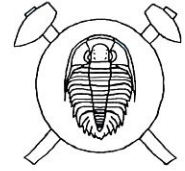


## Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic)



### Graptoliti zón *Pribylograptus leptotheca* a *Lituigraptus convolutus* z Tmaň (silur, Barrandien) (Czech summary)

(11 text-figs, 20 plates)

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The well preserved graptoloid fauna of the middle Aeronian (middle Llandovery) *leptotheca* and *convolutus* biozones comprising 60 species and subspecies is described from Svatý Jiří near Tmaň. The *leptotheca* Biozone has been introduced in the Silurian graptolite zonal scheme of the Barrandian area in place of the lower part of the *convolutus* Biozone of former classifications. A dominance of uniserial rastritid forms (both species and specimen abundance) is documented by quantitative analysis of bulk samples. Seven new species (*Normalograptus? inornatus*, *Petalolithus krizi*, *Neolagarograptus impolitus*, *Monograptus respectabilis*, *M. dracocephalus*, *M. mirificus* and *Campograptus sanctgeorgensis*) and one new genus (*Neolagarograptus*) are erected and ten species are left in open nomenclature. Twenty-three taxa are recorded for the first time in Bohemia.

**Key words:** graptolites, Silurian, middle Llandovery, taxonomy, biostratigraphy, faunal composition

### Introduction

Fields surrounding Svatý Jiří Church near Tmaň, in the western part of the Silurian outcrop area of Barrandian, are rich in loose material of bleached, yellowish or gray siliceous shales with beautiful and abundant black or brown rhabdosomes of middle Llandovery (mid-Aeronian) graptolites. Formerly black siliceous shales were slightly heated by a neighbouring basalt sill of Wenlock-Ludlow age and bleached by late-Tertiary to Pleistocene weathering.

A graptolite fauna comprising 31 species was collected by Bouček and Přibyl and referred to the *convolutus* Biozone by Bouček (1953). He recognized three subzones within the *convolutus* Biozone: in ascending order – a *Monograptus millepeda* Subzone, a *Pristiograptus leptotheca* Subzone, and a *Petalolithus folium* Subzone. Later, examination of several other sections through the *convolutus* Biozone (Štorch 1986) led to abandonment of the three subzones introduced by Bouček (Štorch 1994).

Recent studies on graptolite faunal dynamics (Štorch 1995, Melchin et al. 1998) recorded particularly high diversity in the *convolutus* Biozone assemblages from the Barrandian area of Bohemia and prompted a detailed examination of the biozone and a thorough taxonomic revision of the fauna. New collections, made from loose material and excavations in the field 500 m SE of Svatý Jiří Church, E of Tmaň, comprise more than 10,000 graptolites, about one-quarter of which have been used for detailed taxonomic studies. The rhabdosomes are flattened, rarely preserved in low relief but never tectonically deformed. Even tiny details such as apertural processes, various spines, ancoras and membranous bodies are usually well seen, septa and internal sutures being often preserved through. Species diversity is particularly high, with 60 taxa recorded.

Forty-one (c. two-thirds) of the taxa belong in the Monograptacea, being notably represented by the species with isolated, highly triangulate and rastritiform thecae (14 species of *Rastrites*, *Lituigraptus*, *Torquiraptus* and, in part, *Monograptus*) and spinose hooked thecae (7 species of *Campograptus*). Dorsally curved, arcuate rhabdosomes and rhabdosomes enrolled in loose, commonly helical spirals predominate (29 species). Diplograptacean petalograptids (genera *Petalolithus* and *Cephalograptus*) are diverse, conspicuous but always minor elements of the graptolite fauna. The composition of the fauna and individual species abundance were examined also in four bulk samples (10 kg each) collected in different parts of the section (figures 2 and 3). More than three quarters of the taxa were recorded in these four samples. In the graptoloid taphocenoses some 23–31 % of the rhabdosomes are diplograptacean. Taphocenoses are dominated by monograptacean rhabdosomes which belong to a few species with rastritiform and isolated, highly triangular thecae (41–53 % of the rhabdosomes). Prominent, seemingly common petalograptids (*Petalolithus* and *Cephalograptus*) represent just 1–2 % of the material.

New material allowed recognition of seven new graptolite species and one new genus. Old collections, housed in the Czech Geological Survey and the National Museum in Prague, have been re-examined, including the type material of fifteen taxa erected by Barrande, Perner, Bouček, Přibyl and myself and based wholly or in part upon the material from the *convolutus* Biozone. In addition to the most important locality (Tmaň) other sections in Hlásná Třebaň, Černošice, Karlík, and Velká Chuchle (for explanation see Štorch 1986) were revised. Only seven species recorded by previous authors from the *convolutus* Biozone (in the broad, former sense) have not been identified in the material from Tmaň. These are: *Diplograptus tamariscus* var. *linearis* Perner, 1897 –

based upon a single figured specimen from Litohlavy, subsequently lost; *Petalolithus palmeus ellesi* Bouček & Přibyl, 1941 – based upon a single specimen from Velká Chuchle (Barrande, s. „Colony Haidinger“), *Climacograptus phrygonius* Törnquist – recorded by Perner (1897); *Monograptus nicholsoni* Perner, 1897 – an indeterminate specimen; *Monograptus tubiferus* Perner, 1897; *Streptograptus admirandus* Bouček & Přibyl, 1942 – a single specimen from Velká Chuchle (Barrande’s „Colony Haidinger“) and *Graptolithus nuntius* Barrande, 1850 – an indeterminate specimen. Other taxa reported from this interval belong to the species described herein.

### Biostratigraphy

New material and complete taxonomic revision of the fauna have brought new insights regarding the formerly recognized *convolutus* Biozone. „*Monograptus*“ *convolutus* (Hisinger) as figured by Schauer (1971), Bjerreskov (1975), Štorch (1994), i.e. *M. aff. convolutus* sensu Štorch (1980) and Zalasiewicz (1996), occurs together with *Petalolithus folium* (Hisinger), *Pribylograptus leptotheca* (Lapworth), *Campograptus millepeda* (McCoy), *Rastrites approximatus* Perner and other indices of the lower and middle parts of the *convolutus* Zone as defined by Bouček (1953) and Štorch (1980, 1994). This form differs, however, from *M. convolutus* as figured by Törnquist (1892), Perner (1897), Elles and Wood (1913), Přibyl and Münch (1941) a.o. in having generally shorter metathecae, a number of hooked proximal thecae and later onset of distal thecae with ventrally directed paired lateral apertural processes. The early form of *M. convolutus* with shorter thecae is reassigned herein to *Lituigraptus richteri* (Perner). The original description of *Rastrites*

*richteri* Perner, 1897 was based upon several mesial rhabdosome fragments. The same generic assignment (to *Rastrites*) was retained by Přibyl and Münch (1941) in their brief revision again of fragmentary material. The present collections, however, contain a number of complete rhabdosomes, the mesial parts of which agree well with Perner’s type material and the distal parts refer the species to the genus *Lituigraptus* Ni, the diagnosis of which is emended herein.

*Lituigraptus convolutus* (Hisinger) itself occurs higher and overlaps little with the highest occurrences of *P. folium*, *R. approximatus* and *L. richteri*. It is typically accompanied by *Rastrites peregrinus* Barrande, *Campograptus clingani* (Carruthers) and late members of the *Petalolithus*–*Cephalograptus* lineage: *Petalolithus krizi* n. sp., *Cephalograptus tubulariformis* (Nicholson), *C. cometa cometa* (Geinitz) and *C. cometa extrema* Bouček & Přibyl. Thus the base of the *convolutus* Biozone does not occur at the level used by Bouček (1953) and Štorch (1980, 1994) but significantly higher in the succession. For this reason the *Pribylograptus leptotheca* Biozone is erected herein for those beds lying between the *simulans* Biozone (see Štorch 1994) and the *convolutus* Biozone (text-fig. 1). It comprises the faunas occurring between the lowest occurrence of *Pr. leptotheca* and the lowest occurrence of *L. convolutus* (sensu Elles and Wood 1913, Perner 1897, Törnquist 1892, Hutt 1975 a.o.).

### *Pribylograptus leptotheca* Biozone

*Pr. leptotheca* Biozone is defined as a lowest-occurrence interval zone comprising the stratigraphic section between the lowest occurrence of the two index taxa (see above). It contains a very distinctive assemblage characterized by

Stage	Barrandian area			Bornholm	Wales	Global reference zonal scheme	
	Bouček (1953)	Štorch (1994)	This paper	Bjerreskov (1975)	Loydell (1992) Zalasiewicz (1996) et al.	Koren' et al. (1995)	
middle Llandovery (Aeronian)	sedgwickii	sedgwickii	sedgwickii		halli	sedgwickii	
					sedgwickii		
	convolutus	folium	convolutus	convolutus	convolutus	cometa	-convolutus
		leptotheca		leptotheca		leptotheca	leptotheca
		millepeda					
		pribyli		simulans		simulans	?
	pectinatus	pectinatus	pectinatus	gregarius	pectinatus	magnus	-triangulatus
	triangulatus	-triangulatus	-triangulatus		triangulatus	triangulatus	

Fig. 1. Correlation chart for the Aeronian (middle Llandovery) graptolite biozones. Dashed lines indicate uncertain correlation with the British zonal sequence and the zonal scheme proposed by the International Subcommittee on Silurian Stratigraphy (Koren' et al. 1996). Dotted parts of the zonal schemes indicate stratigraphically relevant barren beds.

