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Elżbieta PORĘBSKA

LATEST SILURIAN AND EARLY DEVONIAN GRAPTOLITES FROM ŻDANÓW SECTION, BARDO MTS. (SUDETES)

(30 Figs, 23 Tables)

Graptolity późnego syluru i wczesnego dewonu z profilu Żdanowa (Góry Bardzkie, Sudety)

(30 fig., 23 tabele)

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Abstract: In the Żdanow Section (Bardo Mts.) there is an almost continuous sequence of deep water sediments, ranging in age from the Late Ordovician to Early Devonian. These sediments represent the Bavarian facies. The Upper Silurian and Lower Devonian sediments contain a rich graptolite fauna from which twenty two graptolite taxons have been identified. Four of them are new. In the continuous section of the Upper Silurian — Lower Devonian black shales there occurs a succession of graptolite zones: transgrediens, uniformis s.l., hercynicus, falcarius, fanicus, and craigensis. The base of the uniformis Zone coincides with the Silurian-Devonian boundary. This boundary is situated within the homogeneous black shales. No change in lithology or sedimentary environment marks this boundary. In the Żdanow Section the extinction of the Silurian graptolites and the incoming of the Devonian graptolite assemblage is separated by a relatively short time interval. During this interval there has been a great increase in the abundance of relict *L. posthumus* (Reinh. Richter), showing a character of the population explosion. The appearance of the Devonian graptolites has here a migration character. Only one Devonian phylogenetic lineage — *aequabilis* — developed from the relict assemblage of Silurian age. The present observations on morphology and stratigraphic ranges of Early Devonian monograptids permit to make some implications on the phylogeny of three lineages: *uniformis*, *hercynicus*, and *aequabilis*. For the last, Devonian episode of the graptolite history, the phylastogeny of the *hercynicus* and *aequabilis* lineages is most representative. The predominating evolutionary changeability displayed by the sicula imparts to the evolution of Early Devonian graptolites its specific individuality.

Key words: graptolites, stratigraphy, evolution, Upper Silurian, Lower Devonian, Żdanów Section.

Elżbieta Porębska: Institute of Geological Sciences of Jagiellonian University, Kraków, Oleandry 2a.

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Treść: Profil Żdanowa reprezentuje najbardziej kompletnie zachowane następstwo osadów dolnopaleozoicznych (ordowik, sylur, dolny dewon) w Górach Bardzkich. Z górnosylurskich i dolnodewońskich osadów opisano 22 taksony graptolitów, w tym ustanowiono 4 nowe. Rozprzestrzenienie stratygraficzne graptolitów w obrębie analizowanego profilu najwyższego syluru i dolnego dewonu daje podstawy do wyróżnienia następujących zon: transgrediens, uniformis s. l., hercynicus, falcarius, fanicus i craigensis. Przyjęta granica sylur-devon pokrywa się ze spągiem zony uniformis i stropem zony transgrediens. Rozkład stratygraficznych zasięgów *M. uniformis Přibyl* i *M. transgrediens* Perner, oddzielonych interwałem bez graptolitów wskaźnikowych dla syluru czy dewonu („linograptid interregnum") jest identyczny jak w profilu stratotypowym granicy sylur-dewon w Klonk. Analiza zmian w obrębie graptolitów na granicy systemów wskazuje, że po wymarciu graptolitów z grupy *transgrediens* następuje migracja nowego zespołu faunistycznego *M. uniformis Přibyl*, *M. sudeticus* nov. sp. i *M. microdon* (Reinh. Richter). Jedynie jedna linia filogenetyczna — *aequabilis* — rozwija się na podłożu tubylczej fauny późnego syluru. Na podstawie obserwacji morfologii oraz stratygraficznych zasięgów dolnodewońskich graptolitów przedstawiono interpretację stosunków filogenetycznych w obrębie trzech linii rozwojowych: *uniformis*, *hercynicus* i *aequabilis*. Dla ostatniego, dewońskiego epizodu ewolucyjnego w historii graptolitów najbardziej reprezentatywna jest filastogeneza linii *hercynicus* i *aequabilis*. Dominująca ewolucyjna zmienność jedynego płciowego osobnika kolonii — sikulozoida — podkreśla odmienność ewolucji dolnodewońskich graptolitów w porównaniu z rozwojem wcześniejszych grup graptolitów.

INTRODUCTION

The Żdanów Section reveals the most complete sequence of Lower Palaeozoic rocks in the Bardo Mountains (Ordovician, Silurian and Lower Devonian). Of particular interest are here the Silurian and Lower Devonian sediments. These sediments contain a rich graptolite fauna which has not been investigated in detail. Silurian graptolites were first discovered here by Krugg von Nidda (1855). Further informations concerning the presence of these graptolites are found in papers by Frech (1898), Dathe (1904), Bederke (1924), Hundt (1924), Finckh (1932), and Fisher & Meister (1942). The graptolite zones from the upper Llandoverian to the lower Ludlovian were recognized by Malinowska (1955). The Early Devonian graptolites were first described by Jaeger (1959) and Teller (1960).

The present paper deals with the northern part of the Żdanów Section. In this part of the section, which has not yet been documented, a rich assemblage of graptolites (approx. 1 200 specimens) was found. Among these graptolites 22 species and subspecies have been identified. The interpretation of stratigraphic ranges of the taxons under discussion leads to the following conclusions: (1) in the section discussed there is a transition from the uppermost Silurian to the Lower Devonian and, (2) the section contains the Lower Devonian sediments (Lochkovian — middle Pragian). Because the graptolite-bearing section is complete and the stratigraphic succession known, it is possible to establish the evolutionary trend and probable phylogenetic history of Early Devonian monograptids. The reconstruction of this evolutionary development is the chief subject of the following considerations.

ACKNOWLEDGMENTS

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GEOLOGICAL SETTING

The Żdanów Section is situated in the northeastern part of the Bardo Mountains which represent one of the largest geological units of the Middle Sudetes (Fig. 1). The Bardo Mts. consist of Ordovician, Silurian and Lower Carboniferous rocks. The geological history of this region is highly complicated and there are still many unsettled questions concerning the stratigraphy and structure.

Oberc (1977) recognized two stages in the structural development of the Bardo Mts., (1) the geosynclinal stage which involves the Silurian and Devonian rocks and, (2) post-geosynclinal stage involving the Early Carboniferous rocks. An alternative explanation has been advanced by Wajsprych (1978). According to this author the Ordovician, Silurian, and Devonian rocks form here a large allochthonous complex distinguished as „melange complex of Żdanów". The complex involves also a considerable part of the Lower Carboniferous rocks. The melange in question was deposited at the final stage of evolution of the Bardo Basin, i.e., in the early late

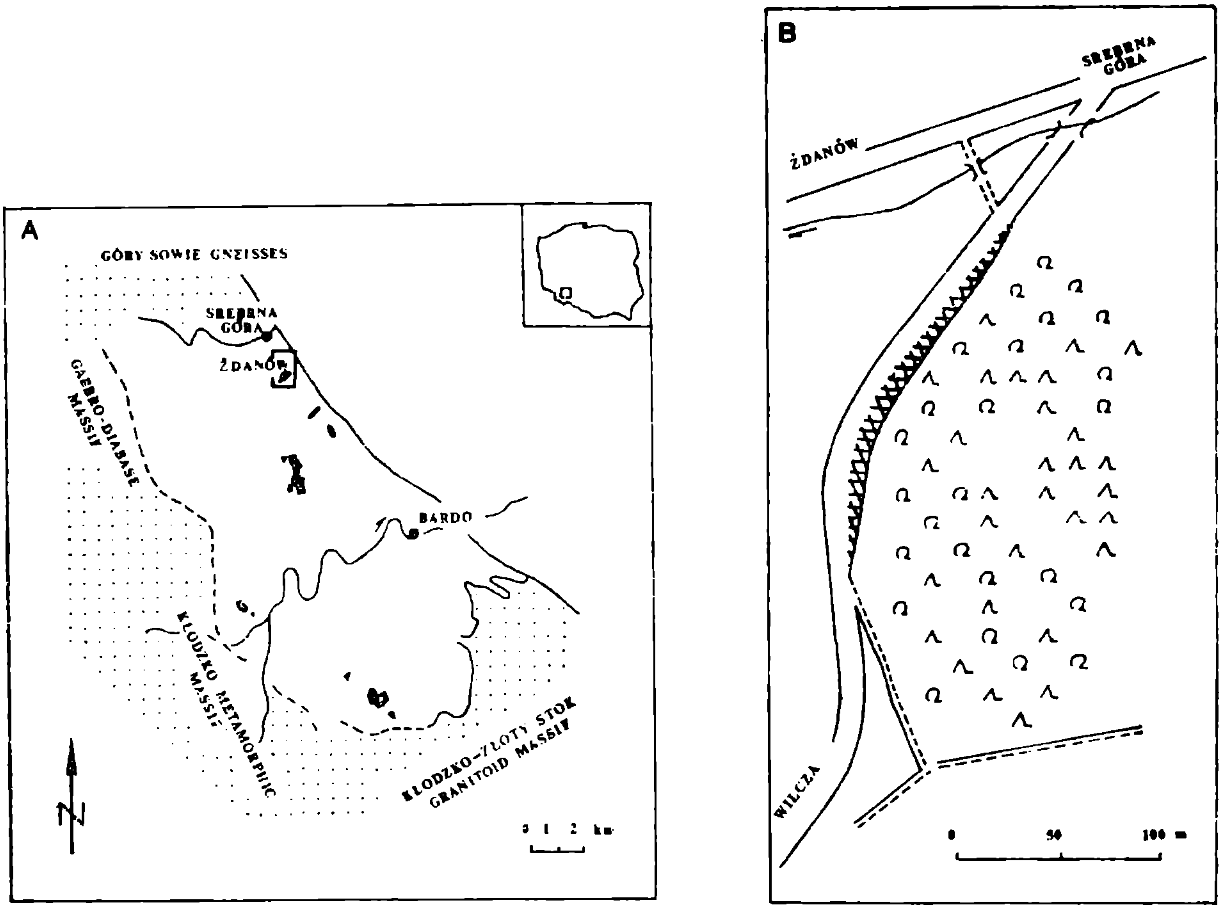

Fig. 1. Distribution of Lower Palaeozoic rocks (shaded areas) in the Bardo Mts. (A); location of the Żdanów Section in inset map (B)

Fig. 1. Występowanie skał dolnopaleozoicznych w Górach Bardzkich (obszary zaciemnione) (A) wraz z lokalizacją profilu Żdanowa (B)

Visean. The source area of the pre-Carboniferous deposits was presumably located in the eastern part of the Kaczawa Mts. which, at that time, were subjected to tectonic uplift.

The Żdanów Section also has been variously interpreted. According to Oberc (1957), the rocks here exposed constitute a faulted pseudosyncline. The oldest rocks, represented by the Ordovician quartzitic sandstones, occur in the central part of the pseudosyncline. The southern limb of the pseudosyncline is cut by a dislocation, the northern limb reveals a relatively complete sequence of the Silurian and Lower Devonian sediments.

The stratigraphic investigations by the present author provides the basis for reinterpretation of the tectonic structure of the Żdanów Section. These investigations have shown that in the northern part of the section, there is a repetition of a complete succession of diagnostic Early Devonian graptolite associations (Fig. 2, 4). This indicates that the sediments of the northern part of the Żdanów Section occur in the form of a normal syncline. There is a good reason to suppose that the section in question involves two faulted structures. One is the normal asymmetric faulted

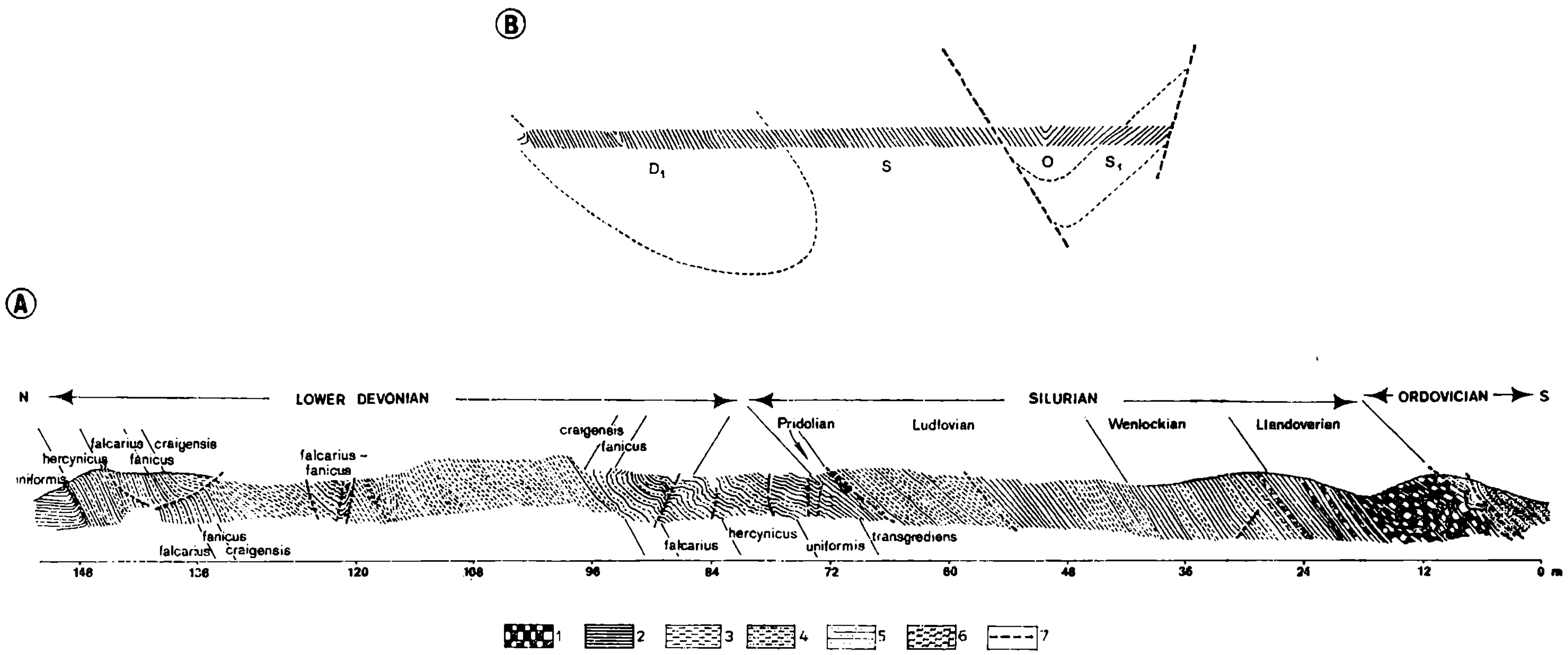

Fig. 2. Field-sketch showing lithology and tectonics of the Żdanów Section. 1 — lydites, 2 — black siliceous and argillaceous shales, 3 — green and gray argillaceous and siliceous shales, 4 — mudstones, 5 — sandstones, 6 — tuffites, 7 — tectonic contact

Fig. 2. Szkic geologiczny profilu Żdanowa wraz z interpretacją tektoniczną. 1 — lidyty, 2 — czarne łupki ilaste i krzemionkowe, 3 — zielone i szare łupki ilaste i krzemionkowe, 4 — mułowce, 5 — piaskowce, 6 — tufity, 7 — kontakt tektoniczny

syncline. The second, is the faulted pseudosyncline. Both these structures are separated from each other by a distinct surface of tectonic discontinuity (Fig. 2).

The northern limb of the normal syncline is made up of the Lower Devonian sediments. The southern limb, in addition to the Lower Devonian also comprises the Silurian deposists. These latter are in tectonic contact with the Ordovician shales and quartzitic sandstones that constitute a central part of the pseudosyncline. In both limbs of the normal syncline, the Lower Devonian sediments of the Żdanów Section reveal an uninterrupted stratigraphic continuity. This is evidenced by identical graptolitic succession and lithology in both limbs of the syncline (Fig. 4). Also the intercalations of tuff and the youngest layer of the black shale provide excellent key horizons which assume the same stratigraphic position in both limbs.

LITHOLOGY AND STRATIGRAPHY

ORDOVICIAN

The oldest sediments of the section consist of two units: (1) dark quartzitic sandstones (a few m thick) and, (2) light coloured mudstones and argillaceous shales (approx. 1 m). The second unit overlies unconformably the first one and both are separated from the overlying Silurian lydites by a tectonic discontinuity (Fig. 3). No fossils have been found in the above mentioned quartzitic and argillaceous sediments. The age of these sediments has been hitherto indicated either as Silurian (Dathe, 1904; Finckh et al., 1942; Oberc, 1957; Tomczyk, 1968) or Ordovician (Dahlgrün & Finckh, 1924; Malinowska, 1955; Teller, 1962).

SILURIAN

The Silurian sediments consist of a condensed sequence of lydites, black graptolitic shales, and light coloured shales with intercalations of tuffs (approx. 60 m). These sediments contain exclusively planctonic fauna: graptolites, conodonts, and radiolarians.

LLANDOVERIAN

This stage (17 m in thickness) is characterised by lydites and black siliceous-argillaceous shales containing phosphoritic nodules (Fig. 3). In the upper part of these sediments (7.5 m) the graptolite zones from Rastri-

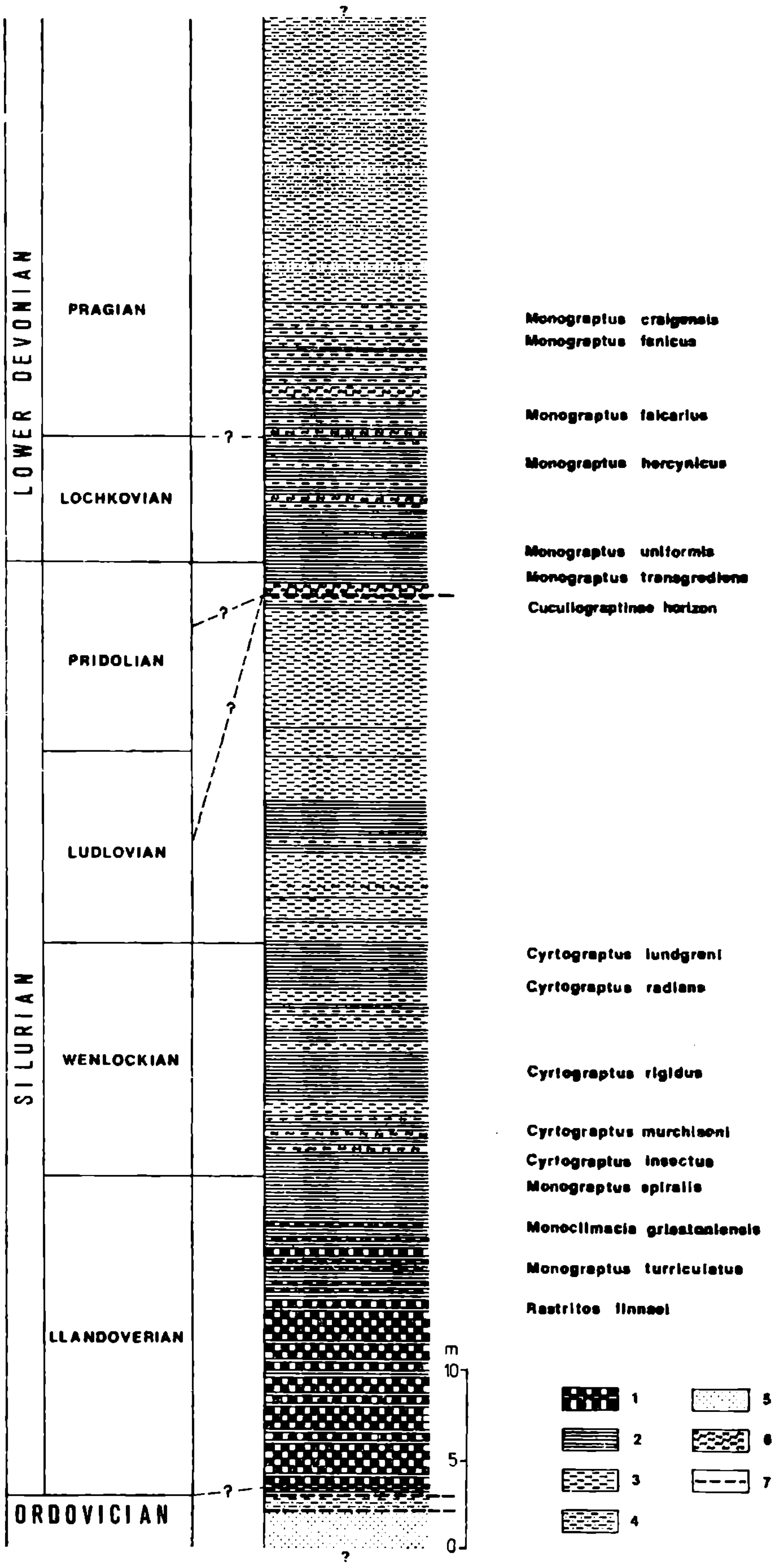

Fig. 3. Lithologic column showing succession of graptolite zones and the location of Silurian-Devonian boundary (S/D) in the studied section. For key to hachures, see caption in Fig. 2

Fig. 3. Litologia i biostratygrafia osadów ordowiku, syluru i dolnego dewonu profilu Żdanowa. Objaśnienia — patrz Fig. 2

tes linnaei to Monograptus spiralis have been recognized (Malinowska, 1955). The underlying lydites (9.5 m) correspond presumably to the lower Llandoverian. It is also possible that the lowermost part of the lydites may include the uppermost Ordovician (Porębska, 1980).

WENLOCKIAN

The sediments of this stage (13 m) include black argillaceous and argillaceous-siliceous shales intercalated with green-gray argillaceous shales (Fig. 3). In the lower and middle part of the above mentioned sediments there occur also brown tuffs and phosphoritic concretions. The following graptolite zones have been identified in the sediments under consideration: Cyrtograptus insectus, C. murchisoni, C. rigidus, C. radians, and C. lundgreni (Malinowska, 1955). The remaining zones of the Wenlockian are presumably enclosed in the unfossiliferous light coloured shales (Fig. 3).

LUDLOVIAN

The lower Ludlovian is made up of a 19 m thick sequence of green and grey-greenish argillaceous and siliceous shales. The sequence also contains rare intercalations of black argillaceous-siliceous shales (Fig. 3). In the uppermost part of the deposits discussed, the present author has identified *Saetograptus chimaera* (Barrande) and *Pristiograptus* sp. It is presumably in this part of the section where *Lobograptus scanicus* (Tullberg) mentioned by Malinowska (1955) comes from. The presence of the above indicated graptolites leads to the conclusion that the youngest Ludlovian sediments correspond to the Cucullograptinae horizon (sensu Teller, 1969).

PRIDOLIAN

Immediately above the lower Ludlovian sediments there occur tuffs and black argillaceous and siliceous shales of the lower Pridolian. These shales (1.8 m), however, are separated from the lower Ludlovian deposits by a tectonic discontinuity (Fig. 2, 3). In the black shales under consideration, the present author has indentified *M. transgrediens transgrediens* Perner, *M. transgrediens praecipuus* Přibyl, *M. chelmiensis* (Teller), *M. praeaequabilis* nov. sp., and *L. posthumus* (Reinh. Richter). Such graptolite assemblage suggests that the shales discussed correspond to the M. transgrediens Zone. Accordingly, in the Żdanów Section the sediments of the upper Ludlovian and lower Pridolian are missing. This is presumably due to tectonic disturbances.

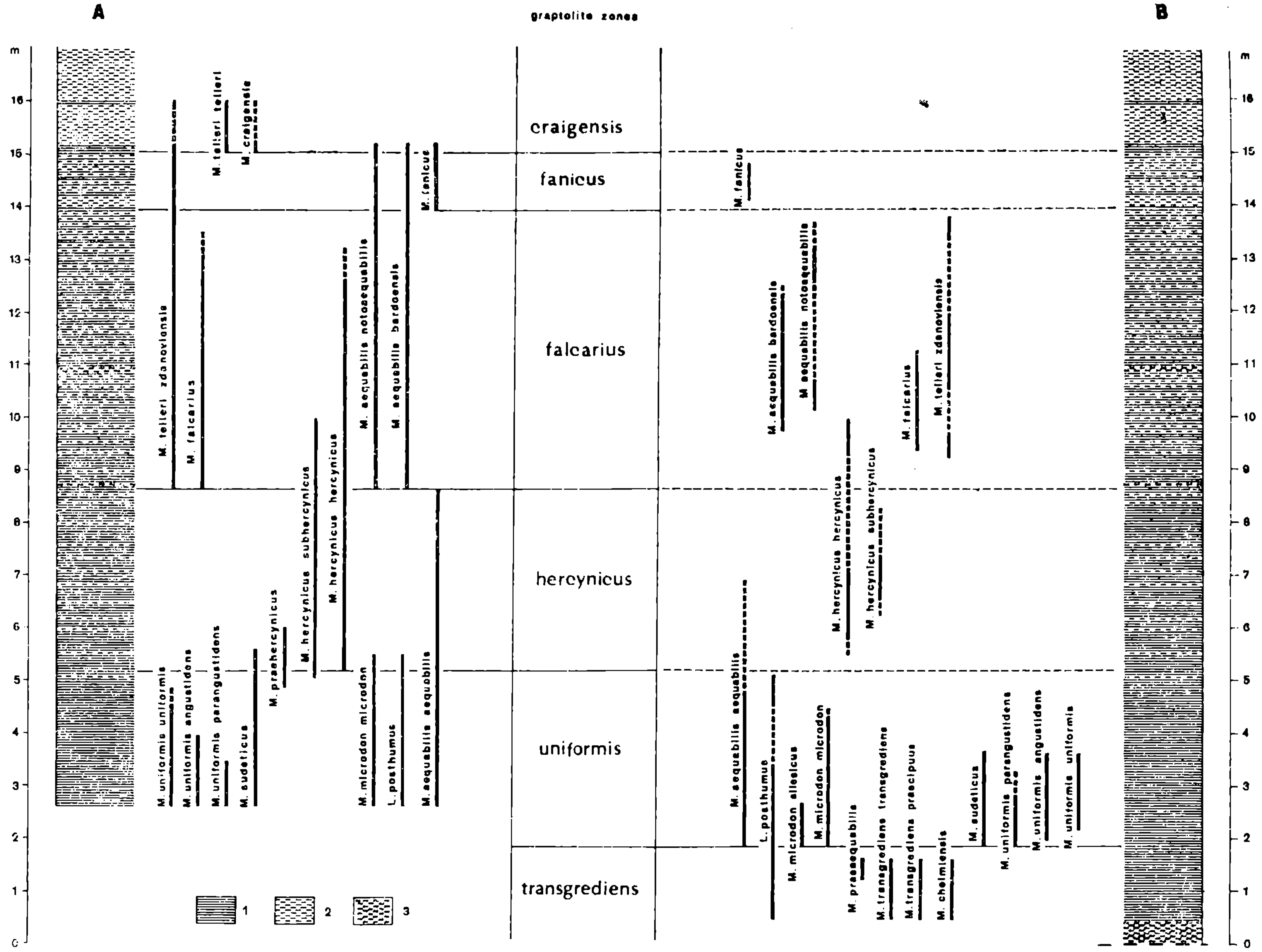

Fig. 4. Detailed lithologic columns of the uppermost Silurian and Lower Devonian strata forming northern (A) and southern (B) limbs of syncline in the Żdanów Section. Vertical lines show stratigraphic ranges of particular taxons here recorded. 1 — black argillaceous and siliceous shales, 2 — green and gray argillaceous and siliceous shales, 3 — tuffites

Fig. 4. Szczegółowy profil osadów najwyższego syluru i dolnego dewonu tworzących północne (A) i południowe (B) skrzydło synkliny w profilu Żdanowa. 1 — czarne łupki ilaste i krzemionkowe, 2 — zielone i szare łupki ilaste i krzemionkowe, 3 — tufity

LOWER DEVONIAN

The deposits which directly overlie the Silurian shales are attributed by the present author to the Devonian (Fig. 3). The lower part of these sediments (14 m) comprises black argillaceous-siliceous shales which are intercalated with light coloured siliceous-argillaceous shales. The upper part of the Lower Devonian (15 m) is composed exclusively of light coloured sediments such as green and yellow argillaceous shales and grey mudstones containing rare intercalations of fine-grained sandstones. The last intercalation of the black graptolitic shale appears at a distance of 14.1 m above the established base of the Devonian (Fig. 3). Starting from this place of the section, the graptolitic facies disappears entirely. The sediments which follow the last graptolitic shale intercalation belong to the Żdanów Beds (sensu Dathe, 1904). The lower part of the Devonian sediments contains graptolites, relatively rare conodonts, and tentaculites. In the overlying Żdanów Beds there are exclusively rare conodonts and tentaculites.

The following graptolite zones have been recognized in the lower part of the Lower Devonian sediments: M. uniformis, M. hercynicus, M. falcarius, M. fanicus, and M. craigensis. The complete succession of these zones have been identified in both limbs of the syncline (Fig. 4). However, the northern limb is palaeontologically better documented and the boundaries of the graptolite zones have been here determined precisely. In the southern limb the boundaries of the zones have been delineated by means of such diagnostic horizons as tuff intercalations (the bottom of the falcarius Zone), the first intercalation of light coloured shale (the top of the uniformis Zone) and the last intercalation of the black shale (within the craigensis Zone).

THE SILURIAN-DEVONIAN BOUNDARY IN THE ŻDANÓW SECTION

The transition from the Silurian to Devonian is observed in layers exposed in the central part of the Żdanów Section (Fig. 2). In these layers, the graptolites are the only fossils which permit to establish the Silurian-Devonian boundary. Conodonts which are sporadically found in

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Fig. 5. Succession of graptolite assemblages recorded in the Silurian-Devonian boundary beds of Żdanów Section. 1 — black siliceous-argillaceous shales, 2 — first occurrence of taxon, 3 — last occurrence of taxon, A — *M. transgrediens transgrediens* Perner, B — *M. transgrediens praecipuus* Přibyl, C — *M. praeaequabilis* nov. sp., D — *M. chelmiensis* (Teller), E — *L. posthumus* (Reinh. Richter), F — *M. uniformis uniformis* Přibyl, G — *M. uniformis angustidens* Přibyl, H — *M. uniformis parangustidens* Jackson & Lenz, I — *M. aequabilis aequabilis* (Přibyl), J — *M. sudeticus* nov. sp., K — *M. microdon silesicus* Jaeger, L — *M. microdon microdon* Reinh. Richter

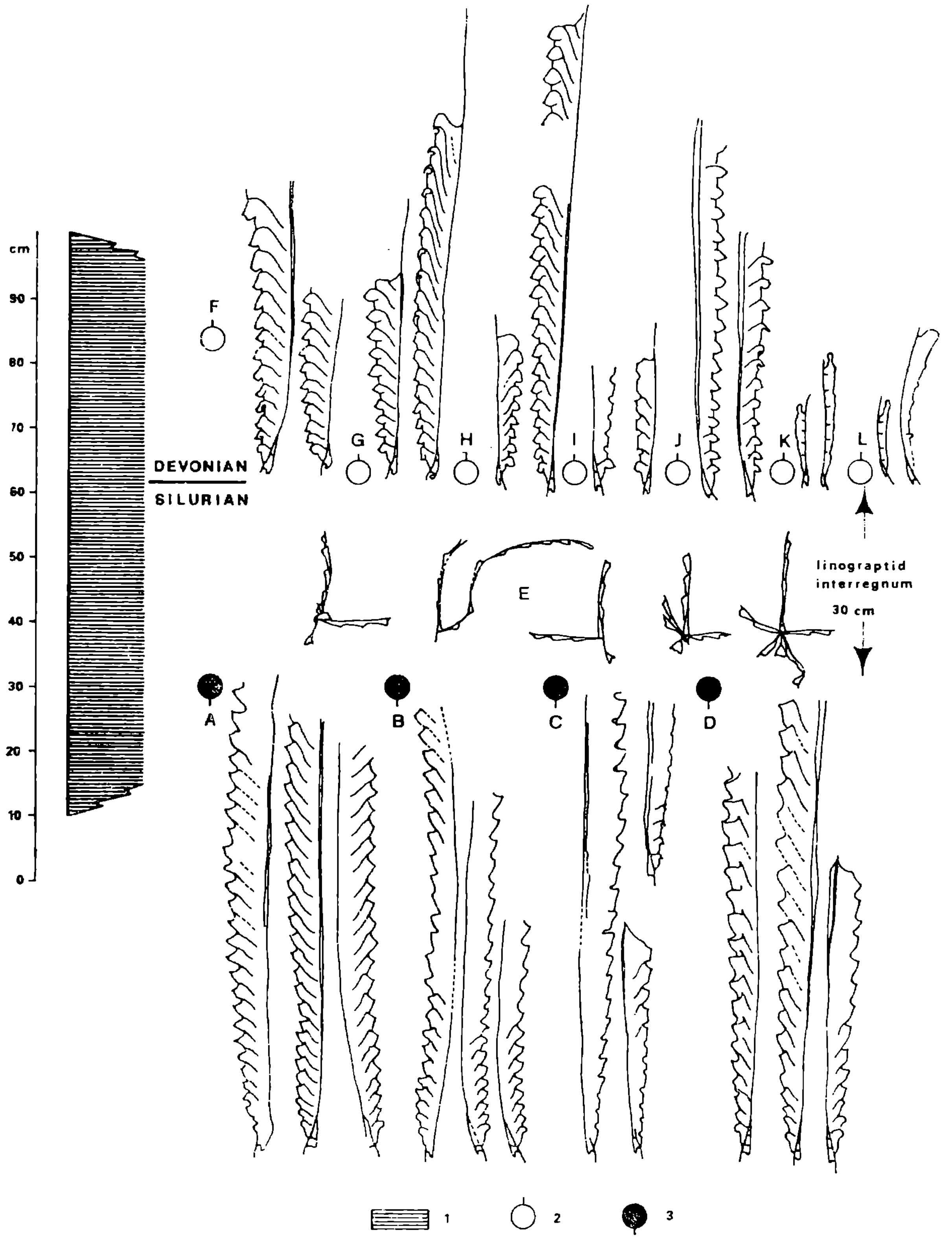

Fig. 5. Następstwo zespołów graptolitów w interwale warstw pogranicza syluru i dewonu w profilu Żdanowa. 1 — czarne łupki krzemionkowo-ilaste, 2 — pierwsze wystąpienie taksonu, 3 — ostatnie wystąpienie taksonu, A — *M. transgrediens transgrediens* Perner, B — *M. transgrediens praecipuus* Přibyl, C — *M. praeaequabilis* nov. sp., D — *M. chelmiensis* (Teller), E — *L. posthumus* (Reinh. Richter), F — *M. uniformis uniformis* Přibyl, G — *M. uniformis angustidens* Přibyl, H — *M. uniformis parangustidens* Jackson & Lenz, I — *M. aequabilis aequabilis* (Přibyl), J — *M. sudeticus* nov. sp., K — *M. microdon silesicus* Jaeger, L — *M. microdon microdon* Reinh. Richter

the layers under consideration have not yet been identified. The biostratigraphic control based on graptolites is so detailed that the boundary may be delineated with a high degree of precision (to a single bed).

The here accepted boundary between the Silurian and Devonian coincides with the base of the uniformis Zone and with the top of the transgrediens Zone. The boundary is situated within the homogeneous black shales, 14 m below the place where the graptolitic facies ends (Fig. 4). The drastic change in the graptolite fauna at the Silurian-Devonian boundary is not followed by any visible change in lithology (Fig. 5).

In the Żdanów Section there is, a 30 cm thick interval between the uppermost occurrence of Silurian graptolites of the *transgrediens* group and the lowermost appearance of the Devonian fauna (Fig. 5). This interval is devoid of diagnostic fossils, however, *L. posthumus* (Reinh. Richter) is of common occurrence (monograpitd „interregnum" sensu Chlupáč et al., 1972. Diagnostic taxa indicative of Lochkovian age tend to appear suddenly and in large qauntity. The first occurrence of *M. uniformis uniformis* Přibyl has been observed 30 cm above lowermost occurrence of *M. uniformis angustidens* Přibyl, *M. uniformis parangustidens* Jackson & Lenz, *M. aequabilis aequabilis* Přibyl, *M. microdon silesicus* Jaeger, *M. microdon microdon* Reinh. Richter, and *M. sudeticus* nov. sp. (Fig. 5).

The correlation of the Silurian-Devonian boundary as delineated in the Żdanów Section with the boundary stratotype at Klonk (Barrandian) can only be accomplished on the base of the graptolite fauna. The stratigraphic distribution of *M. uniformis* Přibyl and *M. transgrediens* Perner separated by the „linograptid interregnum" in the Żdanów sequence is practically identical with that of the stratotype section. Therefore, the correlation can be made with a considerable accuracy. As it is the case with the section at Klonk (Chlupáč & Kukal, 1977), the base of the uniformis Zone sensu lato also coincides with the boundary between the Silurian and the Devonian.

The fossils from Żdanów permit to trace changes in graptolite fauna contained in the Silurian-Devonian boundary beds.

The lowermost occurrence of *M. uniformis parangustidens* Jackson & Lenz and *M. uniformis angustidens* Přibyl is not to be identified with their evolutionary appearance. These monograptids are known from the uppermost Silurian beds in Canada (Lenz, 1977), Roumania (Rickards & Iordan, 1975) and Poland (Tomczyk et al., 1977). The speciation point of *M. uniformis uniformis* Přibyl arbitrary accepted in the continuous morphological sequence of the *uniformis* lineage, 30 cm above the Silurian-Devonian boundary, does not correlate with the evolutionary events in other phylogenetic lineages of graptolites.

In the upper part of the transgrediens Zone there is a characteristic morphologic variability within the *M. praeaequabilis* nov. sp. population, which is regarded by the present author as the beginning of the mosaic evolution within the *aequabilis* phylogenetic lineage. This variability brings about the appearance of *M. aequabilis aequabilis* Přibyl and, probably, *M. ramstalensis* Jaeger in the horizon that is equivalent to the Silurian-Devonian boundary in Żdanów (see Systematic Palaeontology).

The occurrence of *M. microdon microdon* Reinh. Richter in the Żdanów Section cannot be interpreted in terms of evolution. The above mentioned species has been reported from the uppermost Silurian in Nevada (Berry & Murphy, 1975). If there are any evolutionary changes in the *microdon* phylogenetic lineage synchronous with the Silurian-Devonian boundary, such changes may correspond to morphological transformations at the subspecies level.

At the present state of knowledge, the character of the lowermost occurrence of *M. sudeticus* nov. sp. cannot be assessed. It is not known whether the evolutionary appearance of this species coincides with the Silurian-Devonian boundary or dates back to pre-Devonian time.

From the above considerations the following conclusions can be drawn. In the Żdanów Section the extinction of the Silurian graptolites belonging to the *transgrediens* group, and the incoming of the new Devonian graptoloid assemblage are separated by a relatively short time interval. During this interval there has been a strong quantitative increase of the relict *L. posthumus* (Reinh. Richter), showing a character of the population explosion.

The appearance of the majority of the Devonian graptolites has here a migration character. Only one Devonian phylogenetic lineage — *aequabilis* — has developed from relict assemblage of Silurian age.

In Bardo Basin the faunal transformations within the Silurian-Devonian boundary interval occurred presumably under stable abiotic conditions. These transformations may be attributed to changes within the biotic environment (similar transformations have been reported by Urbanek, 1970 from the Ludlovian graptolites of eastern and northern Poland). Such changes explain the „natural" character of the Silurian-Devonian boundary at Żdanów as established by the graptolite assemblage (the term "natural" is used in the meaning of Hedberg, 1976).

LOWER DEVONIAN GRAPTOLITE ZONES OF THE ŻDANÓW SECTION

As demonstrated by Jaeger (1959, 1962, 1964), the succession of Lochkovian fauna in Thuringia and Barrandian has been confirmed in a number of other sections in different regions. The above mentioned author established in the Lochkovian the following zones; uniformis, praehercynicus, and hercynicus. However, only the uniformis and hercynicus Zones are of importance for intercontinental correlation. The geographical distribution of the praehercynicus Zone as compared with that of uniformis and hercynicus is more limited and, therefore, of minor value for correlation.

The stratigraphic succession of Pragian graptolites is not well known. The biostratigraphic division of the Pragian based upon graptolites is not yet universally recognized. Only Koren' (1971, 1974, 1975, 1978a, b) has founded the zonal scheme upon the evolutionary sequence of post-hercynicus fauna. The above mentioned author has shown that in the regions of Pai-Khoi (Urals), Tien-Shan and South Fergana, it is possible to distinguish still younger graptolites zones. In the time interval between the hercynicus and yukonensis Zones (the latter has already been defined earlier in Canada by Lenz, 1967) Koren' identified the falcarius, fanicus and craigensis Zones.

The significance of the zonal scheme proposed by Koren' goes beyond the regions of her studies. Recent investigations of the Żdanów Section by the present author (Kurałowicz, 1976) have shown that this scheme can also be applied to the equivalent strata in Europe.

MONOGRAPTUS UNIFORMIS ZONE

In the Żdanów Section, the base of the uniformis Zone coincides with the Silurian-Devonian boundary. The top of this zone is marked by the appearance *M. hercynicus hercynicus* Perner, a fossil diagnostic of the hercynicus Zone. The uniformis Zone is typified by the incoming of *M. uniformis uniformis* Přibyl, *M. uniformis angustidens* Přibyl and *M. uniformis parangustidens* Jackson & Lenz, which are limited to this zone. The above mentioned graptolites are associated with *M. sudeticus nov.* sp., *M. aequabilis aequabilis* Přibyl, *M. microdon microdon* Reinh. Richter and *M. microdon silesicus* Jaeger. The latter is confined to the lower part of the zone in question. Towards the top of this zone, *M. praehercynicus* Jaeger and *M. hercynicus subhercynicus* Willefert appear. The uniformis Zone is characterized also by the mass-occurrence of *L. posthumus* (Reinh. Richter).

