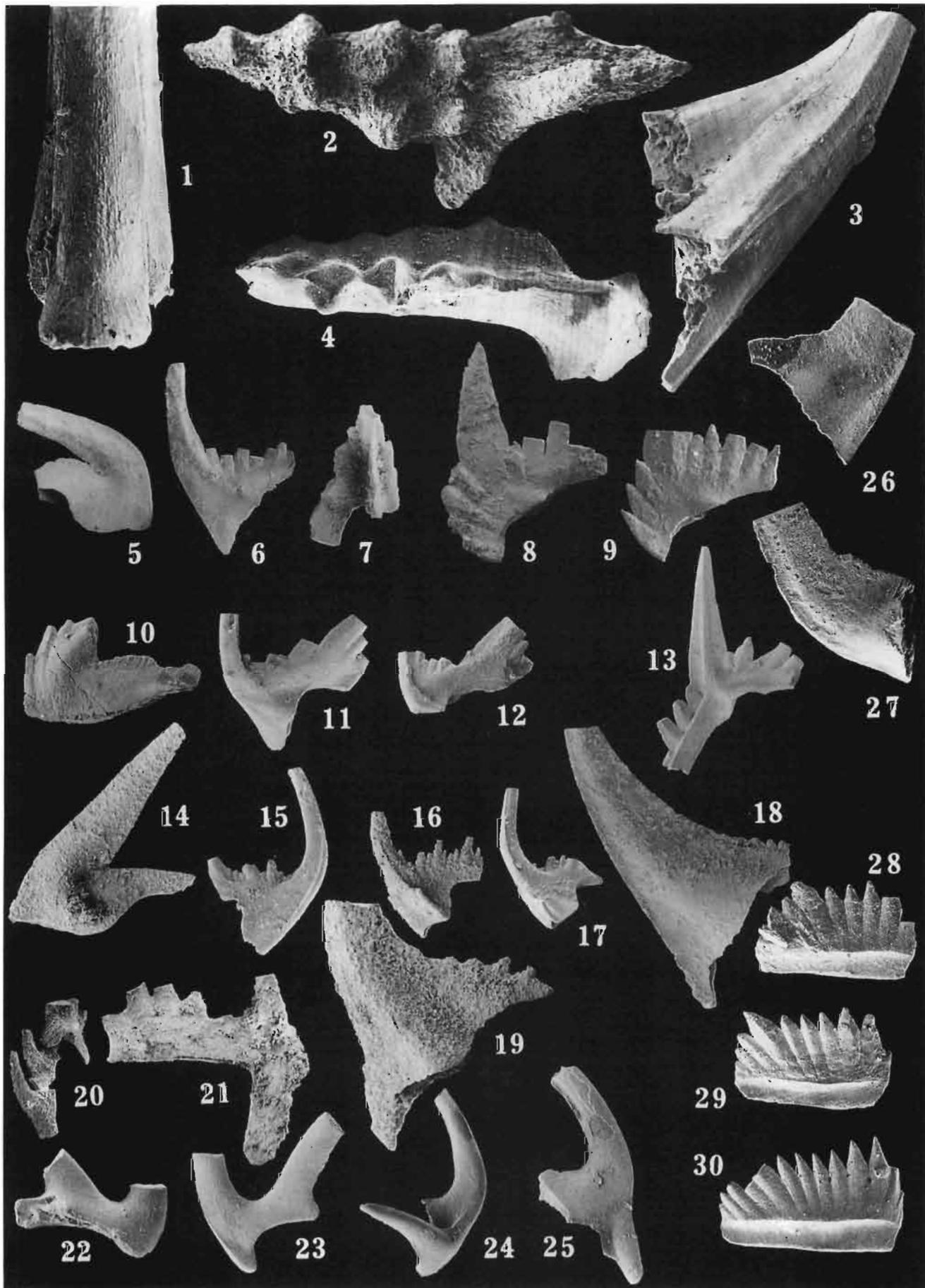


DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

DZIK: CONODONTS OF THE MÓJCZA LIMESTONE

PLATE 24

<i>Panderodus sulcatus</i> (FÄHRÆUS, 1966)	59
Fig. 1. Element tr ZPAL CVI/466 in medial view, sample MA-52 (see also Pl. 12: 24) × 215.	
<i>Icriodella prominens</i> ORCHARD, 1980.	109
Fig. 2. Element sp ZPAL CVI/718, sample MA-116.	
<i>Icriodella</i> n. sp. A NOWLAN, 1983.	109
Fig. 3. Element oz ZPAL CVI/719, sample MA-99.	
Fig. 4. Element sp ZPAL CVI/720, sample MA-98.	
<i>Microzarkodina ozarkodella</i> LINDSTRÖM, 1971	113
Fig. 5. Element ne ZPAL CVI/511, sample MA-131.	
Fig. 6. Element hi ZPAL CVI/510, sample MA-131.	
Fig. 7. Element pl ZPAL CVI/509, sample MA-124.	
Fig. 8. Element oz? ZPAL CVI/507, sample MA-131.	
Fig. 9. Element sp? ZPAL CVI/508, sample MA-131.	
<i>Periodon aculeatus</i> HADDING, 1913 late form.	111
Fig. 10. Element ne ZPAL CVI/704, sample MA-85.	
Fig. 11. Element hi ZPAL CVI/703, sample MA-69.	
Fig. 12. Element pl ZPAL CVI/705, sample MA-85.	
Fig. 13. Element oz? ZPAL CVI/702, sample MA-19.	
<i>Hamarodus brevirameus</i> (WALLISER, 1964)	111
Fig. 14. Element ne ZPAL CVI/701, sample MA-100.	
Fig. 15. Element hi ZPAL CVI/699, sample MA-100.	
Fig. 16. Element pl ZPAL CVI/700, sample MA-100.	
Fig. 17. Element tr ZPAL CVI/698, sample MA-100.	
Fig. 18. Element oz? ZPAL CVI/696, sample MA-100.	
Fig. 19. Element sp? ZPAL CVI/697, sample MA-118.	
<i>Amorphognathus ordovicicus</i> BRANSON <i>et</i> MEHL, 1933?	94
Fig. 20. Element ne ZPAL CVI/359, sample MA-1.	
<i>Yaoxianognathus?</i> sp.	114
Fig. 21. Element hi ZPAL CVI/714, sample MA-115.	
<i>Spinodus spinatus</i> (HADDING, 1913)	113
Fig. 22. Element ne ZPAL CVI/709, sample MA-79.	
Fig. 23. Element hi ZPAL CVI/706, sample MA-19.	
Fig. 24. Element pl ZPAL CVI/708, sample MA-42.	
Fig. 25. Element oz? ZPAL CVI/707, sample MA-57.	
<i>Tripodus?</i> sp.	79
Fig. 26. Element hi ZPAL CVI/665, sample MA-128.	
Fig. 27. Element oz? ZPAL CVI/664, sample MA-128.	
<i>Histiodella kristinae</i> STOUGE, 1984	110
Figs 28–30. Elements sp ZPAL CVI/711–713, sample MA-131.	
All illustrations × 80, except when otherwise stated.	



DZIK: CONODONTS OF THE MÓJCZA LIMESTONE