Species	Biozones:	simulans	leptothecaconvolutus				sedg.
			1	2	3	4	
Tmaň Section							
<i>Normalograptus? inornatus</i> n.sp.		?	x	xxxxxxx	xxxxxxxxxxx	x	
<i>Normalograptus? nikolayevi</i> (Obut)		?	xxxxxxx		xx		
<i>Neodiplograptus thuringiacus</i> (Kirste)		x	x	xxxxxxxxx	x	?x	
<i>Metaclimacograptus hughesi</i> (Nicholson)		x	x	xxxxxxxxx	xxxxxxxxxxx	x	?
<i>Metaclimacograptus bohemicus</i> (Perner)					xxxx		
<i>Glyptograptus tamariscus tamariscus</i> (Nicholson)		x	x	xxxxxxxxx	xxxxxxxxxxx	x	?
<i>Pseudorthograptus insectiformis</i> (Nicholson)		x	x	xxxxxxxxx	xxxxxxxxxxx		
<i>Dittograptus monstrosus</i> (Štorch)		?	x	x			
<i>Rivagraptus bellulus</i> (Törnquist)		x	x	xxxxxxxxx	xxxxxxxxxxx		?
<i>Rivagraptus sentus</i> Koren` & Rickards					x		
<i>Rivagraptus</i> cf. <i>rozmanae</i> Koren` & Rickards					x		
<i>Petalolithus</i> cf. <i>ovatoelongatus</i> (Kurck)		?	xx				
<i>Petalolithus praecursor</i> Bouček & Přibyl		x	x	xxxxxxxxx	xxxx	?x	
<i>Petalolithus folium</i> (Hisinger)		x	xxxxxxx				
<i>Petalolithus krizi</i> n.sp.					xx		
<i>Cephalograptus tubulariformis</i> (Nicholson)					xxxx		
<i>Cephalograptus cometa cometa</i> (Geinitz)					xx		
<i>Cephalograptus cometa extrema</i> Bouček & Přibyl					xxxx	x	x
<i>Pseudoretiolites perlatus</i> (Nicholson)		x	x	xxxxxxxxx	xxxxxxxxxxx	x	x
<i>Pristiograptus concinnus</i> (Lapworth)		x	x	xxx			
<i>Pristiograptus regularis solidus</i> Přibyl				xx	xxxxxxxxxxx		?
<i>Coronograptus gregarius gregarius</i> (Lapworth)		x	x	xxxx			
<i>Coronograptus maxiculus</i> Štorch				xxxxxxx			
<i>Neolagarograptus helenae</i> (Štorch)				xxxxxxx			
<i>Neolagarograptus impolitus</i> n.sp.				x	xxx	x	
<i>Neolagarograptus</i> sp.					x		
<i>Přibylograptus leptotheca</i> (Lapworth)		x	xxxxxxx		xx		
<i>Monoclimacis crenularis</i> (Lapworth)					xxxxxxx		
<i>Monograptus havliceki</i> Štorch		?	xxxxx				
<i>Monograptus</i> aff. <i>imago</i> Zalasiewicz				xxxxxxxxxxx			
<i>Monograptus limatulus limatulus</i> Törnquist					xxxxxxxxxxx	x	?
<i>Monograptus limatulus inopinus</i> Törnquist		x	xxxxxxxxxxx				
<i>Monograptus respectabilis</i> n.sp.		?	xxxxxxx				
<i>Monograptus dracocephalus</i> n.sp.				xxxxxxx	x	x	
<i>Monograptus mirus</i> Perner		x	x	xxxxxxxxxxx	xxxxxxxxxxx		
<i>Monograptus capillaris</i> (Carruthers)				x	xx	xxx	
<i>Monograptus paradenticulatus</i> Zalasiewicz		?	xxx				
<i>Monograptus simulans</i> Pedersen		x	x	xx			
<i>Monograptus</i> sp., aff. <i>simulans</i> Pedersen				xx	x		
<i>Monograptus mirificus</i> n.sp.		x	xxxxxxxxxxx				
<i>Streptograptus</i> sp.				xx	xxx		
<i>Spirograptus</i> sp.				x			
<i>Campograptus lobiferus lobiferus</i> (McCoy)		x	xxxxxxx		?		
<i>Campograptus lobiferus harpago</i> (Törnquist)					xxxxxxxxxxx		?
<i>Campograptus sanctgeorgensis</i> n.sp.				xxxxxxxxxxx			?
<i>Campograptus</i> cf. <i>communis</i> (Lapworth)				xx			
<i>Campograptus clingani</i> (Carruthers)					xxxxxxxxxxx		
<i>Campograptus obtusus</i> (Rickards)					xxxxxxxxxxx		
<i>Campograptus millepeda</i> (McCoy)		x	xxxxxxx				
<i>Torquigraptus urceolinus</i> (Stein)					xxx		
<i>Torquigraptus denticulatus</i> (Törnquist)					xxxxxxxxxxx	x	?
<i>Torquigraptus</i> cf. <i>valens</i> (Přibyl & Münch)				xxxxxx	xx	x	
<i>Torquigraptus? decipiens</i> (Törnquist)					xxxxxxxxxxx		
<i>Rastrites peregrinus</i> Barrande					xxxxxxxxxxx	x	
<i>Rastrites approximatus</i> Perner				xxxxxxxxxxx			
<i>Rastrites geinitzii</i> Törnquist		x	xx				
<i>Rastrites</i> cf. <i>erectus</i> Hutt					x	xx	x
<i>Rastrites spina</i> (Richter)					x	xxx	
<i>Lituigraptus richteri</i> (Perner)		x	xxxxxxx		?		
<i>Lituigraptus convolutus</i> (Hisinger)					xxxxxxxxxxx		?

Fig. 2. Stratigraphical distribution of the graptoloids in the *leptotheca* and *convolutus* biozones (the dotted part of the section is exposed at Tmaň, numbers 1–4 indicate approximate stratigraphic position of bulk samples). Graptolite records below and above this range are based upon the Černošice, Hlásná Třebaň, and Velká Chuchle sections.

Bulk sample no	1	2	3	4
Species	number of specimens			
<i>Normalograptus? inornatus</i> n.sp.	23	23	99	16
<i>Normalograptus? nikolayevi</i> (Obut)	5	13		4
<i>Neodiplograptus thuringiacus</i> (Kirste)	20	14		? 2
<i>Metaclimacograptus hughesi</i> (Nicholson)	33	136		11
<i>Metaclimacograptus bohemicus</i> (Perner)			16	
<i>Glyptograptus tamariscus tamariscus</i> (Nicholson)	36	45	20	13
<i>Pseudorthograptus insectiformis</i> (Nicholson)	1	1	2	2
<i>Rivagraptus bellulus</i> (Törnquist)	2	4	41	50
<i>Petalolithus praecursor</i> Bouček & Přibyl	9	1	4	? 1
<i>Petalolithus folium</i> (Hisinger)	4	9		
<i>Cephalograptus tubulariformis</i> (Nicholson)			5	
<i>Cephalograptus cometa</i> extrema Bouček & Přibyl				3
<i>Pseudoretiolites perlatus</i> (Nicholson)	7	5	20	25
<i>Pristiograptus concinnus</i> (Lapworth)	1			
<i>Pristiograptus regularis solidus</i> Přibyl	3	1	2	23
<i>Coronograptus gregarius gregarius</i> (Lapworth)	2	1		
<i>Coronograptus maxiculus</i> Štorch	8	6		
<i>Neolagarograptus helenae</i> (Štorch)	3	18		
<i>Neolagarograptus impolitus</i> n.sp.	1			1
<i>Přibylograptus leptotheca</i> (Lapworth)	3	1		2
<i>Monoclimacis crenularis</i> (Lapworth)			11	4
<i>Monograptus havliceki</i> Štorch	6	13		
<i>Monograptus</i> aff. <i>imago</i> Zalasiewicz	5	1	3	
<i>Monograptus limatulus limatulus</i> Törnquist			42	38
<i>Monograptus limatulus inopinus</i> Törnquist	18	20	3	
<i>Monograptus respectabilis</i> n.sp.	27	29		
<i>Monograptus dracocephalus</i> n.sp.	12	12		
<i>Monograptus mirus</i> Perner	3			4
<i>Monograptus capillaris</i> (Carruthers)	1		1	3
<i>Monograptus paradenticulatus</i> Zalasiewicz	9			
<i>Monograptus simulans</i> Pedersen	3			
<i>Monograptus mirificus</i> n.sp.	19	49	6	
<i>Streptograptus</i> sp.			5	
<i>Campograptus lobiferus lobiferus</i> (McCoy)	21	58		
<i>Campograptus lobiferus harpago</i> (Törnquist)			70	52
<i>Campograptus sanctgeorgensis</i> n.sp.	14	19		? 2
<i>Campograptus clingani</i> (Carruthers)			4	2
<i>Campograptus obtusus</i> (Rickards)			4	
<i>Campograptus millepeda</i> (McCoy)		4		
<i>Torquigraptus urceolinus</i> (Stein)			3	
<i>Torquigraptus denticulatus</i> (Törnquist)			52	63
<i>Torquigraptus</i> cf. <i>valens</i> (Přibyl & Münch)	1		1	1
<i>Torquigraptus? decipiens</i> (Törnquist)			27	43
<i>Rastrites peregrinus</i> Barrande			265	156
<i>Rastrites approximatus</i> Perner	48	219		
<i>Rastrites geinitzii</i> Törnquist	48			
<i>Rastrites</i> cf. <i>erectus</i> Hutt				1
<i>Lituigraptus richteri</i> (Perner)	160	124		
<i>Lituigraptus convolutus</i> (Hisinger)			53	28

Fig. 3. Composition of graptoloid fauna in the bulk samples from the *leptotheca* (samples 1 and 2) and *convolutus* (samples 3 and 4) biozones of Tmaň.

*Pr. leptotheca* (Lapworth), *P. folium* (Hisinger), *Coronograptus maxiculus* Štorch, *Neolagarograptus helenae* (Štorch), *Monograptus havliceki* Štorch, *M. mirificus* n. sp., *Campograptus lobiferus lobiferus* (McCoy), *C. millepeda* (McCoy), *R. approximatus* Perner and *L. richteri* (Perner). Bulk samples 1 and 2 are dominated

by *R. approximatus*, *L. richteri* and *Metaclimacograptus hughesi* (Nicholson). Altogether, 41 taxa have been found in the *leptotheca* Biozone. The lower part of the Zone, which is poorly exposed at Tmaň, is characterized by *Monograptus paradenticulatus* (Zalasiewicz), *Rastrites geinitzii* Törnquist and rare *Dittograptus monstrosus*

(Štorch). Also, *Monograptus simulans* Pedersen – an index fossil of the underlying Biozone ranges into the lower part of the *leptotheca* Biozone. The important *leptotheca* Biozone indices *P. folium* and *C. maxiculus* make their first appearances at about the beginning of the second quarter of the zonal thickness which ranges from 1.5 to 2 m in the Barrandian area. *Pr. leptotheca* has its acme near the base of the zone, ranges to its uppermost part, and there are rare finds even from the succeeding *convolutus* Biozone. The basal part of the *leptotheca* Biozone is well exposed in the Černošice and Hlásná Třebaň sections. The *leptotheca* Biozone used herein is approximately equivalent to the *argenteus* Biozone of Hutt (1974) and Rickards (1976a), as well as to the *leptotheca* Biozone and, possibly, the lowermost part of the *convolutus* Biozone of Zalasiewicz (1996). *Monograptus argenteus* (Nicholson) itself is missing in Bohemia and elsewhere in peri-Gondwanan Europe. The *leptotheca* Biozone certainly corresponds with the lower part of the *convolutus* Biozone of Bjerreskov (1975) marked by the presence of *P. folium* and *R. approximatus*.

#### **Lituigraptus convolutus Biozone**

The *L. convolutus* Biozone encompasses the entire stratigraphical range of the species (taxon-range zone). The base is defined by the first appearance of *L. convolutus* (Hisinger) (*sensu* Elles and Wood, a.o.), which is followed by the first appearances of *Campograptus lobiferus harpago* (Törnquist), *C. obtusus* (Rickards), *Torquigraptus denticulatus* (Törnquist) and, slightly higher, by *Cephalograptus tubulariformis* (Nicholson), *Campograptus clingani* (Carruthers) and *Rastrites peregrinus* Barrande. The upper part of c. 1.5 m thick zone may be distinguished by the appearance of common *Cephalograptus cometa extrema* Bouček & Přibyl, characterized by a 16–18.4 mm long th 1<sup>1</sup>. The specimens from the *convolutus* Zone, incorrectly assigned to *C. cometa cometa* (Geinitz) by Bouček and Přibyl (1941), Bouček (1953) and Štorch (1994), are *C. cometa extrema*, whilst the true *C. cometa cometa* is a rare, short-ranging taxon found in the middle part of the *convolutus* Zone. At Tmaň the entire evolutionary history of *Cephalograptus* is recorded, this begins with *P. folium*, continues through *P. krizi* n. sp. and *C. tubulariformis*, and may be employed in further subdivision of the Zone. Bulk samples 3 and 4 (figs 2 and 3) yielded 32 of the 43 graptolite taxa recorded in the *convolutus* Biozone as defined herein, at Tmaň. The fauna is dominated by *R. peregrinus* and less abundant *Normalograptus? inornatus* sp. n., *Rivagraptus bellulus* (Törnquist), *Monograptus limatulus limatulus* Törnquist, *C. lobiferus harpago*, *T. denticulatus* and *L. convolutus*. The majority of the *convolutus* fauna species disappears at or near the top of the Zone, at the beginning of the *convolutus* (Štorch 1995) or early *sedgwickii* (Melchin *et al.* 1998) graptoloid extinction event. The top of the *convolutus* Biozone, indicated by the first occurrence of *Stimulograptus sedgwickii* (Portlock) is not accessible at Tmaň.