MONOGRAPTUS HERCYNICUS ZONE

In the Żdanów Section, the hercynicus Zone is defined as a Consecutive-range-zone. The lower boundary of the zone is marked by the evolutionary appearance of *M. hercynicus hercynicus* Perner. The upper boundary is located at the point of the first evolutionary occurrence of *M. falcarius* Koren'. *M. hercynicus subhercynicus* Willefert and *M. aequabilis aequabilis* Přibyl are still common, but *M. microdon microdon* Reinh.

Richter and *L. posthumus* (Reinh. Richter) are restricted to the lowest part of the zone. The full faunal suite is summarized in Fig. 4.

The hercynicus Zone in the Żdanów Section was established for the first time by Teller (1960). According to the present author, however, the graptolite fauna described by Teller corresponds to a younger stratigraphic unit. This fauna consists of numerous rhabdosomes of *M. telleri* Lenz & Jackson and *M. aequabilis notoaequabilis* Jaeger & Stein and of the late population of *M. hercynicus hercynicus* Perner.

Teller (1960, 1969) suggested the possibility of differentation of the praehercynicus Zone in the Żdanów Section. This suggestion was based upon the paper by Jaeger (1959) who described *M. praehercynicus* from the collection housed in the Museum in Görlitz (GDR). According to Jaeger (1959) this species in the Żdanów Section coexists with *M. microdon silesicus* Jaeger. The investigations made by the present author indicate that *M. praehercynicus* Jaeger appears in the Żdanów Section at the top of the uniforms Zone and only 30 cm below the lowest occurrence of *M. hercynicus hercynicus* Perner. *M. praehercynicus* Jaeger disappears already in the lowermost part of the hercynicus Zone. On the other hand, *M. microdon silesicus* Jaeger occurs exclusively in the lower part of the uniformis Zone and does not coexist with *M. praehercynicus* Jaeger. Thus, the recognition of the praehercynicus Zone in the Żdanów Section is unjustified.

MONOGRAPTUS FALCARIUS ZONE

The falcarius Zone has been identified in the Żdanów Section as a Consecutive-range-zone. The time of evolutionary appearance of the name-giver delineates the lower boundary of the zone. The upper boundary has been delineated at the point of the first occurrence of *M. ianicus* Koren'. Contemporaneously or pene-contemporaneously with the *M. falcarius* Koren' there appear here *M. telleri zdanoviensis* nov. subsp., *M. aequabilis notoaequabilis* Jaeger & Stein and *M. aequabilis bardoensis* nov. subsp. (Fig. 4). These taxons are not known from older layers.

The Żdanów Section is the third locality beside Pai-Khoi and South Fergana where it is possible to determine precisely the stratigraphic range of the species *M. falcarius* Koren'. However, the bottom of the falcarius Zone as delineated in Żdanów is not characterized by such a distinct change in the graptolite assemblage as it is observed in Pai-Khoi (Koren', 1975). In Żdanów the replacement of the Lochkovian graptolite assemblage by younger graptolites is gradual (Fig. 4). In Pai-Khoi and South Fergana, however, none of the Lochkovian graptolites has been found above the hercynicus-falcarius boundary (Koren' 1975, 1978b).

MONOGRAPTUS FANICUS ZONE

The fanicus Zone, in the Żdanów Section has been defined as a Partial-range-zone. The bottom of this zone coincides with the lower boundary of the stratigraphic range of *M. fanicus* Koren'. The upper boundary is marked by the first appearance of the index fossil of the craigensis Zone. The fanicus Zone is characterized by the presence of monograptids such as *M. telleri zdanoviensis* nov. subsp., *M. aequabilis notoaequabilis* Jaeger & Stein, and *M. aequabilis bardoensis* nov. subsp. These graptolites are known from the falcarius Zone.

MONOGRAPTUS CRAIGENSIS ZONE

In the Żdanów Section the lower boundary of the craigensis Zone coincides with a distinct morphological change within the late population of *M. telleri* Lenz & Jackson. Similar situation exists in the section of Darai-Khurd, Tien Shan (Koren' 1975, p. 15). In our section the above indicated change resulted in the speciation of *M. craigensis* Jaeger and *M. telleri* Lenz & Jackson. The upper boundary of the zone in question has not been determined in the study section. This is due to the fact that the black graptolite-bearing shales disappear at the distance of ca. 1 m above the lower boundary of the zone (Fig. 4).

In discussing the Żdanów Section, Jaeger (1978) questioned the presence of graptolites younger than the *hercynicus* fauna. The sediments that in the present writer's opinion belong to the falcarius, fanicus and craigensis Zones are regarded by Jaeger as representing the uniformis and hercynicus Zones. In Jaeger's interpretation these zones are thought to be tectonically repeated (Jaeger, oral information, 1977). On the other hand, Koren' (1977; and oral information, 1978) has confirmed the presence of Pragian graptolites in the section discussed and identified here diagnostic taxons of the falcarius Zone — i.e., *M. falcarius* Koren' and *M. aequabilis notoaequabilis* Jaeger & Stein.

The fanicus and craigensis Zones have been distinguished by the present author in sediments which are linked with the shales of the falcarius Zone by an unquestionable sedimentary transition without any visible break in sedimentation. The sediments of the fanicus and craigensis Zones differ drastically from those belonging to the uniformis and hercynicus Zones. The uniformis Zone is enclosed in the black shales (Fig. 4). The first intercalation of the light coloured shales appears at the top of the above mentioned zone. The hercynicus Zone in the study profile is comprised of black and light shales. In the falcarius Zone there is a distinct increase in light coloured shales (Fig. 4). It is also in this zone exclusively where the water-laid tuffs occur. On the other hand, in the fanicus Zone, the black shales are decidedly subordinate in amount to light coloured ones and tend to disappear entirely in the lower part of the craigensis Zone (Fig. 4). This change in colour is associated with a gradual change in mineralogical composition. The shales of the uniformis Zone are siliceous and those of the craigensis Zone are argillaceous. The above mentioned changes in colour and composition of the shales discussed are repeated on both limbs of the syncline.

From the foregoing considerations it appears that the zones distinguished in the Żdanów Section differ one from another not only in their assemblages of characteristic graptolites but also in lithology. The lithology imparts to each of these zones, a specific individuality.

Another question is that of the change of the graptolite assemblages. New suite of graptolites appears in the layers situated above the hercynicus Zone. In this suite such graptolites like *L. posthumus* (Reinh. Richter) and *M. microdon* Reinh. Richter are missing. These species are of common occurrence in the uniformis and hercynicus Zones and their mass-appearance is a characteristic feature of these zones. According to Jaeger (1977b, p. 345) the most distinctive gross feature of the Pragian fauna is the absence of *Abiesgraptus* and *Linograptus*.

In the present author's opinion the controversy arises from difficulties in proper identification of morphologically very similar graptolites which coexist with *M. falcarius* Koren' and *M. aequabilis notoaequabilis* Jaeger & Stein and occur above the range of *M. falcarius* Koren'. Among these graptolites there are newly created taxons as well as those previously recognized. The taxonomic position of these latter is not always precisely established. This is often due to purely typologic approach to the taxonomy on the part of some authors.

The present writer emphasizes the dominant role of the sicula in the evolution of the youngest graptolites and the great importance of the sicula for taxonomy. Therefore, in general, the opinion of the present writer differs slightly from that hitherto held with regard to the taxonomic value of specific morphological features. Consequently, the taxonomic classification accepted in this paper also differs somewhat from that of other authors. It is realized that such classification is open to discussion.

The undisputable fact, however, is the presence of the Pragian graptolite assemblage in the Żdanów Section. The occurrence of graptolites younger than the falcarius Zone fauna is also unquestionable.

CORRELATION

The Ordovician, Silurian,, and Lower Devonian sediments of the Żdanów Section show a striking similarity to the corresponding deposits known from Saxony, Bavaria and Lusatia. All these sediments are of pelagic, deep-water origin and represent so-called Bavarian facies (Jaeger, 1977a). The deposits here described were laid down in the eastern part of the Bavarian Basin. In the type profile of the Bavarian facies four lithostratigraphic units have been distinguished (Jaeger, 1977a): (1) Döbra Sandstone, (2) Lower Graptolitic Shales, (3) Gray-greenish eβ Shales, and (4) Upper Graptolitic Shales.

The oldest sandy-argillaceous and muddy sediments of the Żdanów Section can be correlated with the Ordovician sandstones from Döbra (GDR), the Ordovician age of which has been documented palaeontologically. The Llandoverian, Wenlockian, and lower Ludlovian sediments from the section under consideration (50 m), consisting of lydites, black siliceous shales and, in the upper part of the section, of light coloured argillaceous shales, can be correlated with the Lower Graptolitic Shales of the Bavarian and Thuringian facies, which were developed in the time interval from the early Llandoverian to middle Ludlovian (middle part of eβ — 34/35 Zone according to Jaeger, 1977a).

In the Żdanów Section, the upper Ludlovian and lower Pridolian are absent. This is presumably due to tectonic disturbances. The equivalent sediments in the Bavarian facies of Saxony are represented by the gray--greenish shales eβ and in Thuringia by the Ockerkalk (ochre limestone).

In the Żdanów Section the black siliceous-argillaceous shales intercalated with the light coloured ones (16 m), that include the time interval from transgrediens Zone to, at least, hercynicus Zone, are presumably equivalent to the Upper Graptolitic Shales of Germany. As already noted, in the Żdanów Section there is a tectonic contact between the sediments of the transgrediens Zone and those of the lower Ludlovian. Therefore, it is impossible to establish whether or not the original lower boundary of the Upper Graptolitic Shales corresponds to the base of the transgrediens Zone.

In Germany, the top of the Upper Graptolitic Shales correlates with the upper boundary of the hercynicus Zone (see Jaeger, 1977a). According to Jaeger (1977b), in many regions of Europe and North Africa, this boundary coincides with the disappearance of graptolite-bearing facies, which is so characteristic of the Silurian and Lochkovian. In Bavaria the graptolitic facies is replaced by light siliceous and argillaceous shales; in Thuringia it is superseded by tentaculite-bearing limestone.

In the Żdanów Section the Upper Graptolitic Shales are followed by the previously described Żdanów Beds. The deposition of these beds reflects the disappearance of euxinic conditions in the eastern part of the Bavarian Basin during the earliest Devonian. The evanescence of the graptolitic facies occurred here during the sedimentation of shales with *M. craigensis* Jaeger, i.e., latter than it was suggested by Jaeger (1977b).

Consequently, the evidence from the Żdanów Section does not confirm the hypothesis of synchronous disappearance of the graptolitic facies advanced by the above mentioned author. Also heterochronous is the beginning of the deposition of the Lower Graptolitic Shales and the end of the sedimentation of the Döbra Sandstone. The light coloured shales devoid of graptolite fauna appear in the Żdanów Section already in the Wenlockian and are dominant in the lower Ludlovian. Therefore, the tripartition of the Silurian and Lower Devonian deposits is not here such clear as in the type sections of the Bavarian facies.

AGE OF THE UPPER GRAPTOLITIC SHALES

The succession of graptolite zones from transgrediens to craigensis recognized in the Żdanów Section corresponds to the Upper Graptolitic Shales. The uninterrupted succession of these zones enables the exact correlation with the Bohemian Upper Silurian and Lower Devonian stages.

On graptolite evidence the base of the Upper Graptolitic Shales embracing the transgrediens Zone corresponds to the late Pridolian. The part of these shales which includes the uniformis and hercynicus Zones is of Lochkovian age.

The exact position of the upper boundary of the Lochkovian stage in the sequence of graptolite zones is difficult to establish (Chlupáč, 1976; Koren', 1978b). For the purpose of broad correlation and using the Czechoslovakian chronostratigraphic stages as a standart, it is more convenient to place the boundary of the Lochkovain and Pragian at the base of the falcarius Zone (Koren', 1978b).

Therefore, in the Żdanów Section, the uppermost part of the Upper Graptolitic Shales that overlies the hercynicus Zone and includes falcarius — craigensis Zones, is assigned to the lower and middle Pragian.

PHYLOGENY OF EARLY DEVONIAN GRAPTOLITES

The present observations on morphology and stratigraphic distribution of Early Devonian graptolites permit to make some implications on the phylogeny of three lineages: *uniformis*, *hercynicus*, and *aequabilis*. It should be added, however, that several of the interpretations presented below must still be considered as speculative because relatively few of the taxons here discussed are represented by well-preserved specimens.

The present author also includes into the following considerations the Devonian graptolites which are known from other regions but are absent in the Żdanów Section.

EVOLUTION OF *UNIFORMIS* LINEAGE

Jaeger (1959) suggested that there is a morphological and chronological succession of the following graptolites: *M. uniformis* Přibyl, *M. praehercynicus* Jaeger, and *M. hercynicus* Perner. This order of appearance was corroborated later in different parts of the World, and this strengthened the opinion on the direct phylogenetic relations between these species (cf. Berry & Murphy, 1975; Urbanek, 1973; Rickards et al., 1977; Koren', 1978a). According to this concept, the main evolutionary trends were, among others, the decrease in rhabdosome length and width, increasing crowding of thecae, shortening of sicula and change of its shape (Jaeger, 1959). The origin of *M. praehercynicus* and *M. hercynicus* was supposed to be connected with rapid morphological changes; in the former case, this was the abrupt decrease in rhabdosome width, in the latter, a stepwise widening of sicular aperture. In the species, *M. uniformis* (in which *M. angustidens* Přibyl was also included) Jaeger (1959) did not assume any evolutionary changes. According to this author the side lines of the *M. uniformis* — *M. hercynicus* lineage were supposedly those of *M. ramstalensis* Jaeger and *M. keyseri* Perner.

The observations on phylogenetic modifications of astogeny in *M. uniformis*, based on the Żdanów material, suggest that this species is not directly related to *M. praehercynicus*. The evolutionary trends observed in *M. uniformis* are not continued in the line *M. praehercynicus* — *M. hercynicus* and the stepwise morphological changes connected with the origin of *M. praehercynicus* and *M. hercynicus* seem unconvincing.

In the present author's opinion there are reasons to propose a different concept of the *uniformis* lineage. In the Early Devonian this lineage would

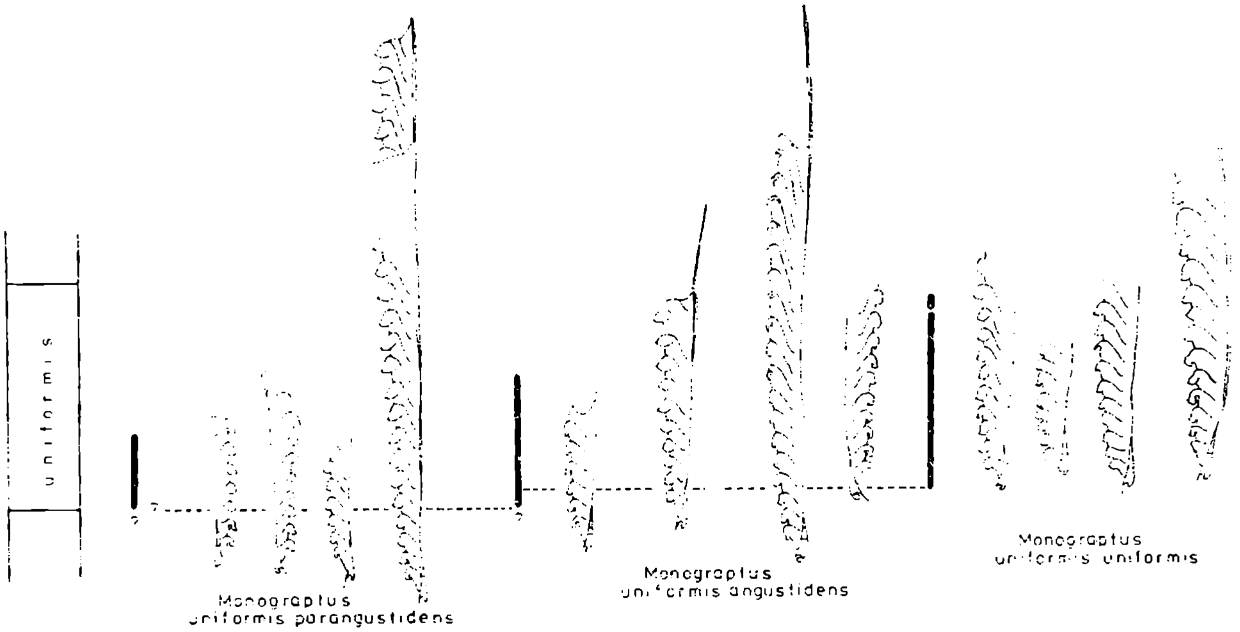

Fig. 6. Phylogenetic scheme suggested for the *uniformis* lineage

Fig. 6. Rekonstrukcja stosunków filogenetycznych w linii rozwojowej *uniformis*

Table 1

Species	S_{rh}				Σ	Sicula		L_{th}		N./10 mm
	th_1	th_1/th_2	th_{10}	max.		L_s	S_a	distal.	medial.	
M. uniformis parangustidens	0.60—0.90 (0.50—0.57)	0.45—0.56	1.30—1.70 (1.00—1.30)	1.80—2.00 (1.60—1.70)	1.30—1.50	1.60—1.95	0.30—0.38	3.20—2.50	2.40—2.50	$10^1/_2$—11
M. uniformis angustidens	0.85—1.05 (0.50—0.70)	0.50—0.75	1.55—1.76 (1.30—1.50)	2.10 (1.80)	1.30—1.50	1.60—2.00	0.30—0.45	3.50—2.70	2.50	$10^3/_4$—$11^1/_2$
M. uniformis uniformis	0.90—1.06 (0.60—0.80)	0.75—0.90	1.90—2.20 (1.60—1.90)	2.60—3.20 (2.30—2.90)	1.05—1.26	1.50—1.90	0.35—0.45	—	2.60	$10^1/_2$—$11^1/_2$

be represented by a succession of only three subspecies: *M. uniformis parangustidens* Jackson & Lenz, *M. uniformis angustidens* Přibyl, and *M. uniformis uniformis* Přibyl (Fig. 6). The evolution of these taxons would be one, possibly the last stage of the Silurian-Devonian history of the *uniformis* lineage.

In the ancestral-descendant succession of the *uniformis* lineage, as recognized on the Żdanów material, the following evolutionary trends emerge:

(1) the change in degree of dorsal curvature of proximal part of rhabdosome from distinct in *M. uniformis parangustidens* through weak in *M. uniformis angustidens* to slight or none in *M. uniformis uniformis* (Fig. 6).

(2) the phylogenetic increase in rhabdosome width most distinct within its proximal part (Table 1) and change of character of the rhabdosome widening — from gradual in *M. uniformis parangustidens* to relatively abrupt in *M. uniformis uniformis,*

(3) the increase in length of the thecae (Table 1); the transversal section across distal thecae cuts across two interthecal septa in *M. uniformis parangustidens* and across three of these in *M. uniformis angustidens* and *M. uniformis uniformis,*

(4) the decrease in the distance between the apical part of the hood of th_1 and the sicular aperture (Table 1),

(5) the increase in width of the sicular aperture (Table 1).

The morphological evolutionary changes in the species *M. uniformis* are slow and continuous. Their character confirms the rightness of the widely accepted taxonomy of graptolites belonging to the *uniformis* group (Koren', 1967, 1968a; Jaeger, 1971; Jackson & Lenz, 1972). However, the morphological limits between the subspecies included in *M. uniformis* have not been precisely defined. The continuity of quantitative and qualitative features in the *uniformis* lineage makes the taxonomic classification difficult, the more so as the stratigraphic ranges of the particular subspecies are to high degree overlapping (Fig. 6).

Because of irregular distribution and small quantity of specimens of *M. uniformis* in the particular beds of the Żdanów Section the application of biometric analysis was not possible. The distinguishing of the particular taxons was based on evaluation of differences between transient rhabdosomes by means of conventional principles employed in taxonomic interpretation (Mayr, 1974). The limits between the particular subspecies are arbitrary ones.

The stratigraphic ranges of the subspecies of M. uniformis are not well recognized; this concerns especially the lower limits. The striking similarity between *M. uniformis parangustidens* and *M.* aff. *angustidens* from the lower Pridolian of the Porcupine River profile (Jackson & Lenz, 1969), implying that both forms may represent the same taxon, suggests that

M. uniformis appears for the first time in the earliest Pridolian. The upper range limit of this species seems to coincide with the upper limit of the uniformis Zone as it has never been recorded with *M. hercynicus*. Then, the known, Silurian part of the *uniformis* line may be represented by *M.* aff. *angustidens, M. uniformis parangustidens* and probably also by *M. birchensis* Berry & Murphy recorded from the uppermost Pridolian (considered by the author phylogenetically close to *M. uniformis parangustidens* and *M. uniformis angustidens*). The Silurian occurrence of *M. uniformis angustidens* is very probable but so far not sufficiently substantiated; the subspecies is characteristic of lowermost Lochkovian. The stratigraphic range of *M. uniformis uniformis* is relatively well known and seems to be restricted to the Devonian (the uniformis Zone).

Origin of *uniformis* lineage

The immediate ancestors of the *uniformis* lineage are not known as the knowledge on Late Silurian graptolites is still inadequate. Rickards and others (1977) suggest that earliest members of this lineage might have evolved from *M. balticus* Teller recorded from the Upper Ludlovian deposits of northern Poland (Teller, 1966), Canada (Jackson & Lenz, 1972), and Lithuania (Paškevicius, 1974; Tzegelnjuk, 1976). In the opinion of Koren' (1978). *M. balticus* represents a different line of development which in the Pridolian time was represented by the new species of graptolites found in Kazachstan but not yet described. According to this author, *M. uniformis* is phylogenetically related to *M. similis* Přibyl from the Lower Pridolian of the Barrandian (Přibyl, 1940).

The presented main tendencies of phylogenetic modifications of astogeny of the species *M. uniformis* imply that its ancestors probably possessed slim rhabdosomes widening gradually, with very distinctly curved proximal part. Thus, the suggestions made by Rickards and co-workers (1977) seem probable and well substantiated, especially those concerning *M.* cf. *balticus* from Canada, in which the apertural lobes are uniform, of hooded type and weakly curved.

In reconstructing of the initial stages of the *uniformis* lineage an important factor to be considered should be phylogenetic modifications of the thecal blastogeny. If *M. uniformis* is related to *M.* cf. *balticus,* one would suppose that the evolutionary transformation of thecal blastogeny, connected with the origin of the *uniformis* group, would consist in simplification of the hood structure.

EVOLUTION OF *HERCYNICUS* LINEAGE

It is believed that *M. hercynicus* Perner and the morphologically related older species *M. praehercynicus* Jaeger evolved from *M. uniformis* Přibyl, forming the lineage *M. uniformis* — *M. praehercynicus* — *M. hercynicus* (Jaeger, 1959). According to Koren' (1970) the last link in this lineage is *M. falcarius* Koren', the immediate descendant of *M. hercynicus.* Berry and Murphy (1975) suggested a slightly modified succession within the *hercynicus* lineage: *M. birchensis* Berry & Murphy — *M. praehercynicus* Jaeger — *M. hercynicus hercynicus Perner* — *M. hercynicus nevadensis* Berry. Jaeger (1970) supposed that if *M. thomasi* Jaeger was phylogenetically related to *M. yukonensis* Jackson & Lenz then the ancestry of the latter could be derived from *M. praehercynicus;* thus, this lineage should be treated as a side line of the *hercynicus* lineage. Lenz and Jackson (1971) noted a similarity between *M. praehercynicus* and *M. telleri* Lenz & Jackson which could be the ancestor of *M. yukonensis.* In the opinion of Koren' (1974, 1975) the roots of the *M.* telleri Lenz & Jackson — *M. craigensis* Jaeger — *M. yukonensis* Jackson & Lenz lineage are to be found among the population of *M. hemiodon* Jaeger.

The studies on graptolites from the Żdanów permit to modify the concept of phylogenetic relations within the *hercynicus* lineage. The presented reconstruction of the *hercynicus* lineage meant in a broad sense (Fig. 7 — see p. 113), is based on detailed observations on the nature and direction of evolutionary changes of sicular ontogeny and blastogeny of the remaining thecae in the particular taxons forming in the Żdanów Section a morphologically continuous succession.

M. sudeticus nov. sp. — *M. praehercynicus* Jaeger — *M. hercynicus subhercynicus* Willefert lineage

The oldest Devonian link of the *hercynicus* lineage is *M. sudeticus,* in which the rhabdosome is most primitive (straight, narrow, widening very gradually and having very narrow, ventrally curved sicula). In this species the phylogenetic modifications of astogeny concern mainly the sicula. Its gradual straightening and lengthening as well as widening of the sicular aperture lead to the *M. praehercynicus* stage. These changes are associated with an increase of the distance between the hood of th$_1$ and the sicular aperture and also with a slight widening of the proximal part of rhabdosome and larger crowding of the thecae (Table 2).

The link intermediate between *M. praehercynicus* and *M. hercynicus* is represented in the Żdanów Section by *M. hercynicus subhercynicus* The transition from *M. praehercynicus* to *M. hercynicus subhercynicus* is continuous and gradual; it consists in the reduction of the sicular dorsal

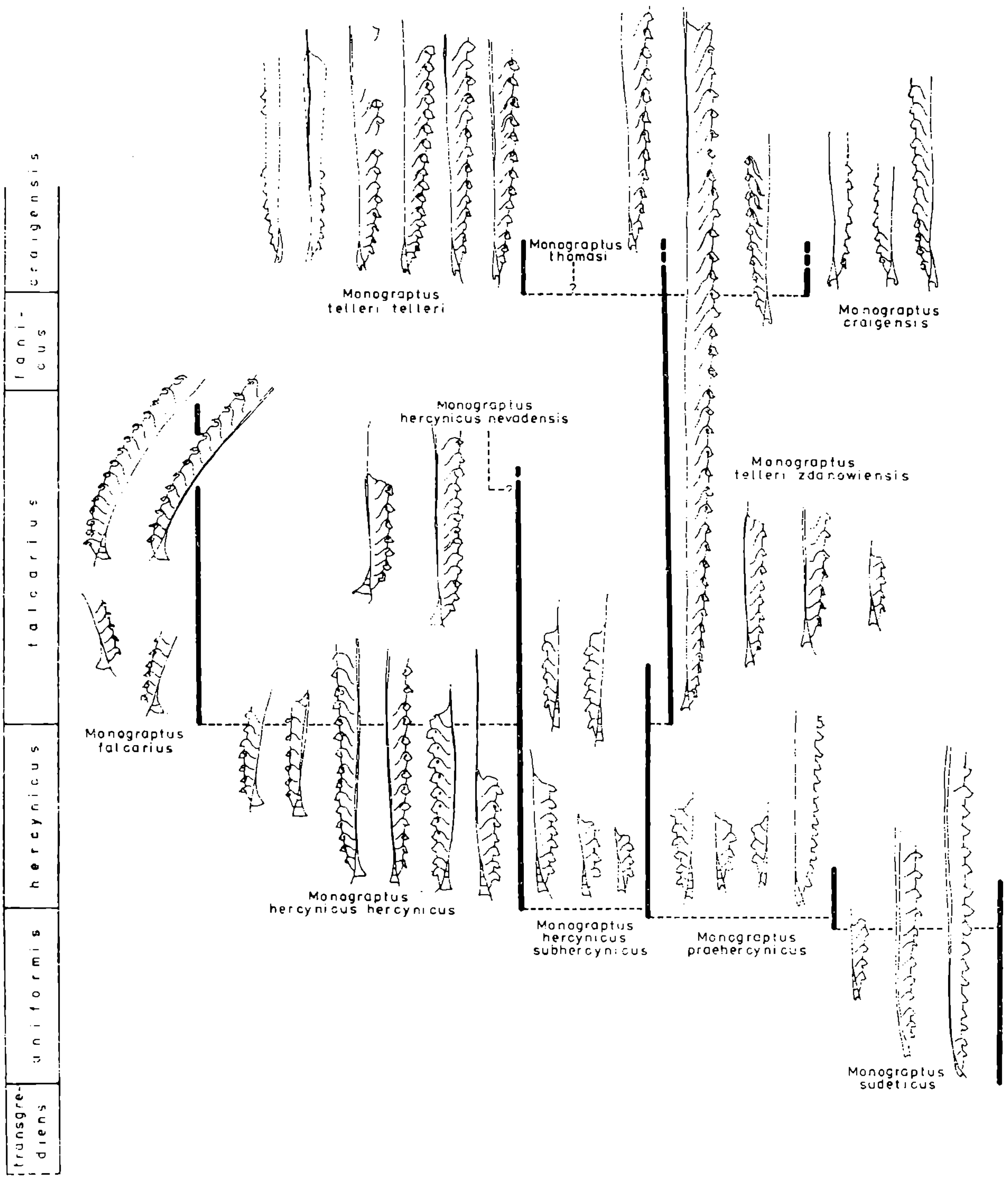

Fig. 7. Phylogenetic scheme suggested for the *hercynicus* lineage

Fig. 7. Rekonstrukcja stosunków filogenetycznych w linii rozwojowej *hercynicus*

process combined with lengthening of the sicula and widening aperture. The observed variability in the population of *M. hercynicus subhercynicus* has probably definite phylogenetic consequences. The rhabdosomes dominant in oldest representatives of this subspecies, which are relatively thick and widening rather rapidly, could be the ancestors of *M. hercynicus hercynicus*. The late population of *M. hercynicus subhercynicus*, represented by slim, gradually widening rhabdosomes with shorter sicula and

Species	S_{rh}				Σ
	th_1	th_1/th_2	th_5	max.	
M. sudeticus	0.70—0.90 (0.50—0.65)	0.44—0.67	1.10—1.50 (0.90—1.20)	1.80 (1.40)	1.20—1.50
M. praehercynicus	0.90—1.10 (0.70—0.80)	0.62—0.78	1.30 (1.00)	—	1.50—1.70
M. hercynicus subhercynicus	0.90—1.10 (0.70—0.80)	0.70—0.80	1.30—1.50 (? —1.10)	1.75—? (1.50—?)	1.30—1.60
M. telleri zdanoviensis	0.80—0.90 (0.60—0.70)	0.60—0.65	1.10—1.30 (0.90—1.00)	2.00—2.60 (1.85—2.20)	1.20—1.50
M. telleri telleri	0.60—0.96 (0.40—0.70)	0.40—0.70	0.90—1.40 (0.75—1.10)	2.00—? (1.85—?)	1.10—1.40
M. craigensis	0.75—0.90 (0.55—0.70)	0.50—0.65	1.00—1.30 (0.75—1.00)	1.95 (1.60)	1.20—1.40

M. hercynicus hercynicus	0.90—1.20 (0.65—0.90)	0.50—0.90	1.20—1.60 (0.90—1.30)	1.70—2.40 (1.40—2.10)	1.10—1.50
M. falcarius	0.90—1.10 (0.65—0.80)	0.65—0.80	1.20—1.40 (0.90—1.20)	1.60—1.65 (1.30—1.45)	1.10—1.30

small dorsal process, might have given rise to *M. telleri zdanoviensis* nov. subsp.

The suggested branching of the formerly uniform line *M. sudeticus* — *M. praehercynicus* — *M. hercynicus subhercynicus* would lead to the rise of two distinct lineages (Fig. 7). The oldest link in one of these would be *M. hercynicus hercynicus* while it would be *M. telleri zdanoviensis* in the other. This branching would be inspired most of all by the divergence in the evolution of the sicula — a continuation of the development of the sicula lacking the dorsal process and of sicula with secondary dorsal process (Fig. 8).

Table 2

Sicula				N_i/5 mm	N_i/10 mm
L_s	S_a	L_{dt}	Shape of sicula		
1.60—2.00	0.20—0.38	0.10—0.20	normal	$4^{3}/_{4}$—5	8—$9^{3}/_{4}$
1.80—2.20	0.35—0.40	0.10—0.30	normal to narrowly conical	5—$5^{1}/_{2}$	—
1.80—2.30	0.40—0.60	—	conical without dorsal process	5—6	9—$10^{1}/_{2}$
1.80—2.00	0.40—0.55	0.15—0.35	conical with dorsal process	$4^{1}/_{2}$—$5^{3}/_{4}$	$8^{1}/_{2}$—$10^{1}/_{2}$
1.55—1.95	0.35—0.40	0.20—0.35	normal	4—$6^{1}/_{2}$	9—$12^{1}/_{2}$
1.60—1.95	0.45—0.60	0.15—0.40	conical with dorsal process	5—$6^{1}/_{3}$	$10^{1}/_{2}$—12
1.60—2.20	0.50—1.15	—	conical to trumpet-like	5—$6^{1}/_{3}$	$9^{1}/_{2}$—12
1.50—1.80	0.80—1.05	—	trumpet-like	$5^{1}/_{2}$—$6^{3}/_{4}$	$10^{3}/_{4}$—$13^{3}/_{4}$

M. hercynicus subhercynicus Willefert — *M. hercynicus hercynicus* Perner — *M. falcarius* Koren' lineage and *M. hercynicus hercynicus* Perner — *M. hercynicus nevadensis* Berry lineage

The ancestral-descendant relation between *M. hercynicus subhercynicus* and *M. hercynicus hercynicus* seems rather unquestionable (cf. Willefert, 1962, 1963; Urbanek, 1973). The phylogenetic modifications associated with this transition are mainly revealed in the development of the sicula (Fig. 8, Table 2). The distinct widening of the aperture is connected with a slight shortening of the sicula. Moreover, the dorsal edge of the sicula becomes dorsally declined.

The morphological variability in *M. hercynicus hercynicus* (see Systematic Palaeontology) probably results in the rise of two evolutionary lines: *M. hercynicus hercynicus* — *M. hercynicus nevadensis* and *M. hercynicus hercynicus* — *M. falcarius.* The divergence is expressed by further modifications of the sicula, widening of the rhabdosome and change of its proximal part.

M. hercynicus nevadensis has not been found in the Żdanów Section. However, the observations on the population intermediate between *M. hercynicus hercynicus* and *M. hercynicus nevadensis,* which occurs in this section, as well as the published opinion of Berry and Murphy (1975) on the development of *M. hercynicus nevadensis* permit to determine the character of morphological changes in this line. These consist in widening of the rhabdosome and dorsal curving of the sicula in which a slight shortening is compensated by rapid widening of the aperture leading to the renewed development of the dorsally deflected metasicular process.

The *M. hercynicus hercynicus* — *M. falcarius* lineage is represented in the Żdanów Section by a morphologically and stratigraphically continuous succession of populations. The present observations corroborate the opinion of Koren' (1975, 1978a) that the development of this line consists in very strong dorsal curving of proximal rhabdosome part, narrowing and shortening of rhabdosome (the tendency opposite to that in the above described lineage), shortening of the sicula and widening of its aperture (the tendency similar to that in the former lineage). Moreover, in both lines there is a tendency towards increasing crowding of the thecae associated with decrease in size of the hoods (Table 2, Fig. 7).

M. hercynicus subhercynicus Willefert — *M. telleri zdanoviensis* nov. subsp. — *M. telleri telleri* Lenz & Jackson lineage and *M. telleri zdanoviensis* nov. subsp. — *M. craigensis* Jaeger lineage

The present suggestion concerning the immediate relation between *M. hercynicus subhercynicus* and *M. telleri zdanoviensis* is supported by the analysis of the evolutionary modifications of astogeny of both taxons. One can suppose that the distinct shortening of the sicula and slight decrease of its width accompanying the speciation of *M. telleri zdanoviensis* (Table 2) is connected with the appearance of the dorsal sicular process which becomes gradually larger in the successive, younger rhabdosomes of this taxon. In the uppermost part of the fanicus Zone, the late population of *M. telleri zdanoviensis* displays a considerable morphological variability (see Systematic Palaeontology). It can be assumed that this high degree of intrasubspecific variability was a starting point for a splitting of the *M. hercynicus subhercynicus* — *M. telleri zdanoviensis* lineage into three different evolutionary trends represented by *M. telleri telleri, M. craigensis,* and possibly *M. thomasi* (Fig. 7).

The transition from *M. telleri zdanoviensis* to *M. telleri telleri* is connected, first of all, with a distinct change in the sicular shape. The straight, almost triangular and widened at aperture sicula becomes more cylindrical within its metasicular portion, due to distinct decrease in the aperture width, and successively more and more curved ventrally (Fig. 8). This type of sicula is conventionally described as normal. The phylogenetic changes of rhabdosome width are in the *M. telleri zdanoviensis* — *M. telleri telleri* lineage fluctuating. Initially, the width increases slightly then, in late population of *M. telleri telleri,* it decreases considerably. Similarly, fluctuating in character is crowding of the thecae (Table 2). The rhabdosomes of this line are successively more and more dorsally curved within the proximal portion.

In the *M. telleri zdanoviensis* — *M. craigensis* lineage the shape of the sicula is almost constant. The sicula remains nearly triangular and becomes only very slightly shorter and wider at aperture (Fig. 8, Table 2) whereas the shape of the proximal end changes distinctly from straight to dorsally curved.

M. thomasi has not been found at Żdanów. However, its affinity to *M. telleri zdanoviensis* seems very probable. Among rhabdosomes of the younger population on the latter species there occur some with sparsely spaced proximal thecae (Fig. 22/20—22), similar to those of *M. thomasi.* It seems that evolutionary changes occuring in the *M. telleri zdanoviensis* — *M. thomasi* line consist in decrease in crowding of the proximal thecae, resulting in some isolation of these and in appearance of characteristic ventro-dorsal curvature of the proximal part of rhabdosome. The shape of the sicula, on the other hand, does not change in any essential way.

M. telleri telleri and *M. craigensis* represent the youngest stages of the *hercynicus* lineage noted in the Żdanów Section. Their inception, and possibly also the speciation of *M. thomasi,* would be connected with mosaic evolution of the youngest part of this lineage.

The graptolites of the *yukonensis* group, which are the youngest known representatives of Graptoloidea, have not been found in Żdanów. There are different views on their origin (Jaeger et al., 1969, 1970; Lenz & & Jackson, 1971; Churkin et al., 1970; Koren', 1974, 1975; Rickards et al., 1977) due to their relatively great morphological differentiation. The common feature of these graptolites is the strong dorsal curvature marked within the proximal portion or within the whole rhabdosome. The differences concern, among others, the rhabdosome width, character of increase of its width, degree of isolation of the proximal thecae, and shape of the sicula. These are the features considered important in taxonomical differentiation of the older graptolites of the Early Devonian.

The attempts at taxonomical division of the discussed graptolites (Jaeger et al., 1969, 1970 — *M. yukonensis yukonensis, M. yukonensis fangensis, M.* nov. sp. aff. *yukonensis)* are based on ambiguously defined phylogenetic relations. Lenz and Jackson (1971) suggested the existence of a relationship between *M. yukonensis*, *M. thomasi* and *M. telleri*. Similarly Jaeger (1970) supposed that the latter species may be the descendant of *M. thomasi*. Koren' (1974, 1975) traced a continuous transition from *M. craigensis* to *M. yukonensis*. Rickards and others (1977) suppose that there is a phylogenetic connection between the *yukonensis* group and both *M. thomasi* and *M. falcarius*.

The present observations seem to indicate that the tendency towards the stronger and stronger dorsal curvature of rhabdosomes can be observed in all youngest branching lines of the *M. hercynicus subhercynicus* — *M. telleri* lineage. This tendency develops in the *M. telleri zdanoviensis* — *M. craigensis* line as well an in *M. telleri zdanoviensis* — *M. telleri telleri line*. The last representatives of *M. telleri telleri* from the Żdanów Section display the dorsal curvature of the proximal part, which is characteristic of the *M. craigensis* stage (*sensu* Koren', 1975). It is very probable that the evolution of the *M. telleri zdanoviensis* — *M. thomasi* line led in the same direction through forms close to *M. craigensis* towards the „*yukonensis*" stage.

The evolution leading to stronger and stronger dorsal curvature of rhabdosome may have resulted in evolving of similar evolutionary stages in different, though related, phylogenetic lineages. The phenotypes representing these stages may be erroneously assigned to the same species — *M. yukonensis*.

It seems that the stage „*yukonensis*" of the *M. telleri zdanoviensis* — *M. craigensis lineage* may be represented by some Tien Shan specimens considered by Koren' to belong to the *M. yukonensis* population (Koren' 1974; Pl. 25, Figs 11, 13, Text-Figs 3, 24; 1975 Pl. 7, Figs 7, 11, Pl. 9, Fig. 14). These specimens have a triangular sicula which is relatively wide at the aperture. This aspect of the sicula makes these rhabdosomes superficially similar to those of *M. falcarius* (*cf.* Koren', 1975: Pl. 1, Fig. 3) and *M. yukonensis* (*op. cit.* Pl. 7, Fig. 11), from which they differ in fact in several qualitative and quantitative properties. This homeomorphy between the two species mentioned resulting from similar evolutionary trends occurring in separate and not coeval side lines of the *M. hercynicus* lineage was probably a reason why Rickards and others (1977) supposed that *M. yukonensis* evolved from *M. falcarius*.

The stage „*yukonensis*" of the *M. telleri zdanoviensis* — *M. thomasi* lineage may be, on the other hand, represented by the rhabdosomes from Nevada (Berry & Murphy, 1972: Text-Fig. 2A, B) and from Yukon Territory Lenz & Jackson, 1971: Pl. 2, Figs 10, 11, 12), and possibly also by the specimens described as *M. yukonensis fangensis* from Thailand (Jaeger et al., 1969). These forms are characterized by rapid slimming of the proximal part connected with a distinct isolation of the thecae.