The Barrandian *convolutus* Biozone correlates well with the *convolutus* Biozone of Hutt (1974) and Rickards (1976a), which has *C. cometa cometa* in the lower part and *C. cometa extrema* in the upper part of the zonal range. The zone corresponds with the *cometa* band of Bjerreskov (1975) and encompasses also the upper part of her *convolutus* Biozone with *C. tubulariformis*, *T. denticulatus*, *C. clingani* and *R. peregrinus*. The same level may be proposed for the middle and upper parts of the *peregrinus* Subzone of the *convolutus* Biozone used by Schauer (1971).

Many species have been found to be useful in biostratigraphical subdivision and correlation of the Aeronian (middle Llandovery) strata deposited between the *triangularatus-pectinatus* and *sedgwickii* biozones. Miscorrelations, however, resulted from past misidentifications of some taxa of similar appearance but different stratigraphical ranges (e.g. *C. cometa cometa* and *C. cometa extrema*, *P. toernquisti* Bouček & Přibyl, *P. krizi* and *C. tubulariformis*, *M. paradenticulatus* and *T. denticulatus*, *L. richteri* and *L. convolutus*, *R. peregrinus* and *R. hybridus*, etc.). This study, including taxonomic revision of the *leptotheca* and *convolutus* biozone faunas of the Barrandian area aims to improve the degree of precision in global Aeronian biozonation and to remove some of nomenclatorial barriers to graptolite correlation.

#### Depositories of the graptolite material

Specimens from author's collection prefixed PŠ and the specimens from Bouček's collection prefixed BB are housed in the Czech Geological Survey in Prague. The specimens prefixed L are housed in the collections of the National Museum in Prague.

#### Systematic descriptions

In the systematic descriptions the terminology used is largely that of Loydell (1992, 1993), Štorch (1988, 1998), Štorch and Serpagli (1993) and Melchin (1998). Thecal spacing is preferably expressed, particularly in curved and coiled rhabdosomes, as two-thecae repeat distance (an abbreviation 2 TRD) as defined by Howe (1983). The present paper utilizes the graptoloid classification proposed by Loydell (1992), Štorch and Serpagli (1993), Koren, and Rickards (1996) and Melchin (1998). Astogenetic patterns introduced by Mitchell (1987), Melchin and Mitchell (1991) and Melchin (1998) are used for classification at generic and suprageneric level.

Synonymies for the globally recognized taxa are restricted to refer to the original paper, all Bohemian references, the most important post-1960 references and non-references.

Type specimens are specified and diagnoses included for new taxa and for taxa based upon Bohemian material.

Superfamily *Diplograptacea* Lapworth, 1880; emend. Melchin, 1998

Family *Normalograptidae* Štorch & Serpagli, 1993

***Normalograptus* Legrand, 1987**

Type species: Original designation; *Climacograptus scalaris normalis* Lapworth, 1877 from the Llandovery of Dob's Linn, Scotland.

Diagnosis: after Štorch & Serpagli (1993)

***Normalograptus? inornatus* n. sp.**

Pl. I, figs 3, 4, ?5, 7; pl. II, figs 3, 7; pl. XIX, fig. 7; text-fig. 4, figs 4 A–D

Holotype: Complete flattened specimen no. PŠ 742 (pl. I, fig. 7; text-fig. 4, fig. 4 A) from the *leptothea* Biozone (middle Llandovery), Svätý Jiří near Tmaň, Bohemia.

Material: 42 complete specimens and over 50 incomplete and fragmentary rhabdosomes.

Diagnosis: Rhabdosome 15–30 mm long, parallel-sided. Initial width 0.7–0.85 mm. Maximum width of 1.7–2.0 mm reached at th12–th18. Proximal thecae with slightly convex and inward-sloping supragenicular walls; distal thecae typically climacograptid with parallel-sided supragenicular walls. Apertural excavations narrow, deeply incised. Distal thecae number 10.5–11 in 10 mm.

Description: The rhabdosome is parallel-sided distally and slightly tapering proximally. It widens from 0.7–0.85 mm at th1<sup>1–2</sup>, to 1.2–1.5 mm at th5, 1.6–1.8 mm, exceptionally 1.9 mm at th10 to 1.7–2.0 mm, attained at th12–th18. The maximum width – 2.3 mm – was measured near the distal end of the most mature specimens. The thecate part of the rhabdosome is 15–25 mm long (a maximum length of 38 mm was recorded). The median septum appears at about the level of th2 aperture. The nema is slender, 0.02–0.05 mm wide in the immature rhabdosomes and thickens to 0.1–0.25 mm in mature specimens. The sicula is seen to be 1.2 mm long in juvenile specimens possessing a single thecal pair. The th1<sup>1</sup> extends 0.2 mm below the sicular aperture then bends strongly and grows upwards for another 0.7 mm. The sicular aperture is 0.2 mm wide and possesses a c. 1 mm long virgella with a considerably thickened base. The thecae are typically climacograptid, having strong genicula and straight and parallel sided supragenicular walls. In proximal thecae, the supragenicular walls are often slightly

convex and inwardly sloping. The thecal aperture faces a narrow, c. 0.2 mm wide excavation which occupies about one-fourth of the rhabdosome width. The 2TRD is 1.3–1.6 mm at th2, 1.7–1.8 mm at th5 (with extremes 1.45 and 1.95 mm respectively). Distal thecae number 10.5–11 (exceptionally 12.5) in 10 mm.

Remarks: *Normalograptus? inornatus* sp. n. occurs in both *leptothea* and *convolutus* biozones. It may be distinguished from *N. normalis* in its having greater dorso-ventral width (1.7–2.0 mm as oppose to 1.4 mm) and gradually tapering proximal portion. *Normalograptus rectangularis* has broader distal part (2.0–2.5 mm) and more tapering proximal portion. *Normalograptus? scalaris* (Hisinger) *sensu* Rickards (1972) and Zalasiewicz (1996) is narrower distally (1.3–1.7 mm) and less tapering proximally. Its thecae have parallel-sided supragenicular walls as oppose to the inward-sloping supragenicular walls of *N.? inornatus*. As opposed to the specimens of *Clinoclimacograptus retroversus* preserved in either partial or full relief (Bulman & Rickards 1968, Rickards 1970) *inornatus* is considerably wider distally and tapers proximally. Its median septum is gently undulose in the proximal portion of the rhabdosome, as in many other biserial graptolites. The thecal apertures of *N.? inornatus* are deeply incised unlike those of clinoclimacograptids. Some thecal retroversion, however, resembling that of clinoclimacograptids was seen in the most proximal thecae, so the generic assignment of the new species is uncertain.

***Normalograptus? nikolayevi* (Obut, 1965)**

Pl. II, fig. 5; pl. III, figs 5, 6; text-fig. 4, figs 5 A–D

1965 *Glyptograptus nikolayevi* n. sp.; Obut, p. 36, pl. 1, fig. 5.

1966 *Glyptograptus tamariscus nikolayevi* Obut; Obut & Sobolevskaya, p. 14, pl. 3, figs 8, 9; text-fig. 6.

1967 *Glyptograptus tamariscus nikolayevi* Obut; Obut et al., p. 56, pl. 2, figs 10–11.

1968 *Glyptograptus tamariscus nikolayevi* Obut; Obut et al., p. 67, pl. 5, figs 4–10.

1989 *Glyptograptus nikolayevi* Obut; Melchin, p. 1738, fig. 9c.

1996 *Glyptograptus tamariscus nikolayevi* Obut, 1965; Koren' & Rickards, pp. 29–30, pl. 3, fig. 2; text-fig. 5 O,P.

1998 *Normalograptus nikolayevi* (Obut, 1965); Melchin, pl. 1, figs 4–9. Material: 16 complete and over 30 incomplete specimens.

Description: Up to 32 mm long, proximally tapering septate rhabdosome with robust proximal end possesses stout virgella and conspicuous nema, 0.1–0.2 mm

Fig. 4. 1 A, B. *Neodiplograptus thuringiacus* (Kirste); 1 A – PŠ 731, 1 B – PŠ 789.

2. *Metaclimacograptus bohemicus* (Perner); PŠ 832.

3 A, B. *Metaclimacograptus hughesi* (Nicholson); 3 A – PŠ 743, 3 B – PŠ 736.

4 A–D. *Normalograptus? inornatus* n. sp.; 4 A – PŠ 742 (holotype), 4 B – PŠ 739, 4 C – PŠ 770, 4 D – PŠ 739.

5 A–D. *Normalograptus? nikolayevi* (Obut); 5 A – PŠ 753, 5 B – PŠ 738, 5 C, D – PŠ 799.

6 A–D. *Glyptograptus tamariscus tamariscus* (Nicholson); 6 A – PŠ 778, 6 B – PŠ 713/2, 6 C – PŠ 734, 6 D – 713/1.

7. *Rivagraptus cf. rozmanae* Koren' & Rickards; PŠ 784/1.

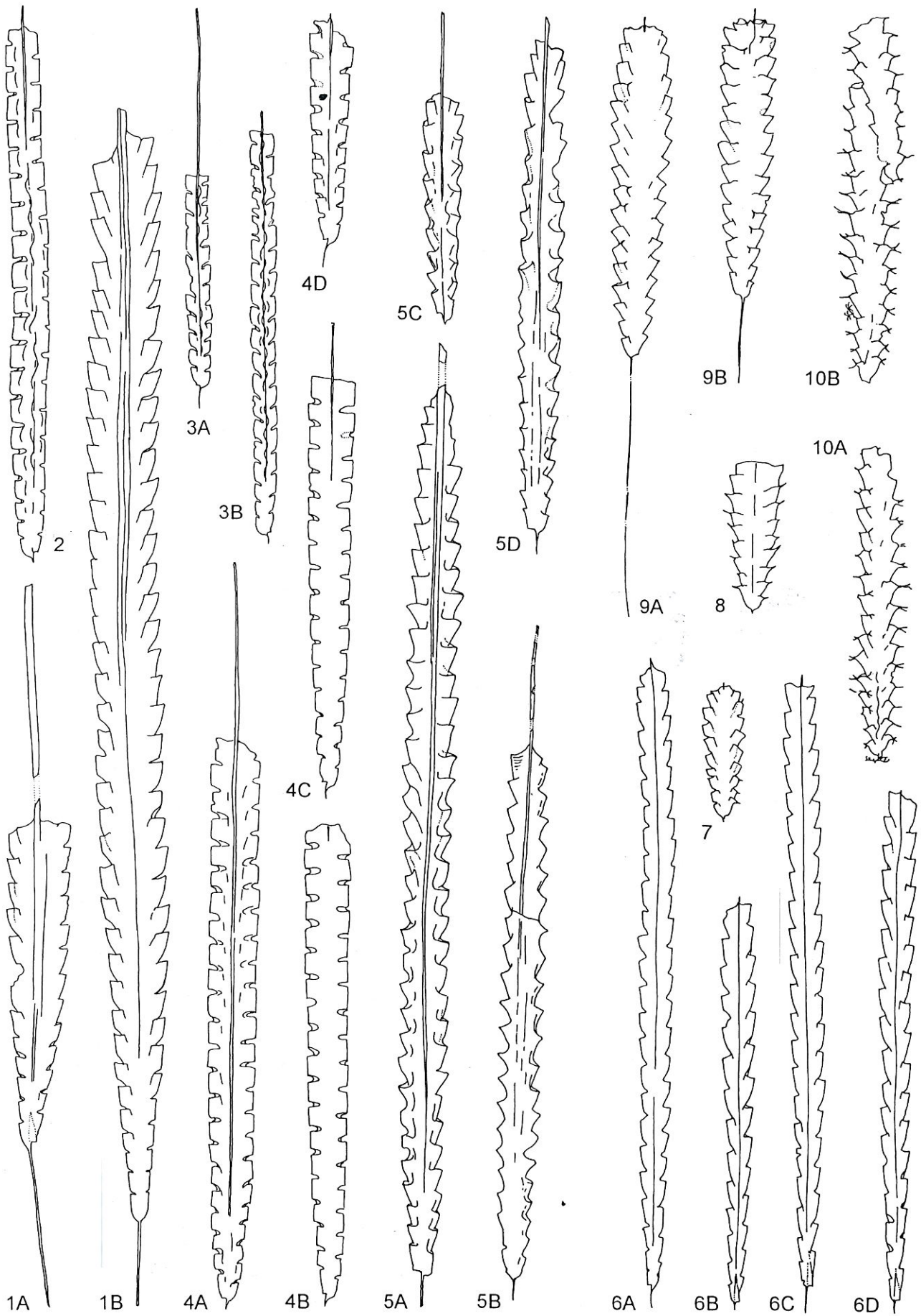
8. *Rivagraptus sentus* Koren' & Rickards; PŠ 784/2.

9 A, B. *Rivagraptus bellulus* (Törnquist); 9 A – PŠ 787, 9 B – PŠ 857/1.

10 A, B. *Pseudorthograptus insectiformis* (Nicholson); 10 A – PŠ 771, 10 B – PŠ 813/1.

All specimens x 5. Specimens on figs 2, 8 and 9 A, B from the *convolutus* Biozone, other specimens from the *leptothea* Biozone.

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wide and up to 10 mm long. The early astogeny belongs in pattern H (see Melchin 1998). There largely obscured sicula has a broad aperture 0.25–0.35 mm across. Th1 extends *c.* 0.1 mm below the sicular aperture and then turns abruptly and grows upwards for another 0.75–0.85 mm. The rhabdosome is 0.8–0.95 mm across at the th1<sup>1</sup>–1<sup>2</sup> apertures and thereafter widens to 1.1–1.3 mm at th3, and 1.35–1.6 mm at th5. The maximum width of 1.7–1.9 mm is attained at th10. The thecae are glyptograptid having a flowing geniculum, broad, everted apertures and supragenicular walls inclined at *c.* 20° to the rhabdosome. The thecae overlap for *c.* one-third to one-half their length, the apertures occupying one-fourth to one-third of the rhabdosome width. The 2TRD is 1.3–1.5 mm at th2, 1.7–1.8 mm at th5, and 2.0–2.2 mm distally. The distal thecae number 9–10 in 10 mm.

**Remarks:** The present material agrees well with the descriptions given by Obut (1965) and Koren' and Rickards (1996). *Normalograptus? nikolayevi* may be easily distinguished from *G. tamariscus* div. ssp. by its broader, septate rhabdosome, a less tapering, more robust proximal end, flowing genicula and more inclined thecal supragenicular walls. Another similar species – *G. incertus* Elles & Wood is yet broader and also more geniculate. *N.? nikolayevi* has been previously described from the *triangulatus* Biozone of the Norilsk and Kolyma regions (Obut 1965), from the *gregarius* Biozone of the southern Urals (Rickards and Koren' 1996) and from the *cyphus* Biozone of the Canadian Arctic (Melchin 1989). Using isolated specimens from Cornwallis Island, Melchin (1998) assigned the species in *Normalograptus* due to its pattern H early astogeny. Also the complete medial septum of *N.? nikolayevi* more resembles septate normalograptids than pattern I glyptograptid taxa which are partially septate or aseptate. Septate glyptograptid taxa with pattern H astogeny, such as *N.? nikolayevi*, *G. incertus* and *G. serratus* Elles & Wood may be potentially assigned in a new genus recognized within the *Normalograptidae* and distinguished by their uniform glyptograptid thecae, tapering proximal end and complete median septum. The present material from the *leptothea* Biozone of Tmaň represents the stratigraphically highest record of this apparently long-ranging form.

#### ***Neodiplograptus* Legrand, 1987; emend. Melchin 1998**

**Type species:** Original designation; *Diplograptus magnus* Lapworth, 1900 from the Llandovery of Rhyader, Wales.  
**Diagnosis:** after Melchin (1998).

#### ***Neodiplograptus thuringiacus* (Kirste, 1919)**

Pl. I, fig. 6; pl. II, fig. 6; text-fig. 4, figs 1 A, B

- 1919 *Diplograptus thuringiacus* Eisel, Kirste, p. 135.  
1952 *Diplograptus* (s. str.) *thuringiacus* Eis; Münch, p. 58, pl. 4, figs 10 a–c.  
1965 *Diplograptus* (*Diplograptus*) *thuringiacus* Eisel MS in Münch; Stein, pp. 169, 170; fig. 18a, b.

1971 *Diplograptus thuringiacus* Eisel; Schauer, pp. 34–35; pl. 6, figs 9, 10; pl. 7, fig. 1.

1975 *Diplograptus thuringiacus* Eisel; Bjerreskov, p. 27, pl. 4 C; text-fig. 10 A.

1983 *Diplograptus thuringiacus* Eisel; Štorch, pp. 166, 167; pl. 3, figs 1–5; text-fig. 3 E–G.

**Type specimen:** Not yet designated. The type material come from Eisel's collection, Altmannsgrün, Germany. Repository unknown.

**Material:** 15 mostly complete rhabdosomes from Tmaň, another 50 specimens from other localities of the Barrandian area.

**Description:** The robust, proximally tapering septate rhabdosome is 30–40 mm long and possesses a long and robust virgella and nema. The rhabdosome is 0.6–0.8 mm wide at the th1<sup>1</sup>–1<sup>2</sup> apertures, and widens to 1.0–1.4 mm at th4, and 1.8–2.3 mm at th10. The maximum width (2.4–2.7) mm is attained at th12–15 (exceptionally 10–11). An early astogeny of pattern H (*sensu* Mitchell 1987) may be proposed for *N. thuringiacus* though the sicula is largely obscured, being rarely visible for *c.* 0.3 mm from the reverse side. The sicular aperture is 0.2–0.25 mm wide. The prominent virgella is 7–12 mm long and 0.1–0.15 mm wide near its thickened base. Th1<sup>1</sup> extends *c.* 0.1 mm below the sicular aperture before strongly turning upwards. Its upward growing portion measures *c.* 0.9 mm. The proximal thecae are climacograptid having sharp genicula, almost parallel sided supragenicular walls and narrow apertural excavations. The thecae are glyptograptid from th5–7. The distal thecae overlap for *c.* one-half their length and their supragenicular walls incline at 15–20° to the rhabdosome. The 2TRD is 1.6–1.7 mm (exceptionally 1.4 mm) at th2, 1.6–1.9 mm at th5, and 1.9–2.0 mm at th10. The distal thecae number 9.5–10.5 in 10 mm. The nema is robust, 0.2–0.4 mm wide and projects for 20–40 mm beyond the rhabdosome. For further details on the Barrandian material see Štorch (1983).

**Remarks:** *D. thuringiacus* ranges from the *simulans* Biozone to the middle part of the *convolutus* Biozone. Rare finds from the upper *convolutus* Biozone differ from earlier specimens in having a slender virgella and nema and more gradual change from climacograptid to glyptograptid thecae. On the other hand, some specimens with rapidly expanding proximal portions resemble *Neodiplograptus mucroterminatus* (Churkin & Carter 1970) and suggest that the rate of rhabdosome expansion and related change in thecal morphology varies considerably in these and related taxa. *Neodiplograptus tcherskyi* (Obut & Sobolevskaya 1967) from the *leptothea*, *millepeda* and *convolutus* biozones of Siberia (Obut et al. 1967), China (Chen 1984, Ge 1990), and Arctic Canada (Melchin 1989) looks closely similar to *N. thuringiacus* and may be distinguished only by its smaller virgella and more inclined glyptograptid thecae which number 7.5–8 in 10 mm distally. *Neodiplograptus sinuatus* (Nicholson 1869) differs from *N. thuringiacus* in having less climacograptid thecae (three pairs), an abrupt change in thecal morphology and a more slender virgella and nema. *Neodiplograptus magnus* (Lapworth) and *N. peggyae* Cullum



& Loydell have less geniculate, more overlapping thecae and lack robust virgella and nema typical of *N. thuringiacus*.

### Genus *Metaclimacograptus* Bulman & Rickards, 1968

Type species: Original designation; *Diplograpsus hughesi* Nicholson, 1869 from the Llandoverly of the Lake District, England.

Diagnosis: after Koren' & Rickards (1996).

#### *Metaclimacograptus hughesi* (Nicholson, 1869)

Pl. I, figs 1, 2; pl. II, fig. 2; text-fig. 4, figs 3 A, B

1869 *Diplograpsus Hughesi*; Nicholson, p. 235, pl. 11, figs 9, 10.

1897 *Climacograptus phrygonius* Trnq.; Perner, p. 11, pl. 10, fig. 17.

1906 *Climacograptus Hughesi* Nicholson; Elles & Wood, pp. 208–210, pl. 27, fig. 11; text-fig. 140.

non 1968 *P. (Metaclimacograptus) hughesi* (Nicholson); Bulman & Rickards, pp. 3–6, fig. 1a–c.

1970 *Pseudoclimacograptus (Metaclimacograptus) hughesi* (Nicholson); Rickards, p. 33, text-fig. 14, fig. 6.

1970 *P. (Metaclimacograptus) hughesi* (Nicholson); Hutt, Rickards & Skevington, p. 4, pl. 1, figs 1–4.

1974 *Pseudoclimacograptus (Metaclimacograptus) hughesi* (Nicholson); Hutt, p. 22, pl. 2, figs 6, 7, 13, 14.

1975 *Pseudoclimacograptus undulatus* (Kurck, 1882); Bjerreskov, p. 26, pl. 4 E.

1991 *Metaclimacograptus hughesi* (Nicholson, 1869); Loydell, p. 675, pl. 1, figs 3, 4, 6, 9, 12.

1996 *Metaclimacograptus hughesi* (Nicholson, 1869); Zalasiewicz, text-fig. 2 A–C.

Material: 22 complete flattened rhabdosomes.

Description: The narrow, parallel-sided mature rhabdosome is 10–15 mm long. The *c.* 0.9–1.3 mm long sicula is rarely seen pressed through, otherwise it appears to be completely covered. Its apex attains the level of the middle part of the supragenicular wall of th<sup>2</sup>. The sicular aperture is 0.15–0.2 mm wide and possesses tiny, 0.6–0.9 mm long virgella. The strongly undulose median septum and interthecal septa are barely recognizable, whilst the virgella is robust, easily visible when pressed through, and distally projects for 2–6 mm. The proximal end is rounded, th<sup>1</sup> extending *c.* 0.1 mm below the sicular aperture before turning upwards for another 0.6–0.7 mm. The thecae are strongly sigmoidal, with parallel or slightly convex supragenicular walls and apparently thickened genicula. The apertures are introverted, inclined at 65–70° to the rhabdosome axis. Narrow apertural excavations comprise *c.* one-third of the rhabdosome's dorso-ventral width. The rhabdosome widens from 0.7–0.75 mm at th<sup>1</sup>–<sup>2</sup>, to 0.75–0.85 mm at th<sup>3</sup>. The maximum dorso-ventral width of 0.9–1.0 mm is attained at th<sup>4</sup>–<sup>6</sup>. The 2TRD is 1.15–1.25 mm at th<sup>2</sup> and distally ranges between 1.45–1.65 mm.

Remarks: *M. hughesi* may be distinguished from *M. undulatus* (Kurck) by its considerably greater width and from *M. slalom* Zalasiewicz by its greater width and rather angular than wavy median septum. The latter feature is poorly seen in the preservational mode shown by

the present material. For the differences from *M. bohemicus* (Perner) see below. *Metaclimacograptus hughesi* is limited to the *leptotheca* Biozone and lower and middle part of the *convolutus* Biozone.