The "*yukonensis*" stage of the *M. telleri zdanoviensis* — *M. telleri telleri* lineage would be represented by slim rhabdosomes widening gradually and with normal sicula. *M.* nov. sp. aff. *yukonensis* from Thailand (Jaeger et al., 1969) might be included here.

The possibility of different rates in progression of rhabdosome curvature in the particular lines of development suggested here seems to be worth noting. It would result in different degrees of dorsal curvature of rhabdosomes in the synchronous last stages of these lines. The taxonomy of the *yukonensis* group and views on its phylogeny suggested by Jaeger and Stein (in Jaeger et al., 1969), based exclusively on the assumption that less curved rhabdosomes are older from the more curved ones, may prove to be not always justified.

In the taxonomy of this group more attention should be paid to the shape of sicula. The dorsal rhabdosome curvature is the feature developing parallelly in three different lines: *M. telleri zdanoviensis* — *M. telleri telleri, M. telleri zdanoviensis* — *M. craigensis,* and possibly *M. telleri* — *M. thomasi.* This results in the homeomorphy of the last stages of these lines and may cause false "horizontal" taxonomy.

Phylogenetic modifications of sicular ontogeny in *hercynicus* lineage

In this lineage the most primitive sicula is very narrow, ventrally curved and provided with a very small dorsal metasicular process (the *M. sudeticus* stage, Fig. 8). In younger generations the sicula becomes vertical and its length increases gradually (the *M. praehercynicus* stage). The successive modifications lead to the reduction of the dorsal process and this is associated with a maximum elongation of the sicula (Table 2). This results in evolving of a triangular, straight or slightly dorsally curved sicula with straight apertural margin (the *M. hercynicus subhercynicus* stage). The subsequent microevolution of the sicula leads to the rise of two evolutionary trends (Fig. 8). One trend appears in the lines: *M. hercynicus hercynicus* — *M. hercynicus nevadensis* and *M. hercynicus hercynicus* — *M. falcarius.* This trend of development manifests in widening of the sicular aperture, which is connected with shortening of the sicula and its stronger dorsal curving. The second trend is revealed by the *M. telleri zdanoviensis* population and consists mainly in renewed appearance of the dorsal metasicular process and, possibly related to this, shortening of the sicula whereas the width of the aperture changes hardly at all (Table 2, Fig. 8).

At this stage, there two trends again appear in the sicular development (Fig. 8). One tendency (in *M. telleri telleri)* leads to the rise of the sicula of normal shape, which is due to the decrease in width of sicular aperture. The result of the development of the second tendency (in *M. craigensis)* is the dorsally curved sicula the shape of which is not much altered.

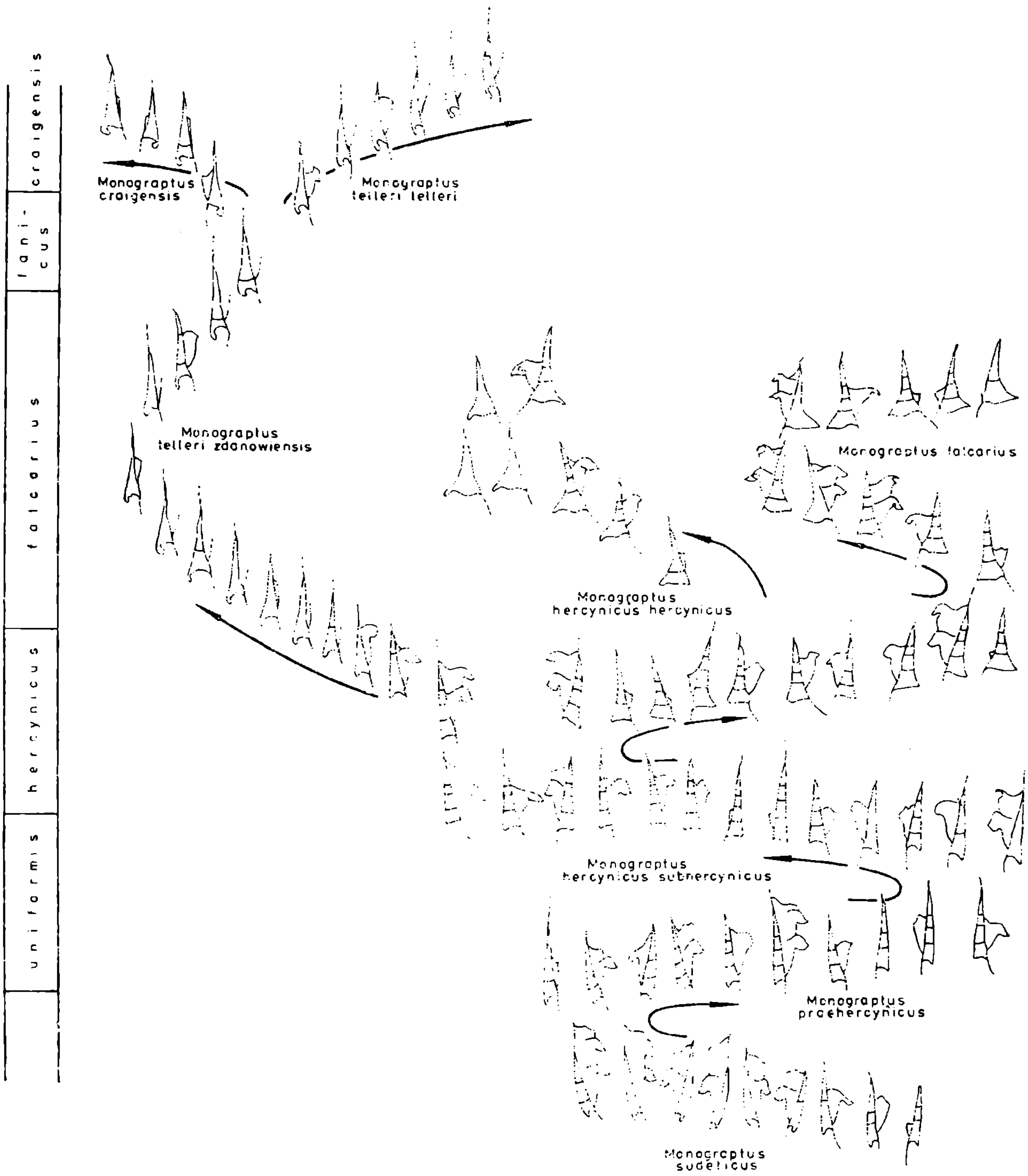

Fig. 8. Diagram showing phylogenetic modifications of sicular ontogeny in the *hercynicus* lineage

Fig. 8. Diagram obrazujący filogenetyczne modyfikacje ontogenezy sikuli w linii rozwojowej *hercynicus*

Changes in the development of the dorsal process, consisting mainly in the increase of its size, are considered by some authors to represent one of the most important trends in the development of the youngest graptolites (Jaeger, 1970, 1978; Koren', 1978a). The present observations on the evolutions of the *hercynicus* lineage seem to confirm the existence of such a trend. However, this general tendency is obliterated by the fluctuating character of the microevolution of the process: large —

small — reduction — small — large (the zig-zag evolution in the sense of Henningsmoen, 1964). The study on the Żdanów fauna permits, moreover, to suggest that the development of the dorsal process may be correlated, due to morphophysiological compensation, with fluctuating changes of other parameters of the sicula (length, width of aperture, etc.,) and it may display some deviations from the general tendency. In last representatives of *M. telleri telleri* from the Żdanów Section and in some specimens of *M. yukonensis* (among others in those from Tien Shan and Yukon Territory), the return of the normal shape of the sicula is accompanied by the diminution of the dorsal process to the standard size.

Phylogenetic modifications of thecal blastogeny in *hercynicus* lineage

It is accepted that most of the taxons of this lineage have biform thecae. The proximal thecae are usually provided with well developed hoods, the size of which diminishes distally; in the distal end of rhabdosome their presence is marked only by a short apertural process.

The present observations, in some cases limited by the poor preservation of the rhabdosomes, imply that in all colonies the size of the most proximal hoods increases slightly towards the medial part; it remains largely unchanged within this part of rhabdosome and, next, it distinctly decreases distally. In longest rhabdosomes of *M. telleri*, the most distal thecae are of climacograptid appearance showing no trace of apertural process.

There exists also another regularity. In older taxons of the *hercynicus lineage (M. sudeticus, M. praehercynicus,* early populations of *M. hercynicus subhercynicus* and *M. hercynicus hercynicus)* the hoods of the proximal and medial thecae are usually greatly extended laterally obscuring the thecal apertures, while in younger taxons of this lineage the width of the hoods is reduced in various degrees.

The above trends of development compared with the phylogenetic changes of the sicular ontogeny seem to indicate that there is a correlation between the degree of the morphological complexity of the sicula and the intensity of reduction of the hoods. For example, in the *M. hercynicus hercynicus* — *M. falcarius* lineage the maximum increase in size of the sicula is associated with the strongest reduction of the hood size and the number of the thecae. So, the mentioned progressive modifications of the sicula result not only in a morphological simplification of the remaining thecae but also in the reduction of their number. In the *M. telleri zdanoviensis* — *M. craigensis* lineage, in which the morphological modifications of the sicula are less distinct, the reduction of the hoods is not so strong and the secondary return of the normal shape of the sicula is accompanied by a slight equalization of the hood size.

Phylogenetic changes of proximal-end shape in *hercynicus* lineage

In the earliest taxons of this lineage the proximal end is very narrow and slightly ventrally curved or straight. In younger structural stages it begins to curve dorsally coming up to various effects in the particular side lines of the *hercynicus* lineage (Fig. 7).

Phylogenetic changes of rhabdosome width and crowding of thecae in *hercynicus* lineage

After the initial slight increase in colony width and in the number of thecae (from *M. sudeticus* to *M. hercynicus subhercynicus)* there occurs a distinct differentiation in the further changes of these parameters in the particular side lines of the *hercynicus* lineage (Table 2). In the *M. hercynicus hercynicus* — *M. falcarius* lineage the rhabdosome becomes gradually narrower and the thecae more densely spaced while in the *M. hercynicus hercynicus* — *M. hercynicus nevadensis* line both these parameters increase (Table 2). In a lineage begun by *M. telleri* the width of rhabdosome initially does not undergo any significant change and, then, in the youngest stages it more or less decreases in some taxons (Table 2).

Main evolutionary trends in *hercynicus* lineage

To summarize, it can be concluded that the phylastogeny in the *hercynicus* lineage consists mainly in transformations of the sicular ontogeny and the blastogeny of the remaining thecae. During these transformations, reverse in their morphological character, the distinct, rapid and progressive differentiation of the sicular structure (hypertrophy of sicula according to Urbanek, 1973) is accompanied by a relatively slow process of simplification of the structure of the remaining thecae. On the other hand, the inhibition in the evolutionary changes of the sicula and its morphological simplification (gracilization — Urbanek, 1966) is associated with some complications of the thecal morphology. Consequently, the modifications of the sicular ontogeny and thecal blastogeny are closely interrelated.

Origin of *hercynicus* lineage

The very close morphological similarity between *M. sudeticus* nov. sp., *M. similis* Přibyl and some approximate forms (i.e. *M.* sp. aff. *similis* from the Łeba-1 borehole in Pomerania — Jaeger, 1966, and *M.* aff. *similis* from Kazakhstan — Mikhailova, 1976) suggests that the roots of the *hercynicus* lineage are to be found in this group monograptids.

EVOLUTION OF *AEQUABILIS* LINEAGE

The species *M. aequabilis* Přibyl, known from the lowermost Lochkovian (*uniformis* and *hercynicus* Zones) from various parts of the World, is supposed to be phylogenetically connected with *M. hemiodon* Jaeger

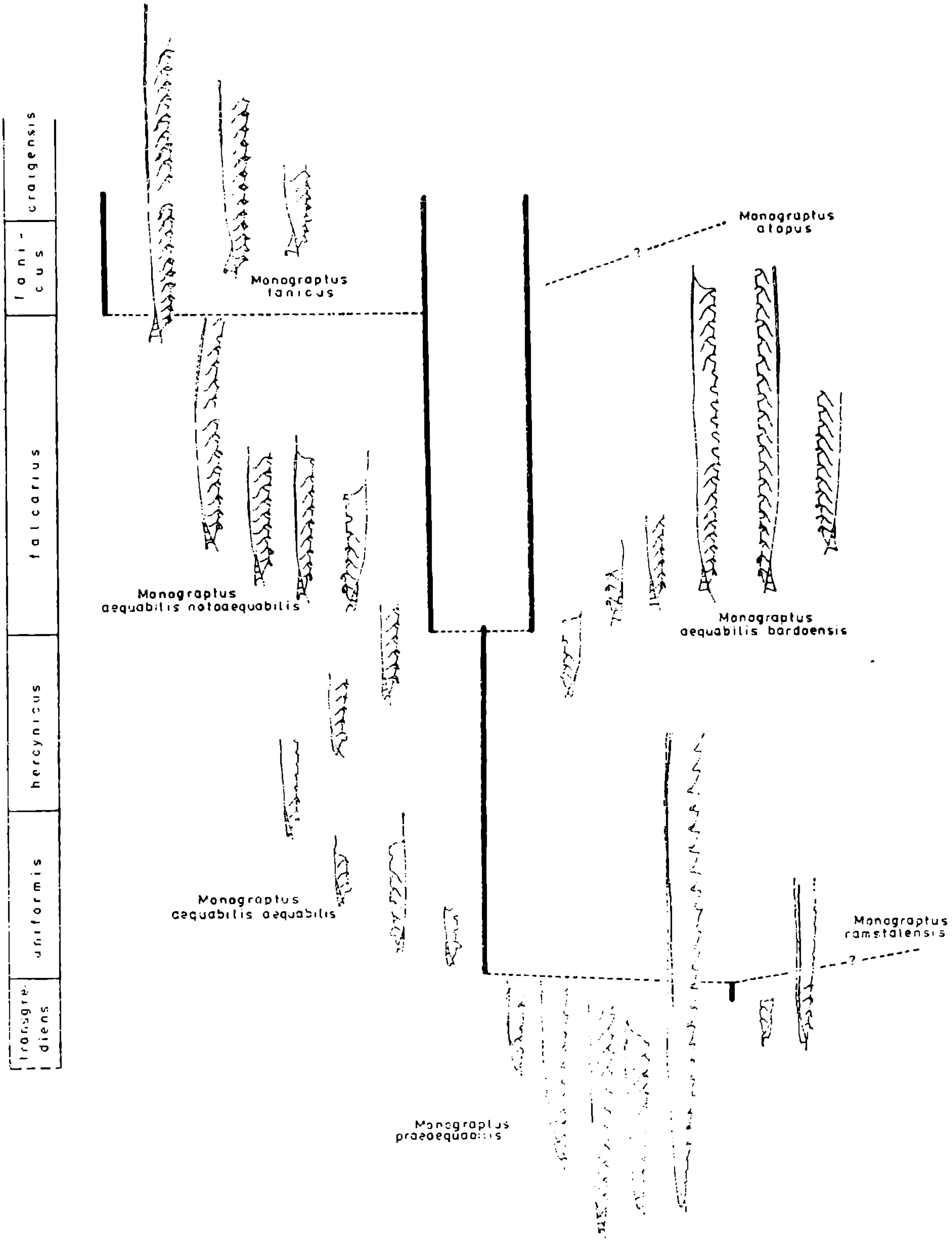

Fig. 9. Phylogenetic scheme suggested for the *aequabilis* lineage

Fig. 9. Rekonstrukcja stosunków filogenetycznych w linii rozwojowej *aequabilis*

recorded from the *hercynicus* Zone in Thuringia (Jaeger, 1959). It appeared later (Jaeger et al., 1969) that *M. aequabilis* ranges up to the yukonensis Zone of the Pragian; the Lochkovian representatives of this species were referred to *M. aequabilis aequabilis* Přibyl, while the Pragian ones to *M. aequabilis notoaequabilis* Jaeger & Stein. Jaeger (1970, 1971) supposed that the phylogenetic modifications in the species *M. aequabilis* were restricted to the size increase of the dorsal process. The works by Koren' (1974, 1975) revealed that the lower range of *M. aequabilis notoaequabilis* corresponds to the boundary between the hercynicus and falcarius Zones, and that in the late Pragian this subspecies evolves into *M. fanicus* Koren'. According to Koren', the main evolutionary tendencies in the *M. aequabilis aequabilis* — *M. aequabilis notoaequabilis* — *M. fanicus* lineage involve the increase in number of the hooded thecae and in a change of the sicula shape during the speciation of *M. fanicus.*

In the Żdanów Section, it was possible to trace the evolution of the *aequabilis* lineage from the Silurian transgrediens Zone to the craigensis Zone of the Lower Devonian (Fig. 9 see p. 123). Apart from *M. aequabilis aequabilis, M. aequabilis notoaequabilis,* and *M. fanicus,* also two new taxons *M. praeaequabilis* and *M. aequabilis bardoensis* have been included in this lineage. The phylogeny of such postulated lineage seems to imply that three other species absent in the Żdanów Section, i.e. *M. ramstalensis* Jaeger, *M. hemiodon* Jaeger, and *M. atopus* Bouček, the phylogenetic relations of which are so far poorly recognized, belong also to this lineage.

The oldest known, Silurian (Late Pridolian) structural stage of the *aequabilis* lineage is represented by *M. praeaequabilis.* The evolutionary changes of the astogeny of this species concern proximally progressive modifications of thecal blastogeny consisting in transformation of pristograptid thecae into climacograptid ones and these into hooded thecae. The characteristic morphological variability in late population of *M. praeaequabilis* (forms having incipient hood of th_1 and those in which the first three to four thecae are terminated with hoods of distally diminishing size) may by explained as the beginning of divergence in further modifications of thecal blastogeny (Fig. 9). Resulting from this divergence, by the beginning of the Devonian, there appear two lines of development: *M. praeaequabilis* — *M. ramstalensis* and *M. praeaequabilis* — *M. aequabilis aequabilis.* In these two lines, the basic shape of rhabdosome and sicula do not change in any essential manner, while the modifications of thecal blastogeny progress more rapidly in the first line than in the second.

M. praeaequabilis nov. sp. — *M. ramstalensis* Jaeger lineage

In rhabdosomes of *M. praeaequabilis,* which could represent the population initial for the development of *M. ramstalensis* (Fig. 9), the spreading of the hooded thecae is restricted to th_4, while in *M. ramstalensis* it reaches th_{6-8} (Jaeger, 1959). It is important that in both taxons, directly above the hooded thecae, there are those intermediate between the pristograptid and climacograptid type. Thus, one can suppose that in the lineage under discussion, directly after the primary transformation of the pristograptid theca into the climacograptid one, a second type of modification was rapidly introduced giving rise to the formation of the apertural lobe.

M. praeaequabilis nov. sp. — *M. aequabilis aequabilis* Přibyl lineage

A somewhat different pattern of evolution of thecal blastogeny is observed in this lineage. In the rhabdosomes considered to be intermediate between *M. praeaequabilis* and *M. aequabilis aequabilis* only the first theca is of hooded type while the remaining 4—8 are climacograptid. During the phylogenetic changes of blastogeny in *M. aequabilis aequabilis,* the climacograptid theca spreads into younger and younger rhabdosome portions. Judging from a number of climacograptid thecae, the rhabdosomes of this species known from Europe (Thuringia, Barrandian), Australia and Cañada represent probably heterochronous populations. The new type of theca — the hooded one — appears in the *M. praeaequabilis* — *M. aequabilis aequabilis* lineage when the primary modifications have involved 5—8 proximal thecae. In the Silurian part of this lineage the progression of the new feature, still with a low phenotypic expressivity, is limited to th_1; while in the oldest Devonian *M. aequabilis aequabilis* stage it spreads onto 2—3 proximal thecae, but its full expressivity is only displayed by th_1.

It is not known whether the *M. praeaequabilis* — *M. ramstalensis* lineage, the existence of which was suggested earlier, continues above the uniformis Zone or whether *M. ramstalensis* represents its last stage. The possible descendants have been found neither in Żdanów nor in other Lower Devonian sites. It is likely that this lineage was much more short-lived than the "main" line, initiated by *M. aequabilis aequabilis,* which is traced within the Żdanów Section as far up as the craigensis Zone. Within the uniformis and hercynicus Zones this "main" line is represented in Żdanów by the *M. aequabilis aequabilis* stage.

M. kayseri Perner recorded from the upper part of the hercynicus Zone in Barrandian could represent a side line of the *aequabilis* lineage in which the spreading of hooded thecae was more rapid and accompanied by a dorsal curving of the proximal part of rhabdosome.

The beginning of the falcarius chron corresponds in the Żdanów Section to splitting of the "main" *aequabilis* lineage (Fig. 9). There appear two descendant lines: *M. aequabilis notoaequabilis* — *M. fanicus* and the one represented in its oldest part, by *M. aequabilis bardoensis.* The splitting of this lineage is largely due to the divergence in the development of the sicula (Fig. 10). This is an example of divergence on a microevolutionary scale; its beginning is expressed in intrasubspecific variability of late population of *M. aequabilis aequabilis.*

M. aequabilis aequabilis Přibyl — *M. aequabilis notoaequabilis* Jaeger & Stein — *M. fanicus* Koren' lineage

The observations on evolutionary changes of this lineage, based on the Żdanów material, confirm the evolutionary pattern suggested by Koren' (1974, 1975). The similarity of the evolutionary process recognized in the Żdanów specimens to that reconstructed in the Pai-Khoi and Tien Shan material is expressed by the same stratigraphic succession of the phylogenetic events and the same trends of development.

The development from *M. aequabilis aequabilis* to *M. aequabilis notoaequabilis* is continuous. It consist in a slow spreading of the hooded-type theca onto the younger thecae (up to th_{5-7}), widening of the proximal part of rhabdosome (Table 3) and, finally, in some small changes in the morphology of the sicula (Fig. 10). In the longest, known hitherto, rhabdosomes of *M. aequabilis notoaequabilis* all the distal thecae display excavations. It seems, therefore, that the first type of the thecal blastogeny modification (spreading of the climacograptid theca) reached its full penetrance in the structural stage represented by *M. aequabilis notoaequabilis.*

It is worth noting that a certain correlation exists between evolutionary changes in the thecal blastogeny and changes in the sicular ontogeny; this is especially distinct when the speciation of *M. aequabilis notoaequabilis* is concerned. With the beginning of the relatively distinct structural modification of the sicula (i.e. shortening, widening of aperture, lengthening of dorsal process in the stage of late population of *M. aequabilis notoaequabilis)* the hood of th_1 decreases in size. In the *aequabilis* line the stage of *M. fanicus* is attained gradually, first of all, through the spreading of the hooded theca onto younger part of rhabdosome, the increase of phenotypic expressivity of these modifications (7—11 thecae are provided with hoods of similar size), and the distinct morphological modifications of the sicula (dorsal curvature, slight decrease in length, strong widening of aperture, ventral curvature of dorsal process). The widening of rhabdosome, increase of the rate of its widening and increase in crowding of the thecae, are also observed (Table 3).

Table 3

Species	S_{rh}				Sicula			hooded thecae	N_l/10 mm
	th_1	th_1/th_2	th_5	max.	L_s	S_a	L_{dt}		
M. praeaequabilis	0.62—0.75	0.50—0.70	1.10—1.30	1.97—2.10	1.76—2.0	0.30—0.37	0.10—0.20	0— 1	10—8
M. aequabilis aequabilis	0.90—1.00 (0.60—0.70)	0.60—0.70	1.10—1.30 (1.10—1.20)	1.70—?	1.70—2.0	0.30—0.40	0.10—0.30	1— 3	10½—8¼
M. aequabilis bardoensis	0.90—1.10 (0.70—0.90)	0.70—0.85	1.20—1.43 (1.10—1.40)	1.50—1.62 (1.40—1.60)	1.6 —2.3	0.40—0.70	—	2— 4	10½—9
M. aequabilis notoaequabilis	0.80—1.10 (0.60—0.90)	0.65—0.82	1.30—1.45 (1.10—1.30)	1.65—1.70 (1.60—1.65)	1.70—2.00	0.40—0.60	0.20—0.30	3— 7	10—10½
M. fanicus	1.00—1.20 (0.75—0.90)	0.80—0.90	1.20—1.70 (1.10—1.40)	1.70—2.20 (1.50—2.10)	1.40—1.75	0.60—0.80	0.20—0.40	7—11	11—12

M. aequabilis aequabilis Přibyl — *M. aequabilis bardoensis* nov. subsp. *M. atopus* Bouček lineage

Parallel to the *M. aequabilis notoaequabilis* — *M. fanicus* lineage there develops in the Żdanów Section another line initiated by *M. aequabilis bardoensis* (Fig. 9). A course of the phylogenetic modification of the sicular ontogeny is somewhat different in this line.

The speciation of *M. aequabilis bardoensis,* synchronous with the origin of *M. aequabilis notoaequabilis,* is a gradual process. It consists in a slight spreading of the hooded theca and in reduction of the metasicular dorsal process. This reduction is probably connected with the distinct increase in the length of the sicula and widening of the aperture (possible morpho-physiological compensation). Much the same as in the formerly discussed lineage, there occurs a distinct correlation between the micro-evolution of the sicula and modifications of the thecal blastogeny. From the moment when the sicula begins to change the expressivity of the phylogenetic modifications in the thecal blastogeny decreases; the hood of th_1 distinctly diminishes its size. The correlation of these changes is characteristic feature of the described line, the more so as it seems to influence the further evolution.

The morphological changes of the sicula are much more conspicuous in the *M. aequabilis aequabilis* — *M. aequabilis bardoensis* line than in the *M. aequabilis aequabilis* — *M. aequabilis notoaequabilis* line. The spreading and development of the hooded thecae is just reverse; in the latter lineage there are much more thecae provided with hoods and these are somewhat wider than those observed in the former lineage. It seems that the degree of morphological specialization of the siculozooid determines the rate and the degree of expressivity of further modifications of the thecal blastogeny.

The youngest link in the *M. aequabilis aequabilis* — *M. aequabilis bardoensis* line may be represented by *M. atopus* recorded so far only from the Barrandian (Bouček, 1966) and by the related or even synonymous forms (cf. Jaeger, 1978), i.e., *Neomonograptus himalayensis* and *N. atopus* var. *rigidus* described from China (Mu & Ni, 1975). The creation of the *M. atopus* stage would be connected with an increase in rhabdosome width, shortening of sicula (fluctuating character of evolution of this parameter!), strong widening of sicular aperture, and a slight rise in the expressivity of thecal blastogeny modifications (the hood of th_1 attains again the largest dimension, hoods of the remaining proximal thecae sharply decrease in length distaly.

In the parallel lineage *M. aequabilis notoaequabilis* — *M. fanicus,* the modifications of the sicula are not so basic in character while the similar phylogenetic changes of blastogeny (consisting in intensification of penetration of the hooded theca and in increase of hood size) display a higher rate, stronger penetration and expressivity. The effects of differentiation in the rate of these phylogenetic changes are noticeable even in early, coeval structural stages of these two lineages. In *M. aequabilis notoaequabilis*, 4—7 thecae possess hoods of more or less equal size while in *M. aequabilis bardoensis* this concerns only 2—4 proximal thecae and the hoods are much smaller. In the last known stages of these lineages the consequences of different rate and expressivity of hooded theca introduction are much more noticeable. In *M. fanicus* the proximal thecae and, in part, the medial ones are provided with hoods of more of less equal size, while in *M. atopus* this is the case only in respect to the first proximal thecae.

Phylogenetic modifications of sicular ontogeny in *aequabilis* lineage

If the small, narrow, ventrally curved sicula in *M. praeaequabilis* is to be considered primitive, then its gradual lengthening and straightening occurring in the late population of *M. aequabilis aequabilis* (Table 3), should be regarded as progressive tendency. At the beginning of the falcarius chron, there appears a divergence in the sicular development resulting in the rise of two descendant lines (Fig. 10). In one of these — *M. aequabilis notoaequabilis* — *M. fanicus*, the sicula lengthens and widens gradually and after attaining its maximum length it becomes slightly shorter and markedly curved dorsally (Table 3). The dynamics of modifications of sicular morphology is also stressed by the gradual lengthening of the metasicular dorsal process (Table 3).

In the second line — *M. aequabilis bardoensis* — *M. atopus*, the dorsal process becomes reduced, which results in the appearance of a relatively long, triangular sicula (Table 3). In the final stage of the development of this line, the sicula reduces its length, the aperture widens and the sicula curves dorsally.

Phylogenetic modifications of thecal blastogeny in *aequabilis* lineage

The modifications are of two sorts and their introduction is proximal. The first one causes the change of pristiograptid theca into the climacograptid one. In the successive stages of the *aequabilis* lineage, one observes a gradual increase of penetration and phenotypic expressivity of this modification. Probably, in the colonies of the late population of *M. aequabilis aequabilis* the penetration and expressivity are complete. After the first modification involves higher proximal thecae the next modification is introduced. This latter consists in the introduction of the hooded theca in place of the climacograptid one (the hoods are prolongations of the

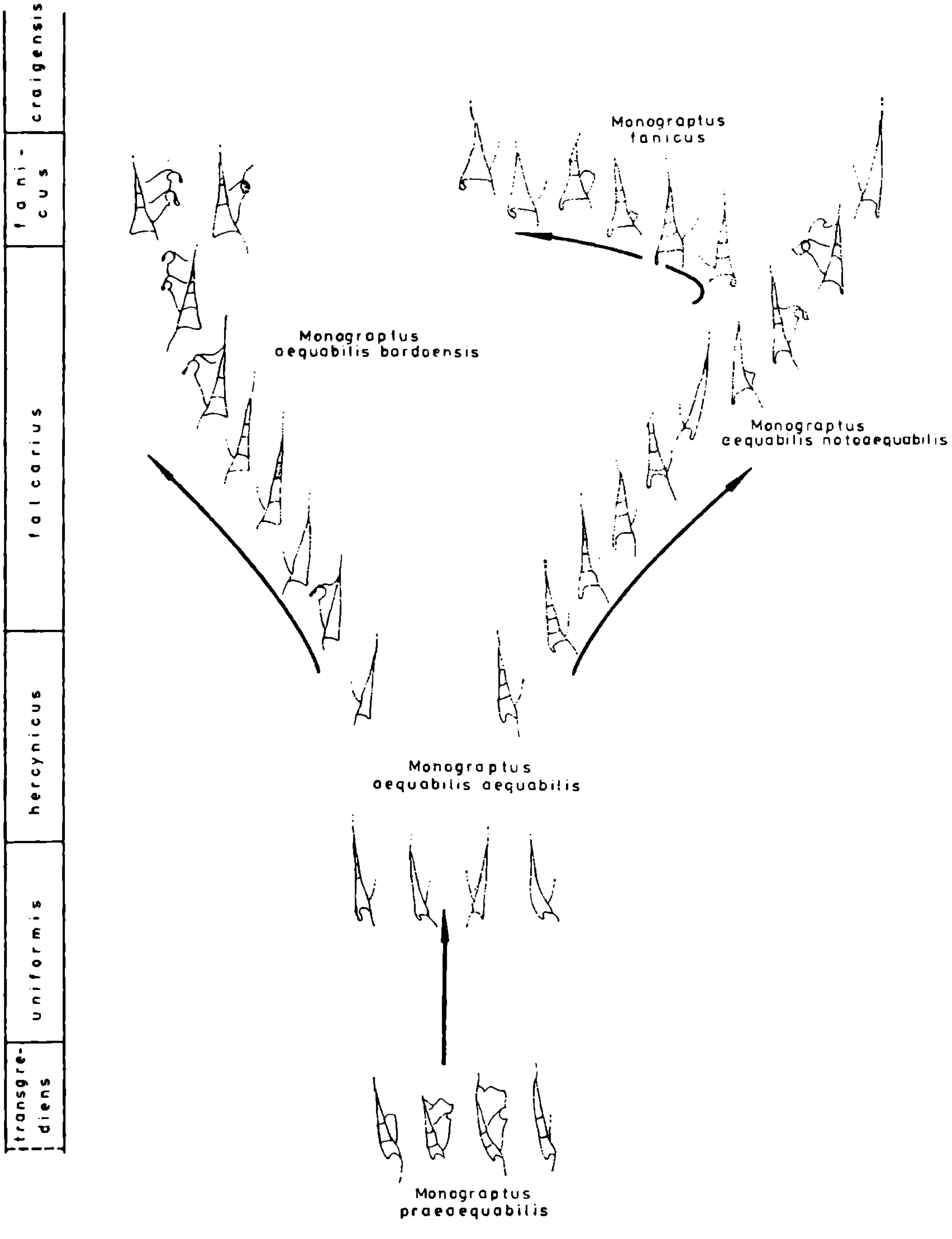

Fig. 10. Diagram showing phylogenetic modifications of sicular ontogeny in the *aequabilis* lineage

Fig. 10. Diagram obrazujący filogenetyczne modyfikacje ontogenezy sikuli w linii rozwojowej *aequabilis*

thecal dorsal walls). This type of blastogeny modification probably reaches its full penetrance in colonies of the late population of *M. aequabilis notoaequabilis* while its expressivity is greatest in rhabdosomes of *M. fanicus* (though these do not reach the stage of secondarily uniform forms).

In the particular side lines of the *aequabilis* lineage both types of evolutionary modifications of the thecal blastogeny display different degrees of penetration and expressivity and various rates of progress. This differentiation is probably caused by the differences in complexity of the sicular ontogeny.

Phylogenetic changes of proximal-end shape in *aequabilis* lineage

The most primary, proximal part is very narrow and weakly ventrally curved *(M. praeaequabilis* stage and early population of *M. aequabilis aequabilis).* In the successive structural stages (late population of *M. aequabilis aequabilis,* early population of *M. aequabilis notoaequabilis* and *M. aequabilis bardoensis)* it becomes vertical and next (in late population of *M. aequabilis notoaequabilis* and *M. aequabilis bardoensis)* becomes slightly wider and displays dorso-ventral curvature. In the youngest stages *(M. fanicus, M. atopus),* the proximal end is the widest and most strongly dorso-ventrally curved. It is likely that the side line *M. aequabilis aequabilis* — *M. kayseri,* the existence of which has been suggested by the author, displays a somewhat different evolutionary tendency which would consist in rapid dorsal curving of the proximal end.

Phylogenetic changes of rhabdosome width and crowding of thecae in *aequabilis* lineage

The rhabdosome width and the crowding of the thecae change gradually in this lineage. The differences are conspicuous when the oldest and the youngest taxons of the lineage are compared (Table 3).

Main evolutionary trends in *aequabilis* lineage

One may assume that in the *aequabilis* lineage there are, in general, two parallel evolutionary tendencies. One consists in a gradual progressive differentiation of the thecal morphology. The second involves changes in the sicular morphology, which are also progressive. The rate and character of the morphological specialization of the sicula influences distinctly, in a negative way, the rate and character of the morphological complication of the remaining thecae. In the oldest stages of the *aequabilis* lineage, the modifications of the thecal blastogeny proceed at a high rate, while the sicula develops slowly. In younger stages, the sicula starts to evolve more rapidly and the further modifications of the thecal blastogeny become gradual.

Both these processes are of a high taxonomic value. They represent a rare model of evolutionary changes in the known graptolite lineage (cf. Urbanek, 1966, 1973). This model is characterized by the parallel evolution of the sicula and the remaining thecae.

Origin of *aequabilis* lineage

The origin of the *aequabilis* line has been discussed so far by few authors. Rickards and others (1977) suggest that *M. aequabilis* — the oldest Devonian taxon of this lineage — may have evolved from graptolites of the *transgrediens* group or from those of *P. kosoviensis* Bouček type. Koren' (1978) believes that the ancestry of this lineage can be found among those Pridolian monograptids which gave rise to the *uniformis* group. The present investigations allow to suggest that *M. aequabilis* could have evolved directly from *M. praeaequabilis* which represents an intermediate stage between the monograptids of the discussed lineage and pristiograptids of the Late Silurian. The character of the astogenetic modifications of *M. praeaequabilis* implies that its ancestry can be found among graptolites of the *kosoviensis* group rather than in those of the *transgrediens* group.

CONCLUDING REMARKS

The evolutionary trend peculiar to graptolites shows remarkable directive tendencies resulting in the appearance of certain "morphological fashions" (Kuźnicki & Urbanek, 1970) which stamp particular stages of the Ordovician and the Silurian. Such overall regularity can also be traced in the last. Devonian episode of the graptolite history, of which the most representative is, perphaps, the phylastogeny of the *hercynicus* and *aequabilis lineage**.

These lineages have developed a closely similar evolutionary "program" based upon synchronous modifications of the sicula and the remaining thecae. The phylogenetic modifications of the sicula and changes in the proximal-end shape show in both lineages, basically the same trend of transformations. On the other hand, the evolutionary modifications of the thecal blastogeny proceeded in two opposite directions (the increasing

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* The *uniformis* line represents, in the present authors opinion, the youngest stage of the lineage which has a long, though still unknown, Silurian past. In this connection it is difficult to evaluate the similarity or dissimilarity of the evolution of this line in relation to the remaining Lower Devonian phylogenetic lineages. *M. microdon* may represent similar Lower Devonian relict of typical Silurian lineages.

complexity in the morphology of thecae in the *aequabilis* lineage and the simplification of thecae in the *hercynicus* lineage) which independently resulted in the creation of morphologically similar forms. Such an evolutionary model can account for a great morphological resemblance between all taxons of the Early Devonian graptolites.

The predominating evolutionary changeability displayed by the sicula (the manner of the sicular evolution is referred by Urbanek 1973, to as — "exclusion") imparts to the evolution of Early Devonian graptolites its specific individuality. Such dynamic evolution of the sicula contrasts with the evolutionary conservatism of the sicula ("noninvolvement" — according to Urbanek, 1973) revealed by most evolutionary schems of earlier graptolite groups.

The view here presented on the fundamental influence of the sicular ontogeny on the phylogenetic modifications of the thecal blastogeny is consistent with previous Urbanek's opinions (1960, 1966, 1973) with respect to the morphological and physiological significance of the siculozooid and its responsibility for the "monarchical" organization of the colony.

SYSTEMATIC PALAEONTOLOGY

The graptolites described below were collected from all layers of black argillaceous and siliceous shales exposed in the northern part of the Żdanów Section. The graptolite fauna is scare in the siliceous shales but it is more abundant in argillaceous shales. A number of specimens yielded by lower Devonian sediments of the section is considerably lower than that found in the deposits of the uppermost Silurian. Approximately 1200 specimens were collected and among them only the best preserved individuals have been chosen for palaeontological analysis. Most graptolites collected, are flattened and commonly show well preserved fusellar structure. The specimens are usually broken and represent various segments of rhabdosomes. Especially numerous are proximal fragments and juvenile stages of rhabdosomes. Such a state of preservation of the Żdanów graptolites has limited, to some degree, the accuracy of their morphological analysis.

A dozen or so of here described specimens of the subspecies *M. hercynicus hercynicus* Perner and *M. hercynicus subhercynicus*. Willefert were kindly delivered to the author by Prof. L. Teller. Observations on the fauna collected have been carried out using stereoscopic microscope MST-130 provided with a drawing adapter MNR-3. The poor preservation of the fauna made it impossible to take any good photos. Accordingly the pictoral material is limited to drawings.

All the specimens studied are in the collection of the Institute of Geological Sciences of Jagiellonian University, Cracow (coll. No 60P).

SYMBOLS AND ABBREVIATIONS

L_{rh} — length of rhabdosome
L_s — length of sicula
L_{dt} — length of dorsal process of the sicula
L_{th} — length of theca
L_h — length of hood
S_{rh} — width of rhabdosome (the first figure indicates width at the hood level; the second, given in brackets, its width below the hood)
S_a — width of sicular aperture
S_{dt} — width of dorsal process of the sicula
S_{th} — width of thecae
S_h — width of hoods
$N_1/5$ mm — thecal number in 5 mm of proximal part of rhabdosome
$N_1/10$ mm — thecal number in 10 mm of proximal part of rhabdosome
$N_2/5$ mm — thecal number in 5 mm of distal part of rhabdosome
$N_2/10$ mm — thecal number in 10 mm of distal part of rhabdosome
th_1, th_2, etc. — the first theca, the second theca
th_1^1, th_2^1, etc. — the lower number denotes the successive theca, the upper one the successive branch (for genus Linograptus only)
Σ — distance from top of hood of th_1 to sicular aperture
α — angle between the dorsal line of the rhabdosome and the ventral wall of the theca

All measurements are given in mm.

Order Graptoloidea Lapworth, 1875
Suborder Monograptina Lapworth, 1880
Family Monograptidae Lapworth, 1873
Genus *Monograptus Geinitz,* 1852 (sensu Bulman, 1970)

Monograptus chelmiensis (Teller, 1964)
Fig. 11/1—12

1964 *Pristiograptus chelmiensis* nov. sp.; Teller, pp. 45—47, Pl. 3, Figs 5, 6; Pl. 4, Figs 1, 6—8; Pl. 7, Figs 1—7; Pl. 13, Fig. 6; Text-Fig. 7a—c
1969 *Monograptus chelmiensis* (Teller); Jackson & Lenz, pp. 24—26, Pl. 5, Figs 5, 8—9
1973 *Colonograptus chelmiensis* (Teller); Biske & Rinenberg, pp. 172—173, Pl. 1, Fig. 2

Material. — Forty rhabdosomes in various growth stages; many specimens lacking distal parts, seven devoid of proximal ends.