#### *Metaclimacograptus bohemicus* (Perner, 1897)

Pl. I, fig. 8; text-fig. 4, fig. 2

1897 *Climacograptus bohemicus* n. sp.; Perner, p. 11, pl. 10, fig. 7a, b.

Lectotype: Selected by Přibyl, 1948. The specimen no. L31117 figured by Perner 1897, pl. 10, fig. 7b from the *convolutus* Biozone of Litolhavy near Beroun, Bohemia.

Material: 4 complete and 3 incomplete flattened rhabdosomes.

Diagnosis: Parallel-sided rhabdosome up to 20 mm long, slightly tapering proximally. Proximal end rounded, 0.75–0.9 mm wide. Maximum dorso-ventral width of 1.25–1.45 mm attained at th<sup>7</sup>–<sup>8</sup>. Strongly geniculate alternating thecae with deeply incised, horizontal, slit-like apertural excavations outlined by thickened rims. Thecae number 10–11.5 in 10 mm. Median septum undulatory.

Description: The rhabdosome is almost 20 mm long, parallel-sided, having a slightly tapering proximal part. The sicula is not visible except for the 0.2 mm wide aperture. A tiny, 0.8 mm long virgella is developed. Th<sup>1</sup> extends *c.* 0.1 mm below the sicular aperture, and then grows upwards for 0.6–0.7 mm. The rhabdosome widens from 0.75–0.9 mm at the 1<sup>st</sup> thecal pair, to 0.95–1.1 mm at th<sup>3</sup>. The maximum dorso-ventral width of 1.25–1.45 mm is attained at th<sup>7</sup>–<sup>8</sup>. The thecae are strongly geniculate, with narrow, almost horizontal, *c.* 0.3–0.4 mm wide apertures outlined by thickened rims. Slit-like apertural excavations occupy *c.* one-third of the rhabdosome width. Straight, ventral supragenicular walls tend to slope inwards in some specimens, otherwise they are parallel to the rhabdosome axis. The ventral supragenicular wall of th<sup>5</sup> is 0.8 mm long. The median septum is rarely visible and probably undulating in the present material. The nema has not been preserved. The 2TRD is 1.25–1.3 mm at th<sup>2</sup>, and 1.75–2.05 mm at th<sup>5</sup>. The latter thecal spacing is maintained until the distal end of the rhabdosome.

Remarks: Original description and figures of „*Climacograptus bohemicus*“ given by Perner (1897) are based on two poorly preserved specimens. This material, however, matches well the present specimens in both the basic parameters (dorso-ventral width, thecal spacing, slit-like apertures perpendicular to the rhabdosome axis) and in the stratigraphical level (*convolutus* Biozone, associated with *T. denticulatus* and *M. limatulus*). *M. bohemicus* may be distinguished from *M. hughesi*, *M. undulatus* and other metaclimacograptids by its greater dorso-ventral width, more tapering proximal portion, parallel-sided or slightly inward sloping ventral supragenicular walls, and widely spaced, slit-like horizontal thecal apertures (perpendicular to the rhabdosome).

Family Petalograptidae Bulman, 1955; emend. Melchin 1998

**Genus *Glyptograptus* Lapworth, 1873;** emend. Melchin 1998

Type species: Original designation; *Diplograpsus tamariscus* Nicholson, 1869 from the Llandoverly of Duffkinnel Burn, Scotland.

Diagnosis: after Melchin (1998).

***Glyptograptus tamariscus tamariscus* (Nicholson, 1868)**

Pl. III, figs 1–4, 7; text-fig. 4, figs 6 A–D

1868 *Diplograpsus tamariscus* sp. n.; Nicholson, p. 526, pl. 19, figs 10, 11, 13 (non 12).

1962 *Glyptograptus tamariscus tamariscus* (Nicholson), Packham, pp. 504–506, pl. 71, figs 1–4, 11, 13; text-figs 1 g–j, m–u.

1992 *Glyptograptus tamariscus* (Nicholson, 1868); Loydell, pp. 33–36, pl. 1, fig. 7; text-fig. 11, figs 18, 19, 25, 28. (see for full synonymy of the species).

1996 *Glyptograptus tamariscus tamariscus* (Nicholson, 1868); Koren' & Rickards, p. 25, pl. 2, figs 11, 12; text-fig. 5 F–I.

Material: Over 100 more or less complete rhabdosomes.

**Description:** The rhabdosome is 20–30 mm long, gradually widening from a slender proximal end. The sicula is 1.0–1.4 mm long when seen pressed through. The apex attains halfway up  $th_2^2$ . The sicular aperture is straight, 0.15–0.2 mm wide and possesses a tiny, c. 1 mm long virgella.  $Th_1$  abruptly bends 0.1 mm below the sicular aperture and grows upwards for 0.6–0.9 mm. The rhabdosome widens from 0.55–0.6 mm at  $th_1^1$ – $1^2$  to 0.7–0.85 mm at  $th_3$ , 0.85–1.0 mm at  $th_5$  and 1.1–1.3 mm at  $th_{10}$ . Thereafter the maximum width of the rhabdosome – 1.2–1.4 mm – is slowly attained at the level of  $th_{12}$ –18. The thecae are strongly alternating, glyptograptid, with gentle geniculum and slightly everted apertures. The supragenicular wall inclines slightly to the rhabdosome axis (angle of inclination c. 5°). The thecae overlap for c. one-quarter to one-third their length, the aperture occupies c. one-third the rhabdosome width. The 2TRD is 1.9–2.1 (2.2) mm and does not change along the rhabdosome length. Among the specimens it varies between 1.8 and 2.3 mm (the thecae number 8.5–11 in 10 mm). The virgula appears to be attached to the obverse side of the rhabdosome along with a partial septum. Distally projected nema is thread-like and short.

**Remarks:** All of the many specimens collected in Tmaň match well the type subspecies of *G. tamariscus* (Nicholson) redefined by Packham (1962) except by having a slightly greater distal dorso-ventral width (1.2–1.4 mm as opposed to max. 1.3 mm in the British material). The thecal shape and gradually widening proximal part also match *G. tamariscus tamariscus*. Perner (1897) described *G. tamariscus linearis* from the *convolutus* Bizozone of Litohlavy near Beroun. The basic distinguishing feature of his new subspecies was a more rapidly widening rhabdosome. The only figured specimen (holotype by monotypy), however, is lost and no other was found in Perner's collection. Perner's type locality at Litohlavy

has also disappeared. No specimen comparable with the rapidly tapering *G. tamariscus linearis* has been found among the large numbers of mid-Aeronian glyptograptids collected from the Barrandian since the times of Bouček and Přibyl.

**Genus *Pseudorthograptus* Legrand, 1987**

Type species: Original designation; *Diplograpsus insectiformis* Nicholson, 1869 from the Llandoverly of the Lake District, England.

Diagnosis: after Koren' & Rickards (1996).

***Pseudorthograptus insectiformis* (Nicholson, 1869)**

Pl. VI, fig. 2; text-fig. 4, figs 10 A, B

1869 *Diplograpsus insectiformis* Nicholson, p. 237, pl. 11, fig. 13.

1907 *Diplograptus (Orthograptus) insectiformis* Nicholson; Elles & Wood, pp. 228–229, pl. 28, fig. 7; text-fig. 150.

?1944 *Orthograptus (?) inopinatus* n. sp.; Bouček, p. 2, pl. 1, fig. 8; text-fig. 1 b, c.

1971 *Orthograptus (?) inopinatus* Bouček; Schauer, p. 37, pl. 7, fig. 14.

1974 *Orthograptus insectiformis* (Nicholson, 1869); Hutt, pp. 34, 35; text-fig. 9, figs 1–3, 13.

1975 *Orthograptus insectiformis* (Nicholson, 1869); Bjerreskov, p. 29; text-fig. 10 C.

1985 *Orthograptus inopinatus* Bouček, 1944; Štorch, p. 91, pl. 1, figs 8, 9 (?6, 7), pl. 2, fig. 3; text-fig. 2 A, B, D, K (?C, E).

1991 „*Orthograptus*“ *insectiformis* (Nicholson, 1869); Loydell, pp. 678, 679; pl. 1, figs 7, 8, 13.

1996 *Pseudorthograptus (Pseudorthograptus) inopinatus* (Bouček, 1944); Koren' & Rickards, pp. 69, 71; pl. 11, fig. 10; text-figs 16 B, F; 17.

Material: 32 specimens, mostly complete.

**Description:** The spinose, 5–15 mm long aseptate rhabdosome widens from 0.85–0.95 mm (excluding spines) at the 1<sup>st</sup> thecal pair to the maximum of 1.3–1.5 mm, attained at  $th_4$ –6. Distally the rhabdosome is parallel-sided. The sicula is c. 1.7–2.2 mm long. Its apex is obscured in mature rhabdosomes. The true sicular length has been observed in juvenile specimens with one or two thecal pairs where the sicular end remains free. The short virgella forks doubly 0.1–0.2 mm below the 0.2 mm wide sicular aperture and forms a circular pseudancora composed of four principal rods connected with concentric threads. This structure develops early being observed in juvenile specimens.  $Th_1^1$  grows slightly below the sicular aperture before it strongly turns upwards. The upwardly growing part of  $th_1^1$  is 0.7–0.8 mm long. The  $th_1^2$  grows upwards for its entire length. The thecae are alternating, 1.0–1.1 mm long and almost straight tubes which all possess paired and bifurcated, ventrally and ventro-laterally projected ventro-lateral apertural spines. The thecae incline at c. 30° to the rhabdosome axis. The apertural spine immediately bifurcates at an angle of 80–120° in two, c. 0.6 mm long, stout branches. Distal thecae overlap for one-third to one-half their length. The 2TRD is 1.1–1.2 mm at  $th_2$ , and c. 1.25 mm at  $th_5$ . Distal thecae number 13–13.5 in 10 mm. The rhabdosome is 2.7–2.8 mm wide including spines.

**Remarks:** Usually two but often three or even four spines are visible on each thecal aperture. Koren, & Rickards (1996) pointed out that *Pseudorthograptus inopinatus* (Bouček) differs from *P. insectiformis* (Nicholson) in having distinctly bifurcating stout spines. These spines, however, have been recorded by Loydell (1991) in the isolated specimens from Sweden assigned in *P. insectiformis*. Loydell's isolated material shows lateral direction of one of the two branches of the apertural spine. In flattened material just one or both branches of each apertural spine may be visible. Since the other parameters of the two species are identical, I suppose that *P. inopinatus* may be considered as a preservational artefact and placed in synonymy with *P. insectiformis*. All the material from the *convolutus* Biozone of the Barrandian area is assigned herein to the latter species.

### Genus *Dittograptus* Obut & Sobolevskaya, 1968

**Type species:** Original designation; *Dittograptus fortuitus* Obut & Sobolevskaya (in Obut et al. 1968), from the Llandovery of Norilsk, Siberia.

**Diagnosis:** after Koren' and Rickards (1996).

### *Dittograptus monstrosus* (Štorch, 1985)

Pl. XX, fig. 2; text-fig. 6, fig. 4

1953 *Dimorphograptus ciliatus* Manck; Hundt, fig. 19.  
cf. 1969 *Diplograptus* cf. *magnus* Lapworth; Müller & Schauer, figs 21, 22.  
cf. 1975 *Diplograptus* cf. *magnus* Lapworth; Müller, text-fig. 13.  
1985 *Orthograptus monstrosus* sp. n.; Štorch, pp. 93, 94; pl. 2, fig. 2; pl. 3, fig. 3; text-fig. 2 I, L, M.