Description: Rhabdosome. Narrow, up to 14—25 mm long. Dorsal line initially straight, and next slightly ventrally curved. Width

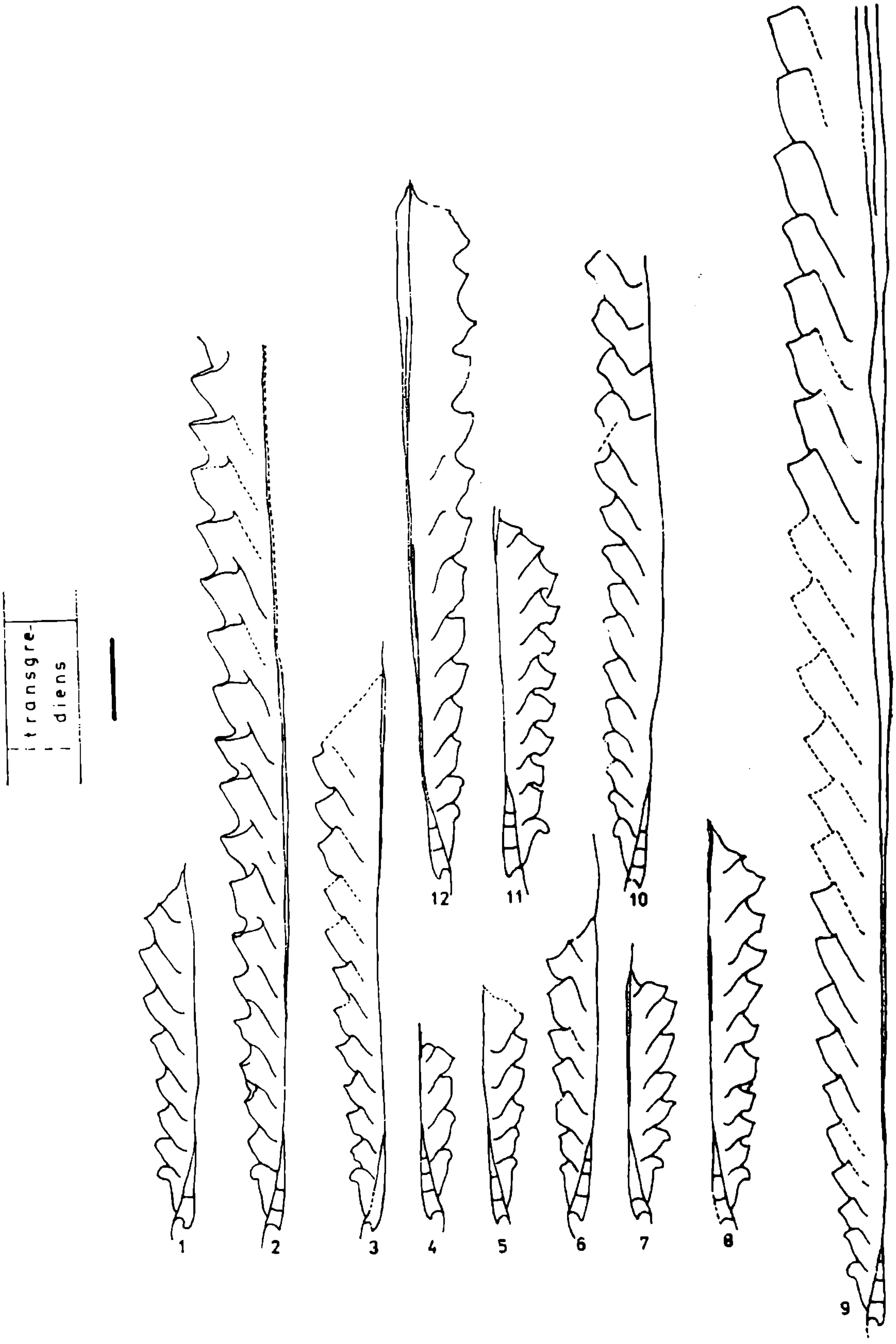

Fig. 11. *Monograptus chelmiensis* (Teller); 1—9 — 60P 578, 548, 507, 535, 567, 565, 517, 549, 524, × 6, lower part of the transgrediens Zone; 10—12 — 60P 541, 506, 547, × 6, upper part of the transgrediens Zone

Fig. 11. *M. chelmiensis* (Teller); 1—9 — 60P 578, 548, 507, 535, 567, 565, 517, 549, 524, × 6, dolna część zony transgrediens; 10—12 — 60P 541, 506, 547, × 6, górna część zony transgrediens

Table 4

60P No.	S_{rh}						α	N_1/5 mm	N_1/10 mm	N_2/5 mm	N_2/10 mm
	th_1	th_1/th_2	th_2	th_5	th_{10}	max.					
553	0.75	0.60	0.88	1.04	1.45	1.80	38°	$5\frac{1}{3}$	9	—	—
548	0.83	0.57	0.85	1.25	1.63	2.30	28°—37°	5	9	$3\frac{3}{4}$	$7\frac{1}{2}$
502	0.85	0.60	0.96	1.32	1.37	—	35°—37°	$5\frac{1}{4}$	10	—	—
507	0.86	0.60	0.88	1.10	1.45	1.90	33°—35°	6	$10\frac{1}{3}$	—	—
		—	—	—	—	2.25	30°—34°	—	—	$3\frac{3}{4}$	$7\frac{1}{2}$
	—	—	—	—	—	2.30	28°—30°	—	—	$3\frac{1}{2}$	7

increases gradually; it is 0.70—0.85 mm at th_1, 0.60 mm just above th_1, 1.10—1.30 mm at th_5, 1.40—1.60 mm at th_{10}; it attins maximum of 2.30 mm at the level of last thecae.

Thecae. Biform. The first theca markedly though not sharply curved downwards (Fig. 11/1—3, 7—12), the next two slightly hooked (Fig. 11/4—5, 7, 9, 10, 12), the remaining thecae straight, tubular, of pristiograptid type (Fig. 11/2, 3, 9). Length of thecae increases distally from 1.50—1.95 mm (proximal end), through 2.00—2.30 mm (medial part) to 3.10—3.30 mm (distal end). Width varies between 0.60—0.80 mm. Ventral walls of proximal thecae most often sigmoidal (Fig. 11/1, 5, 8), those of distal thecae straight (Fig. 11/9). Free ventral walls range in length from 0.70 to 1.50 mm. Apertures of medial and distal thecae perpendicular to ventral walls (Fig. 11/2, 9). Interthecal walls inclined at 28°—38° to rhabdosome axis. $N_1/5$ mm is 5—6, $N_1/10$ mm — 9—10 1/2; $N_2/5$ mm — 3 1/2—3 3/4, $N_2/10$ mm — 7—7 1/2.

Sicula. Long, narrow, ventrally curved, and reaching the base or the middle of th_3. Dorsal process 0.10—0.20 mm long, ventrally curved. Virgella 0.50—0.90 mm long, ventrally deflected. Dimensions: L_s = 1.80—2.20 mm; S_a = 0.30—0.40 mm; Σ = 1.30—1.60 mm.

Measurements of some specimens of *M. chelmiensis* are given in Table 4.

Comparison and Remarks. — The specimens of *M. chelmiensis* under discussion are closely similar to those known from the lowermost Pridolian of the Chełm IG-1 borehole. A slight difference is that in the value of the angle α (30°—35° in the case of the Chełm specimens and 28°—37° in the described ones) and in the number of distal thecae in 10 mm (7—7 1/2 and 8—9, respectively). *M. chelmiensis* from Canada (Jackson & Lenz, 1969) differs by having wider rhabdosomes (proximally 1.00—1.10 mm compared to 0.70—0.90 mm in the Polish specimens). Slight differences are in the number of proximal thecae in 10 mm, which in the Canadian specimens is 11 3/4—7, in those from the Chełm borehole is 10—8, and in those from Żdanów is 10 1/2—7 1/2. *M. chelmiensis* from Tien Shan (Biske & Rinenberg, 1973) differs from the Polish specimens in having wider rhabdosome (2.50 mm) and slightly stronger crowding of the proximal thecae ($N_1/10$ mm — 10—11).

The taxon under description differs from the associated *M. transgrediens transgrediens* Perner only by having narrower rhabdosome, less crowded thecae ($N_2/10$ mm is 7 1/2 compared to 9—10 in *M. transgrediens transgrediens)*, and more acute angle α (28°—37° and 40°—50°, respectively). In many cases, such differences are not taken as a basis for separating sympatric taxons. Within the discussed population of *M. chelmiensis* there occur rhabdosomes (Fig. 11/9) the taxonomic position of which could not be ascertained on the above mentioned criteria. In these specimens the angle α and the proximal width are those typical of *M. chel-*

miensis but their maximum width (2.60—3.10 mm) should be considered diagnostic of *M. transgrediens transgrediens*. Jackson and Lenz (1969) mentioned additional features which permit to distinguish both species: these are stronger crowding of distal thecae and the presence of nodes and pits in the proximal part of rhabdosome, observable in *M. chelmiensis*. The validity of the first criterion has been confirmed neither by the present work nor by that on the Tien Shan specimens; as for the nodes and pits, these occur in specimens of numerous other taxons from Żdanów. Strong morphological resemblance between *M. transgrediens transgrediens* and *M. chelmiensis*, and their similar stratigraphic ranges suggest that these taxons are related.

M. transgrediens praecipuus Přibyl, sympatric with *M. chelmiensis*, differs distinctly in having narrower rhabdosome (maximum 1.40—1.70 mm and 2.30 mm, respectively) and distinctly ventrally curved proximal end.

The described species has been included in the genus *Monograptus sensu lato* (Bulman, 1970), similarly as the other taxons of the *transgrediens* group from the Żdanów Section (such assignement was suggested earlier by Berry & Murphy, 1975; Jaeger, 1978c; Koren', 1978a).

The phylogeny of the graptolites belonging to the *transgrediens* group is not known and this is certainly the cause of different ways of their classification (cf. Tzegelnjuk, 1976; Jaeger, 1977b).

Distribution. — Żdanów Section, transgrediens Zone; the accompanying assemblage is shown in Figure 4. *M. chelmiensis* has been known, till now, from the lowermost "postludlov" of the Chełm IG-1 borehole of eastern Poland (Teller, 1964) and from beds in a similar stratigraphic position in Yukon Territory, Canada (Jackson & Lenz, 1969) and in USSR — Tien Shan (Biske & Rinenberg, 1973).

Monograptus transgrediens praecipuus Přibyl, 1940

Fig. 12/1—7

1940 *Monograptus (Pristiograptus) transgrediens* var. *praecipuus* nov. subsp.; Přibyl, p. 69, Text-Figs 1—5

1943 *Pristiograptus transgrediens praecipuus* (Přibyl; Přibyl, pp. 32—33, Pl. 3, Figs 2—3; Text-Figs 2H, 3E

1971 *Monograptus transgrediens praecipuus* Přibyl; Lenz & Jackson, pp. 14—15, Pl. 2, Figs 5—8; Text-Fig. 4A—D

Material. — Ten complete small rhabdosomes and seventeen most distal or proximal parts.

Description: — Rhabdosome. Length less than 30 mm (2.10—2.70 mm). Only two specimens longer than 30 mm. Proximal part distinctly ventrally curved most commonly up to the level of aperture of th$_{10-11}$ (Fig. 12/2), occasionally to the level of th$_{4-5}$ (Fig. 12/4—7). Rhabdo-

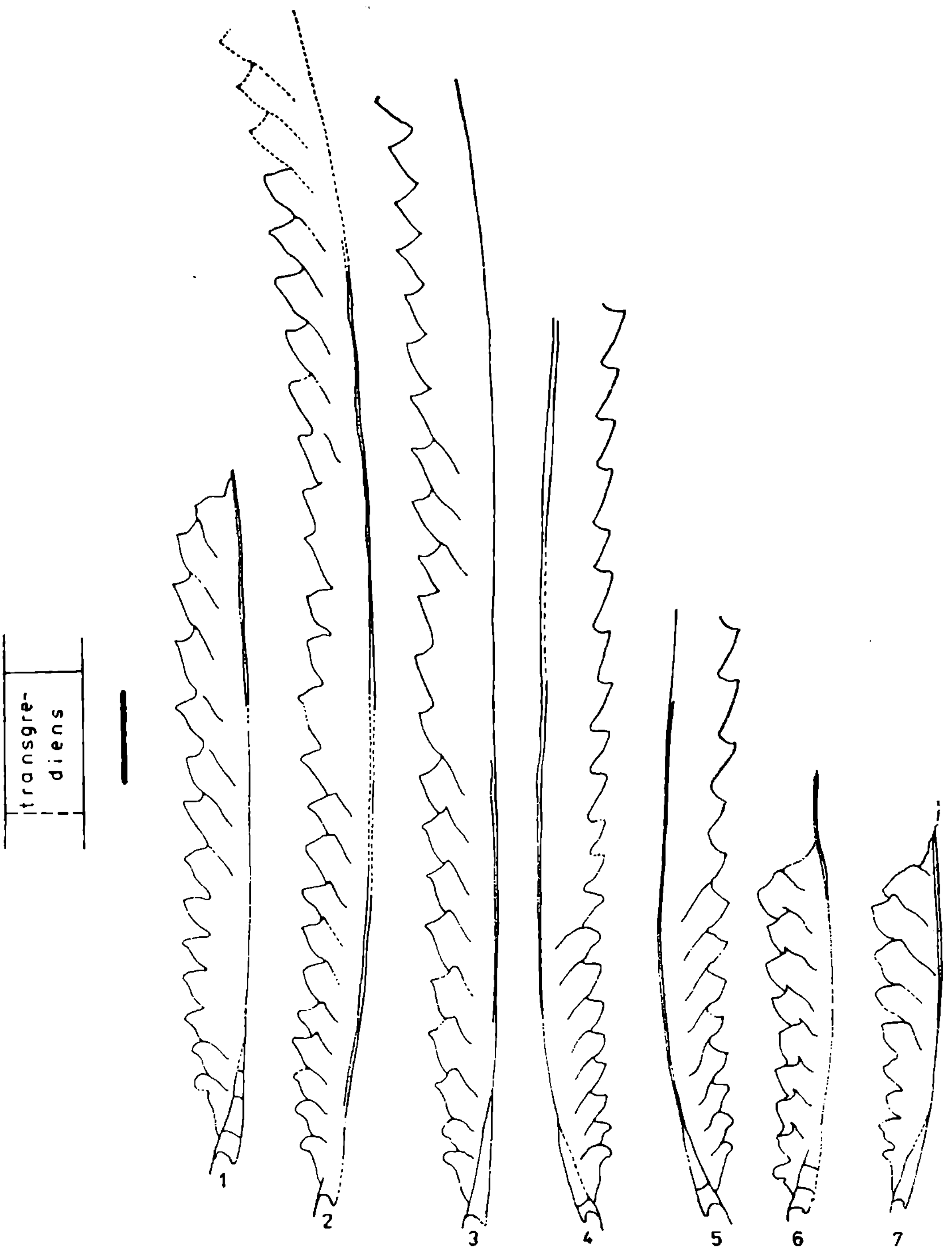

Fig. 12. *Monograptus transgrediens praecipuus* Přibyl; 1—7 — 60P 509, 527, 512, 513, 499, 505, 701, × 6, transgrediens Zone

Fig. 12. *M. transgrediens praecipuus* Přibyl; 1—7 — 60P 509, 527, 512, 513, 499, 505, 701, × 6, zona transgrediens

some width at th$_1$ is 0.90 to 1.00 mm, it increases to 1.20—1.40 mm at th$_5$, and attains its maximum of 1.40—1.70 mm at aperture th$_{9-10}$.

Thecae. Biform. Usually two first thecae (Fig. 12/1—5) or only the first one (Fig. 12/6) of hooked type; the remaining thecae straight, tubular. Proximal thecae are 1.20—1.45 mm long, medial — 1.70—2.10 mm, distal — 2.48 mm; width of thecae is 0.50—0.70 mm. Free ventral walls of the

Table 5

60P No.	S_{rh}						α	N_1/5 mm	N_1/10 mm	N_2/5 mm	N_2/10 mm
	th_1	th_1/th_2	th_2	th_5	th_{10}	max.					
509	0.96	0.67	1.10	1.35	1.60	1.63	35°—40°	6	11	$4^{1}/_{3}$	—
527	0.90	0.63	1.04	1.37	1.56	1.62	35°—38°	6	11	$4^{1}/_{3}$	$8^{1}/_{3}$
512	1.04	0.78	1.08	1.44	1.70	1.70	35°—38°	5	9	—	—
513	0.90	0.67	1.04	1.30	1.32	1.45	45°—40°	$5^{3}/_{4}$	10	$4^{1}/_{2}$	—
499	0.90	0.63	1.00	1.20	1.58	1.60	45°	$6^{1}/_{2}$	—	—	$8^{1}/_{3}$

first four or five thecae slightly sigmoidal (Fig. 12/2, 5), those of the higher thecae straight, 1.20—1.60 mm long. These walls are most commonly almost perpendicular to the concave line of the medial and distal apertures. Interthecal walls inclined at 32°—45° to rhabdosome axis. $N_1/5$ mm is 5—$6^1/_2$, $N_1/10$ mm — 10—11; $N_2/5$ mm — $4^1/_3$—$4^1/_2$, $N_2/10$ mm — $8^1/_2$.

Sicula. Very distinctly ventrally curved. Apex reaches the base of th_4 (Fig. 12/1, 3) or the centre of th_3 (Fig. 12/4, 5). Ventrally curved virgella and dorsal process are 0.80 mm and 0.10—0.20 mm long, respectively. Dimensions: $L_s = 1.80$—2.30 mm; $\Sigma = 1.10$—1.40 mm.

Table 5 shows measurements taken from several specimens of *M. transgrediens praecipuus.*

Comparison and Remarks. —The described taxon is very similar to the Bohemian and Canadian specimens of latest Pridolian age (Přibyl, 1940, 1943; Lenz & Jackson, 1971).

M. transgrediens transgrediens Perner associated with the described subspecies has much wider and shorter rhabdosome ($S_{max} = 2.30$—2.50 mm in comparison to 1.40—1.70 mm in *M. transgrediens praecipuus*) and considerably less curved proximal end. *M. chelmiensis* Teller is longer, proximally narrower (S_{rh} at th_1 is 0.70—0.85 mm in comparison with 0.90 —1.00 mm in *M. transgrediens praecipuus)* and curved ventrally only within the most proximal end.

Distribution. — Żdanów Section, transgrediens Zone; the accompanying assemblage is shown in Figure 4. *M. transgrediens praecipuus* occurs also in the uppermost Pridolian of the Barrandian (Přibyl, 1940, 1943) and of Yukon Territory (Lenz & Jackson, 1971).

Monograptus transgrediens transgrediens Perner, 1899

Fig. 13/1—9

1899 *Monograptus transgrediens* nov. sp.; Perner, p. 13, Pl. 17, Fig. 24

1940 *M. (Pristiograptus) transgrediens* Perner; Přibyl, pp. 68—69

1943 *Pristiograptus transgrediens transgrediens* (Perner); Přibyl, pp. 30—31, Pl. 2, Fig. 7; Pl. 3, Fig. 7

1964 *P. transgrediens* (Perner); Teller, pp. 52—54, Pl. 2, Fig. 3; Pl. 3, Figs 1—4; Pl. 7, Figs 8—12; Text-Fig. 11a—c

Material. — Twelve rhabdosomes lacking extreme distal parts, eighteen specimens representing juvenile stages and six rhabdosomes lacking proximal parts.

Description: Rhabdosome. Straight within distal and medial parts, slightly ventrally curved from the level of aperture th_{7-8}; 30 mm long. Width is 1.00 mm at th_1, 0.70—0,78 mm between th_1, and th_2, 1.30—1.60 mm at th_5, 1.70—1.97 mm at th_{10}, and 2.10—2.40 mm in medial part; maximum width in distal part reaches 2.30—2.60 mm.

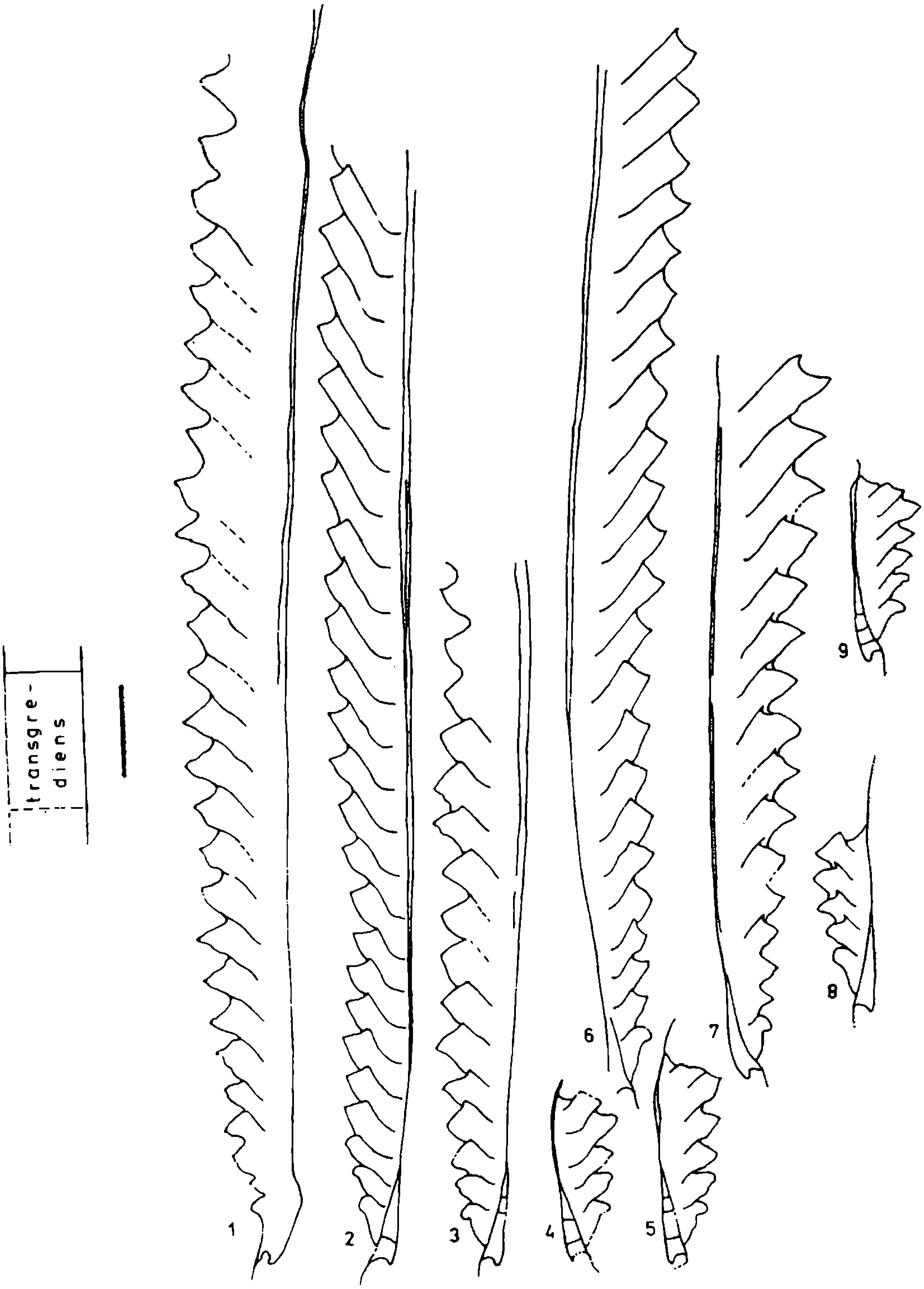

Fig. 13. *Monograptus transgrediens transgrediens* Perner; 1—5 — 60P 526, 870, 60, 546, 550, X 6, lower part of the transgrediens Zone; 6—9 — 60P 1118, 528, 529, 503, X 6, upper part of the transgrediens Zone

Fig. 13. *M. transgrediens transgrediens* Perner; 1—5 — 60P 526, 870, 60, 546, 550, X 6, dolna część zony transgrediens; 6—9 — 60P 1118, 528, 529, 503, X 6, górna część zony transgrediens

Table 6

60P No.	S_{rh}							α	N_1/5 mm	N_1/10 mm	N_2/5 mm	N_2/10 mm
	th_1	th_1/th_2	th_2	th_3	th_{10}	th_{15}	max.					
528	0.96	0.65	1.04	1.32	1.97	2.40	2.50	45°	6	11	4	10
526	1.00	0.66	—	1.56	1.90	2.20	2.50	45°—55°	6	11	$4^3/_4$	9
501	0.98	0.73	1.04	1.30	1.70	1.90	2.00	50°—53°	6	11	$4^2/_3$	—
555	1.05	0.90	1.17	1.63	1.90	2.10	2.30	50°—55°	7	12	—	—

Thecae. Biform. Two most proximal thecae or sometimes only the first one of hooked type, the remaining thecae straight, tubular of pristiograptid appearance. Length of proximal thecae is 1.10—1.35 mm, of medial ones 2.40 mm, and of distal ones 2.50—2.60 mm; width of thecae varies between 0.60 and 0.85 mm. Free ventral walls slightly convex or straight, 0.70 mm long in proximal part of rhabdosome, 0.80 mm in medial part, and 1.00—1.30 in distal part. Interthecal septa straight or slightly sigmoidal, inclined at 40°—55° to rhabdosome axis. $N_1/5$ mm is 6—7, $N_1/10$ mm — 11—12; $N_2/5$ mm — 4—$4^3/_4$, $N_2/10$ mm — 9—10.

Sicula. Long, narrow, ventrally curved. Apex reaches aperture of th_2 (Fig. 13/4, 6, 9) or sometimes the base of th_4 (Fig. 13/2, 5, 7, 8). Dorsal process ventrally curved, 0.10 mm long. Three peridermal rings may be seen occasionally. Dimensions: L_s = 1.10—1.90 mm; S_a = 0.40—0.44 mm; Σ = 1.20 mm.

Measurements of some specimens of *M. transgrediens transgrediens* are given in Table 6.

Comparison and Remarks. — No essential differences between the described specimens and those recorded from the uppermost Silurian of other regions (Přibyl, 1943; Teller, 1964) have been observed.

Distribution. — Żdanów Section, the transgrediens Zone; the accompanying assemblage is shown in Figure 4. For global distribution, see Koren' (1973a).

Monograptus uniformis parangustidens Jackson & Lenz, 1972
Fig. 14/1—11

1972 *Monograptus uniformis parangustidens* nov. subsp.; Jackson & Lenz, pp. 594—595, Text-Fig. 1d—i, m—o

1973a *M. uniformis?* Přibyl; Koren', pp. 142—144, Pl. 4, Figs 11—16

Material. — Nine complete rhabdosomes, fifteen specimens lacking distal and proximal parts, six rhabdosomes representing juvenile stages.

Description: Rhabdosome. Middle-sized, up to 26 mm in length. Distal and medial parts are straight; proximal part ventrally curved to the level of th_{2-5}. Rhabdosome widens gradually from 0.60—0.90 (0.50—0.59) mm at th_1, through 0.44—0.56 mm between th_1 and th_2, 0.83—0.93 (0.57—0.70) mm at th_2, 1.00—1.30 (0.70—0.90) at th_5, to 1.30—1.68 (1.00—1.30) mm at th_{10}. Maximum width of 1.80—2.00 (1.60—1.70) mm is attained between th_{12} and th_{20}.

Thecae. Long, straight and narrow. Proximal thecae 1.20—2.00 mm long, medial 2.30—2.50 mm, distal 2.50—3.20 mm. All thecae provided with hoods of distally increasing size. Hoods of proximal thecae are 0.40—0.50 mm long, those of medial thecae 0.65—0.75 mm; width of hoods is up to 0.35 mm. In some rhabdosomes hoods of medial and distal thecae

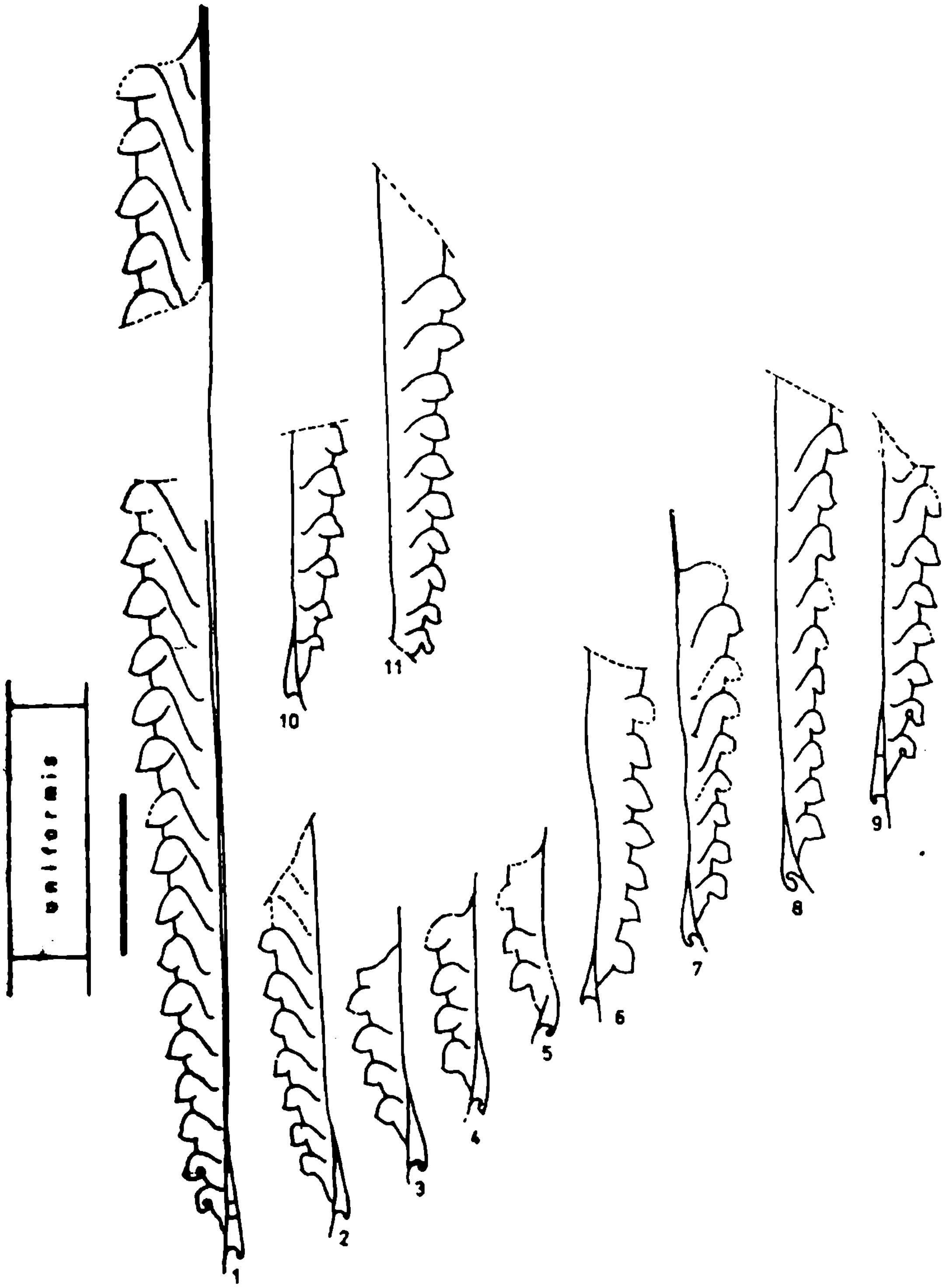

Fig. 14. *Monograptus uniformis parangustidens* Jackson & Lenz; 1—6 — 60P 622, 623, 93, 59, 52, 144, × 6, lower part of the uniformis Zone; 7—11 — 60P 95, 63, 612, 945, 40, × 6, upper part of the uniformis Zone

Fig. 14. *M. uniformis parangustidens* Jackson & Lenz; **1—6 — 60P 622, 623, 93, 59, 52, 144,** × 6, dolna część zony uniformis; 7—11 — 60P 95, 63, 612, 945, 40, × 6, górna część zony uniformis

partly expose the apertures. Transversal section of the most distal part of rhabdosome cuts across two interthecal septa. Free ventral walls of proximal thecae parallel to rhabdosome axis while those of distal thecae inclined at an acute angle, maximum up to 10°. Length of ventral walls usually less than 0.40 mm. Interthecal septa inclined at 24°—40° to rhabdosome axis. $N_1/5$ mm is $5^1/_2$—$6^1/_3$, $N_1/10$ mm — $10^1/_2$—11; $N_2/5$ mm — 5—$5^3/_4$.

Sicula. Long and narrow. Apex extends below or slightly above aperture of th_2. Dorsal process ventrally curved, 0.10—0.30 mm long. Ventral sicular margin commonly straight, occasionally slightly concave; it passes into a ventrally curved virgella, 0.50—0.78 mm long. Dimensions: L_s = 1.56—1.95 mm; S_a = 0.30—0.38 mm; Σ = 1.30—1.50 mm.

Comparison and Remarks. — The population of *M. uniformis parangustidens* from Żdanów does not differ in any essential aspect from that reported from the highest Pridolian of Canada (Jackson & Lenz, 1972). It is also similar to *M. uniformis angustidens* Přibyl. However, owing to its relatively narrow rhabdosome and strongly curved proximal end, the taxon under discussion represents a taxonomically distinct form within graptolites of the *uniformis* group. The described specimens as well as those of *M. uniformis parangustidens* from Canada, due to the shape of the proximal end and the relatively small proximal width of the rhabdosome, are closely similar to the population of *M. uniformis?* Přibyl from Urals (Koren', 1973a). The taxonomical identity of *M. uniformis?* and *M. uniformis parangustidens* has been confirmed by Koren' (Koren', personal communication, 1977).

Among the population of *M. uniformis parangustidens* from Żdanów there occur some rhabdosomes (Fig. 14/1) which bear resemblance to *M. birchensis* Berry & Murphy. The morphology of *M. birchensis* implies a close affinity between this species and the graptolites from the *uniformis* group, especially *M. uniformis parangustidens* and *M. uniformis angustidens*. The only noticeable differences between *M. birchensis* and *M. uniformis* angustidens concern the maximum width of rhabdosome and the degree of dorsal curvature of the proximal end. The rhabdosome width in *M. uniformis parangustidens* is, however, similar to or only slightly smaller than that in *M. birchensis*.

The similarity between the described species and *M.* aff. *angustidens* Přibyl recorded from the lowermost Pridolian of Canada (Lenz & Jackson, 1971) is also worth mentioning. The only essential difference concerns the degree of dorsal curvature of the proximal end. In *M.* aff. *angustidens* the curvature involves the part of rhabdosome between th_1 and th_8 while in *M. uniformis parangustidens* it includes the segment joining th_1 and th_5.

Distribution. — Żdanów Section, the uniformis Zone; the accompanying assemblage is shown in Figure 4. Recorded also from the uppermost Pridolian of the Yukon Territory (Lenz, 1977), and from Urals (Koren', 1973a) where its exact stratigraphic position is not known.

Monograptus uniformis angustidens Přibyl, 1940
Fig. 15/1—7

1940 ***Monograptus (Pomatograptus) angustidens*** **nov. sp.; Přibyl, pp. 70—71, Text-Figs 1, 2; Pl. 1, Figs 3, 4**

1964 *M. angustidens* Přibyl; Teller, pp. 60—62, Pl. 2, Fig. 11; Pl. 8, Figs 1—3; Pl. 9, Figs 13—15; Pl. 13, Fig. 5; Text-Fig. 15a—b

1968b *M. uniformis angustidens* Přibyl; Koren', pp. 939—940, Pl. 1, Figs 7—11

1968 *M. uniformis angustidens* Přibyl; Obut, pp. 946—947, Pl. 1, Fig. 4

1972 *M. uniformis angustidens* Přibyl; Jackson & Lenz, pp. 593—594, Text-Figs 1J, Q, 4C, B, K, L

Material. — Twelve complete rhabdosomes and ten medial and distal fragments.

Description: Rhabdosome. Relatively narrow, especially up to the aperture of th_{5-6}, up to 19 mm in lenght. Straight within distal and medial parts, occasionally more of less dorsally curved within the proximal end. Width of rhabdosome increases gradually; it is 0.85—1.05 (0.50—0.70) mm at th_1, 0.50—0.75 mm between th_1 and th_2, 0.90—1.10 (0.55—0.85) mm at th_2, 1.00—1.30 (0.80—1.10) mm at th_4, and 1.55—1.76 (1.30—1.50) mm at th_{10}. The maximum width of 2.10 (1.80) mm is attained at th_{16}, thereafter it is the same or slightly diminishing.

Thecae. Long and narrow. Proximal thecae 1.20—2.00 mm long, medial 2.50 mm, distal 2.70—3.50 mm. Width of distal thecae ranges between 0.40 and 0.65 mm. Proximal thecae and partly also the medial ones, are terminated with well developed, distinctly down-curved hoods, 0.30—0.60 mm long and ca. 0.40 mm wide. In a higher part of rhabdosome hoods diminish in size and are replaced with dorsal shields 0.30—0.50 mm long, which partly expose thecal apertures (Fig. 15/7). Ventral walls of proximal thecae inclined at 10°—15° to rhabdosome axis (Fig. 15/1) or parallel to it in some specimens (Fig. 15/4). Walls of other thecae parallel to rhabdosome axis. Length of free ventral walls of proximal thecae is 0.52—0.60 mm, of medial ones 0.75 mm, of distal ones usually 0.90 mm. Distal thecae have supragenicular and infragenicular parts of ventral walls perpendicular to each other. Excavations are rather shallow, semicircular, 0.18—0.30 mm wide. Interthecal septa of proximal thecae inclined at 32°—45° to rhabdosome axis, those of the distal thecae at 13°—20°. $N_1/5$ mm is $5^1/_2$—$6^1/_2$; $N_1/10$ mm — $10^3/_4$—$11^1/_2$; $N_2/5$ mm — $5^1/_2$—$4^1/_3$; $N_2/10$ mm — 9.

Sicula. Long, narrow, straight (Fig. 15/2, 3) or slightly ventrally deflected (Fig. 15/1, 5), 1.60—2.00 mm long. Length of prosicula is 0.30 mm. Prosicula is very narrow within the apical portion slightly widening towards the base attaining the width of 0.10—0.12 mm. Metasicula widens gradually and its apertural width is 0.30—0.45 mm. Ventral margin of sicula forms usually a slightly concave line passing into distinctly curved virgella, 0.20—0.60 mm long. Dorsal process curved ventrally, round or

Fig. 15. *Monograptus uniformis angustidens* Přibyl; 1—6 — 60P 224, 631, 41, 94, 97, 96 × 6, lower part of the uniformis Zone; 7 — 60P 1119, × 6, upper part of the uniformis Zone

Fig. 15. *M. uniformis angustidens* Přibyl; 1—6 — 60P 224, 631, 41, 94, 97, 96, × 6, dolna część zony uniformis; 7 — 60P 1119, × 6, górna część zony uniformis

tongue-shaped, up to 0.30 mm long. Some siculae have two peridermal rings. $\Sigma = 1.30—1.50$ mm.

Comparison and Remarks. — The morphology of the studied specimens agrees with the diagnostic features of *M. uniformis angustidens* Přibyl. For comparison with other representatives of the *uniformis* group, see Table 1.

Distribution. — Żdanów Section, the uniformis Zone; the accompanying assemblage is given in Figure 4. It occurs also in the same stratigraphic position in Barrandian (Přibyl, 1940; Chlupáč, 1977), Podolia (Koren', 1968b; Obut, 1968), and in Yukon Territory (Jackson & Lenz, 1972). In eastern Poland *M. uniformis angustidens* occurs in deposits referred to as the uppermost "Postludlov" (Teller, 1964).

Monograptus uniformis uniformis Přibyl, 1940
Fig. 16/1—9

1940 *Monograptus (Pomatograptus) uncinatus* var. *uniformis;* Přibyl, pp. 71—72, Pl. 1, Fig. 1

1959 *M. uniformis* Přibyl; Jaeger, pp. 94—98, Pl. 1, Fig. 3; Pl. 3, Figs 9—10, Pl. 4, Figs 4—15; Text-Fig. 16d—h

1968b *M. uniformis uniformis* Přibyl; Koren', pp. 938—939, Pl. 1, Figs 1—4

1968 *M. uniformis uniformis* Přibyl; Obut, pp. 945—946, Pl. 1, Figs 1—3

1970 *M. uniformis* Přibyl; Berry, Fig. 2b, g

1971 *M.* cf. *uniformis* Přibyl; Lenz & Jackson, p. 16, Text-Fig. 3C—G

1972 *M. uniformis uniformis* Přibyl; Jackson & Lenz, p. 595, Text-Figs 1P, 4H—J

1973a *M. uniformis uniformis* Přibyl; Koren' pp. 140—142, Pl. 4, Figs 1—6; Pl. 5, Figs 1—13

1975 *M. uniformis* Přibyl; Berry & Murphy, pp. 62—63, Pl. 1, Fig. 5; Text-Fig. 18b, f

1978b *M. uniformis* Přibyl; Koren', pp. 118—119, Pl. 1, Figs 2, 3; Text-Fig. 3g—j

Material. — Twelve complete rhabdosomes, seven lacking proximal or distal parts, eight specimens representing juvenile stages.

Description. Rhabdosome. Medium sized; the largest specimens more than 15 mm long. Straight or with slightly dorsally curved proximal part. Width increases rapidly to the level of th_{10-21}; it is 0.90—1.06 (0.60—0.80) mm at th_1, 0.75—0.90 mm between th_1 and th_2, 1.40—1.65 (1.20—1.35) mm at th_5, 1.90—2.20 (1.60—1.90) mm at th_{10}, and 2.30—2.50 mm at th_{15}. Maximum width is 2.60 mm in completely preserved rhabdosomes, width of distal fragments is 2.60—3.20 (2.30—2.90) mm.