**Holotype:** The specimen no. PŠ 61 figured by Štorch (1985) on pl. 3, fig. 3, text-fig. 2 I (refigured herein on pl. XX, fig. 2; text-fig. 6, fig. 4); from the lower part of the *leptotheca* Biozone (mid-Aeronian) of Svatý Jiří near Tmaň, Bohemia.

**Material:** One flattened complete specimen and one fragment from Tmaň and several incomplete specimens from Černošice.

**Diagnosis:** The robust rhabdosome widens from c. 1.6 mm to a maximum of 3.0–3.4 mm which is attained at th15 or later. Thecae are simple and almost straight tubes numbering 10–11 in 10 mm. The proximal end is obscured due to a large membranous sac-like structure composed by the appendages growing from robust, strut-like apertural spines of the proximal thecae. Sac-like appendages are also developed in several distal thecae.

**Description:** Because of the biscalariform view of the specimens, the sac-like structure bearing spines may have originated from the lateral margin of the thecal aperture. For further description see Štorch (1985).

**Remarks:** No additional material of *D. monstrosus* has been found at Tmaň since the original description of the species (Štorch 1985). Several recent findings at the Černošice locality suggest, however, that the stratigraphical range of this rare species is confined to the uppermost *simulans* and lowermost *leptotheca* Biozones. A closely similar form, figured from the *gregarius* Biozone of Germany (Hundt 1953, Müller and Schauer 1969, and Mül-

ler 1975) is badly preserved and no thecal details are visible. Threads attaching its sac-like appendages twist. *D. fortuitus* Obut & Sobolevskaya may be distinguished from *D. monstrosus* by its rapidly widening rhabdosome in which the sac-like appendages are not concentrated at the proximal end (see also Koren' and Rickards 1996).

### Genus *Rivagraptus* Koren' & Rickards, 1996

**Type species:** Original designation; *Diplograptus bellulus* Törnquist, 1890 from the Llandovery of Sweden.

**Diagnosis:** after Koren' and Rickards (1996).

### *Rivagraptus bellulus* (Törnquist, 1890)

Pl. VI, figs 4, 75, 6; text-fig. 4, figs 9 A, B

1890 *Diplograptus bellulus* n. sp.; Törnquist, p. 28, pl. 1, figs 25–29.  
1897 *Diplograptus bellulus* Törnq.; Perner, p. 7, pl. 9, figs 14, 15; text-fig. 1.  
1967 *Rectograptus* (?) *bellulus* (Törnquist); Obut et al., p. 62, pl. 3, fig. 6.  
1970 *Orthograptus bellulus* (Törnquist, 1890); Rickards, p. 46, pl. 3, fig. 5 (see for synonymy).  
1974 *Orthograptus bellulus* (Törnquist, 1890); Hutt, p. 37, pl. 3, figs 1, 2; pl. 6, fig. 13; text-fig. 8, figs 2–4.  
1975 *Orthograptus bellulus* (Törnquist, 1890); Bjerreskov, p. 28, pl. 4, fig. F.  
1985 *Orthograptus bellulus* (Törnquist, 1890); Štorch, p. 92, pl. 11, figs 4, 6.  
1996 *Rivagraptus bellulus* (Törnquist, 1890); Koren' & Rickards, pp. 62, 63; pl. 10, figs 1, 3; text-fig. 12 A–D.  
1998 *Rivagraptus?* *bellulus?* (Törnquist, 1890); Melchin, pl. 6, figs 4–9, 13.

**Material:** 14 complete, flattened specimens.

**Description:** The rhabdosome is usually 10–25 mm long, aseptate or partially septate. The maximum length of the thecate part is 22 mm in the present material. The rhabdosome possesses a stout, over 10 mm long (max. 14 mm) long virgella and short, tiny nema. The sicula has 0.3–0.4 mm wide aperture, its apex is obscured. The thecae are simple tubes, broader in transversal cross-section (see also Melchin 1998, pl. 6, fig. 8). The thecal aperture, perpendicular to the thecal axis, bears short, rarely seen paired lateral spines. The th1<sup>1</sup> extends slightly below the sicular aperture and then bends sharply upwards for 0.6 mm, the th1<sup>2</sup> grows upwards for 0.7–0.85 mm. The distal thecae overlap for c. one-half of their length, the free ventral thecal walls are inclined at an angle of 25–30° to the rhabdosome axis. The rhabdosome widens from 0.8–1.1 mm at the level of the 1<sup>st</sup> thecal pair to 1.35–1.6 mm at the level of th3, and 1.6–1.85 mm at th5. The maximum width of the rhabdosome – 2.1–2.4 mm – is attained with 9<sup>th</sup>–12<sup>th</sup> thecal pair. In case of biscalariform breakdown of the rhabdosome the respective maximum values of the dorso-ventral width are attained. 2TRD is 1.2–1.3 mm at th2, 1.3–1.5 mm at th5, and 1.5–1.8 mm at th10. Distal thecae number 11–13 in 10 mm.

**Remarks:** *Rivagraptus bellulus* may be easily mistaken for agetograptids (*Agetograptus primus* Obut & Sobolevskaya and *A. secundus* Obut & Sobolevskaya).

These two species have the rhabdosomes closely similar to that of *R. bellulus* in shape and size. They also match *R. bellulus* in having a long and robust virgella and thecal apertures with paired lateral spines (see Loydell 1991, pl. 1, figs 16, 19). As oppose to the typical Pattern I astogeny (after Mitchell 1987) of *Rivagraptus*, however, agetograptids have an asymmetrical proximal end with an unusually long  $th1^2$ , the aperture of which extends above the aperture of  $th2^2$ . Due to easy misidentification, the greater part of „*O. bellulus*“ reported and figured from the early Llandovery of the Circum-Equatorial graptolite province (*sensu* Melchin 1989) actually belongs within *Agetograptus* (e.g. Churkin and Carter 1970, Ni 1978, Chen and Lin 1978). Conversely, agetograptids have not yet been recorded in the peri-Gondwanan Europe. *R. bellulus* is uncommon in the *leptothecca* Biozone and common in the *convolutus* Biozone of Tmaň.

#### ***Rivagraptus sentus* Koren' & Rickards, 1996**

Pl. VI, fig. 3; text-fig. 4, fig. 8

1996 *Rivagraptus sentus* gen. et sp. nov., Koren' & Rickards, pp. 66–67, pl. 10, fig. 9; text-fig. 14 B–E.

**Material:** one flattened specimen.

**Description:** Rhabdosome is 5.5 mm long and widens from 1.0 mm at the level of the 1<sup>st</sup> thecal pair to 1.35 mm at  $th3$ , 1.7 mm at  $th5$  and 1.9 mm at  $th7$ . The proximal end is rounded, possessing a tiny, 0.2 mm long virgella. The sicula is obscured. The upward-growing portion of  $th1^1$  is 0.5 mm long and that of  $th1^2$  0.9 mm long. The thecal aperture is provided with a 0.3 mm long, straight spine thickened at the base. The spine is probably single, situated on the ventro-lateral margin of the aperture.

**Remarks:** Single specimen with broad proximal end and probably single apertural spine was assigned in *Rivagraptus sentus* Koren' & Rickards which differs from other rivagraptids basically by its non-paired apertural spines. In other rivagraptids, however, lateral apertural spines may also look to be unpaired, depending on the preservational mode and on the orientation of the rhabdosome on the bedding plane. More material may help to determine the true assignment of this unusual rivagraptid form.

#### ***Rivagraptus cf. rozmanae* Koren' & Rickards, 1996**

Text-fig. 4, fig. 7

cf. 1996 *Rivagraptus rozmanae* gen. et sp. nov.; Koren' & Rickards, p. 66, pl. 10, figs 6–8; text-figs 13, 14 A.

**Material:** Three flattened specimens.

**Description:** The maximum length of the Tmaň material is 5.2 mm. The proximal end is rounded and provided with a c. 0.5 mm long virgella. The rhabdosome is probably aseptate or partially septate. The sicula is ob-

scured; its aperture is 0.2–0.3 mm across. The thecae are straight, c. 1 mm long and overlap for one-half of their length. Ventral thecal walls incline at 25–30° to the rhabdosome axis. Thecal apertures possess paired, slightly curved, 0.2–0.3 mm long lateral spines. The rhabdosome widens from 0.85–1 mm at  $th1$  to 1.25–1.35 mm at  $th3$  and c. 1.5 mm at  $th5$ . The maximum width of 1.6 mm is attained at the 5<sup>th</sup> or 6<sup>th</sup> thecal pair. The 2TRD is 0.85–1 mm at  $th2$  and 1.1 mm at  $th5$ .

**Remarks:** From *R. bellulus* this species differs in having a smaller rhabdosome, a shorter virgella, densely packed thecae, and consistently present lateral apertural spines.

#### **Genus *Petalolithus* Suess, 1851**

**Type species:** *Prionotus folium* Hisinger, 1837 from the Llandovery of Sweden. Subsequently designated by Lapworth (1873).

**Diagnosis:** after Koren' and Rickards (1996).

#### ***Petalolithus cf. ovatoelongatus* (Kurck, 1882)**

Pl. II, fig. 1; pl. IV, fig. 3; text-fig. 5, figs 3 A, B

cf. 1882 *Cephalograptus ovato-elongatus* n. sp.; Kurck, p. 303, pl. 14, fig. 10.

cf. 1908 *Petalograptus palmeus* var. *ovato-elongatus* (Kurck); Elles & Wood, p. 277, pl. 32, fig. 4a (*non b–d*); text-fig. 191a–c.

cf. 1941 *Petalolithus ovato-elongatus* (Kurck 1881); Bouček & Přibyl, pp. 2–4; pl. 1, figs 1, 2; text-fig. 1 a–e.

cf. 1974 *Petalograptus ovatoelongatus* (Kurck, 1882); Hutt, p. 39, pl. 9, figs 3–5, pl. 10, fig. 6 (see for further synonymy).

cf. 1975 *Petalograptus ovatoelongatus* (Kurck, 1882); Bjerreskov, pp. 32, 33, pl. 4 H.

cf. 1996 *Petalolithus ovatoelongatus* (Kurck, 1882); pp. 54, 56; pl. 9, figs 2, 4; text-figs 10 I, J; 11 D.

**Material:** four complete specimens.

**Description:** Rhabdosome 6.0–7.4 mm long, broadly ovoid, attaining its maximum width of 4.2–4.5 mm at  $th5$ . On one specimen the sicula is pressed through. It is 1.55 mm long and attains the point of origin of  $th3^1$ . The sicular aperture is 0.25–0.35 mm wide. The virgella divides 0.2 mm below the sicular aperture and immediately bifurcates into four thin, ventro-distally curved rods. Fine structures of the ancora are not preserved. The upward growing portion of  $th1$  is 1.8–2.2 mm long.  $Th1^1$  and  $1^2$  are ventrally curved and inclined at an angle of 50–80° to the rhabdosome. Distal thecae incline at 45–70° and are almost straight.  $Th5$  is 2.1–2.55 mm long. Fusellae are well developed and widely spaced, apertures are perpendicular to the thecal axis. The 2TRD is 1.1–1.5 mm at  $th2$  and 1.45–1.8 mm at  $th5$ . Distal thecae overlap for c. four-fifths their length. The nema is short, thread-like.

**Remarks:** The material of *P. ovatoelongatus* (Kurck) of the same maturity is usually narrower and has less curved thecae. *P. minor* Elles is narrower (max. 3 mm wide) and its proximal thecae are inclined at lower angle to the rhabdosome axis.