Thecae. Terminated by well developed hoods of distally increasing size. Hoods of proximal thecae are 0.70 mm long and 0.37 mm wide, those of medial thecae 1.10 mm and 1.00 mm, respectively. Occasionally the hoods partly expose thecal apertures, most commonly of distal thecae. Lenght of proximal and medial thecae is 1.30—2.60 mm; width 0.40—0.60 mm. Free ventral walls of proximal and medial thecae inclined at $10^\circ—25^\circ$ to rhabdosome axis; within the distal thecae they are most

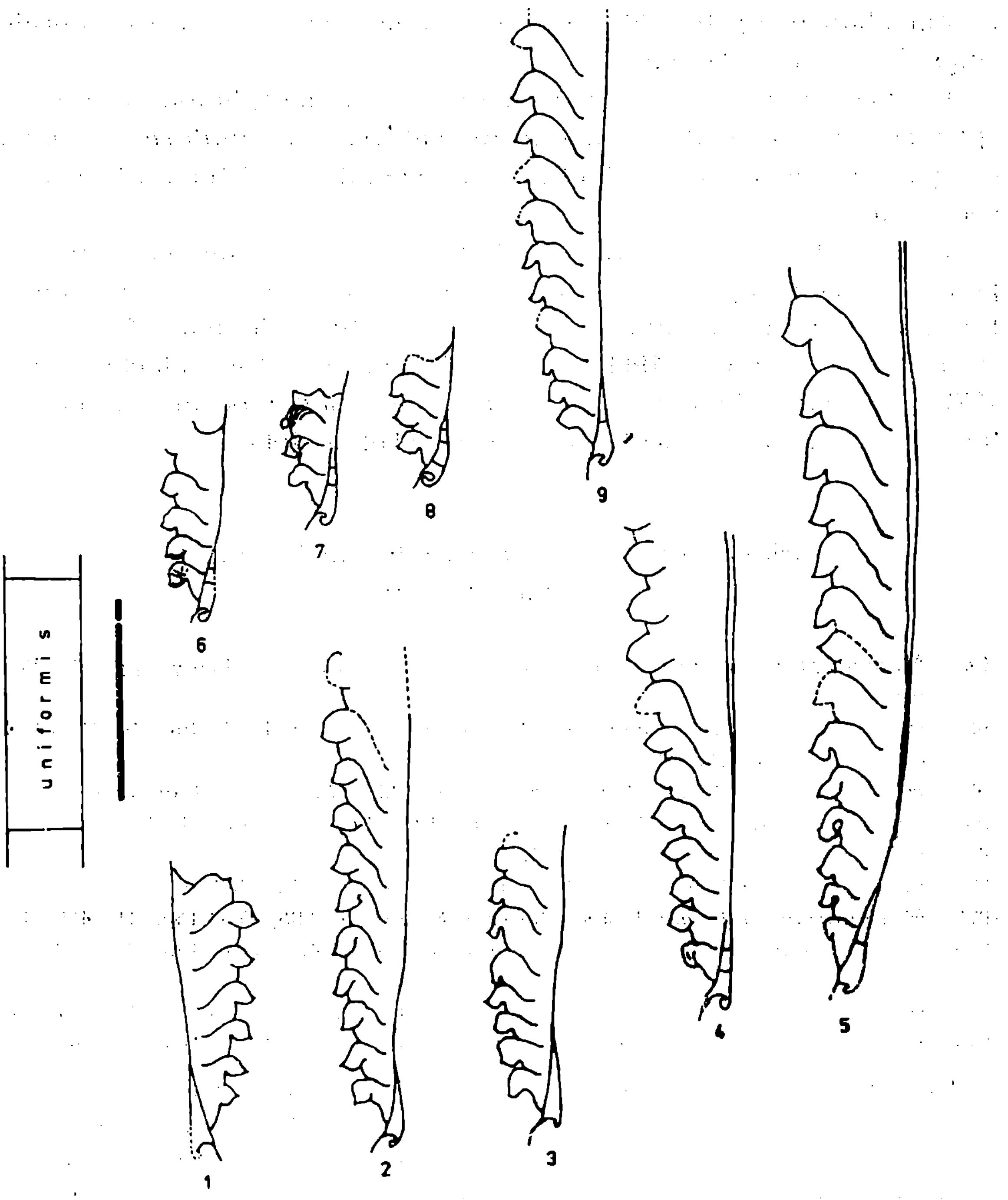

Fig. 16. *Monograptus uniformis uniformis* Přibyl; 1—5 — 60P 20, 91, 148, 93, 103, × 6, lower part of the uniformis Zone; 6—9 — 60P 40, 98, 99, 85, × 6, upper part of the uniformis Zone

Fig. 16. *M. uniformis uniformis* Přibyl; 1—5 — 60P 20, 91, 148, 93, 103, × 6, dolna część zony uniformis; 6—9 — 60P 40, 98, 99, 85, × 6, górna część zony uniformis

commonly parallel to the axis. Length of free ventral valls is 0.50—0.60 mm. Interthecal walls inclined at 15°—45° to rhabdosome axis. $N_1/5$ mm is $5^1/_2$—$6^1/_3$, $N_1/10$ mm — $10^1/_2$—$11^1/_2$; $N_2/5$ mm — 5—$5^3/_4$.

Sicula. Straight or slightly dorsally curved; in some specimens, however, the proximal part of metasicula is slightly ventrally curved (Fig. 16/2, 8). Apex exstends to aperture of th$_2$ or slightly above. Ventrally deflected virgella is 0.20—0.60 mm long. Dorsal process, ventrally curved, 0.20—0.30 mm long. Rim of the aperture is thickened, slightly concave or straight. In some specimens the fusellar structure of sicula is preserved and three sicular rings are visible. Dimensions: L_s = 1.50—1.90 mm; S_a = 0.35—0.45 mm; Σ = 1.05—1.26 mm.

Comparison and Remarks. — The morphology of the studied specimens agrees with the diagnostic features of *M. uniformis uniformis* Přibyl.

Distribution. — Żdanów Section, the uniformis Zone, the accompanying assemblage is given in Figure 4. For global distribution, see Koren' (1973a) and Jaeger (1978).

Monograptus microdon microdon Reinh. Richter, 1875

Fig. 17/1—5

1875 *Monograptus microdon* nov. sp.; Reinh. Richter, p. 268, Pl. 8, Figs 4—6
1959 *M. microdon microdon* Reinh. Richter; Jaeger, pp. 107—110, Pl. 1, Fig. 6; Pl. 5, Figs 7—13; Text-Fig. 17g (see synonymy)
1970 *M. microdon* Reinh. Richter; Berry, Fig. 2c
1973a *M. microdon* Reinh. Richter; Koren', pp. 149—151, Pl. 7, Figs 1—4
1975 *M. microdon* Reinh. Richter; Berry & Murphy, p. 54, Pl. 3, Fig. 3
1977 *M. microdon* Reinh. Richter; Xiao-feng, p. 197, Fig. 1

Material. — Eighteen complete rhabdosomes representing juvenile stages, fifteen rhabdosomes lacking distal parts.

Description. — Rhabdosome. Very small, up to 15 mm long. Usually distinctly ventrally curved within the proximal part up to the level of th_{3-5}. Width is relatively small, it is 0.32—0.44 (0.28—0.40) mm at th_1 and 0.30—0.44 mm between th_1 and th_2; attaining its maximum of 0.80—0.90 (0.70—0.80) mm at th_{5-7}.

Thecae. Hoods are small and often it is not possible to determine their position due to bad state of preservation (Fig. 17A/4, 5). N_t/5 mm is 6—6$^1/_2$, N_t/10 mm — 12.

Sicula. Small, distinctly ventrally curved. It is terminated with a relatively short virgella (length up to 0.50 mm) and very small dorsal process. Occasionally one or two sicular rings may be observed. Dimensions: L_s = 1.04—1.35 mm; S_a = 0.20—0.26 mm.

Measurements of some specimens of *M. microdon microdon* are given in Table 7.

Comparison and Remarks. — The described rhabdosomes of *M. microdon microdon* are closely similar to those kown from Thuringia (Jaeger, 1959) and Nevada (Berry & Murphy, 1975). Due to the ventral curvature of the proximal end they differ distinctly from the rhabdoso-

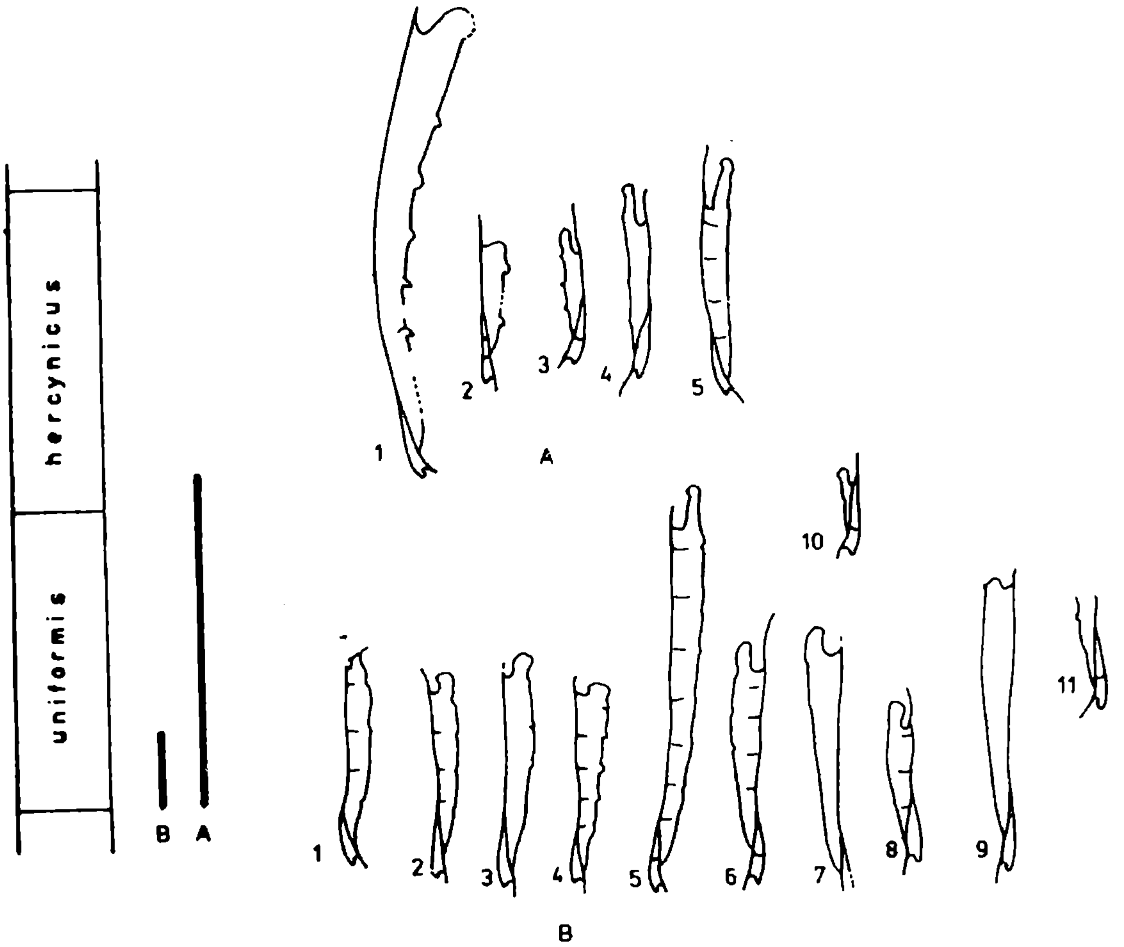

Fig. 17. A — *Monograptus microdon microdon* Reinh. Richter; 1 — 60P 58, X 6, lower part of the uniformis Zone; 2—5 — 60P 1120, 918, 1121, 936, X 6, upper part of the uniformis Zone. B — *M. microdon silesicus* Jaeger; 1—9 — 60P 936, 617, 938, 919, 941, 626, 943, 940, 944, X 6, lower part of the uniformis Zone; 10—11, X 6, — *M. microdon* Reinh. Richter, lower part of the uniformis Zone

Fig. 17. A — *M. microdon microdon* Rinh. Richter; 1 — 60P 58, X 6, dolna część zony uniformis; 2—5 — 60P 1120, 918, 1121, 936, X 6, górna część zony uniformis. B — *M. microdon silesicus* Jaeger; 1—9 — 60P 936, 617, 938, 919, 941, 626, 943, 940, 944, X 6, dolna część zony uniformis; 10—11, X 6 — *M. microdon* Reinh. Richter, dolna część zony uniformis

mes of *M. microdon silesicus* Jaeger which has the proximal end curved in the opposite direction. No other important features differing these two taxons have been observed. Also no evolutionary modifications of astogeny of *M. microdon microdon* have been noted. However, the observations may not be too accurate due to the poor state of preservation of the specimens studied.

Distribution. — Żdanów Section, the uniformis and hercynicus Zones; the accompanying assemblage is given in Figure 4. For global distribution, see Koren' (1973a). Moreover, this taxon was recorded recently from the lowermost Devonian deposits of the Carnic Alps (Jaeger, 1975) and from China (Xiao-feng, 1977).

Table 7

60 P	S_{rh}				Sicula		N_1/5 mm	N_1/10 mm
	th$_1$	th$_1$/th$_2$	th$_5$	max.	L_s	S_a		
915	0.37	0.44	0.90 (0.78)	0.90 (0.80)	—	0.26	$6^1/_2$	12
1110	0.44 (0.40)	0.40	0.78 (0.67)	0.78 (0.70)	1.04	0.23	$6^1/_4$	12
918	0.36	0.46	0.90	0.90 (0.78)	1.35	0.21	6	—
936	0.32 (0.28)	0.30	—	—	1.30	0.20	—	—

Monograptus microdon silesicus Jaeger, 1959

Fig. 17B/1-9

1959 *Monograptus microdon silesicus* nov. subsp.; Jaeger, pp. 100—112, Pl. 1, Fig. 9; Pl. 5, Fig. 6; Text-Fig. 17d—f

1963 *Monograptus microdon silesicus* Jaeger; Spasov, p. 131, Pl. 2, Fig. 2

Material. — Twenty complete rhabdosomes representing juvenile stages, six rhabdosomes lacking distal parts.

Description: Rhabdosome. Very small, length commonly less than 10 mm. Usually distinctly dorsally curved to the level of th$_{2-4}$, occasionally th$_1$. The dorsal curvature is usually proceded by a slight

Table 8

60P No.	S_{rh}				Sicula		N_1/5 mm
	th$_1$	th$_1$/th$_2$	th$_5$	max.	L_s	S_a	
919	0.40 (0.36)	—	—	—	1.04	0.20	—
940	0.36	0.39	0.54	—	1.28	0.26	—
626	0.36	0.39	0.55	0.82	1.30	0.26	$6^1/_2$
941	0.33	0.40	0.59	0.96	1.22	0.26	6

ventral curvature. Width is 0.33—0.40 mm at th_1, 0.40 mm between th_1 and th_2, and 0.54—0.60 mm at th_5; maximum width is 0.80—0.96 mm.

Thecae. Terminated by very small hoods the exact size and morphology of which are not observable due to bad state of preservation. $N_1/5$ mm is 6—$6^1/_2$.

Sicula. Narrow, distinctly ventrally curved. Small virgella and sicular process also ventrally curved. Dimensions: L_s = 1.05—1.44 mm; S_a = = 0.20—0.26 mm; Σ = 0.90—1.18 mm.

Measurements of some specimens of *M. microdon silesicus* are given in Table 8.

Comparison and Remarks. — The holotype of *M. microdon silesicus* was described by Jaeger (1959) from the Żdanów Section but its exact stratigraphic position in the section was not defined. The present evidence indicates that the occurrence of *M. microdon silesicus* in the type locality is limited to the lowermost part of the uniformis Zone.

There is, till now, little accurate information concerning the stratigraphic distribution of *M. microdon* in Silurian deposits. Berry and Murphy (1975) do not discern the subspecies in the population of *M. microdon* occurring in the uppermost Pridolian deposits of Nevada. In the other localities (Germany, Czechoslovakia, Bulgaria, USSR, and Austria) *M. microdon* is restricted to the Devonian deposits. Thus, the pre-Devonian history of *M. microdon* is poorly known.

Distribution. — Żdanów Section, the uniformis Zone; the accompanying assemblage is shown in Figure 4. The subspecies was, moreover, recorded from the lowermost Devonian in Thuringia (? praehercynicus Zone — Jaeger, 1959) and from Bulgaria (the uniformis Zone — Spasov, 1963).

Monograptus sudeticus nov. sp.

Fig. 18/1-18

Holotype: specimen shown in Figure 18/1, 60P 29.

Type locality: Żdanów, Bardo Mts. (Sudetes).

Stratum typicum: Lower Devonian, the uniformis and hercynicus Zones.

Derivation of the name: after the Sudety Mts.

Diagnosis. — A straight monograptid of medium size, relatively narrow. Thecae of hooded type. Width of rhabdosome is equal to 0.70—0.90 (0.50—0.65) mm at th_1, maximum width is 1.80 (1.40) mm. Sicula of normal shape, ventrally curved, 1.60—2.00 mm long and 0.20—0.38 mm wide at aperture. $N_1/10$ mm is 8—$9^3/_4$.

Material. — Twenty rhabdosomes lacking most distal parts, sixteen rhabdosomes representing juvenile stages.

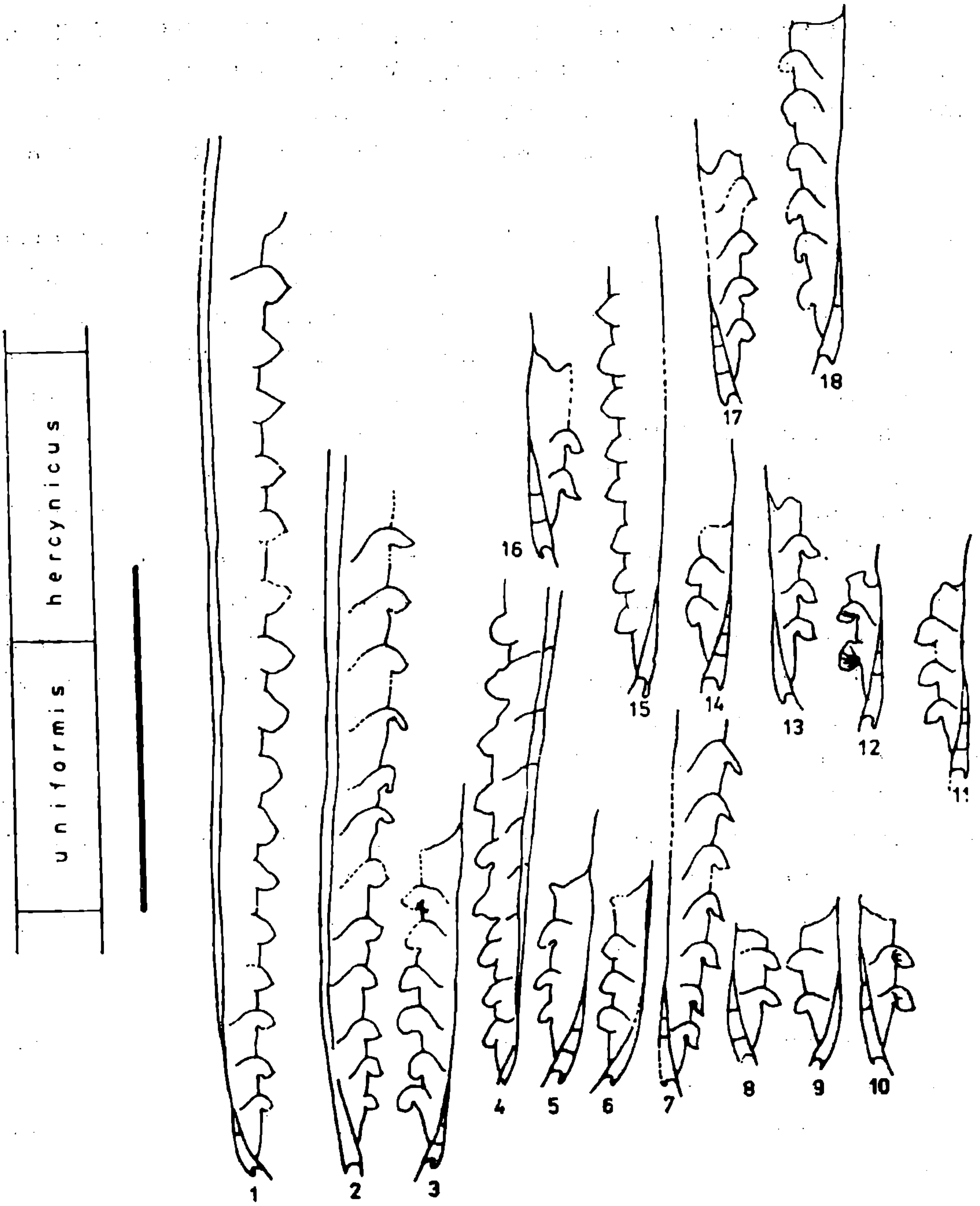

Fig. 18. *Monograptus sudeticus* nov. sp.; 1—10 — 60P 29, 86, 13, 28, 32, 38, 109, 42, 24, 15, × 6, lower part of the uniformis Zone; 11—15 — 60P 613, 105, 950, 72, 641, × 6, upper part of the uniformis Zone; 16—18 — 60P 114, 667, 71, × 6, lower part of the hercynicus Zone

Fig. 18. *M. sudeticus* nov. sp.; 1—10 — 60P 29, 86, 13, 28, 32, 38, 109, 42, 24, 15, × 6, dolna część zony uniformis; 11—15 — 60P 613, 105, 950, 72, 641, × 6, górna część zony uniformis; 16—18 — 60P 114, 667, 71, × 6, dolna część zony hercynicus

Description: — Rhabdosome. Narrow, straight; most common are specimens 5—10 mm long. The largest but not complete specimens are up to 35 mm long. Width increases very gradually so that rhabdosome appears to be apparently parallel-sided along its whole length (Fig. 18/1, 2, 7, 15). Owing to this, the ventral line is almost parallel to rhabdosome axis also in its proximal part. Width is equal to 0.70—0.90 (0.50—0.65) mm at th_1, 0.44—0.67 mm between th_1 and th_2, 0.80—1.00 (0.60—0.70) mm at th_2, and 1.10—1.50 (0.90—1.20) mm at th_5. Within its higher part the rhabdosome widens gradually, and from the aperture of th_{6-10} width is 1.40—1.50 (1.00—1.20) mm. Maximum width at the level of distal thecae does not exceed 1.80 (1.40) mm.

Thecae. Short and hooded. Their fusellar structure can be observed in very few cases only. Proximal thecae 0.40 mm long, medial 0.60—0.70 mm long. They are provided with well developed hoods which in proximal thecae are 0.75 mm long and 0.35 mm vide. Hoods extend down below level of ventral and lateral margin of apertures thus obscuring them. Free ventral walls, 0.30—0.65 mm long, are parallel to rhabdosome axis. Interthecal septa inclined at about 30° to axis. Thecal crowding is relatively low. Tangential section of rhabdosome always cuts across only one theca. $N_1/5$ mm is $4^3/_4$—5, $N_1/10$ mm — 8—$9^3/_4$; $N_2/5$ mm — $3^1/_4$—$4^1/_4$.

Sicula. Narrow, ventrally curved, Apex reaches aperture of th_1 or th_2; in some specimens it is situated between apertures of th_1 and th_2. Within the metasicular part, sicula widens gradually attaining maximum width of a 0.20—0.38 mm in the middle of its length; the width only seldom increases close to aperture. The most common apertural width is 0.31—0.33 mm. Metasicula is distinctly ventrally curved. Its inner margin passes into ventrally curved virgella and the outer one is terminated by a ventrally curved dorsal process, 0.10—0.20 mm long. Rim of the sicular aperture is slightly concave. In some specimens two sicular rings are visible. Dimensions: $L_s = 1.60—2.00$ mm; $S_a = 0.20—0.38$ mm: $\Sigma = 1.20—1.50$ mm.

Table 9 shows measurements taken from several specimens of *M. sudeticus*.

Comparison and Remarks. — The specimens of *M. sudeticus* from the lower part of the uniformis Zone have a more ventrally curved sicula in which the metasicular parts of dorsal and ventral margin are almost parallel to each other (Fig. 18/1, 5, 6, 8, 9, 10). In younger specimens, from the upper part of the uniformis Zone and from the hercynicus Zone (Fig. 18/13, 14, 17, 18), the metasicula is slightly wider ($S_a = 0.38$ mm, while it averages 0.30 mm in the older rhabdosomes). The dorsal margins of the sicula is, in younger rhabdosomes, sligthly ventrally curved (Fig. 18/12, 15, 18) or almost vertical (Fig. 18/11, 14, 16, 17). Except of these features and of a probable gradual, upward shifting of the sicular apex, no other astogenetic changes in the development of *M. sudeticus* have been seen.

M. sudeticus differs distinctly from the associated *M. uniformis angustidens* Přibyl and *M. uniformis parangustidens* Jackson & Lenz mainly in having a straight proximal end and in displaying less closely spaced thecae. Compared with *M. uniformis uniformis* Přibyl, it has a much

Table 9

60P No.	S_{rh}						Σ	Sicula			$N_1/5$ mm	$N_1/10$ mm	$N_2/5$ mm
	th_1	th_1/th_2	th_2	th_5	th_{10}	max.		L_s	S_a	L_{dt}			
89	—	—	—	—	—	1.80 (1.40)	—	—	—	—	$4^3/_4$	8	$3^1/_4$
667	0.80 (0.57)	0.60 (0.62)	0.90 (0.62)	1.20 (0.90)	1.60 (1.30)	1.60 (1.30)	1.37	1.80	0.30	0.13	5	$9^1/_2$	—
1111	—	—	—	—	—	1.82	—	—	—	—	5	$9^3/_4$	$3^3/_4$
71	0.93 (0.65)	0.65	1.00	1.50 (1.20)	—	—	1.22	1.70	0.32	0.10	$4^3/_4$	—	—
86	0.78 (?)	0.62	1.00 (0.70)	1.30 (1.00)	1.54 (1.20)	1.70 (1.40)	1.43	1.82	0.33	—	5	$9^1/_2$	4
29	? (0.51)	0.60	0.90 (0.65)	1.20 (0.90)	1.50 (1.20)	1.60 (1.30)	1.30	1.80	0.36	0.13	5	$9^1/_2$	$4^1/_2$

narrower rhabdosome and the hood of th$_1$ is situated higher (comp. Tables 1 and 2).

M. sudeticus, and especially its youngest representatives (Fig. 18/15, 18) is very small similar to *M. praehercynicus* Jaeger. The differences concern: (1) the proximal and distal width of rhabdosome (0.70—0.90 mm and 1.80 mm in the former; 0.90—1.10 mm and 1.80—2.30 mm in the latter), (2) the character of rhabdosome widening (more rapid in *M. praehercynicus)*, (3) the proximal thecal spacing (8—$9\frac{3}{4}$ and $8\frac{1}{2}$—$10\frac{1}{2}$, respectively), (4) the length of sicula (1.60—2.00 mm and 1.80—2.20 mm), (5) the width of sicular aperture (0.20—0.38 mm and 0.35—0.50 mm), (6) the curvature of sicula (distinctly ventrally curved and straight or sligthly dorsally curved, respectively), and (7) the value of Σ (1.20—1.50 mm and 1.50—1.70 mm respectively).

The described taxon bears a great resemblance to *M. similis* Přibyl known from the ultimus Zone of lower Pridolian of Barrandian (Přibyl, 1940), *M.* sp. aff. *similis* found in the ultimus Zone of the Łeba-1 borehole in Pomerania (Jaeger, 1966, Fig. 1h), and also to *M.* aff. *similis* from Kazachstan (Mikhailova, 1976). The similarity concerns especially the gradual widening of rhabdosome, its small maximum width, and the shape of the sicula. The lack of detailed descriptions of graptolites from the *similis* group makes their close comparison with *M. sudeticus* impossible.

Distribution. — Żdanów Section, the uniformis and hercynicus Zones; the accompanying assemblage is shown in Figure 4.

Monograptus praehercynicus Jaeger, 1959
Fig. 19A/1—6

1959 *Monograptus praehercynicus* nov. sp.; Jaeger, pp. 92—94, Pl. 1, Fig. 2; Pl. 3, Fig. 2; Text-Figs 5—8
1962? *M. uniformis* Přibyl; Willefert, Pl. 2, Figs 10, 12, 15, 17; Text-Figs 4, 2a
1964 *M. uniformis Přibyl vel M. praehercynicus* Jaeger; Willefert, p. 76, Pl. 2, Figs 1, 15, 17, 19—21; Text-Figs 6A—B, 7A—F
1973a *M. praehercynicus* Jaeger; Koren', pp. 144—145, Pl. 6, Figs 4—6, 7, 8, ? 9

Material. — Twelve juvenile rhabdosomes, seven distal and five proximal fragments.

Description: — Rhabdosome. Straight (Fig. 19A/1, 3, 5) or slightly dorsally curved within the portion corresponding to sicula (Fig. 19A/6) or very slightly ventrally curved within the proximal end (Fig. 19A/2). Due to the lack of adult specimens it is not possible to determine

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Fig. 19. A — *Monograptus praehercynicus* Jaeger; 1—2 — 60P 639, 1123, × 6, upper part of the uniformis Zone; 3—6 — 60P 654, 171, 172, × 6, lower part of the hercynicus Zone. B — *M. hercynicus subhercynicus* Willefert; 1—3 — 60P 146, 1124, 1125, × 6, upper part of the uniformis Zone; 4—12 — 60P 189, 575, 157, 227, 174, 162, 225, 154, 164, × 6, lower part of the hercynicus Zone; 13—18 — 60P 165, 166, 163, 853, 651, 1126, × 6, middle part of the hercynicus Zone; 19—22 — 60P 1127, 1128, 860, 859, × 6, upper part of the hercynicus Zone

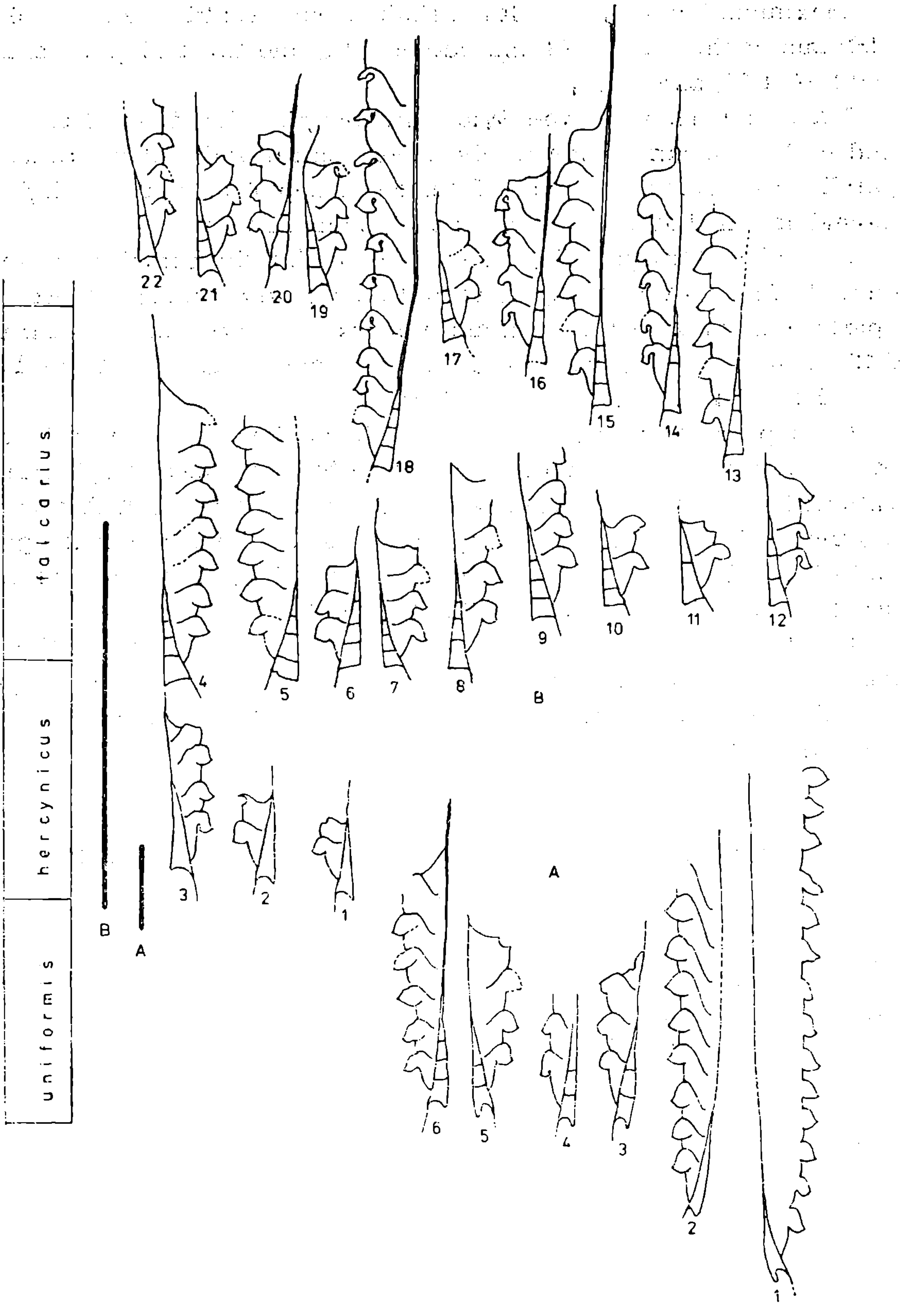

Fig. 19. A — M. *praehercynicus* Jaeger; 1—2 — 60P 639, 1123, X 6, górna część zony uniformis; 3—6 — 60P 654, 171, 172, X 6, dolna część zony hercynicus. B. — M. *hercynicus subhercynicus* Willefert; 1—3 — 60P 146, 1124, 1125, X 6, górna część zony uniformis; 4—12 — 60P 189, 575, 157, 227, 174, 162, 225, 154, 164, X 6, dolna część zony hercynicus; 13—18 — 60P 165, 166, 163, 853, 651, 1126, X 6, środkowa część zony hercynicus; 19—22 — 60P 1127, 1128, 860, 859, X 6, górna część zony hercynicus

the maximum length and width of rhabdosome. Width is 0.90—1.10 (0.65—0.90) mm at th_1, 0.62—0.78 mm between th_1 and th_2, 1.30 (1.00) mm at th_5, and 1.57 (1.35) mm at th_{10}.

Thecae. Hooded type. Width and length of hoods are 0.40—0.50 mm and 0.30—0.50 mm, respectively. Free ventral walls of proximal thecae parallel to rhabdosome axis. Interthecal septa straight or slightly sigmoidal, inclined at 25°—30° to axis. N_1/5 mm in 5—$5^1/_2$.

Sicula. Straight (Fig. 19A/3—5) or slightly dorsally or ventrally curved (Fig. 19A/6, 1—2), normal to narrowly conical. Apex reaches aperture of th_2. Apertural rim more or less concave. Small dorsal process 0.10—0.30 mm long, usually straight. Dimensions: L_s = 1.80—2.20 mm; S_a = 0.35—0.40 mm; Σ = 1.50—1.70 mm.

Comparison and Remarks. — It has been believed till now that *M. praehercynicus* is directly related to *M. uniformis* Přibyl. The observations based upon the Żdanów fauna seem to contradict this view. The differences between these two species concern the shape of the proximal end of rhabdosome, rhabdosome width, crowding of thecae, etc. (cf. Jaeger, 1959; see also Tables 1 and 2 in the text).

Distribution. — Żdanów Section, uppermost part of the uniformis Zone and lowermost part of the hercynicus Zone; the accompanying assemblage is shown in Fig. 4. For global distribution, see Koren' (1973a) and Jaeger (1978).

Monograptus hercynicus subhercynicus Willefert, 1963
Fig. 19B/1—22

1963 *Monograptus* sp. (*sub-hercynicus* nov. sp.?); Willefert, p. 30, Pl. 2, Fig. 13; Text-Fig. 3, 2e

1964 *M. hercynicus* var. *subhercynicus* nov. subsp.; Willefert, p. 75, Pl. 2, Figs 16, 18, 23; Text-Figs 4a—d, 5a—c

1972 *M.* cf. *hercynicus subhercynicus* Willefert; Jackson & Lenz, pp. 591—593, Text-Fig. 4A, B, D

Material. — Nineteen juvenile rhabdosomes, twelve siculae and thirteen proximal fragments.

Description: — Rhabdosome. Straight (Fig. 19B/4, 5) or slightly dorsally curved within most proximal part (Fig. 19B/8, 13, 15). Length of complete rhabdosomes is 0.50—1.80 mm. Width is 0.90—1.10 (0.70—0.80) mm at th_1, 0.70—0.80 mm between th_1 and th_2, 1.30—1.50 (1.00—1.10) mm at th_5, and 1.50—1.75 (1.20—1.48) mm at th_{8-10}.

Thecae. Provided with well developed hoods, 0.30—0.57 mm long and 0.20—0.50 mm wide. Apertures obscured or, rarely exposed (Fig. 19B/18) within medial part of rhabdosome. Free ventral walls parallel or inclined at 5°—15° to rhabdosome axis (Fig. 19B/18, 4—5). Length of free ventral walls of proximal thecae is 0.30—0.40 mm, that of distal ones 0.40—

0.70 mm. Interthecal septa are straight or slightly sigmoidal, inclined at 25°—50° to axis. Proximal and medial thecae are 0.80—1.40 mm long and 0.57—0.80 mm wide. $N_1/5$ mm is 5—6, $N_1/10$ mm — 9—$10^1/_2$.

Sicula. Triangular. Apex usually extends to the level between aperture th_2 and th_3. Prosicula displays the shape of a sharp, symmetric triangle, 0.75—0.80 mm long and 0.14—0.18 mm wide at the base. Metasicula widens relatively rapidly attaining width of 0.40—0.60 mm at the aperture. Dorsal margin of the sicula usually straight and vertical (Fig. 19B/4, 6, 10—12), occasionally curved dorsally (Fig. 19B/13—15). Ventral margin straight or slightly concave, passing into a straight, ventrally curved virgella 0.75 mm long. Rim of aperture straight or forming a small sinus. Dorsal process reduced in most specimens, in the youngest and oldest representatives it occurs in the form of the angular corner of aperture (Fig. 19B/1—2, 19—22). Three sicular rings are visible. Dimensions: L_s = 1.80—2.30 mm; Σ = 1.30—1.60 mm.

Measurements of some specimens of *M. hercynicus subhercynicus* are given in Table 10.

Table 10

60P No.	S_{rh}				Σ	Sicula		$N_1/5$ mm	$N_1/10$ mm
	th_1	th_1/th_2	th_5	th_{10}		L_s	S_a		
189	1.10 (0.78)	0.78	1.43 (1.04)	1.60 (1.30)	1.53	2.15	0.60	5	10
192	1.10 (0.75)	0.75	1.46 (1.12)	1.64 (1.27)	1.48	2.20	0.57	5	$10^1/_2$
136	0.96 (0.68)	0.70	1.22 (0.94)	—	1.58	1.90	0.50	5	—
216	0.94 (0.70)	0.70	1.30 (?)	1.75 (1.50)	1.63	2.15	0.40	$4^3/_4$	$9^1/_2$

Comparison and Remarks. — It seems that the described rhabdosomes of *M. hercynicus subhercynicus* belong to two morphological types. In the uppermost part of the uniformis Zone and in the lowermost part of the hercynicus Zone dominating are the widest rhabdosomes (Fig. 19B/4—5), while in the uppermost part of the hercynicus Zone much slimmer ones have been found (Fig. 19B/13—15, 19—22). The feature making these two morphotypes distinct is the width of the sicular aperture. In the former case this is 0.49—0.62 mm wide and in the latter 0.27—0.49 mm. The dominance of rhabdosomes of the first morphotype in the older strata suggests that there occurs the time correlated succession of these. The first morphotype may represent the earlier evolutionary stage close to *M. hercynicus hercynicus* Perner. The second one, in which the initial form of the sicular dorsal process appears, seems to be closely related to *M. telleri zdanoviensis* nov. subsp. (see Table 2). The slim rhabdosomes with very small dorsal process occur also in the deposits corresponding to the lowermost part of the *M. hercynicus subhercynicus* stratigraphic range (Fig. 19B/1—3). These are very similar to those of *M. praehercynicus* Jaeger.

M. hercynicus subhercynicus from Żdanów differs from the representatives of this subspecies from Morocco (Willefert, 1963) only in having slightly wider rhabdosome. The specimens of *M. hercynicus subhercynicus* recorded from the deposits of the uniformis Zone in Canada (Jackson & Lenz, 1972) and having a very small dorsal sicular process seem to belong to older population of *M. hercynicus subhercynicus*. These rhabdosomes do not differ in any essential respect from those found in the lower part of the uniformis Zone from Żdanów.

Distribution. — Żdanów Section, the uniformis and hercynicus Zones, the lowermost part of falcarius Zone; the accompanying assemblage is shown in Figure 4. Recorded also in the transitional beds of the uniformis and hercynicus Zones from Morocco (Willefert, 1962, 1964) and in the uniformis Zone from Canada (Jackson & Lenz, 1972).

Monograptus hercynicus hercynicus Perner, 1899
Fig. 20/1—19

1899 *Monograptus hercynicus* nov. sp.; Perner, Pl. 3, Figs 10, 11; Text-Fig. 13
1959 *M. hercynicus* Perner; Jaeger, p. 87, Pl. 1, Fig. 10; Pl. 2; Pl. 3, Fig. 1; Text-Fig. 15A—H
1969 *M. hercynicus* Perner; Teller, pp. 331—333, Fig. 1f—g
1973a *M. hercynicus* Perner; Koren' pp. 146—147, Pl. 6, Figs 10—19 (see synonymy)
1975 *M. hercynicus hercynicus* Perner; Berry & Murphy, pp. 51—52, Pl. 1, Fig. 9
1977 *Neomonograptus hercynicus* (Perner); Xiao-feng, pp. 202—203, Pl. 2, Figs 3—4
1978b *M. hercynicus* Perner; Koren', pp. 119—120, Pl. 1, Figs 7, 10; Pl. 2, Figs 1, 2; Text-Fig. 4a—g, 1

Material. — Forty-five specimens including sixteen juvenile rhabdosomes, fifteen proximal fragments and fourteen siculae.