***Petalolithus praecursor* Bouček & Přibyl, 1941**

Pl. II, fig. 4; pl. IV, figs 2, 5, 7; text-fig. 5, figs 1 A–E

1908 *Petalograptus palmeus* s.s. (Barrande), Elles & Wood, pp. 274–275 (partim), pl. 32, fig. 1 c (?a, b, d), (non text-fig. 188 a, b).1941 *Petalolithus praecursor* n. sp., Bouček & Přibyl, pp. 10, 12; text-fig. 1 j, k.?1978 *Petalolithus palmeus* (Barrande), Ni, pl. 2, fig. 11.?1978 *Petalolithus elacatus* sp. nov., Ni, p. 402, pl. 2, fig. 5.?1990 *Petalolithus elacatus* Ni, Ge, p. 68, pl. 7, fig. 29.**Holotype:** Specimen no. L30938 figured by Bouček and Přibyl (1941) on text-fig. 1 j; from the *leptotheca* Biozone (mid-Aeronian, originally lower *convolutus* Biozone) of Černošice, „Barrande's Colony Solopysky“, Bohemia.**Material:** 55 complete specimens at various astogenetic stages.**Diagnosis:** Medium sized, up to 27 mm long, ancorate *Petalolithus* widens from 2.1–2.6 mm at the 1<sup>st</sup> thecal pair to 2.8–3.3 mm at th3 and thence to a maximum of 3.2–3.7 mm, attained at th5–7 in mature specimens. The sicula is 1.4–1.7 mm long. Weakly ventrally curved thecae incline at 40–45° throughout the rhabdosome; the aperture is normal to the thecal axis. Immature (less than 10 mm long) rhabdosomes are markedly narrower, with straight thecae. The 2TRD is 1.35–1.9 mm at th2 and gradually increases to the maximum of 1.8–1.9 mm, attained near the distal end of the mature rhabdosomes.**Description:** This *Petalolithid* has moderately inclined thecae and a medium-sized *c.* 10–20 mm long rhabdosome. The thecate portion of the longest rhabdosome, however, measures 27.5 mm. The rhabdosome widens from 2.1–2.65 mm at the 1<sup>st</sup> thecal pair to 2.8–3.3 mm at th3. The maximum width of 3.2–3.7 mm is attained at th5–th7. The median septum appears to be partially developed on the obverse side of the rhabdosome. The sicula – 1.4–1.7 mm long – is clearly visible in several specimens. It is partly exposed from the obverse view. The sicular aperture is 0.2–0.25 mm wide and possesses a short virgella which divides in two ventro-distally directed rods about 0.2–0.4 mm below the sicular aperture, suggesting the development of an ancora in this species. Th1<sup>1</sup> extends slightly below the sicular aperture and then bends sharply upwards. Upward growing portion of the th1<sup>1</sup> measures 1.6–1.95 mm. The th1<sup>2</sup> grows upwards for its entire length measuring 1.45–2.1 mm. The early thecae are inclined at an angle of 40–45° (exceptionally 50°) to the rhabdosome axis. They are weakly ventrally curved, having slightly concave ventral walls. The aperture is concave and approximately perpendicular to the thecal axis. From *c.* th5, the thecal length of 1.75–2.4 mm and the angle of inclination of 40–45° are maintained until the distal end of the thecate portion. The 2TRD is 1.35–1.9 mm at th2 and 1.5–1.8 mm at th5. In the most mature rhabdosomes the most distal 2TRD is 1.8–1.9 mm. A nema extends *c.* 10 mm from the distal end of the rhabdosome and is *c.* 0.2 mm wide, often being axially twisted. In the most mature specimen, however, the nema gradually broadens from the middle part of the thecate portion. The nema is *c.* 0.7 mm across and extends at least 15 mm from the distal end of the rhabdosome.**Remarks:** The original description of the species was based on immature rhabdosomes, 6–16 mm long and *c.* 2.9 mm wide (maximum width of the holotype). Immature rhabdosomes from Tmaň, composed of 7–8 thecal pairs, compare well with the type material in all parameters. They are 6–7 mm long, 2.65–2.8 mm wide and elongated-ovoid in the outline. Sicular details are not visible. Th1<sup>1</sup> grows upwards for 1.4 mm and th1<sup>2</sup> is 1.5 mm long. Thecae are almost straight or weakly ventrally curved, inclined at 40–45°, and overlap for *c.* two-thirds their length. The thecal apertures are perpendicular to the thecal tubes. The rhabdosome widens from 1.9 mm at the th1<sup>1</sup>–1<sup>2</sup> apertures, to 2.4–2.65 mm at th3. The maximum width is attained at th4–5. The 2TRD is 1.5 mm at th2 and 1.6 mm at th5. *Petalograptus praecursor* differs from *P. ovatoelongatus* (Kurck) in its generally narrower rhabdosome with shorter, less inclined and less ventrally curved thecae. Rhabdosomes of *P. minor* (Elles) may be distinguished from *P. praecursor* rhabdosomes of similar length (degree of maturity) by their greater width, ovoid shape and more ventrally curved thecae.***Petalolithus folium* (Hisinger, 1837)**

Pl. IV, figs 1, 4, 6, 8–10; text-fig. 5, figs 2 A–E

1837 *Prionotus folium*; Hisinger, p. 114, pl. 35, fig. 8.1897 *Cephalograptus folium* Hisinger; Perner, p. 12, pl. 10, fig. 14.1908 *Petalograptus folium* (Hisinger); Elles & Wood (pars), p. 282, pl. 32, figs 8a, ?e, (non b–d); text-fig. 195.1941 *Petalolithus folium* (Hisinger, 1837); Bouček & Přibyl, p. 7 (partim), pl. 1, fig. 6 (non 7); text-fig. 2 a,c (non b).1941 *Petalolithus folium tornquisti* n. subspec.; Bouček & Přibyl, p. 9, pl. 1, fig. 8; text-fig. 2 d, e.1975 *Petalograptus folium* (Hisinger, 1837); Bjerreskov, pp. 35, 36, fig. 12 C.1982 *Petalograptus folium* (Hisinger, 1837); Lenz, pp. 13, 14, figs 2 C, D; 12 D, E.1990 *Petalolithus folium* (Hisinger); Ge, pp. 69, 70 (partim); pl. 7, figs 1–3, 6, (non 4, 5).1996 *Petalolithus folium* (Hisinger, 1837); Koren' & Rickards, pp. 50, 53; pl. 8, figs 4, 5; text-fig. 10 A, B.**Material:** More than 100 complete flattened specimens at various astogenetic stages.**Description:** The thecate part of the rhabdosome attains over 25 mm in length, though is usually 10–15 mm long. The 1.5 mm long sicula is often pressed through, being little exposed from the reverse view. The sicular aperture is 0.25–0.3 mm wide. The virgella divides *c.* 0.3 mm below the sicular aperture in two curved primary rods which bifurcate almost immediately. Four secondary rods of the ancora are up to 1.3 mm long, ventrolaterally directed, growing almost parallel to the ventral walls of th1<sup>1</sup> and 1<sup>2</sup>. Th1<sup>1</sup> extends 0.05–0.1 mm below the sicular aperture. Its upward growing portion measures 3.2–4.5 mm in mature rhabdosomes. Th1<sup>2</sup> grows upwards for its entire length which is 3.4–4.7 mm. Both th1<sup>1</sup> and th1<sup>2</sup> are inclined at an angle of 30–35° (extremes 20–40°); in some specimens they may be weakly ventrally curved.Th5 is 3.4–4.4 mm long and inclined at 30–45°. The distal thecae overlap for *c.* four-fifths their length. The

thecal aperture is perpendicular to the thecal axis. The dorso-ventral width increases from 2.6–3.8 mm at the level of th1 to 3.4–4.6 at th3. The maximum width of 4.7–5.5 mm is attained at th5–7 in the most mature rhabdosomes, which, thereafter, may narrow again. The 2TRD is 2.0–2.5 mm at th2 and 1.7–2.15 mm at th5. A partial septum is developed in *P. folium* as in the most of other petalolithids. In many specimens of *P. folium*, particularly in mature rhabdosomes, a robust, 0.2–0.6 mm wide nema is developed and projects at least 25 mm beyond the thecate part. In some specimens the nema splits into two threads. **Remarks:** Immature rhabdosomes having only 3–4 thecal pairs differ from mature specimens in having considerably shorter initial thecae. In immature rhabdosomes, the upwards growing portion of th1<sup>1</sup> measures 2.0–3.6 mm and that of th1<sup>2</sup> 1.7–4.0 mm respectively. It suggests further growth of the earliest thecae, prolonged into the later stages of the astogenetic development. Similar evidence is provided by the maximum dorso-ventral width of the rhabdosome appearing to increase in later astogenetic stages of rhabdosome growth. Bouček and Přibyl (1941) briefly described and figured two mature specimens with narrower proximal ends and a 3.4–3.8 mm long th1<sup>1</sup>, and erected a new subspecies *Petalolithus folium toernquisti* (Bouček & Přibyl). New examination of the type material does not support the validity of *P. folium toernquisti* even though the narrower, slightly more protracted proximal end may represent a distinct morphogenetic trend expressed also in *P. trajectilis* Ni. This trend subsequently gave origin to the more elongated proximal thecae and thorn-like proximal end which characterize *P. krizi* n. sp.

#### *Petalolithus krizi* n. sp.

Pl. V, figs 6, 10; text-fig. 5, figs 4 A, B

Derivation of name: After Dr. Jiří Kříž.

1908 *Petalograptus folium* (Hisinger); Elles & Wood (pars), p. 282, pl. 32, figs 8 b–d, ?e, (non a).

1941 *Cephalograptus tubulariformis* (Nicholson 1867), Bouček & Přibyl, p. 13, pl. 1, fig. 9; text-fig. 2 f–h.

1971 *Petalolithus* (*Ceph.*) *tubulariformis* (Nicholson, 1867); Schauer, p. 49, pl. 8, figs 5–6, pl. 9, figs 3–5.

**Holotype:** Complete flattened specimen no. PŠ 796 figured on pl. 5, fig. 10 and text-fig. 5, fig. 4 A; from the *convolutus* Biozone (mid-Aeronian) of Svatý Jiří near Tmaň, Bohemia.