Description: Rhabdosome. Medium-sized, maximum length up to 30 mm. Straight, (Fig. 20/1, 3) or with dorsally curved sicula (Fig. 20/17, 18). Some rhabdosomes show ventral curvature from the level of aperture of th_2 to th_{7-10} and dorsal curvature of the outer sicular margin (Fig. 20/8, 9, 10). Width of rhabdosome is 0.90—1.20 (0.65—0.90) mm at th_1, 0.50—0.90 mm between th_1 and th_2, 1.20—1.60 (0.90—1.20) mm at th_5, and 1.60—2.10 (1.20—1.70) mm at th_{10}. Maximum width of 1.70—2.40 (1.40—2.10) mm is attained at th_{8-15}.

Thecae. Hooded type, 1.20—2.50 mm long and 1.60—1.70 mm wide. Size of hoods increases to th_4 or th_{10}, it is constant within medial part and

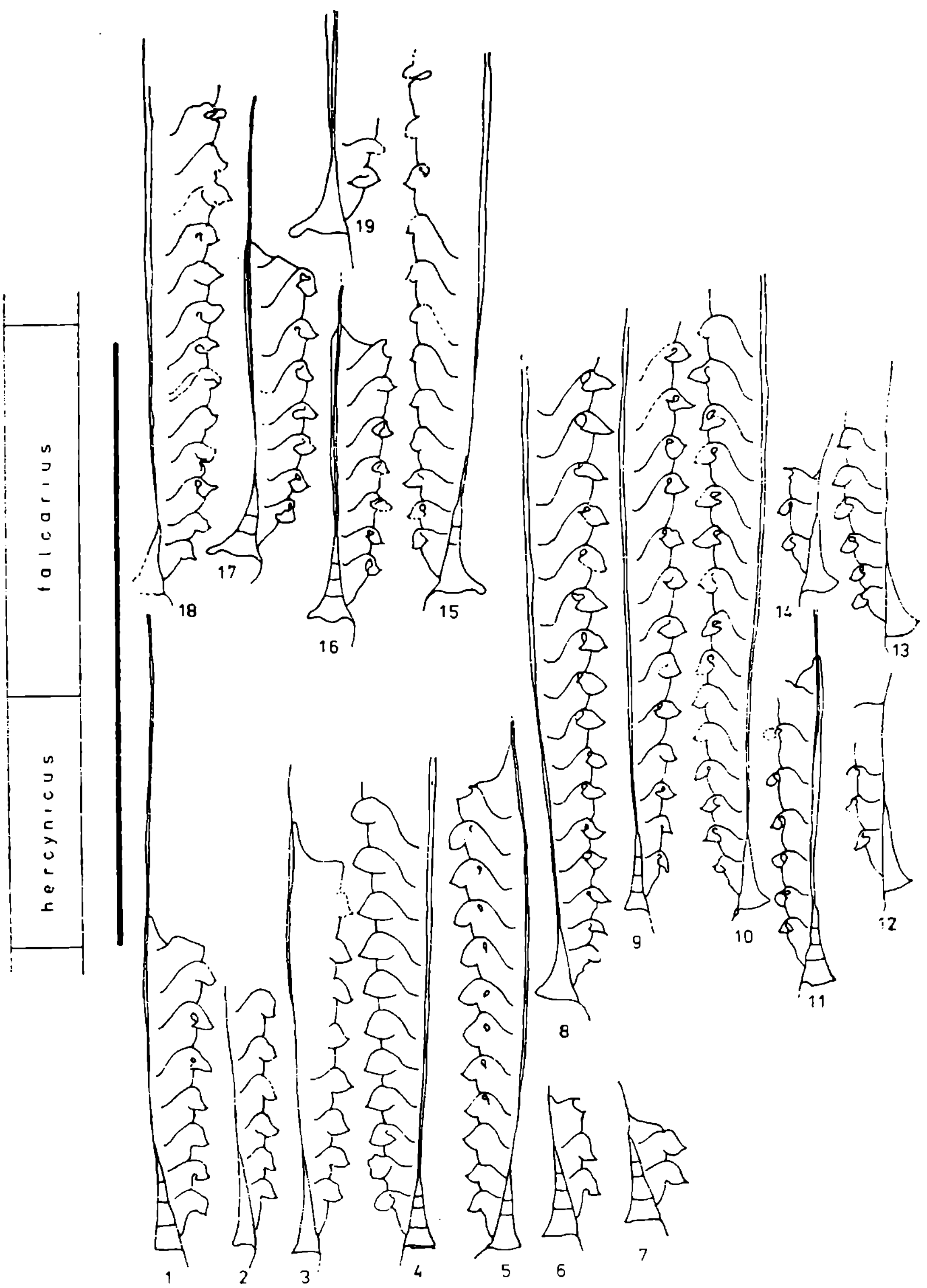

Fig. 20. *Monograptus hercynicus hercynicus* Perner; 1—7 — 60P 690, 694, 490, 637, 632, 117, 288, × 6, the first population, lower part of the hercynicus Zone; 8—11 — 60P 825, 793, 113, 824, ×6, the second population, upper part of the hercynicus Zone; 12—14 — 60P 790, 785, 802, × 6, the second population, lower part of the falcarius Zone; 15—19 — 60P 1112, 713, 724, 1111, 717, × 6, the third population, upper part of the falcarius Zone

Fig. 20. *M. hercynicus hercynicus* Perner; 1—7 — 60P 690, 694, 490, 637, 632, 117, 288, × 6, pierwsza populacja, dolna część zony hercynicus; 8—11 — 60P 825, 793, 113, 824, × 6, druga populacja, górna część zony hercynicus; 12—14 — 60P 790, 785, 802, × 6, druga populacja, dolna część zony falcarius; 15—19 — 60P 1112, 713, 724, 1111, 717, × 6, trzecia populacja, górna część zony falcarius

decreases distally. Length of hoods is 0.50—0.78 mm, width 0.30—0.40 mm. Apertures of proximal and medial thecae are in most cases obscured both ventrally and laterally (Fig. 20/4, 5) while those of distal thecae are often exposed. Occasionally also apertures of proximal thecae are partly laterally exposed (Fig. 20/11, 16). Interthecal septa distinctly sigmoidal; within $^2/_3$ of their length they are inclined at 30°—40° to rhabdosome axis, thereafter perpendicular to it. Free ventral walls straight or slightly convex, 0.30—0.65 mm long, parallel to rhabdosome axis (Fig. 20/2, 11, 12) but in many cases inclined at angle up to 10° (Fig. 20/5, 8, 9). N_1/5 mm is 5—6$^1/_3$, N_1/10 mm — 9$^1/_2$—12.

Sicula. Narrow in the apical part, trumpet-like towards the aperture. Straight (Fig. 20/2, 3) or dorsally curved to various degree (Fig. 20/12, 13, 17, 18). Apex extends to the level of aperture of th_2 (Fig. 20/4, 8, 16) or just above (Fig. 20/2, 5, 7, 15) or below the hood of th_2 (Fig. 20/9, 11, 14). In some specimens dorsally curved dorsal process is visible (Fig. 20/15, 17, 19). Apertural rim straight or slightly undulated. Most siculae have three peridermal rings. Dimensions: $L_s = 1.60—2.20$ mm; $S_a = 0.50—1.15$ mm; $\Sigma = 1.10—1.50$ mm.

Comparison and Remarks. — Within the described specimens of *M. hercynicus hercynicus* three successive population may be distinguished. The quantitative features of rhabdosomes of these populations are summarized in Table 11. The width of rhabdosomes of the earliest population (from the hercynicus Zone, sporadically also from the falcarius Zone; Fig. 20/1—7) is typical of this taxon. In these rhabdosomes the proximal and medial thecae are provided with large hoods. The sicula is longer and has the narrowest aperture in comparison with that in younger populations. In the succeeding population (from the boundary beds between the hercynicus and falcarius Zones; Fig. 20/8—14) the rhabdosomes are narrower, the hoods of the thecae are smaller and they partly expose the thecal apertures ventrally. The sicula becomes shorter and its aperture wider. The crowding of the thecae in these rhabdosomes is greater. The rhabdosomes of the youngest population (the upper part of the falcarius Zone; Fig. 20/15—19) are the thickest, usually straight with distinctly dorsally curved sicula. The hoods of proximal and medial thecae are of almost equal size and the smallest in relation to those in older populations. The thecal crowding is larger than in the first population and similar to that in the second one. The length of sicula is almost the same as in the specimens of the second population. The sicular aperture is the widest and most undulated. There appears a dorsally curved sicular process.

The specimens of the second population are transitional to *M. falcarius* Koren'. The specimens of the youngest population have features which are intermediate between those characteristic of *M. hercynicus hercynicus* and *M. hercynicus nevadensis* Berry. Berry and Murphy (1975) sug-

Table 11

Zone	S_{rh}				Σ	Sicula		N_1/5 mm	N_1/10 mm
	th_1	th_1/th_2	th_{10}	max.		L_s	S_a		
hercynicus	0.90—1.10 (0.65—0.78)	0.60—0.80	1.60—1.70 (1.20—1.35)	1.70—2.00 (1.40—1.80)	1.20—1.50	1.80—2.20	0.50—0.80	5—6½	10—11
transition hercynicus — falcarius	0.90—1.10 (0.65—0.80)	0.54—0.80	1.60—1.70 (1.20—1.30)	1.60—1.95 (1.30—1.60)	1.20—1.35	1.60—2.00	0.70—1.00	5½—6½	10½—12
upper part of falcarius	1.10—1.20 (0.70—0.90)	0.70—0.90	1.70—2.10 (1.60—1.70)	1.80—2.40 (1.60—2.10)	1.10—1.40	1.70—1.95	0.70—1.15	5½—6⅓	10½—11¼

gest that the structural changes leading to the separation of *M. hercynicus nevadensis* from *M. hercynicus hercynicus* were gradual and took place within a wide stratigraphic interval which, however, has not been specified by these authors. The present investigations seem to corroborate this suggestion; the population which are intermediate between the mentioned subspecies occur within nearly the whole profile of the falcarius Zone.

Among the specimens from Żdanów determined by Teller (1960) as *M. hercynicus* Perner the present author identified *M. aequabilis notoaequabilis* Jaeger & Stein, *M. telleri* Lenz & Jackson, and the third population of *M. hercynicus hercynicus*.

Distribution. — Żdanów Section, the hercynicus and falcarius Zones; the accompanying assemblage is shown in Figure 4. For global distribution, see Koren' (1973a) and Jaeger (1978).

Monograptus falcarius Koren' 1969

Fig. 21/1—8

1969 *Monograptus falcarius* nov. sp.; Koren', pp. 1326—1327, Figs 2, 4—8

1978b *M. falcarius* Koren', Koren', p. 121, Pl. 1, Figs 8, 9; Pl. 2, Fig. 4; Text-Fig. 4i—k, m—q (see synonymy)

Material. — Eleven rhabdosomes representing juvenile stages, and ten proximal fragments.

Description: Rhabdosome. The longest fragments less than 20 mm long. Very strongly dorsally curved. Width increasing very rapidly, it is 0.90—1.10 (0.65—0.80) mm at th_1, 0.65—0.80 mm between th_1 and th_2, and 1.20—1.40 (0.90—1.20) mm at th_5. Maximum width of 1.60—1.65 (1.30—1.45) mm is attained between th_7 and th_{10}.

Thecae. Short and hooded. Length and width of thecae are 0.90—2.10 mm and 0.60—0.80 mm, respectively. The hoods in proximal and medial parts of rhabdosome are more or less of equal size. These hoods are initially narrow but rapidly expand transversally. There are only short shields overhanging apertures of extreme distal thecae. In some case fusellar structure of hoods is visible. Thecal apertures are perpendicular to interthecal septa and most commonly exposed laterally as well as from the ventral side. Excavations with thickened edge are 0.30—0.50 mm wide. Free ventral walls 0.30—0.55 mm long, slightly convex, parallel to rhabdosome axis or inclined at angle up to 10°. The septa between first 2—4 thecae extend almost horizontally, remaining septa being curved sigmoidally and inclined at 40°—50°. $N_1/5$ mm is $5^1/_2$—$6^3/_4$, $N_1/10$ mm — $10^3/_4$—$13^3/_4$.

Sicula. Short, trumpet-like. The outer sicular margin sinusous, curved dorsally (Fig. 21/1, 7, 8). Inner margin straight, passing into ventrally curved virgella, 0.30—0.50 mm long. Rim of aperture wavy,

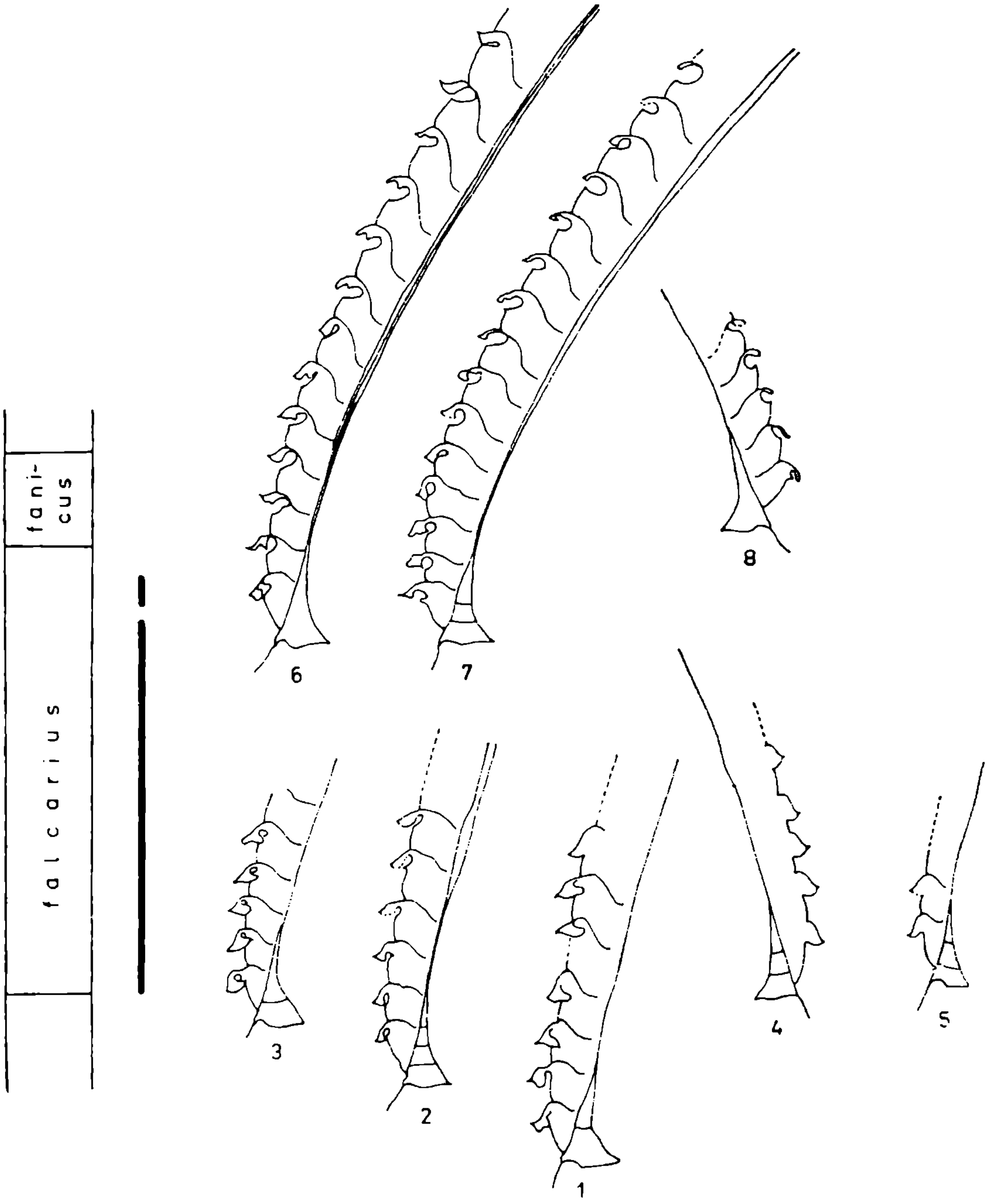

Fig. 21. *Monograptus falcarius* Koren'; 1—5 — 60P 244, 236, 768, 841, 1129, × 6, lower part of the falcarius Zone; 6—8 — 60P 792, 270, 817, × 6, upper part of the falcarius Zone

Fig. 21. *M. falcarius* Koren'; 1—5 — 60P 244, 236, 768, 841, 1129, × 6, dolna część zony falcarius; 6—8 — 60P 792, 270, 817, × 6, górna część zony falcarius

often with a distinctly concave part close to virgella (Fig. 21/1, 5, 6). In some specimens three sicular rings are visible (Fig. 21/2). Dimensions: L_s = 1.50—1.80 mm; S_a = 0.80—1.05 mm; Σ = 1.10—1.30 mm.

Measurements of some specimens of *M. falcarius* are given in Table 12.

Comparison and Remarks. — *M. falcarius* was established basing upon the material from Pai-Khoi, Urals, from the deposits occurring

Table 12

60P No.	S_{rh}				Σ	Sicula		N_1/5 mm	N_1/10 mm
	th_1	th_1/th_2	th_5	max.		L_s	S_a		
270	1.10 (0.80)	0.80	1.43 (1.20)	1.60 (1.30)	1.10	1.80	0.78	$5^1/_2$	—
272	1.05 (1.00)	0.80	1.35 (1.20)	1.60 (1.45)	1.25	1.70	0.90	$6^3/_4$	$13^3/_4$
792	1.10 (0.83)	0.78	1.30 (1.05)	1.57 (1.35)	1.32	1.87	0.90	$5^3/_4$	$10^3/_4$

immediately above the hercynicus Zone (Koren', 1970, 1975). Koren' suggests that its direct ancestor was *M. hercynicus hercynicus* Perner and this conclusion is supported by the evidence from the Żdanów material. The strata transitional between the hercynicus and falcarius Zones in the Żdanów Section contain, among the older (second) population of *M. hercynicus hercynicus*, numerous specimens representing a continuous morphological transition to *M. falcarius* (Fig. 20/11—14). Having the same size as the typical representatives of *M. hercynicus hercynicus* these specimens differ from it in some respects. These differences are: (1) the shorter and wider sicula, (2) the more dorsally curved outer sicular margin, (3) the closer spacing of thecae, and (4) the dorsal curvature between th_2 and th_{3-5} and the ventral one between th_{2-5} and th_{9-10}. On the other hand, *M. falcarius* differs from these transitional forms in having: (1) the more uniform rhabdosome width, (2) the stronger dorsal curvature of rhabdosome, (3) the wider sicular aperture, (4) lower value of Σ, and (5) the closer spacing of thecae.

The Żdanów representatives of *M. falcarius* often display a slighter dorsal curvature than that in some specimens of this species from the Urals (Koren', 1969), while *M. falcarius* from South Fergana (Koren', 1978b) does not differ in this respect from the Żdanów specimens.

Distribution. — Żdanów Section, the falcarius Zone; the accompanying assemblage is shown in Figure 4. For global distribution, see Koren' (1978b).

Monograptus telleri zdanoviensis nov. subsp.

Fig. 22/1—15, 19—22

?1970 *Monograptus* aff. *thomasi* Jaeger; Koren', Text-Fig. 3E, G
?1972 *M. turkparidensis* nov. sp.; Obut, pp. 1218, Figs 2, 2—3
?1974 *M. telleri* Lenz & Jackson; Koren', Pl. 25, Figs 1, 3
?1975 *M. telleri* Lenz & Jackson; Koren', Pl. 1, Fig. 2; Pl. 9, Fig. 5; Pl. 10, Fig. 1

Table 13

60P No.	S_{rh}							Σ	Sicula			N_1/10 mm	N_2/10 mm
	th_1	th_1/th_2	th_2	th_5	th_{10}	th_{15}	max.		L_s	S_a	L_{dt}		
426	0.88 (0.67)	0.65	0.90 (0.70)	1.10 (0.90)	1.50 (1.20)	1.75 (1.50)	1.95 (1.70)	1.20	1.84	0.55	0.20	$10^{1}/_{2}$	8
423	0.78 (0.57)	—	0.90 (0.65)	1.27 (0.96)	1.45 (1.20)	1.95 (1.50)	2.20 (1.80)	1.38	1.95	0.47	0.35	$8^{3}/_{4}$	8
499	0.83 (0.57)	0.57	0.93 (0.67)	1.24 (0.96)	1.43 (1.10)	—	—	1.30	1.80	0.46	0.33	10	—
726	0.92 (0.70)	0.65	1.00 (0.80)	1.30 (1.10)	1.70 (1.30)	—	—	1.50	—	0.55	0.15	9	—
910	0.83 (0.57)	0.54	0.90 (0.78)	1.35 (1.10)	1.70 (1.30)	—	—	1.30	2.00	0.45	0.30	$9^{3}/_{4}$	—
900	0.76 (0.57)	0.60	—	1.20 (0.80)	1.60 (1.20)	1.82 (?)	2.00 (1.70)	1.44	1.80	0.40	0.25	$9^{3}/_{4}$	—

Holotype: specimen shown in Figure 22/1, 60P 426.

Type locality: Żdanów, Bardo Mts. (Sudetes).

Stratum typicum: Lower Devonian, falcarius, fanicus, craigensis Zones.

Derivation of the name: after village Żdanów.

Diagnosis. — A straight monograptid of large size commonly showing straight, conical sicula with a prominent dorsal process. Thecae are biform; proximal and medial thecae of hooded type, the extreme distal thecae geniculate. Width of rhabdosome is 0.80—0.90 (0.60—0.70) mm at th_1; maximum width of 2.00—2.60 (1.85—2.20) mm is attained at th_{15-20}. Sicula 1.80—2.00 mm long and 0.40—0.55 mm wide at aperture. N_1/10 mm is $8^1/_2$—$10^1/_2$.

Material. — Fifteen complete rhabdosomes, thirty proximal fragments, eleven distal fragments.

Description: Rhabdosome. Length of complete rhabdosomes up to 50 mm. Straight or with a slight dorso-ventral curvature of proximal and to the level of th_5 (Fig. 22/21, 22). Sporadically, the extreme proximal end is slightly curved dorsally due to the shape of sicula (Fig. 22/1, 5, 8, 9). Width increases gradually, especially up to aperture of th_{8-9}. Width is 0.80—0.90 (0.60—0.70) mm at th_1, 0.60—0.65 mm between th_1 and th_2. Up to aperture of th_{7-8} the width increase is, on the average, 0.06—0.10 mm for each theca. Maximum width of 2.00—2.60 (1.85—2.20) mm is attained at th_{7-18}. Occasionally, the width decreases in the extreme distal part.

Thecae. Biform. Proximal thecae provided with well developed hoods, 0.50—0.70 mm long and 0.40—0.65 mm wide. These hoods are very narrow within their topmost part and widen rapidly downwards, extending one half length beyond the margins of thecal apertures. Initially, the size of hoods increases (Fig. 22/1, 4) attaining its maximum within medial part of rhabdosome. Hoods of medial thecae, 0.52—0.78 mm long and 0.78 mm wide, widen more rapidly but are slightly less curved downwards, extending $^1/_3$ of their length beyond thecal apertures. Distal thecae provided with apertural processes 0.50—0.10 mm long (Fig. 22/2); within

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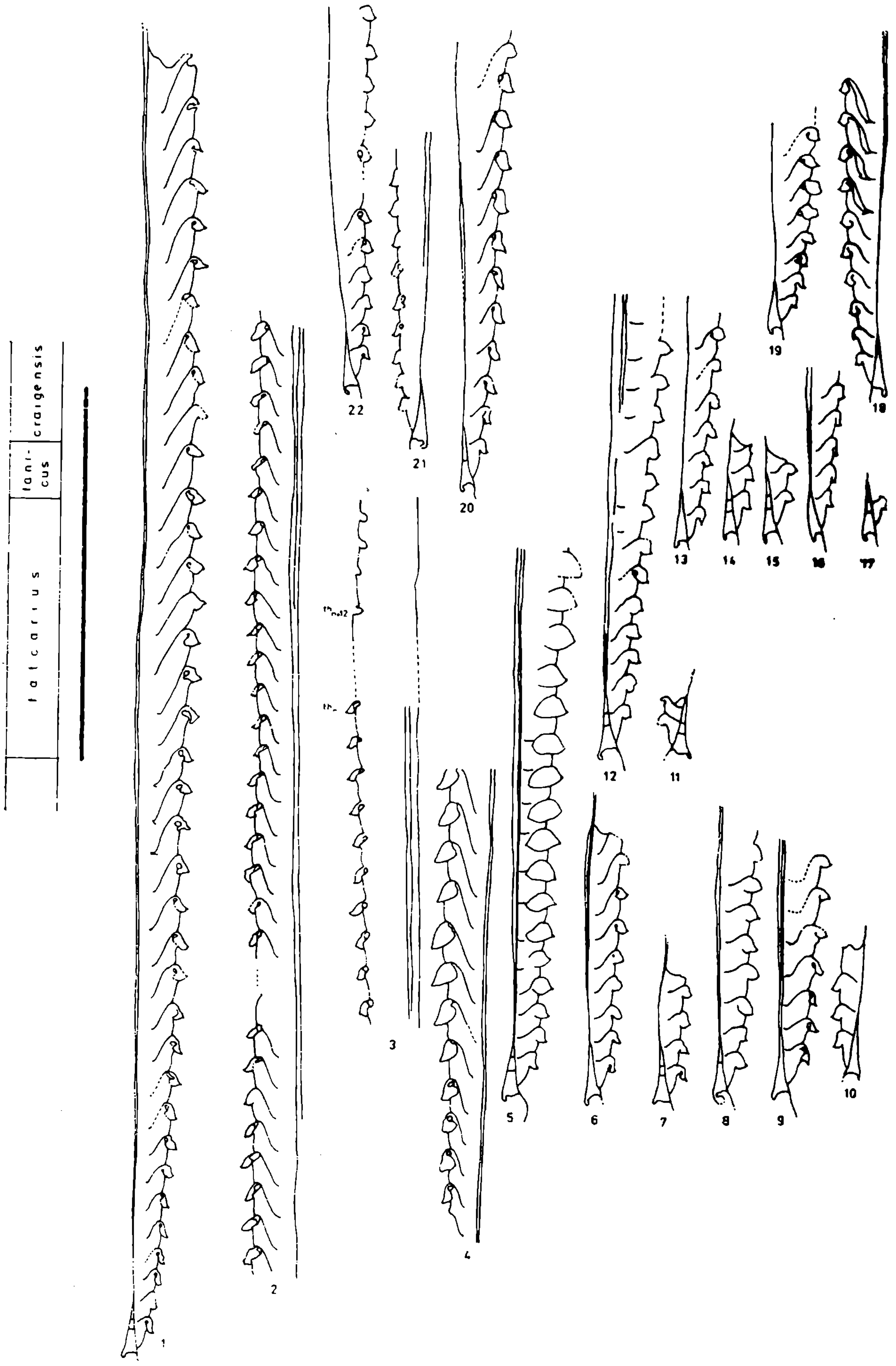
Fig. 22. *Monograptus telleri zdanoviensis* nov. subsp.; 1—10 — 60P 426 (holotype), 1115, 1116, 1117, 394, 908, 480, 1030, 726, × 6, falcarius Zone; 11—15 — 60P 376, 455, 1135, 410, 1136, × 6, fanicus Zone; 19—22 — 60P 423, 499, 910, 900, × 6, craigensis Zone; 16—18, × 6 — specimens transitional between *M. telleri zdanoviensis* nov. subsp. and *M. telleri telleri* Lenz & Jackson, uppermost part of the fanicus Zone

Fig. 22. *M. telleri zdanoviensis* nov. subsp.; 1—10 — 60P 426, (holotyp), 1115, 1116, 1117, 394, 908, 480, 1030, 726, × 6, zona falcarius; 11—15 — 60P 376, 455, 1135, 410, 1136, × 6, zona fanicus; 19—22 — 60P 423, 499, 910, 900, × 6, zona craigensis; 16—18, × 6 — formy przejściowe między *M. telleri zdanoviensis* nov. subsp. i *M. telleri telleri* Lenz & Jackson, najwyższa część zony fanicus


falcarius
lanicus
craigensis
th n+12
th n
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Species	S_{rh}				
	th_1	th_1/th_2	th_5	th_{10}	max.
M. telleri zdanoviensis (Żdanów), falcarius, fanicus, craigensis Zones	0.80—0.90 (0.60—0.70)	0.60—0.65	1.10—1.30 (0.90—1.00)	1.60—1.70 (1.20—1.30)	2.20—2.60 (1.85—2.20)
M. telleri telleri (Żdanów), craigensis Zone	0.60—0.95 (0.40—0.70)	0.40—0.70	0.90—1.40 (0.75—1.10)	1.30—1.70 (1.10—1.40)	2.00—? (1.85—?)
M. telleri (Yukon Territory), yukonensis Zone	0.90—1.10 (0.50—0.70)	—	1.40—1.75 (1.10—1.45)	1.80—2.30 (1.60—1.80)	1.80—2.50
M. telleri (Pai-Khoi, Tien-Shan), falcarius, fanicus, yukonensis Zones	0.80—1.00 (0.60—0.70)	0.60—0.70	1.20—1.30 (0.90—1.00)	1.60—1.80 (1.30—1.60)	2.30—2.50 (2.00—2.20)

the youngest part of the colony, the thecae are geniculate (Fig. 22/3). Excavations are shallow. Free ventral walls, 0.40—0.52 mm long in proximal part and 0.50—0.65 mm long in medial part, parallel to rhabdosome axis. Within distal part these walls, 0.78—0.91 mm long, are parallel or inclined at 10°—15° to rhabdosome axis. Interthecal septa of proximal thecae inclined at 50°—60°, those of medial and distal thecae at 25°—30° and 15°—18°, respectively. Interthecal septa are strongly overlapping distally; a transversal section across th_{24-25} cuts through two of them. Length of thecae is 1.00—2.70 mm, width 0.40—0.65 mm. N_1/5 mm is — $4^1/_2$—$5^3/_4$, N_1/10 mm — $8^1/_2$—$10^1/_2$; N_2/5 mm — 4—$4^1/_4$; N_2/10 mm — 8—$8^1/_3$.

Sicula. Triangular, commonly straight or slightly dorsally curved (Fig. 22/6—8, and 19, 21). Prosicula narrow, apex reaches aperture of th_2 or is slightly below. Length of prosicula is 0.70—0.80 mm, width of aperture 0.15 mm. Metasicula relatively narrow up to the middle of its length, widening rapidly further on towards the aperture. Length of metasicula 1.30 mm, width of aperture 0.40—0.55 mm. Rim of aperture usually concave, occasionally almost straight or slightly wavy. Outer margin of sicula usually more or less curved dorsally. Straight or slightly concave ventral margin of sicula passes into ventrally curved virgella 0.60—0.70

Table 14

Σ	Sicula			N_1/5 mm	N_1/10 mm	N_2/5 mm	N_2/10 mm	Shape of proximal end
	L_s	S_a	L_{dt}					
1.20—1.50	straight or slightly curved dorsally			$4^1/_2$— $5^3/_4$	$8^1/_2$— $10^1/_2$	4—$4^1/_2$	8—$8^1/_3$	straight
	1.80—2.00	0.40—0.55	0.15—0.35					
1.10—1.40	curved ventrally			4—$6^1/_2$	9—$12^1/_2$	—	—	curved dorsoventrally (th_1—th_5)
	1.55—1.95	0.35—0.40	0.20—0.35					
—	curved ventrally			$5^1/_4$— $6^1/_2$	—	$4^1/_2$—6	—	curved dorsally (th_1—th_5) and ventrally (th_6—th_8)
	—	—	—					
1.20—1.50	straight or curved ventrally			—	10—11	—	9—8	straight or curved dorsoventrally (th_1—th_5)
	1.60—1.80	0.50—0.60	0.30					

mm long. Dorsal process 0.15—0.35 mm long, straight or ventrally curved. In all siculae with preserved fusellar structure two metasicular rings and a third one at the pro- and metasicular boundary are visible. Σ = 1.20—1.50 mm.

Table 13 shows measurements taken from several specimens of *M. telleri zdanoviensis*.

Comparison and Remarks. — *M. telleri* Lenz & Jackson was created based on the material derived from deposits ascribed to the yukonensis Zone of Yukon Territory (Lenz & Jackson, 1971). In the Tien Shan and Pai-Khoi areas (Koren', 1975) as well as in South Fergana (Koren', 1978b) this species is also known from older strata corresponding to the falcarius, fanicus and craigensis Zones. No morphological differences have been so far observed in heterochronous populations of this species. Koren' (1975, p. 15) even remarked upon the morphological stability of this species.

In the Żdanów Section *M. telleri* was found in deposits of the falcarius, fanicus and craigensis Zones. The abundant material regularly distributed throughout the wide stratigraphic profile enabled the author to observe evolutionary changes of *M. telleri* and to discern two successive populations. The older one includes rhabdosomes from the falcarius, fanicus, and craigensis Zones; the younger one comprises exclusively those from the craigensis Zone. The structural differences between the representatives of the two populations of *M. telleri*, their different stratigraphic ranges and the similarity between the specimens of the younger type and those of *M. telleri* from Canada have been the reasons for creating the two subspecies: the older one *M. telleri zdanoviensis* nov. subsp. and the younger one *M. telleri telleri* Lenz & Jackson. The comparison of the features of both taxons and of *M. telleri* from Canada, Pai-Khoi and Tien Shan is presented in Table 14. The essential difference between *M. telleri zdanoviensis* and *M. telleri telleri* from Żdanów is that in morphology of the sicula. In the former the sicula is triangular, straight or slightly dorsally curved, relatively long and wide at aperture, while in the latter subspecies it is normal, curved ventrally, cylindrical within the metasicular part (the dorsal and ventral margins are almost parallel), shorter, and narrower at the aperture. Of other differing features the shape of the proximal part of rhabdosome may be of some importance; it is straight in *M. telleri zdanoviensis* and dorso-ventrally curved in *M. telleri telleri*. The free ventral walls of proximal and medial thecae are straight, parallel to rhabdosome axis in the former subspecies and convex, inclined at 15°—20° in the latter. There are also some differences in the thecal spacing (see Table 14).

The earliest representatives of *M. telleri zdanoviensis* (Fig. 22/6, 7) are similar, owing to the size of rhabdosomes, to the *M. hercynicus subhercynicus* Willefert the stratigraphic range of which is, in part, overlapping with that of the former taxon (Fig. 4). The similarity includes, first of all, the shape of the proximal end of rhabdosome (narrow, straight, occasionally slightly dorsally curved) and the shape of the sicula (triangular, straight or slightly dorsally curved, lacking dorsal process in *M. hercynicus subhercynicus* and with a dorsal process in *M. telleri zdanoviensis).*

M. turkparidensis Obut, occurring in the yukonensis Zone of Tien Shan (Obut, 1972), is included by Koren' (1975) to *M. telleri*. The relatively wide, triangular sicula of *M. turkparidensis* suggest that this taxon could be included in *M. telleri zdanoviensis*. The populations of *M. telleri* known from the Pai-Khoi and Tien Shan (Koren', 1970, 1974, 1975) embody probably both discussed subspecies as well as transitional forms.

In the youngest population of *M. telleri zdanoviensis* from Żdanów (the uppermost part of the fanicus Zone and the craigensis Zone) there occur rare specimens which, owing to the sicular shape, the relatively narrow, slightly dorsally curved proximal end of rhabdosome and the proximal spacing of thecae ($N_1/5$ mm is $4^1/_2$) resemble *M. thomasi* Jaeger (Fig. 22/21, 22). However, their proximal thecae are not isolated, which is so characteristic for *M. thomasi*. Therefore, it seems highly probable that the earlier discussed affinity of *M. thomasi* to *M. telleri* (Lenz & Jackson, 1971, p. 18; Koren', 1975 p. 15) is, in fact, the affinity between *M. thomasi* and the subspecies *M. telleri zdanoviensis* nov. subsp.

Distribution. — Żdanów Section, the falcarius, fanicus and craigensis Zones; the accompanying assemblage is shown in Figure 4.

Monograptus telleri telleri Lenz & Jackson, 1971

Fig. 23/4—12

1971 *Monograptus telleri* nov. sp.; Lenz & Jackson, pp. 9—11, Pl. 1, Figs 11—15, Text-Fig. 2G—J
?1972 *M. aivili* nov. sp.; Obut, pp. 1217—1218, Figs. 2, 10, 11
?1974 *M. telleri* Lenz & Jackson; Koren', Pl. 5, Figs 1, 2
?1975 *M. telleri* Lenz & Jackson; Koren', Pl. 7, Fig. 1; Pl. 9, Figs 1, 2; Pl. 10, Fig. 1

Material. — Twenty three rhabdosomes of which six are juvenile forms, the remaining lack extreme distal parts.

Description: Rhabdosome. The longest fragments up to 25 mm in length. Proximal part to the level of th$_{1-5}$ more or less distinctly dorsally curved. The remaining part straight. Width is 0.60—0.96 (0.40—0.70) mm at th$_1$, 0.40—0.70 mm between th$_1$ and th$_2$, 0.90—1.40 (0.75—1.10) mm at th$_5$, and 1.35—1.95 (1.20—1.40) mm at th$_{15}$. Maximum width, commonly attained at the level of th$_{15-20}$, does not exceed 2.00 (1.85) mm.

Thecae. Proximal and medial thecae provided with hoods the size of which increases in the most proximal thecae only. Starting from the level of th$_{4-6}$ (Fig. 23/4, 5, 8) all hoods show similar dimensions (L_h = 0.50—0.70 mm, S_h = 0.40—0.80 mm). Apertures of proximal and medial thecae are partly exposed laterally; apertures of medial thecae are sometimes exposed ventrally as well (Fig. 23/3). Apertural margins are almost perpendicular to interthecal septa. Free ventral walls slightly convex and inclined at 15°—20° to rhabdosome axis. Interthecal septa straight and inclined at 25°—30° to axis. Thecae are 1.00—2.50 mm long, their width is 0.50—0.60 mm. N_1/5 mm is 4—6$^1/_2$, N_1/10 mm — 9—12$^1/_2$.

Sicula. Normal, ventrally curved or rarely straight (Fig. 23/4, 7, 8). Outer margin usually displays a ventral curvature. Apex reaches aperture of th$_2$. Dorsal process 0.20—0.35 mm long, is commonly ventrally curved, although straight forms occur too (Fig. 23/4, 8, 11). Virgella 0.50—0.60 mm long is also ventrally deflected. Apertural rim is distinctly concave. Dimensions: L_s = 1.55—1.95 mm; S_a = 0.35—0.40 mm; Σ = 1.10—1.40 mm.

Table 15 shows measurements taken from several specimens of *M. telleri telleri*.

Comparison and Remarks. — The described specimens of *M. telleri telleri* can be subdivided into two populations. The major characters of rhabdosomes of these populations are given in Table 16. The early population, occurring in the bottommost part of the craigensis Zone (Fig. 23/4—8), bears a striking resemblance to the population of *M. telleri telle-*

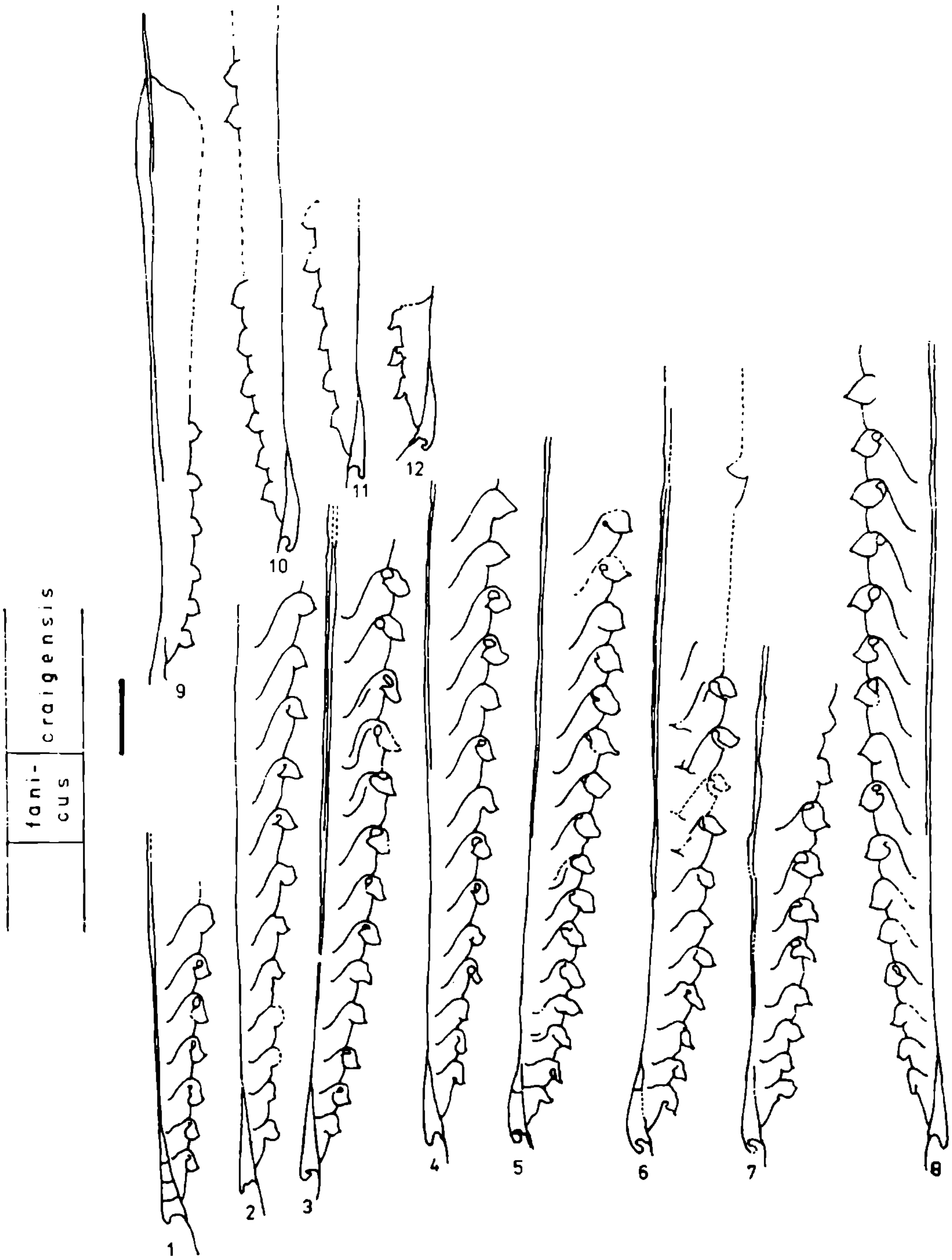

Fig. 23. *Monograptus telleri telleri* Lenz & Jackson; 4—8 — 60P 898, 1056, 1045, 981, 901, × 6, early population, lower part of the craigensis Zone; 9—12 — 60P 1080, 889, 486, 485, × 6, late population, higher part of the craigensis Zone; 1—3 — 60P 899, 911, 902, × 6, specimens transitional between *M. telleri zdanoviensis* nov. subsp. and *M. telleri telleri* Lenz & Jackson, lowermost part of the craigensis Zone

Fig. 23. *Monograptus telleri telleri* Lenz & Jackson; 4—8 — 60P 898, 1056, 1045, 981, 901, ×, 6, wczesna populacja, dolna część zony craigensis; 9—12 — 60P 1080, 889, 486, 485, × 6, późna populacja, wyższa część zony craigensis; 1—3 — 60P 899, 911, 902, × 6, formy przejściowe między *M. telleri zdanoviensis* nov. subsp. i M. telleri telleri Lenz & Jackson, najniższa część zony craigensis

Table 15

60P No.	S_{rh}					Σ	Sicula		$N_1/5$ mm	$N_1/10$ mm
	th_1	th_1/th_2	th_5	th_{10}	max.		L_s	S_a		
889	0.96 (0.65)	0.52	1.20 (0.85)	1.55 (1.20)	2.30 (?)	1.40	1.70	0.40	$5^{1}/_{2}$	10
901	0.75 (0.57)	0.52	1.20 (0.90)	1.70 (1.30)	2.00 (1.50)	1.30	1.95	0.36	$5^{1}/_{2}$	10
900	0.75 (0.57)	0.55	1.20 (0.80)	1.60 (1.20)	**1.90** (1.50)	1.40	1.70	0.40	$5^{1}/_{3}$	10
461	0.96 (0.70)	0.70	1.40 (1.10)	1.65 (1.40)	2.00 (1.70)	1.20	1.60	0.40	$5^{3}/_{4}$	$10^{3}/_{4}$
1045	0.96 (0.60)	0.62	1.25 (1.00)	1.55 (1.35)	—	1.15	1.82	0.40	$5^{3}/_{4}$	11
1056	**0.90** (0.68)	0.65	1.25 (1.00)	1.60 (1.40)	2.00 (1.80)	1.05	1.55	0.40	$6^{1}/_{2}$	$12^{1}/_{2}$
899	0.75 (0.60)	0.50	1.15 (0.80)	1.50 (1.30)	—	1.25	1.55	0.35	5	9
891	0.70 (0.55)	0.50	1.05 (0.85)	—	—	1.30	1.60	0.35	4	—
1080	0.60 (0.40)	0.40	0.90 (0.75)	1.30 (?)	1.80 (?)	—	—		$5^{1}/_{2}$	—

Table 16

M. telleri telleri	S_{rh}					Σ	Sicula		$N_1/5$ mm	$N_1/10$ mm
	th_1	th_1/th_2	th_5	th_{10}	max.		L_s	S_a		
early population	0.75—0.96 (0.57—0.70)	0.52—0.70	1.20—1.40 (0.80—1.10)	1.55—1.70 (1.20—1.40)	1.90—2.00 (1.50—1.80)	1.10—1.40	1.55—1.95	0.40	5—6 ½	9¾—12⅓
late population	0.60—0.75 (0.40—0.60)	0.40—0.50	0.90—1.15 (0.75—0.85)	1.30—1.50 (1.10—1.30)	—	1.25—1.30	1.55—1.60	0.35	4—5 ½	9—10

ri recorded from the yukonensis Zone in Canada (Lenz & Jackson, 1971). The differences between the aforementioned groups of graptolites concern the rate of rhabdosomal width increase and the maximum width value. The width of the Canadian individuals of *M. telleri* increases more rapidly to the level of th_5 than it does in the Polish representatives of this taxon.

The late population of *M. telleri telleri*, collected from higher beds of the craigensis Zone in the Żdanów Section (Fig. 23/9—12), comprises rhabdosomes which, compared with those of the early population, are much narrower showing a gradual increment in rhabdosomal width and lesser crowding of thecae as well as having shorter and narrower siculae. The proximal end of these rhabdosomes shows a relatively distinct dorsal curvature, and both proximal and medial thecae have smaller hoods of almost equal size. The late population of *M. telleri telleri* reveals a great similarity to *M. aivili* Obut (Obut, 1972), which was referred by Koren' (1975) to *M. craigensis* Jaeger. However, the above population of *M. telleri telleri* and *M. aivili* show certain morphological differences as against *M. craigensis*. Their sicula in considerably narrower (S_a = 0.30—0.35 mm and 0.40—0.60 mm, respectively) and shorter (L_s = 1.55—1.60 mm and 1.50—2.00 mm) and its metasicular part is more cylindrical in shape. Furthermore, the crowding of thecae is lesser than in the case of *M. craigensis*.

Most of the individuals of *M. telleri* illustrated by Koren' (1974, 1975) belong probably to the subspecies under consideration, although the lack of detailed drawings of the sicula precludes a precise identification to be made.

Distribution. — Żdanów Section, the craigensis Zone; the accompanying assemblage is shown in Figure 4. In Canada, *M. telleri telleri* is known to occur in the yukonensis Zone (Lenz & Jackson, 1971). The Tien Shan forms which could possibly be included into this subspecies, are derived from the strata belonging to the craigensis and yukonensis Zones.

Monograptus craigensis Jaeger, 1970
Fig. 24/1—6

1970 ***Monograptus craigensis*** **nov. sp.; Jaeger *in* Churkin et al., pp. 198—202, Figs 7B, 8D, C, 9A, F, K; 6**

1975 *M. craigensis* Jaeger; Koren', pp. 15—17, Pl. 5, Fig. 4; Pl. 6, Figs 5—6; Pl. 7, Figs 1—8; Pl. 9, Figs 7—12; Pl. 10, Figs 2—13 (see synonymy)

Material. — Fifteen rhabdosomes: four juvenile specimens and the remaining lacking distal parts.

Description: Rhabdosome. The largest but incomplete rhabdosomes average 20 mm in length. Proximal end with profound dorsal curvature involving sicula and the first 2—3 thecae. Rhabdosome width

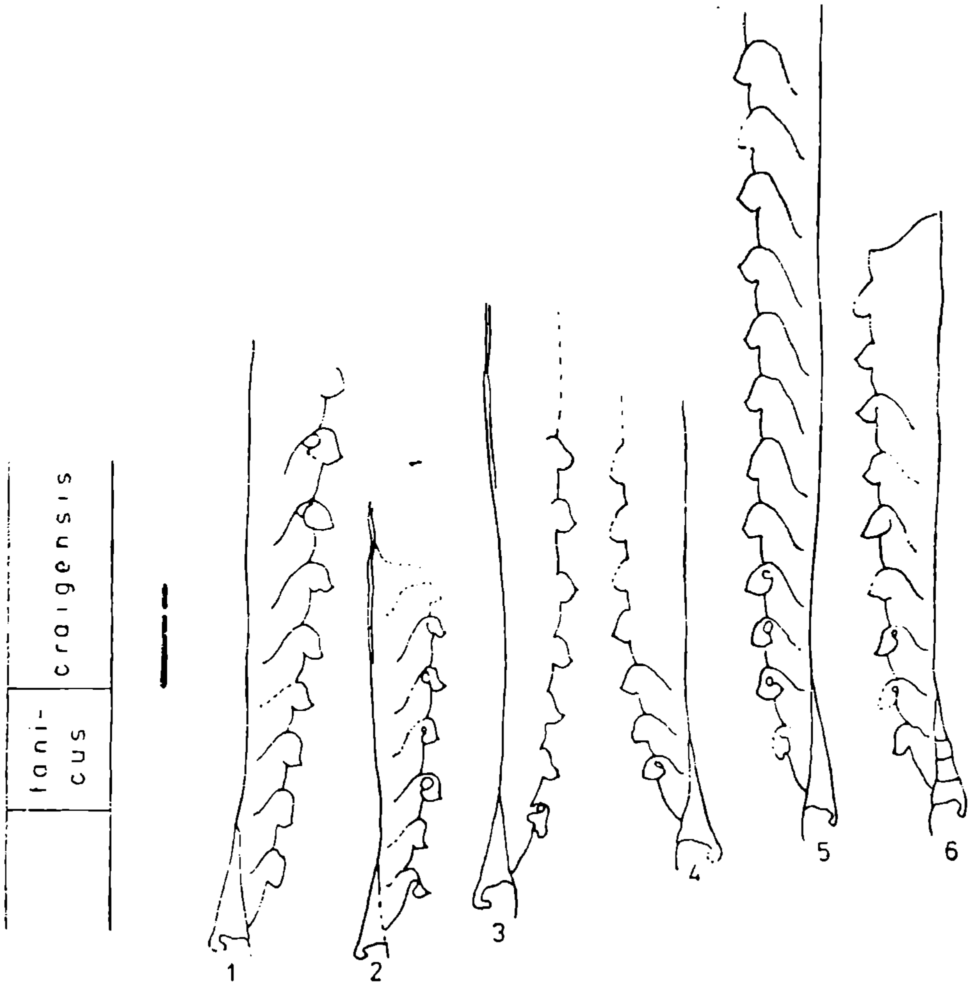

Fig. 24. *Monograptus craigensis* Jaeger; 1—6 — 60P 1051, 435, 1031, 1028, 890, 458, × 6, craigensis Zone

Fig. 24. *M. craigensis* Jaeger; 1—6 — 60P 1051, 435, 1031, 1028, 890, 458, × 6, zona craigensis

increases progressively attaining its maximum between th$_{15}$ and th$_{20}$; it is 0.75—0.90 (0.55—0.70) mm at th$_1$, 0.50—0.65 mm between th$_1$ and th$_2$, 1.00—1.30 (0.75—1.00) mm at th$_5$, 1.25—1.60 (1.00—1.30) mm at th$_{10}$, 1.40—1.55 (1.20—1.35) mm at th$_{15}$, and max. 1.95 (1.60) mm.

Thecae. Proximal and medial thecae of hooded type. Hoods of almost equal size partly expose apertures laterally (Fig. 24/2). Hoods are 0.40—0.50 mm long and 0.25—0.30 mm wide. In some cases the width of hoods diminishes in medial part. Free ventral walls straight (Fig. 24/5) or slightly convex (Fig. 24/1), up to 0.40—0.65 mm long. Interthecal walls of medial thecae inclined at 25°—30° to rhabdosome axis. N$_1$/5 mm is 5—6$^1/_3$, N$_1$/10 mm — 10$^1/_2$—12.

Sicula. Roughly triangular, slightly dorsally curved. Apex reaches aperture of th$_2$, or is a little beyond of it. Dorsal process ventrally deflected, up to 0.15—0.40 mm in length. Apertural rim almost straight or insignificantly concave. Dimensions: $L_s = 1.60$—1.95 mm; $S_a = 0.45$—0.60 mm; $\Sigma = 1.20$—1.40 mm.

Table 17

GOP No.	S_{rh}						Σ	Sicula			$N_1/5$ mm
	th_1	th_1/th_2	th_5	th_{10}	th_{15}	max.		L_s	S_a	L_{dt}	
890	0.75 (0.55)	0.60	1.00 (0.75)	1.35 (1.10)	1.45 (1.35)	—	1.20	1.95	0.46	0.40	5
1031	0.88 (1.00)	—	1.40 (1.00)	1.60 (1.30)	—	1.95 (1.60)	1.35	1.90	0.60	0.50	5
435	0.92 (0.70)	0.52	1.10 (0.80)	—	—	—	1.30	1.60	0.50	0.20	6
458	0.95 (0.70)	0.60	1.30 (0.90)	—	—	—	1.30	1.85	0.50	0.25	$5^3/_4$
897	0.80 (0.65)	0.54	1.00 (0.80)	1.40 (1.10)	1.55 (1.30)	—	1.35	1.80	0.46	0.25	$5^3/_4$
1028	0.90 (0.70)	0.65	1.20 (1.00)	—	—	—	1.40	1.70	0.57	0.30	6
1032	0.80 (0.65)	0.65	1.00 (0.80)	1.25 (1.00)	1.40 (1.20)	1.95 (1.60)	1.30	—	0.45	—	$6^1/_3$

Table 18

Species	S_{rh}				Σ	Sicula		N_1/10 mm
	th_1	th_1/th_2	th_{10}	max.		L_s	S_a	
***M. craigensis*, Żdanów** (craigensis Zone)	0.75—0.90 (0.55—0.70)	0.50—0.55	1.25—1.60 (1.00—1.30)	1.95 (1.60)	1.20—1.40	1.60—1.95	0.45—0.60	10½—12
***M. craigensis*, Alaska** (yukonensis Zone)	0.70—0.90	0.40—0.50	—	1.80—2.20 (1.40—1.80)	1.50	1.50—2.00	0.40—0.50	11—13
M. craigensis, Tien Shan **(craigensis, yukonensis Zones)**	0.80—0.90 (0.70—0.60)	0.60—0.70	1.60—1.90 (1.40—1.70)	2.00 (1.80)	1.50	**1.50—2.00**	0.40—0.50	12

Table 17 shows measurements taken from several specimens of *M. craigensis.*

Comparison and Remarks. — The comparison of numerical features of the population under description with those reported in the literature (Churkin et al., 1970; Koren', 1975) is expressed in Table 18. All mentioned features show a great overall similarity. The Żdanów rhabdosomes represent most probably the oldest astogenetic stage of this species (from lower part of the craigensis Zone). Considering a degree of dorsal curvature of the proximal end they closely approximate the Tien Shan population of *M. craigensis* derived from the craigensis Zone.

The similarity of *M. craigensis* both to its ancestral species *M. telleri* Lenz & Jackson and its descendant *M. yukonensis* Jackson & Lenz was broadly discussed by Lenz and Jackson (1971) and Koren' (1975). The present observations of the Żdanów fauna support the above opinions on the phylogenetic affinity between *M. craigensis* and *M. telleri;* they also give a resonable base to define this relationship more precisely referring it directly to *M. telleri zdanoviensis* nov. subsp. The sicular shape is most important in respect of the suggested affinity. Both taxons have almost triangular siculae (the sicula of *M. craigensis* is a little shorter and broader at aperture; comp. Churkin et al., 1970, their Figs 6, 7B, C and especially Fig. 9K). The sicula of *M. telleri telleri* is of normal shape and is relatively narrow at the aperture.

Distribution. — Żdanów Section, the craigensis Zone; the accompanying assemblage in given in Figure 4. Known from the yukonensis Zone of Alasca (Jaeger et al., 1970) and of Yukon Territory (Jackson & Lenz, 1972), as well as reported from the craigensis and yukonensis Zones of Tien Shan (Koren', 1975).

Monograptus praeaequabilis nov. sp.
Fig. 25/1—21

Holotype: specimen shown in Figure 25/1, 60P 916.

Type locality: Żdanów, Bardo Mts. (Sudetes).

Stratum typicum: Upper Silurian, the transgrediens Zone.

Derivation of the name: the species is named after earlier described *M. aequabilis* Přibyl. The prefix "prae" refers to its stratigraphic position preceding that of *M. aequabilis.*

Diagnosis. — A narrow monograptid of medium size, straight in the dorsal and medial parts and slightly ventrally curved in the most proximal end. Proximal thecae are of climacograptid or hooded type, medial thecae intermediate in shape between that of climacograptid and pristiograptid, distal thecae of pristiograptid appearance. Width of rhabdosome is 0.62—0.75 mm at th_1, maximum width reaches 2.10 mm. Sicula of normal

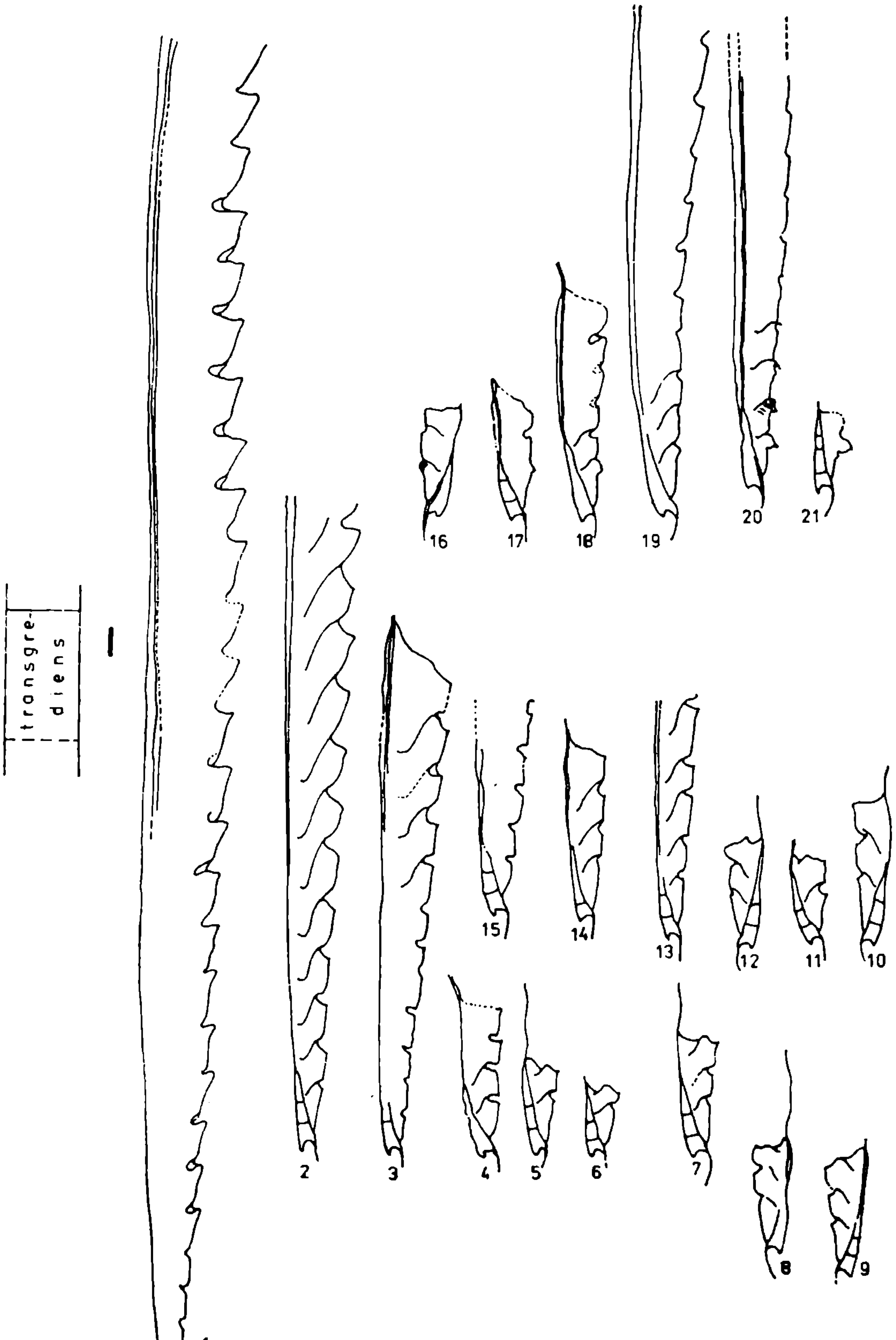

Fig. 25. *Monograptus praeaequabilis* nov. sp.; 1—15 — 60P 916 (holotype), 563, 952, 951, 561, 1130, 1131, 572, 564, 579, 590, 592, 566, 581, 954, × 6, upper part of the transgrediens Zone; 16—21 — 60P 1011, 570, 876, 569, 1009, 573, × 6, uppermost part of the transgrediens Zone

Fig. 25. *M. praeaequabilis* nov. sp.; 1—15 — 60P 916 (holotyp), 563, 952, 951, 561, 1130, 1131, 572, 564, 579, 590, 592, 566, 581, 954, × 6, górna część zony transgrediens; 16—21 — 60P 1011, 570, 876, 569, 1009, 573, × 6, najwyższa część zony transgrediens

shape, ventrally curved, 1.76—2.00 mm long and 0.30—0.37 mm wide at aperture. N_1/10 mm is 8—10.

Material. — Twenty eight rhabdosomes of which twelve represent juvenile stages, ten proximal fragments.

Description: Rhabdosome. Straight except for the extreme proximal end which is slightly ventrally curved (Fig. 25/1, 3, 19). The largest, complete rhabdosomes are about 40 mm long. Width increases progressively by about 0.1 mm/th up to the level of th_5; it is equal to 0.62—0.75 mm at th_1, 0.50—0.70 mm between th_1 and th_2, 1.10—1.30 mm at th_5 and 1.50—1.70 mm at th_{10}. In the extreme distal part and often already at the aperture of th_{13-14} it reaches 1.90—2.00 mm. The maximum width measured in the distal ends is 2.10 mm.

Thecae. Biform. Proximal thecae till th_{5-8} of climacograptid appearance, medial thecae of intermediate appearance between climacograptid and pristiograptid, distal thecae of pristiograptid type. A few of the youngest specimens have the first theca furnished with a hood, whilst the development of remaining thecae is the same as in the above described rhabdosomes (Fig. 25/16—19, 21). Two specimens have the first four thecae terminated with hoods of distally diminishing size (Fig. 25/20). The hood of th_1 is fully developed whereas at th_4 there occur only a very short apertural process. Hoods exhibit a fusellar structure. Most likely they originated due to a continuing growth of the dorsal walls of climacograptid-type thecae. The hoods are developed in the rhabdosomes of the youngest representatives of *M. praeaequabilis* irrespective of an astogenetic stage reached by the colony. Medial thecae are 2.40 mm long, distal thecae up to 2.70 mm; their width varies between 0.60 mm and 0.80 mm. Free ventral walls straight or weakly concave, parallel or subparallel to rhabdosome axis (Fig. 25/1—4, 13); they are inclined at up to 20° in medial part (Fig. 25/1, 2). Ventral walls of distal thecae are straight and inclined at 20°—35° to rhabdosome axis. Length of free ventral wall measured in medial part of rhabdosome reaches 0.85 mm. Apertural excavations of proximal thecae commonly occupy about $^1/_8$ of rhabdosome width. Interthecal walls straight or weakly sigmoidal, inclined at 29°—31° to rhabdosome axis. N_1/5 mm is $4^1/_2$—$5^1/_2$, N_1/10 mm 8—10.

Sicula. Long, narrow, ventrally curved having a fragile, initially vertical nad next dorsally deflected virgella, 0.60—0.80 mm long. Dorsal process curved ventrally, 0.10—0.20 mm long. Apex occurs usually at the aperture of th_2 or slightly below (Fig. 25/18, 20 and 25/2, 4, 13—17). Most studied specimens show two sicular rings. Dimensions: L_s = 1.75—2.00 mm; S_a = 0.30—0.37 mm; Σ = 1.20—1.60 mm.

Table 19 shows measurements taken from several specimens of *M. praeaequabilis* nov. sp.

Comparison and Remarks. — The rhabdosomes of *M. praeaequabilis* having the first four thecae provided with hoods (from the

Table 19

60P No.	S_{rh}						Sicula		$N_1/5$ mm	$N_1/10$ mm
	th_1	th_1/th_2	th_2	th_5	th_{10}	max.	L_s	S_a		
567	0.67	0.52	0.80	1.05	—	—	1.90	0.30	5	—
571	0.75	0.62	0.83	1.10	—	—	1.75	0.30	5	9
565	0.70	0.52	0.78	1.17	1.70	2.00	1.82	0.36	$5^1/_2$	10
559	0.65	0.62	0.70	1.05	1.50	1.60	1.85	0.33	$5^1/_2$	8

uppermost part of the transgrediens Zone) bear a resemblance to *M. ramstalensis* Jaeger described from Thuringia (Jaeger, 1959). The similarity is expressed in the size of the rhabdosome and sicula, the shape of sicula, as well as in the identical spacing of thecae. These two species differ from each other only in the number of hooded thecae (*M. ramstalensis* has nine, *M. praeaequabilis* — four). The morphological similarity and stratigraphic ranges (*M. ramstalensis* occurs in the lowermost part of the uniformis Zone) seem to suggest a close phylogenetic affinity of the two taxons under consideration.

The rhabdosomes of *M. praeaequabilis* having the first thecae provided with hood or its incipient form (Fig. 25/16—19) display a great morphological similarity to those of *M. aequabilis aequabilis* (Přibyl). The only differences exist in the angle α (38°—55° and 28°—31°, respectively) and the length and curvature of virgella (*M. aequabilis aequabilis* has a much shorter and ventrally curved virgella). Furthermore, the apertural excavations of *M. aequabilis aequabilis* cover usually $^1/_5$ of rhabdosome width whereas those in *M. praeaequabilis* occupy $^1/_8$ of it. The knowledge of basic phylogenetic principles in the development of the *aequabilis* line, in which the evolutionary trend involves an increase in the number of hooded thecae (Koren', 1974, 1975), as well as the morphological similarity between *M. praeaequabilis* and *M. aequabilis aequabilis* and their stratigraphic ranges, all justify the supposition that these taxons display a close phylogenetic relationship. The earlier suggested affinity of the population of *M. praeaequabilis* having the first four thecae ended with hoods to *M. ramstalensis* seems to be additionally supported by the fact that the earliest representatives of *M. aequabilis aequabilis* from the Żdanów Section have the only first theca furnished with hood, whereas the following two often possess short apertural processes.

The rhabdosomes of *M. praeaequabilis* having climacograptid proximal thecae (from the lower part of the transgrediens Zone) show a certain similarity to those of *M. kosoviensis* Bouček known from the Ludlovian of Barrandian (Bouček, 1931; Přibyl, 1943) and *M.* aff. *kosoviensis* reported from the lowermost Pridolian in Canada (Jackson & Lenz, 1969). These rhabdosomes are also very similar to that described as *P. aequabilis* Přibyl (Münch, 1952, Taf. 19, Fig. 13) which was found in the uniformis Zone of the Barrandian. The lack of detailed description of this latter precludes the comparison of this graptolite to *M. praeaequabilis*. The general structure and the stratigraphic position of *P. aequabilis* may suggest its taxonomic identity with the newly described species.

Distributions. — Żdanów Section, the transgrediens Zone; the accompanying assemblage is given in Figure 4.

Monograptus aequabilis aequabilis (Přibyl), 1941
Fig. 26/1—11

1941 *Pristiograptus aequabilis* nov. sp.; Přibyl, p. 8, Pl. 1, Figs 6—8
1973a *Monograptus aequabilis aequabilis* (Přibyl); Koren', pp. 148—149, Pl. 7, Figs 5—16
1978b *M. aequabilis aequabilis* (Přibyl); Koren', pp. 121—122, Pl. I, Figs 4, 5; Text-Fig. 5a—e (see synonymy)

Material. — Ten juvenile rhabdosomes, eight proximal parts and fifteen distal parts.

Description: Rhabdosome. Straight (Fig. 26/1—4) or slightly ventrally curved in the extreme proximal end (Fig. 26/5, 10, 11). Width is 0.90—1.00 (0.60—0.70) mm at th_1, 0.60—0.70 mm between th_1 and th_2, 1.10—1.30 (1.10—1.20) mm at th_5, and acquires its maximum values of 1.60—1.70 mm at th_{7-8}.

Thecae. Biform. The first theca is provided with a large hood, 0.40—0.50 mm long and 0.30—0.40 mm wide, which always obscures the thecal aperture. The second and sometimes the third theca can exhibit a hooded appearance (Fig. 26/9—11), however, their apertural terminations are developed in the form of small processes which do obscure apertures neither ventrally nor laterally. The other proximal thecae are sometimes furnished with short apertural processes, 0.10—0.15 mm long. Except for th_1, the remaining proximal and medial thecae can sometimes display a climacograptid appearance showing no traces of apertural processes (Fig. 26/1, 2). Distal thecae are of intermediate type between that of climacograptid and pristiograptid. Free ventral walls parallel (Fig. 26/2) or weakly inclined at up to 10° to rhabdosome axis (Fig. 26/10, 11). Interthecal septa straight or slightly sigmoidal, inclined at 27°—31°. Apertural excavations nearly perpendicular to interthecal walls. In the proximal part of rhabdosome excavations cover $^1/_6$—$^1/_4$ of its width, in the distal — $^1/_5$—$^1/_3$. Excavations are 0.20—0.40 mm deep. $N_1/5$ mm is $4^3/_4$—$5^1/_2$, $N_1/10$ mm — $8^1/_4$—$10^1/_2$.

Sicula. Narrow, slightly ventrally curved. Apex reaches aperture of th_2 (Fig. 26/1, 3, 8—10) or occurs a little below of it (Fig. 26/2, 4—7, 11). Apertural margin concave. Dorsal process up to 0.10—0.30 mm long, ventrally curved. Dimensions: $L_s = 1.70$—2.00 mm; $S_a = 0.30$—0.40 mm. $\Sigma = 1.20$—1.50 mm.

Comparison and Remarks. — The Żdanów specimens bear a striking resemblance to the representatives of *M. aequabilis aequabilis* described from the uniformis Zone of Barrandian (Přibyl, 1941, 1943), Thuringia (Jaeger, 1959), Bulgaria (Spasov, 1963), Nevada (Berry & Murphy, 1975), Yukon Territory (Jackson & Lenz, 1972) as well as to those derived from the uniformis and hercynicus Zones of the Urals (Koren', 1973a).

The large hood of th_1 as well as the initially climacograptid and subsequently climacograptid-pristiograptid appearance of the remaining the-

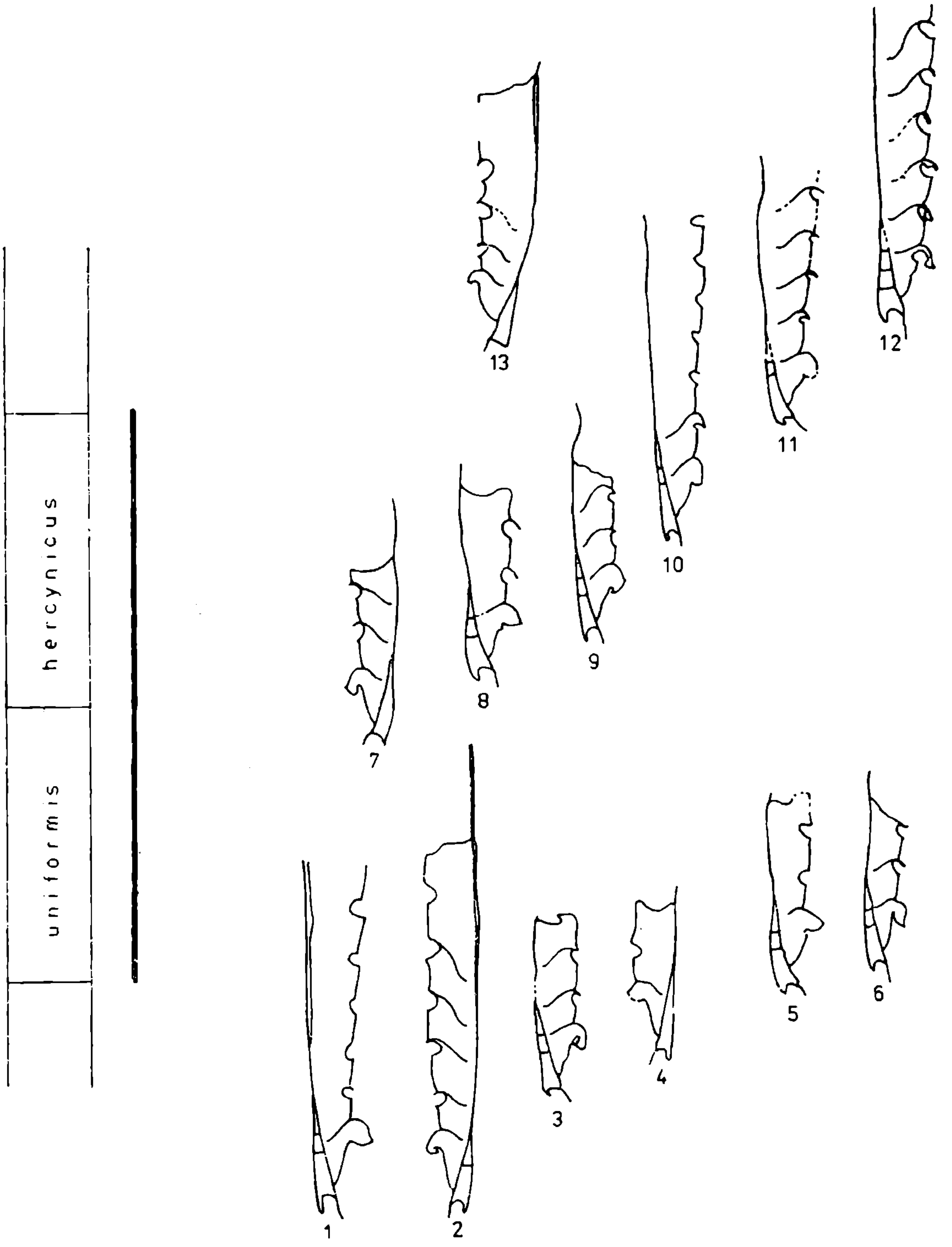

Fig. 26. *Monograptus aequabilis aequabilis* Přibyl; 1—6 — 60P 75, 350, 100, 90, 102, 347, × 6, uniformis Zone; 7—11 — 60P 80, 67, 101, 27, 18, × 6, hercynicus Zone; 12 — 60P 336, × 6 — specimen transitional between *M. aequabilis aequabilis* Přibyl and *M. aequabilis notoaequabilis* Jaeger & Stein, upper part of the hercynicus Zone; 13 — 60P 120, × 6, specimen transitional between *M. aequabilis aequabilis* Přibyl and *M. aequabilis bardoensis* nov. subsp., upper part of the hercynicus Zone

Fig. 26. *M. aequabilis aequabilis* Přibyl; 1—6 — 60P 75, 350, 100, 90, 102, 347, × 6, zona uniformis; 7—11 — 60P 80, 67, 101, 27, 18, × 6, zona hercynicus; 12 — 60P 336, × 6 — forma przejściowa między *M. aequabilis aequabilis* Přibyl i *M. aequabilis notoaequabilis* Jaeger.& Stein, górna część zony hercynicus; 13 — 60P 120, × 6, forma przejściowa między *M. aequabilis aequabilis* Přibyl i *M. aequabilis bardoensis* nov. subsp., górna część zony hercynicus

cae are the features which allow to distinguish between the taxon under consideration and *M. aequabilis notoaequabilis* Jaeger & Stein and *M. aequabilis bardoensis* nov. subsp.

Distribution. — Żdanów Section, the uniformis and hercynicus Zones; the accompanying assemblage is given in Figure 4. For global distribution, see Koren' (1973a).

Monograptus aequabilis notoaequabilis Jaeger & Stein, 1969

Fig. 27/1—16

1969 *Monograptus aequabiilis notoaequabilis* nov. subsp.; Jaeger & Stein; pp. 182—184; Text-Fig. 1E—F; Pl. 15, Figs A and B

1978b *M. aequabilis notoaequabilis* Jaeger & Stein; Koren', p. 123; Pl. I, Fig. 6; Text--Fig. 5/f—g (see synonymy)

Material. — Eighteen specimens lacking distal parts and fifteen juvenile rhabdosomes.

Description: Rhabdosome. Straight, 20—30 mm long. The most proximal and straight or slightly ventrally curved (Fig. 27/4, 9, 10), it can also exhibit a weak dorsal curvature (Fig. 27/5, 6). Width increases rapidly to the level of th_{5-6}, it subsequently changes insignificantly sometimes diminishing a little at the level of youngest thecae (Fig. 27/8—10). Width is equal to 0.80—1.10 (0.60—0.90) mm at th_1, 0,65—0.82 mm between th_1 and th_2, 1.10—1.20 (0.90—1.00) mm at th_2, 1.30—1.45 (1.10—1.30) mm at th_5, it reaches its maximum of 1.65 (1.60) — 1.70 (1.65) mm at th_{10-11}.

Thecae. Biform. The earliest representatives have the first 3—4 thecae furnished with relatively small hoods of distally diminishing size (Fig. 27/2, 5, 6) and exposing aperture laterally. Hood of th_1 is 0.30—0.60 mm long, hoods of th_2 and th_{3-4} are 0.35 mm and 0.25—0.35 mm long, respectively. Hoods of the first 2—3 thecae are distinctly curved downwards extending down below the margin of thecal aperture. Medial and distal thecae furnished with apertural processes 0.10—0.20 mm long. Rhabdosomes of subsequent representatives (Fig. 27/8—10, 15) show the first 4—7 thecae ended with equally sized hoods, 0.40—0.45 mm long. Medial thecae of these rhabdosomes are provided with apertural processes 0.20—0.30 mm long. The longest rhabdosomes have the youngest thecae always terminated with short processes 0.10—0.15 long. Hood of th_1, rarely greater than the others (Fig. 27/8), attains a maximum width of 0.28 mm. The hoods have been formed due to the continuous growth of interthecal walls. Thecae vary in length from 1.30 mm to 2.30 mm, and from 0.44 to 0.65 mm in width. Free ventral walls commonly weakly convex, 0.44—0.66 mm long, parallel to rhabdosome axis. Supragenicular and infragenicular parts of ventral wall almost perpendicular. Excavations of proximal thecae up to 0.25 mm deep, those of distal thecae to 0.39 mm deep. Apertural margins thickened and markedly inclined to rhabdosome axis. Interthecal walls

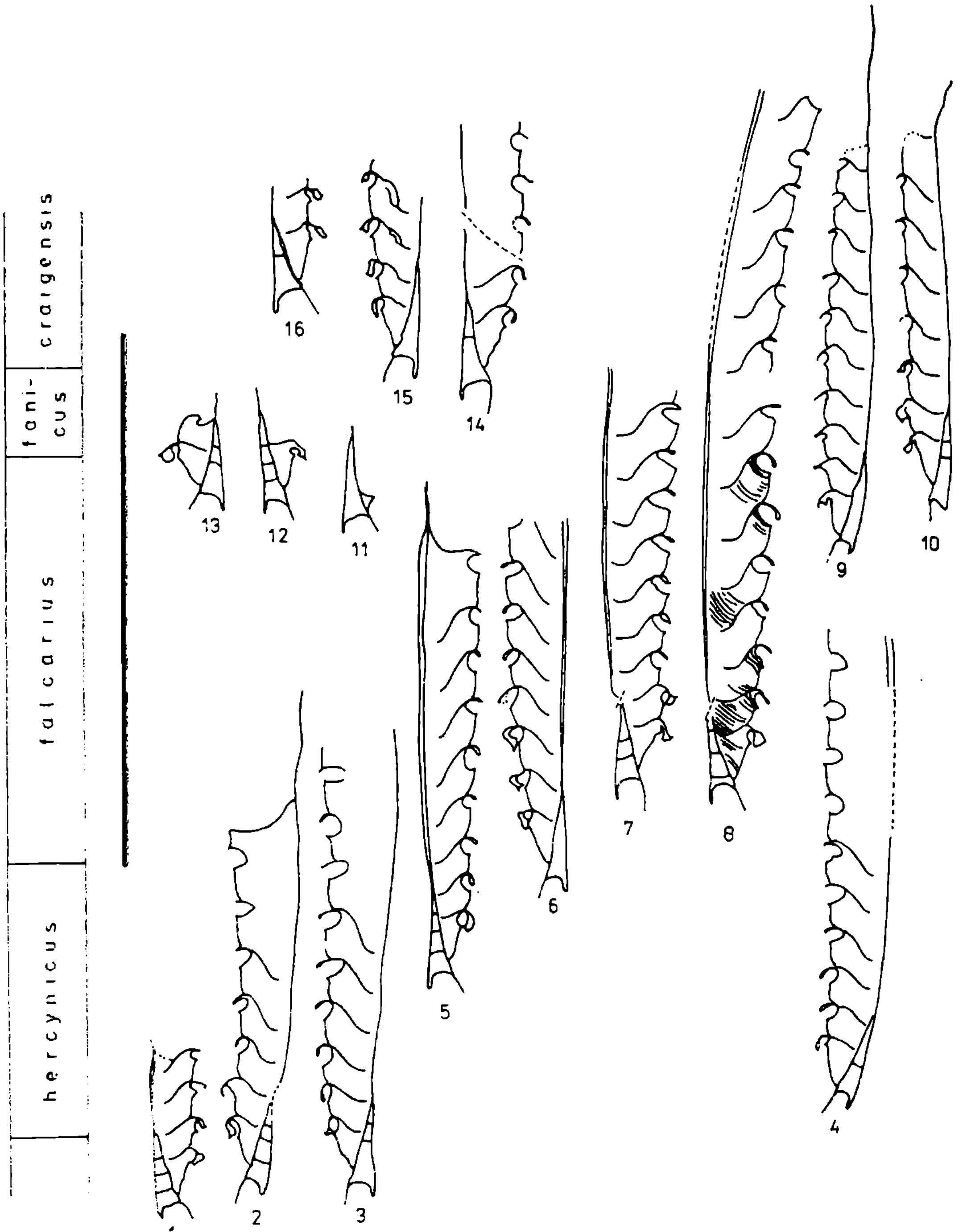

Fig. 27. *Monograptus aequabilis notoaequabilis* Jaeger & Stein; 1—6 — 60P 1033, 317, 1034, 314, 791, 390, × 6, falcarius Zone; 7—13 — 60P 843, 337, 1135, 1136, 1137, 1138, 1139, × 6, fanicus Zone; 14—16 — 60P 1140, 1141, 1142, × 6, craigensis Zone

Fig. 27. *M. aequabilis notoaequabilis* Jaeger & Stein; 1—6 — 60P 1033, 317, 1034, 314, 791, 390, × 6, zona falcarius; 7—13 — 60P 843, 337, 1135, 1136, 1137, 1138, 1139, × 6, zona fanicus; 14—16 — 60P 1140, 1141, 1142, × 6, zona craigensis

of sigmoidal shape, inclined at 25°—30° to axis. N_1/5 mm is 5—6, N_1/10 mm — 10—$10\frac{1}{2}$.

Sicula. Narrow, weakly ventrally curved (Fig. 27/4, 9, 10) or distinctly widened towards aperture, straight or slightly dorsally curved (Fig. 27/5—8 and 11—16). Narrow prosicula up to 0.60—0.70 mm in length

Table 20

60P No.	S_{rh}					Σ	Sicula			$N_1/5$ mm	$N_1/10$ mm
	th_1	th_1/th_2	th_2	th_5	max.		L_s	S_a	L_{dt}		
843	0.90 (0.70)	0.75	1.10 (0.88)	1.30 (1.22)	—	1.20	1.70	0.40	0.20	5	—
390	1.10 (0.75)	0.75	1.10 (0.85)	1.35 (1.20)	1.70 (1.65)	1.40	2.00	0.45	0.30	$5^1/_4$	$10^1/_2$
288	1.05 (0.78)	0.85	1.20 (0.98)	1.45 (1.15)	1.60 (1.50)	1.35	1.82	0.50	0.20	$5^1/_2$	$10^1/_2$
366	1.05 (0.75)	—	1.10 (0.85)	1.50 (1.33)	1.50 (1.40)	1.22	1.80	0.53	0.35	5	10

with aperture 0.40—0.60 mm wide. Metasicula up to 1.20—1.30 mm in length. Sicular process straight or slightly ventrally deflected, 0.18—0.30 mm long. Virgella always ventrally curved, 0.20—0.47 mm long. Most examined siculae reveal two metasicular rings and one situated at the pro- and metasicula boundary (Fig. 27/1, 2, 5, 8, 12). Apertural margin of sicula forms commonly a deep sinus. Dimensions: L_s = 1.70—2.00 mm; S_a = 0.40—0.60 mm; Σ = 1.10—1.40 mm.

Measurements of some specimens of *M. aequabilis notoaequabilis* are given in Table 20.

Comparison and Remarks. — As it was demonstrated by Koren' (1975) asynchronous populations of *M. aequabilis notoaequabilis* from Australia, Asia, Europa, and North America do not show any significant morphological variability. The Żdanów specimens do not differ from others, earlier described from various regions.

M. aequabilis notoaequabilis exhibits a variety of morphological analogies with *M. aequabilis aequabilis* Přibyl (com. Jaeger, 1967; Jaeger et al., 1969). The basic feature which can afford to distinguished between these two taxons is, according to Jaeger, the length of dorsal sicular process — greater in the case of *M. aequabilis notoaequabilis*. However, the present observations as well as those of Koren' (1974, 1975) seem to indicate that the structure of the thecae is of primary importance in the discrimination between the taxons mentioned above. The length of the sicular process varies considerably even among one population of *M. aequabilis aequabilis* or *M. aequabilis notoaequabilis*, and it is largely dependent on the state of preservation of the material examined. Only the first theca of *M. aequabilis aequabilis* has a hood obscuring the thecal aperture; the second, and sometimes third theca is ended with short apertural processes whereas the remaining thecae exhibit climacograptid appearance. The hood of th_1 in the oldest rhabdosomes of *M. aequabilis notoaequabilis* is still dominating, but it is considerably smaller than in the case of *M. aequabilis aequabilis*, and the hoods of th_{2-3} are markedly curved downwards. The hood of th_1 of younger representatives of *M. aequabilis notoaequabilis* decreases in size, and the first 4—7 thecae are provided with hoods of approximately equal dimensions; the remaining thecae are terminated with apertural processes. The differences between *M. aequabilis aequabilis* and *M. aequabilis notoaequabilis* embody also the proximal crowding of thecae ($8^1/_4$—9 and 10—$10^1/_2$, respectively) and the width of sicular aperture (0.30—0.40 mm and 0.40—0.60 mm).

Distribution. — Żdanów Section, the falcarius, fanicus, and craigensis Zones; the accompanying assemblage is given in Figure 4. For global distribution, see Koren' (1975).

Monograptus aequabilis bardoensis nov. subsp.
Fig. 28/1—16

?1975 *Monograptus aequabilis notoaequabilis* Jaeger & Stein; Koren'; Pl. 1, Fig. 1

Holotype: specimen shown in Fig. 28/7, 60P 293.

Type locality: Żdanów, Bardo Mts. (Sudetes).

Stratum typicum: Lower Devonian, the falcarius, fanicus and craigensis Zones.

Derivation of the name: after Bardo Mountains.

Diagnosis: A medium size monograptid, straight or with a moderate dorso-ventral curvature of the proximal end. The proximal thecae have small hoods, the medial and distal ones of geniculate appearance and furnished with short apertural processes. Width of rhabdosome is 0.90—1.10 (0.70—0.90) mm at th_1 reaching its maximum of 1.50—1.62 (1.40—1.60) mm at th_{6-9}. Triangular sicula, 1.60—2.30 mm long and 0.40—0.70 mm wide, lacking dorsal process. N_1/10 mm is 9—$10^1/_2$.

Material. — Twenty five rhabdosomes of which twelve represent juvenile stages, twelve proximal fragments.

Description: Rhabdosome. Middle-sized, the largest but incomplete is 25 mm long. Straight (Fig. 28/1—5) or slightly dorso-ventrally curved between th_1 and th_{4-6} (Fig. 28/7, 8, 14, 15). Width is 0.90—1.10 (0.70—0.90) mm at th_1, 0.70—0.85 mm between th_1 and th_2, and 1.20—1.43 (1.10—1.40) mm at th_5 reaching its maximum of 1.50—1.62 (1.40—1.60) mm at th_{6-9}.

Thecae. Biform. The first 2—4 thecae provided with hoods 0.30—0.45 long which can reach out below apertural margins (Fig. 28/5, 8, 14, 15). Medial and distal thecae terminated by apertural process 0.10—0.20 mm long. All thecae show expose apertures. Interthecal walls slightly sigmoidal, inclined at 40°—55° to rhabdosome axis in the case of proximal thecae, those of distal thecae inclined at 20°—30°. Free ventral walls 0.52—0.70 mm long, slightly convex, and in the proximal and medial parts of rhabdosome inclined at 15° to its axis. Proximal and medial thecae have length of 0.80—1.00 mm and 1.05—1.60 mm, respectively, and are 0.52—0.65 mm wide. N_1/5 mm is $4^3/_4$—$5^1/_2$, N_1/10 mm — 9—$10^1/_2$; N_2/5 mm — $4^1/_2$; N_2/10 mm — $8^1/_2$—9.

Sicula. Long, triangular, lacking dorsal process. Apex reaches aperture of th_2 (Fig. 28/1, 2, 6—8, 12—16) or is situated a little above it (Fig. 28/2, 4, 5, 9). Apertural margin slightly concave or straight. Virgella 0.50—0.78 mm long, ventrally curved. Some specimens show three sicular rings (Fig. 28/2, 5—7, 9—12). Dimensions: L_S = 1.60—2.30 mm; S_a = 0.40—0.70 mm; Σ = 1.10—1.60 mm.

Table 21 shows measurements taken from several specimens of *M. aequabilis bardoensis* nov. subps.

Comparison and Remarks. — In the uppermost part of the

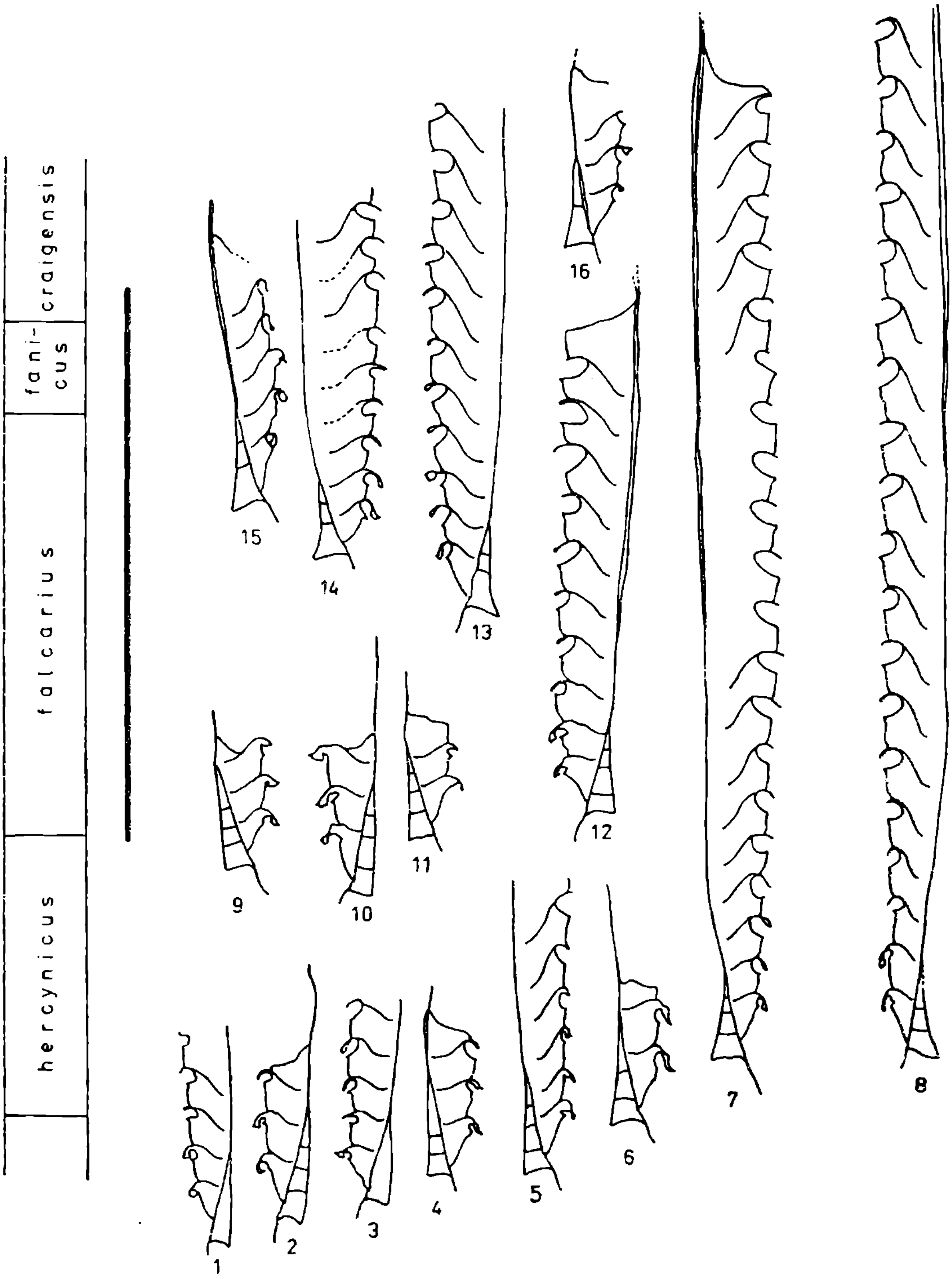

Fig. 28. *Monograptus aequabilis bardoensis* nov. subsp.; 1—6 — 60P 1143, 339, 1144, 848, 540, 229, × 6, lower part of the falcarius Zone; 7—10 — 60P 293 (holotype), 295, 856, 364, × 6, upper part of the falcarius Zone; 11—14 — 60P 480, 296, 1145, 664, × 6, fanicus Zone; 15—16 — 60P 1146, 1152, × 6, craigensis Zone

Fig. 28. *M. aequabilis bardoensis* nov. subsp.; 1—6 — 60P 1143, 339, 1144, 848, 540, 229. × 6, dolna część zony falcarius; 7—10 — 60P 293 (holotyp), 295, 856, 364, × 6, górna część zony falcarius; 11—14 — 60P 480, 296, 1145, 664, × 6, zona fanicus; 15—16 — 60P 1146, 1152, ×6, zona craigensis

Table 21

60P No.	S_{th}				Σ	Sicula		N_1/5 mm	N_1/10 mm	N_2/5 mm	N_2/10 mm
	th_1	th_1/th_2	th_5	max.		L_s	S_a				
852	0.98 (0.87)	0.70	1.30 (1.20)	—	1.58	2.34	0.46	—	—	—	—
853	1.10 (0.93)	0.78	1.43 (1.35)	1.60 (1.50)	1.37	2.10	0.44	$5^1/_2$	10	—	—
856	1.17 (0.88)	0.83	1.40 (?)	—	1.40	2.20	0.52	—	—	—	—
296	1.10 (0.95)	—	1.35 (1.30)	1.50 (1.45)	1.10	1.82	0.58	$5^1/_2$	10	—	—
913	0.93 (0.70)	0.70	1.32 (1.10)	1.62 (1.60)	1.04	1.74	0.60	5	10	—	—
293	1.04 (0.78)	0.80	1.10 (0.83)	1.65 (1.60)	1.25	1.82	0.66	$5^1/_2$	$10^1/_2$	$4^1/_2$	9
295	0.80 (0.62)	0.65	1.05 (0.90)	1.48 (1.45)	1.30	1.70	0.60	$4^3/_4$	9	$9^1/_2$	$8^1/_2$

hercynicus Zone occur rhabdosomes which can be interpreted as transitional forms between described subspecies and M. *aequabilis aequabilis* Přibyl (Fig. 26/13). These transitional rhabdosomes have the first theca furnished with a hood which is, hovewer, smaller than that of *M. aequabilis aequabilis*, and only in few cases inconsiderably greater than hoods of th_2 and th_3. The following thecae are provided with short apertural processes only in the medial part of rhabdosomes. Sicula of the rhabdosomes under considerations is devoid of a dorsal process.

Rhabdosomes of the earliest representatives of *M. aequabilis bardoensis* are straight along the entire length (Fig. 23/1—5). Their siculae are straight and relatively long (L_s = 1.82—2.30 mm) reaching repeatedly above the base of th_3. Later representatives of *M. aequabilis bardoensis* (higher part of the falcarius Zone, and the fanicus and craigensis Zones) are typified by a slight dorso-ventral curvature of the proximal part of rhabdosome (Fig. 28/7, 8, 15). Sicula maintains its triangular shape but, in comparison with older rhabdosomes of this taxon, it becomes shorter (L_s = 1.60—1.80 mm), wider at the aperture (S_a is 0.50—0.72 mm as against 0.40—0.60 mm of older representatives), and weakly dorsally deflected. The number of hooded thecae does not undergo any significant changes, whereas the width of rhabdosome attains its maximum value quicker, i.e., at the aperture of th_{6-7}.

The youngest representatives of *M. aequabilis bardoensis* show a considerable similarity to *M. atopus* Bouček found in the uppermost Pragian of Barrandian (Bouček, 1966; Jaeger, 1973, p. 104, Fig. $1m_1$). They also greatly resemble Chinese specimens defined as *Neomonograptus himalayensis* Mu & Ni, *M. latus* Mu & Ni, and *M. atopus* var. *rigidus* Mu & Ni (Mu & Ni, 1975), which are associated with fauna characteristic of the yukonensis Zone and closely related to, or even representing, *M. atopus* (com. Jaeger, 1978). This similarity is expressed in the structure of thecae (extreme proximal thecae of hooded type remaining of climacograptid appearance), thecal crowding, uniform width of rhabdosome, and in the shape of sicula (triangular, lacking dorsal process). Differences are only of quantitative nature and concern sicula which is, unlike that of *M. aequabilis bardoensis*, in both the Chinese specimens and the Barrandian *M. atopus* is considerably shorter and wider and its apex lies markedly lower.

The taxon under description differs from *M. aequabilis notoaequabilis* Jaeger & Stein in the structure of sicula (metasicula lacks a dorsal process) and a lower number of hooded thecae (2—4 and 3—7, respectively).

The populations of *M. aequabilis notoaequabilis* described from Pai-Khoi and Tien Shan contain rhabdosomes displaying a dorso-ventral curvature of the proximal end and having the sicula devoid of dorsal process (Koren', 1975, p. 8). Such rhabdosome is illustrated by Koren' (1975, Pl. 1, Fig. 1), and its similarity to here described subspecies may indicate a taxonomic identity of these two forms.

Distribution. — Żdanów Section, the falcarius, fanicus and craigensis Zones; the accompanying assemblage is shown in Figure 4.

Monograptus fanicus Koren', 1974

Fig. 29/2—7

1974 *Monograptus fanicus* nov. sp.; Koren', p. 251, 254, 256, Pl. 26, Figs 1—7; Text-Figs 2, 3/8—3/15; nomen nudum
1978b *M. fanicus* Koren'; Koren', p. 124, Text-Fig. 5h—l (see synonymy)

Material. — Nine rhabdosomes lacking distal parts, seven siculae, and five rhabdosomes representing juvenile stages.

Description: Rhabdosome. The largest, incomplete are about 20 mm long. Proximal part straight, with dorsally deflected sicula. In some specimens, the rhabdosome axis shows ventral curvature between th_4 and th_2 passing down in a dorsally deflected sicular margin (Fig. 29/5, 6). Width increases rapidly in proximal part and reaches its maximum between th_8 and th_{15}; it often decreases in distal part. Width is 1.00—1.20 (0.75—0.90) mm at th_1, 0.80—0.90 mm between th_1 and th_2, 1.20—1.70 (1.10—1.40) mm at th_5, 1.50—1.80 (1.35—1.60) mm at th_{10}, and it attains maximum of 1.70 (1.50) — 2.20 (2.10) mm at the level of distal thecae.

Thecae. Biform. Proximal thecae from th_1 to th_{7-11}, have hoods of approximately equal size. They are 0.30—0.50 mm in length and width, obscuring thecal apertures only ventrally (Fig. 29/3, 4). Hoods of most proximal thecae sometimes expose entire apertures (Fig. 29/2). The remaining thecae (th_{15}—th_{24}) provided with apertural processes 0.25—0.50 mm long. Proximal and medial thecae are 0.90—1.70 mm long and 0.50—0.65 mm wide. Free ventral walls of proximal thecae 0.40—0.50 mm long, distinctly convex, and inclined at 30°—40° to rhabdosome axis. Those of medial thecae 0.70—0.75 mm long, weakly convex, and inclined at about 15° to axis. Infragenicular and supragenicular walls perpendicular to each other (Fig. 29/2). Excavation up to 0.30—0.40 mm deep. Interthecal septa of the first proximal thecae (th_{1-2}) slightly sigmoidal, and almost horizontal; those of medial thecae inclined at 30°—35° to rhabdosome axis. $N_1/5$ mm is $6^1/_5$—$6^3/_4$, $N_1/10$ mm — 11—12.

Sicula. Dorsally curved, sharply expanding towards aperture. Apex reaches aperture of th_2. Dorsal process 0.20—0.40 mm long, more or less distinctly curved ventrally. Virgella 0.40—0.60 mm long, initially straight or weakly ventrally deflected, and then curved dorsally. Most of the observed siculae show two sicular rings, one metasicular, and second situated at the pro- and metasicula boundary. Dimensions: $L_s = 1.40—1.75$ mm; $S_a = 0.60—0.80$ mm; $\Sigma = 1.00—1.20$ mm.

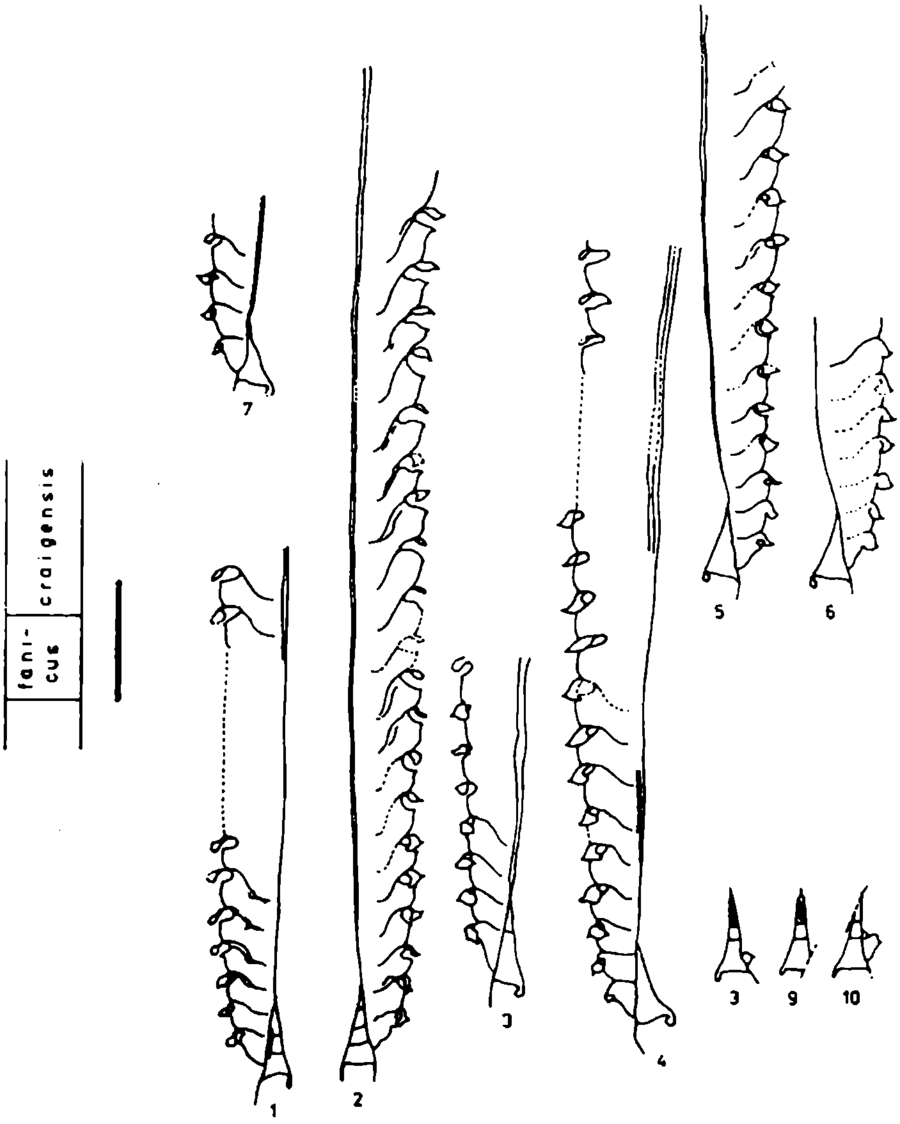

Fig. 29. *Monograptus fanicus* Koren'; 2—4, 8—10 — 60P 1040, 1047, 1082, 1149, 1150, 1151, × 6, lower part of the fanicus Zone; 5—6 — 60P 1082, 1044, × 6, upper part of the fanicus Zone; 7 — 60P 1148, × 6, craigensis Zone; 1 — 60P 1160, × 6 — specimen transitional between *Monograptus aequabilis notoaequabilis* Jaeger & Stein and *Monograptus fanicus* Koren', lower part of the fanicus Zone

Fig. 29. *M. fanicus* Koren'; 2—4, 8—10 — 60P 1040, 1047, 1082, 1149, 1150, 1151, × 6, dolna część zony fanicus; 5—6 — 60P 1082, 1044, × 6, górna część zony fanicus; 7 — 60P 1148, × 6, zona craigensis; 1 — 60P 1160, × 6 — forma przejściowa między *M. aequabilis notoaequabilis* Jaeger & Stein i *M. fanicus* Koren', dolna część zony fanicus

Measurements of some specimens of *M. fanicus* are given in Table 22.

Comparison and Remarks. — *M. fanicus* was first described by Koren' (1974, 1975) from a higher part of the Lower Devonian deposits of Tien Shan. Koren', also found here a series of transient forms between *M. fanicus* and *M. aequabilis notoaequabilis* Jaeger & Stein. Among specimens collected in the Żdanów Section few such rhabdosomes have been met (Fig. 29/1). Unlike *M. aequabilis notoaequabilis,* their siculae are shorter (1.40—1.70 mm), wider at the aperture (0.60 mm),

Table 22

60P No.	S_{rh}				Σ	Sicula			N_i/5 mm	N_i/10 mm
	th_1	th_1/th_2	th_5	max.		L_s	S_a	L_{dt}		
1082	1.10 (0.80)	0.80	1.15 (1.05)	2.30 (2.10)	1.00	1.56	0.80	0.40	$6^1/_2$	$11^3/_4$
1083	1.05 (0.85)	0.83	1.36 (1.30)	—	1.00	1.44	0.57	0.40	—	—
1044	1.00 (0.75)	0.78	1.50 (1.30)	—	1.10	1.50	0.76	0.25	$6^3/_4$	—
1047	1.06 (0.75)	0.78	1.50 (1.25)	—	1.20	1.75	0.70	0.30	$6^1/_5$	—
386	1.20 (0.90)	0.90	1.70 (1.42)	1.70 (1.50)	1.10	1.60	0.78	0.20	$6^1/_2$	$11^3/_4$

and display a slight dorsal curvature; the hoods of proximal thecae and the apertural processes of distal thecae are considerably greater though the thecal apertures remain still exposed ventrally. In addition, the rhabdosomes under description differ from those of *M. aequabilis notoaequabilis* in being wider and displaying a greater crowding of thecae.

The population of *M. fanicus* collected in the Żdanów Section bear a close morphological resemblance to that described from Tien Shan. The slight differences between these two populations comprise the number of hooded thecae (7—11 and 9—15, respectively), the length of sicula (1.40—1.75 mm and 1.70—2.00 mm), and the length of dorsal sicular process (0.20—0.40 mm and 0.50—0.70 mm).

Distribution. — Żdanów Section, the fanicus and craigensis Zones; the accompanying assemblage is given in Figure 4.

Subfamily Linograptinae Obut, 1957
Genus *Linograptus* Frech, 1897

Linograptus posthumus (Reinh. Richter, 1875)
Fig. 30/1—18

1963 *Linograptus posthumus* (Reinh. Richter); Urbanek, pp. 174—193, Text-Figs 8—12; Fig. 3

1964 *L. posthumus posthumus* (Reinh. Richter); Teller, pp. 62—76, Pl. 10, Figs 1—6; Pl. 11, Figs 1—8; Pl. 12, Figs 1—4; Pl. 13, Figs 2—4; Pl. 14, Figs 1—4; Pl. 15, Figs 1—3; Pl. 16, Figs 1—5 (see synonymy)

1969 *L. posthumus* (Reinh. Richter); Jaeger, Figs 1—2

1969 *L. posthumus tenuis* Jaeger; Jackson & Lenz, p. 21, Pl. 4, Fig. 3

1973a *L. posthumus* (Reinh. Richter); Koren', pp. 154—157, Pl. 2, Figs 1—8; Pl. 3, Figs 1—6

1975 *L. posthumus posthumus* (Reinh. Richter); Berry & Murphy, pp. 94—95, Pl. 13, Fig. 4; Pl. 14, Fig. 5; Text-Fig. 23a, b

Material. — Twenty five rhabdosomes differing in the number of cladia (2—5) and representing various stages of astogenetic development. Numerous fragments of proximal and distal parts of branches.

Description: Rhabdosome. It consists of procladium and 1—4 sicular cladia budded from sicular aperture. The longest cladia of bi-ramose rhabdosomes have over 20 thecae. Fragments of cladia are 30 mm long; their width is equal to 0.20—0.52 (0.08—0.20) mm in proximal part, and it increases to 0.40—0.96 (0.20—0.62) mm in distal part.

Thecae. Uniform, narrow, tubular, 1.30—1.95 mm long. Ventral walls sigmoidal or straight. Proximal part of sigmoidal walls is often parallel to or inclined at up to 10° to cladium axis. Distal segment of ventral walls inclined at 10°—22° to axis. Straight ventral walls inclined at 10°—15° to cladium axis. Thecal apertures can be straight, perpendicular to axis, or with slight elevated margin. $N_1/5$ mm is $3^1/_2$—4, $N_1/10$ mm — 7—8; $N_2/5$ mm — $3^1/_2$; $N_2/10$ mm — 7.

and display a slight dorsal curvature; the hoods of proximal thecae and the apertural processes of distal thecae are considerably greater though the thecal apertures remain still exposed ventrally. In addition, the rhabdosomes under description differ from those of *M. aequabilis notoaequabilis* in being wider and displaying a greater crowding of thecae.

The population of *M. fanicus* collected in the Żdanów Section bear a close morphological resemblance to that described from Tien Shan. The slight differences between these two populations comprise the number of hooded thecae (7—11 and 9—15, respectively), the length of sicula (1.40—1.75 mm and 1.70—2.00 mm), and the length of dorsal sicular process (0.20—0.40 mm and 0.50—0.70 mm).

Distribution. — Żdanów Section, the fanicus and craigensis Zones; the accompanying assemblage is given in Figure 4.

Subfamily Linograptinae Obut, 1957

Genus *Linograptus* Frech, 1897

Linograptus posthumus (Reinh. Richter, 1875)

Fig. 30/1—18

1963 *Linograptus posthumus* (Reinh. Richter); Urbanek, pp. 174—193, Text-Figs 8—12; Fig. 3

1964 *L. posthumus posthumus* (Reinh. Richter); Teller, pp. 62—76, Pl. 10, Figs 1—6; Pl. 11, Figs 1—8; Pl. 12, Figs 1—4; Pl. 13, Figs 2—4; Pl. 14, Figs 1—4; Pl. 15, Figs 1—3; Pl. 16, Figs 1—5 (see synonymy)

1969 *L. posthumus* (Reinh. Richter); Jaeger, Figs 1—2

1969 *L. posthumus tenuis* Jaeger; Jackson & Lenz, p. 21, Pl. 4, Fig. 3

1973a *L. posthumus* (Reinh. Richter); Koren', pp. 154—157, Pl. 2, Figs 1—8; Pl. 3, Figs 1—6

1975 *L. posthumus posthumus* (Reinh. Richter); Berry & Murphy, pp. 94—95, Pl. 13, Fig. 4; Pl. 14, Fig. 5; Text-Fig. 23a, b

Material. — Twenty five rhabdosomes differing in the number of cladia (2—5) and representing various stages of astogenetic development. Numerous fragments of proximal and distal parts of branches.

Description: Rhabdosome. It consists of procladium and 1—4 sicular cladia budded from sicular aperture. The longest cladia of bi-ramose rhabdosomes have over 20 thecae. Fragments of cladia are 30 mm long; their width is equal to 0.20—0.52 (0.08—0.20) mm in proximal part, and it increases to 0.40—0.96 (0.20—0.62) mm in distal part.

Thecae. Uniform, narrow, tubular, 1.30—1.95 mm long. Ventral walls sigmoidal or straight. Proximal part of sigmoidal walls is often parallel to or inclined at up to 10° to cladium axis. Distal segment of ventral walls inclined at 10°—22° to axis. Straight ventral walls inclined at 10°—15° to cladium axis. Thecal apertures can be straight, perpendicular to axis, or with slight elevated margin. $N_1/5$ mm is $3^1/_2$—4, $N_1/10$ mm — 7—8; $N_2/5$ mm — $3^1/_2$; $N_2/10$ mm — 7.

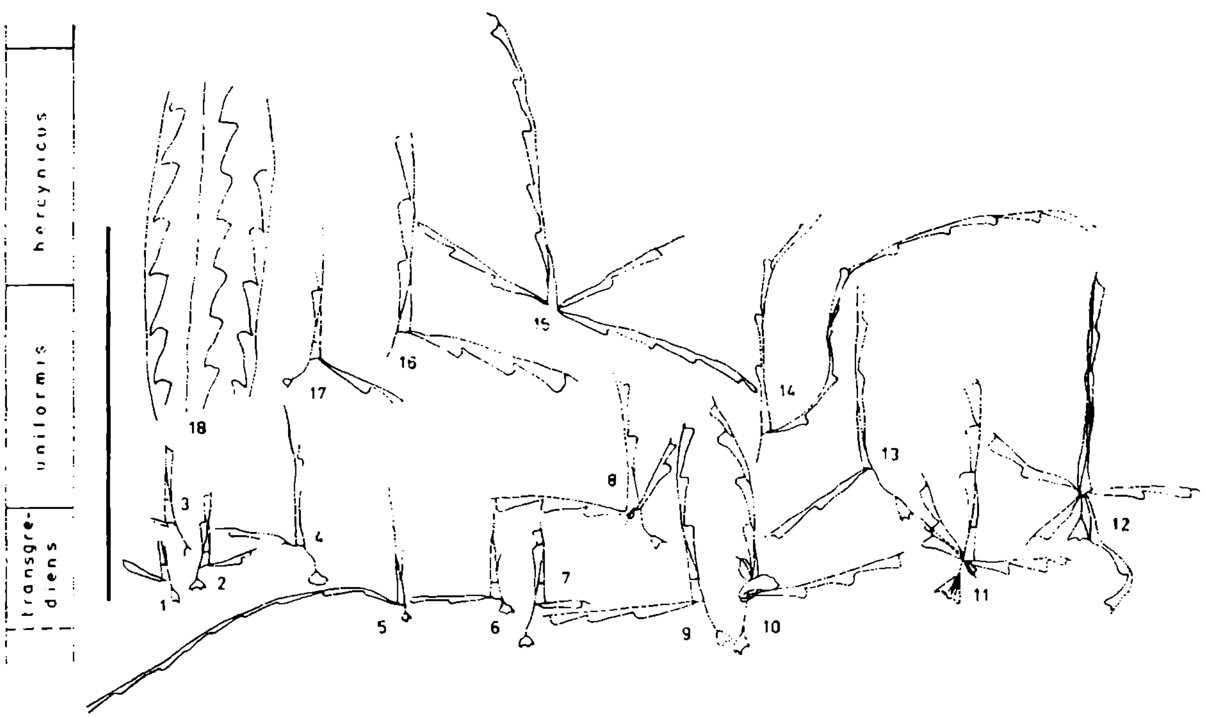

Fig. 30. *Linograptus posthumus* (Reinh. Richter); 1—14 — 60P 561, 562, 563, 1108, 1109, 1107, 566, 598, 570, 564, 565, 572, 569, 567, × 6, transgrediens Zone; 15—16 — 60P 1105, 1106, × 6, uniformis Zone; 17—18 — 60P 571, 1132, × 6, hercynicus Zone

Fig. 30. *L. posthumus* (Reinh. Richter); 1—14 — 60P 561, 562, 563, 1108, 1109, 1107, 566, 598, 570, 564, 565, 572, 569, 567, × 6, zona transgrediens; 15—16 — 60P 1105, 1106, × 6, zona uniformis; 17—18 — 60P 571, 1132, × 6, zona hercynicus

Sicula. Very narrow, conical, 1.00—1.80 mm long. Margin of sicular aperture flat or slightly concave, 0.18—0.30 mm wide. Virgella strongly varying in length from 0.09—0.30 mm (most often between 0.70 and 0.80 mm). Virgellaria flattened, varying in shape and length. They commonly assume a bell shape, more or less wide at the base, and are provided with incomplete digital outgrowths (Fig. 30/1—2, 6—10). Bell-shaped virgellaria are 0.30—0.40 mm wide and 0.30—0.60 mm high). Two rhabdosomes have the a larger virgellarium which is conical in shape (Fig. 30/11, 12); the cone, 0.83 mm wide at the base and 0.30 mm high, is connected with the sicula by a virgella of 0.35 mm in length.

Comparison and Remarks. — A rhythm in the formation of sicular cladia in *L. posthumus* have been discussed by Jaeger (1959), Urbanek (1963), and Teller (1964). The Żdanów rhabdosomes shows a more complex and, in some cases, even different mode of growth of the particular cladia in comparison with that hitherto described. The difference becomes noticeable already in the earliest stage of the formation of the first sicular cladium. In one of the rhabdosomes (Fig. 30/1) th_1 of the procladium does not reach the sicular apex, however th_1 of the first sicular cladium is twice as long as that of the procladium. Considering Teller's suggestion on quicker growth of each newly produced cladia, one can assume that the budding of the first sicular cladium in previously mentioned rhabdosome had occurred more or less simultaneously with a growth of the first theca of procladium. In other rhabdosomes (Fig. 30/3, 7), th_1 of the first sicular cladium might have appeared when th_1 of procladium had reached the apex of prosicula. This is agreement with observations of Urbanek and Teller.

The moment of the formation of the second sicular cladium, as recognized in only one rhabdosome (Fig. 30/10), took place simultaneously with the growth of th_4 of procladium but before the end of formation of th_3 on the first sicular branch.

The budding of the third sicular cladium can be recognized also from one specimens (Fig. 30/8). The procladium of this rhabdosome is poorly preserved and no precise definition of its growth stage is possible. However, since the first sicular cladium has three thecae, it can be reasonably assumed that the budding of th_2 of the third cladium was simultaneous with the growth of th_4 of procladium, th_4 of the first sicular cladium, and more or less synchronous with the development of th_2 of the second sicular cladium.

The growth of th_1 of the fourth sicular cladium can be recognized on the basis of two rhabdosomes (Fig. 30/11, 12). It took place simultaneously with development of the highest part of th_3 of procladium, lower part of th_3 of the first sicular cladium, and higher part of th_2 of the second sicular cladium. The budding of th_1 of the fourth sicular cladium was synchronous with that of th_2 of the third cladium.

The material from Żdanów contains no specimens that have more than five branches, therefore, the manner of the formation of next sicular cladia cannot be recognized. Apart from the above mentioned rhabdosomes representing early astogenetic stages of *L. posthumus*, two specimens show later stages. These rhabdosomes are bi-ramose forms. However, we cannot exclude the possibility that next sicular cladia were broken away. It is also possible that this was due to a primary cause, i.e., either the third and next cladia budded in a later stage or the development of these rhabdosomes was limited to a bi-ramose form (the existence of such forms is expected by Jaeger (1959) and Koren' (1973a).

From the above considerations it follows that the rhabdosomes of *L. posthumus* known from the Thuringia, Chełm, and Żdanów Section reveal a distinct differentiation with respect to the rhythm in the formation of successive sicular cladia (Table 23). The present observations suggest, moreover, that a certain correlation exists between the mode of growth of the sicular cladia on one hand, and the length of virgella as well as shape of virgellarium on the other. The rhabdosomes showing the most rapid rate in the budding of the successive cladia have the shortest virgellae (0.30—0.35 mm) and the greatest virgellaria (Fig. 30/11, 12). The longest virgellae (0.70—0.80 mm) and, accordingly smaller virgellaria, are carried by rhabdosomes typified by the slowest growth of the sicular cla-

Table 23

First thecae of successive sicular cladia	Thecae of procladium			**Thecae of second cladium**			Thecae of third cladium		Thecae of fourth cladium		Thecae of fifth cladium
	Thuringia	Chełm	Żdanów	Thuringia	Chełm	Żdanów	Chełm	Żdanów	Chełm	Żdanów	Chełm
th_1^2	th_1^1	th_1^1	th_1^1 (?) th_1^1								
th_1^3	th_{7-8}^1	th_{5-6}^1	th_4^1	th_{7-8}^2	th_{5-6}^2	th_3^2					
th_1^4	th_{6-7}^1	th_{6-7}^1	th_4^1	th_{7-8}^2	th_{6-7}^2	th_4^2	th_3^3	th_2^3			
th_1^5			th_3^1			th_3^2		th_2^3	th_3^4	th_2^4	
th_1^6											th_3^5

dia (Fig. 30/9, 10, 13). The precise indication of the type of this correlation is not yet possible. The relatively poor collection of *L. posthumus* gained from the Żdanów Section does not permit to settle whether or not there is a correlation between abundance of rhabdosomes displaying a specific budding rhythm and the age of strata containing these rhabdosomes. Consequently it is difficult to evaluate a taxonomic significance of the morphological differenes here recorded.

The species *L. posthumus* is divided into two subspcies *L. posthumus posthumus* and *L. posthumus tenuis* on the basis of differences in the width of cladia (Jaeger, 1959). The Żdanów rhabdosomes of *L. posthumus* have cladia displaying the width range typical for both its subspecies (Fig. 30/5, 14 and 30/16, 18). Furthemore, many cladia show intermediate widths (Fig. 30/9, 10, 11) which practically precludes the subdivision of the measured population into two taxons. The width of the cladia found in Devonian strata of the Żdanów Section commonly exceeds 0.50 mm, whereas in the uppermost Silurian specimens this value is seldom reached.

Distribution. — Żdanów Section, the transgrediens, uniformis, and hercynicus Zones; the accompanying assemblage is shown in Figure 4. For global distribution and stratigraphic occurrence of the species, see Teller (1964) and Koren' (1973a).

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