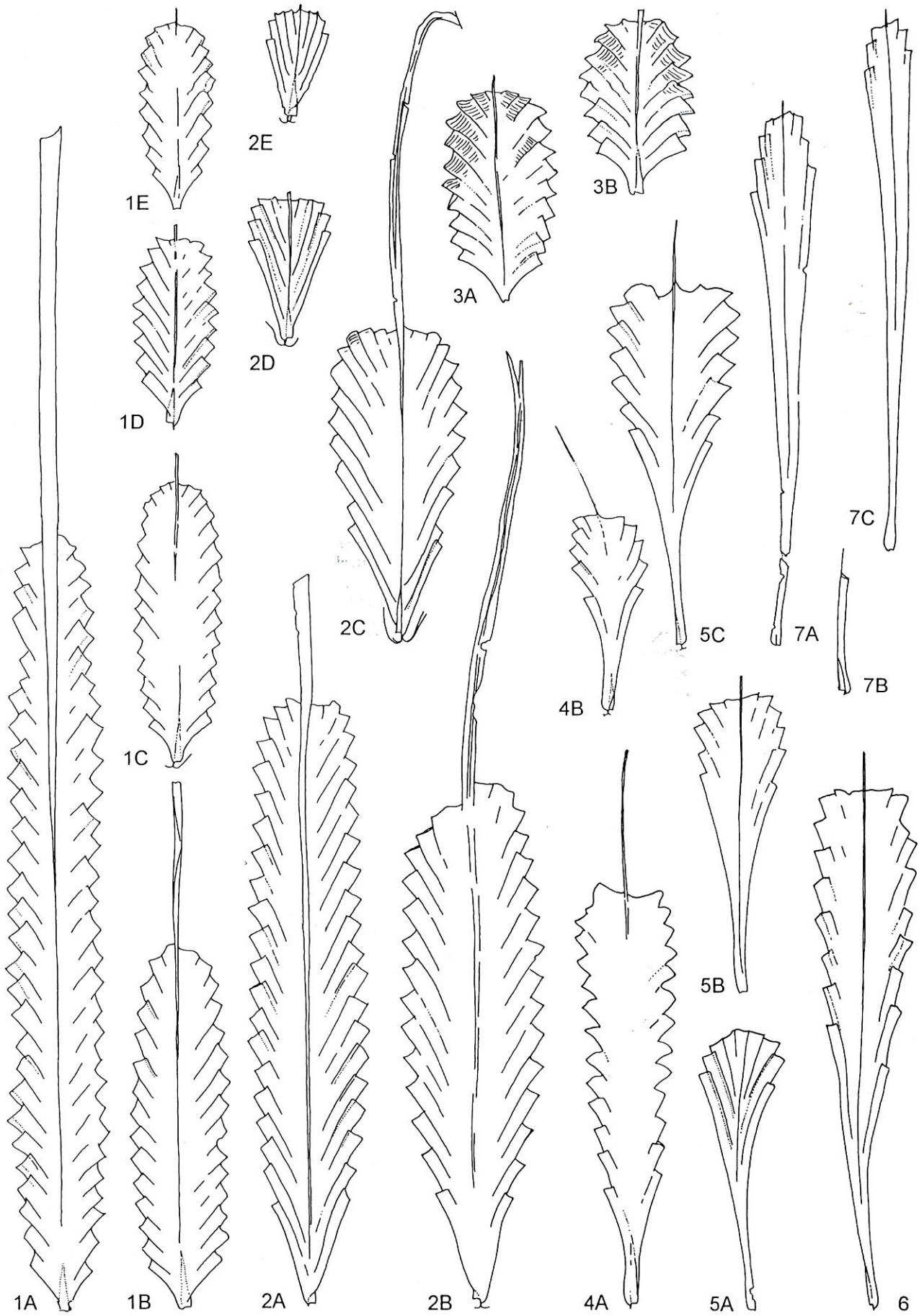
**Material:** Two complete and two incomplete flattened specimens and the specimens figured by Bouček and Přibyl (1941).

**Diagnosis:** Rhabdosome up to 25 mm long, with wedge-shaped, protracted proximal part. Proximal end slightly bulbous, possessing partly exposed sicula and rudimentary ancora. Initial thecae 4.3–4.8 mm long, slightly ventrally curved, inclined at 25–30°; the distal thecae inclined at 40°. The rhabdosome widens from 2.3–2.45 mm at th1 and 2.9–3.0 mm at th3 to the maximum of 3.8–4.2 mm attained at th11. The 2TRD is 1.95–2.1 mm at th2 and decreases to 1.7 at th10.

**Description:** The rhabdosome is up to 25 mm long, possessing a conspicuously protracted proximal end. The origin of th1<sup>1</sup> and sicula are obscure. Th1<sup>1</sup> bends up 0.05 mm below the c. 0.2 mm wide sicular aperture and gives a slightly bulbous appearance to the proximal end. The tiny virgella divides 0.2–0.25 mm below the sicular aperture and immediately bifurcates in four secondary rods, suggesting the presence of a tiny, rudimentary ancora. The sicula is exposed for 0.6–0.8 mm on the reverse side of the rhabdosome, but is not seen on the obverse view. The initial thecae are ventrally curved, having concave ventral walls. The upward growing portion of the th1<sup>1</sup> is 4.3–4.5 mm long, while th1<sup>2</sup> is 4.4–4.8 mm long. The initial thecae are inclined at an angle of 25–30° to the rhabdosome axis. The distal thecae are inclined at 40°. The dorso-ventral width is 2.3–2.45 mm at the level of th1, and 2.9–3.0 mm at th3. The maximum width of 3.8–4.2 mm was measured at th11. The 2TRD is 1.95–2.1 mm at th2 and decreases to 1.7 mm at th10. A thread-like nema, over 10 mm long, is developed in less mature specimens. The specimen no. L27489 figured by Bouček and Přibyl (1941) has a robust nema, 0.8 mm wide and over 34 mm long.

**Remarks:** *Petalolithus krizi* n. sp. has been confused with *Cephalograptus tubulariformis* (Nicholson) in the past (Bouček and Přibyl 1941, Schauer 1971 a.o.). It differs from the latter species in having a less protracted but narrower proximal part, considerably shorter initial thecae and a gradually widening rhabdosome which attains its maximum width at the level of the 11–12<sup>th</sup> thecal pair. *Petalolithus folium* (Hisinger) may be easily distinguished from *P. krizi* by its generally shorter and more inclined initial thecae and less protracted proximal end. Mature rhabdosomes of *P. krizi* are narrower than those of *P. folium*. *P. krizi* is assigned to *Petalolithus* Suess with respect to its moderately protracted proximal end and the presence of an ancora.

Fig. 5. 1 A–E. *Petalolithus praecursor* Bouček & Přibyl; 1 A – PŠ 762, 1 B – PŠ 711/2, 1 C – PŠ 801/2, 1 D – PŠ 801/1, 1 E – PŠ 915/1. ⇨  
2 A–E. *Petalolithus folium* (Hisinger); 2 A – BB 697, 2 B – PŠ 791, 2 C – PŠ 821, 2 D – PŠ 730, 2 E – PŠ 795.  
3 A, B *Petalolithus* cf. *ovatoelongatus* (Kurck); 3 A – PŠ 811, 3 B – PŠ 746.  
4 A, B *Petalolithus krizi* n. sp.; 4 A – PŠ 796 (holotype), 4 B – PŠ 781.  
5 A–C *Cephalograptus tubulariformis* (Nicholson); 5 A – PŠ 846/1, 5 B – PŠ 846/2, 5 C – PŠ 920/1.  
6 *Cephalograptus cometa cometa* (Geinitz); PŠ 835, early form.  
7 A–C *Cephalograptus cometa extrema* Bouček & Přibyl; early form; 7 A – PŠ 797, 7 B – PŠ 860 juvenile rhabdosome, 7 C – PŠ 798.  
All specimens x5. Specimens on figs 1 A–E, 2 A–E and 3 A, B from the *leptothecha* Biozone, specimens on figs 4 A, B, 5 A–C, 6, 7 A–C from the *convolutus* Biozone.



### Genus *Cephalograptus* Hopkinson, 1869

Type species: Original designation; *Diplograptus cometa* Geinitz, 1890 from the Llandovery of Germany.

**Diagnosis:** Narrow, wedge-shaped *Petalolithus*-like rhabdosome with extremely elongated and overlapping tubular thecae and extremely protracted proximal end; ancora rudimentary, missing in some species.

**Remarks:** An undoubted evolutionary succession from *Petalolithus folium* (Hisinger) through *Petalolithus krizi* n. sp., *Cephalograptus tubulariformis* and *Cephalograptus cometa cometa* (Geinitz) to *Cephalograptus cometa extrema* Bouček & Přibyl supported by their stratigraphical ranges was recorded in Tmaň. Rapid evolution includes extreme protraction of the proximal end, elongation of the thecae, reduction of the thecal number and eventual loss of the ancora structure.

#### *Cephalograptus cometa cometa* (Geinitz, 1852)

Pl. V, fig. 9; text-fig. 5, fig. 6

- 1852 *Diplograptus cometa*; Geinitz, p. 26, pl. 1, fig. 28.  
 1893 *Cephalograptus cometa* Gein.; Törnquist, p. 11, figs 36–41.  
 1897 *Diplograptus cometa* Geinitz; Törnquist, p. 14, pl. 2, figs 8–14.  
 1897 *Cephalograptus cometa* (Gein.); Elles, p. 204, pl. 13, figs 10–16.  
 1908 *Cephalograptus cometa* (Geinitz); Elles & Wood (pars), p. 285, pl. 32, fig. 10d (non a–c).  
 1941 *Cephalograptus cometa cometa* (Geinitz 1852); Bouček & Přibyl, p. 14, text-fig. 2j, k, (non i).  
 1971 *Petalolithus* (*Ceph.*) *cometa cometa* (Geinitz 1852); Schauer, p. 49, pl. 8, fig. 7, pl. 9, fig. 6–9 (?10).  
 1974 *Cephalograptus cometa cometa* (Geinitz); Hutt, p. 42, pl. 10, fig. 4; text-fig. 11, figs 6, 7.  
 1975 *Cephalograptus cometa cometa* (Geinitz); Bjerreskov, pp. 36, 37; pl. 5 B.  
 1982 *Cephalograptus cometa cometa* (Geinitz); Lenz, pp. 21–22, 24; figs 3 A–C, 14 A–C.

**Material:** one complete and one incomplete flattened rhabdosome.

**Description:** The rhabdosome is 18.5 mm long, having a very protracted and slightly curved proximal end. Partial septum is developed. The specimen figured herein has 8 thecal pairs. The sicula is exposed for 1.0 mm of its length. The sicular aperture is 0.15 mm wide and possesses rudimentary virgella. Th<sup>1</sup> extends below the sicular aperture for 0.1 mm. Thereafter it grows upwards for 9.35 mm. Th<sup>2</sup> is c. 9.2 mm long. The initial thecae incline at 20° to the rhabdosome axis. Free ventral walls of the distal thecae are inclined at 30–35°; the apertures are perpendicular to thecal axes. The dorso-ventral width is 2.65 mm at the th<sup>1</sup>–<sup>2</sup> apertures, 3.4 mm at th<sup>3</sup> and 4.2 mm at th<sup>8</sup>. The 2TRD is 2.55 mm at th<sup>2</sup>. A short, thread-like nema extends beyond the thecate part.

**Remarks:** Geinitz (1852) figured only a distal part of the rhabdosome which, in fact, may belong to either *C. cometa cometa* in the present usage or to *C. cometa extrema* Bouček & Přibyl. The present paper follows the conception of *C. cometa cometa* given by Törnquist

(1893, 1897), Elles (1897) and Hutt (1975) in which the th<sup>1</sup> is 8–12 mm long. The specimens from the upper part of the *convolutus* Biozone having th<sup>1</sup> more than 16 mm long and a greatly reduced number of thecae are assigned to *C. cometa extrema*. Only two specimens of the type subspecies were found in the lower part of the *convolutus* Biozone at Tmaň.

#### *Cephalograptus cometa extrema* Bouček & Přibyl, 1941

Pl. V, figs 1, 2, 7, 8; pl. XX, fig. 4; text-fig. 5, figs 7 A–C

- 1908 *Cephalograptus cometa* (Geinitz); Elles & Wood (pars), pl. 32, figs 10a–c.  
 1941 *Cephalograptus cometa extrema* n. subsp.; Bouček & Přibyl, p. 15, pl. 1, fig. 10; text-fig. 2 l–m.  
 1941 *Cephalograptus cometa cometa* (Geinitz 1852); Bouček & Přibyl, p. 14, text-fig. 2 i.  
 1971 *Petalolithus* (*Ceph.*) *cometa extrema* Bouček & Přibyl 1942; Schauer, p. 49–50, pl. 8, figs 8, 9; pl. 9, figs 12–16, (?11).  
 1974 *Cephalograptus cometa extrema* Bouček & Přibyl, Hutt, p. 43, pl. 6, fig. 1, pl. 10, figs 3, 5; text-fig. 11, figs 1–4, ?5.  
 1975 *Cephalograptus cometa extrema* Bouček & Přibyl, Bjerreskov, p. 37, pl. 5 C.  
 1982 *Cephalograptus cometa extrema* Bouček and Přibyl, 1941; Lenz, p. 24, figs 3 D, 14 G, H.  
 1996 *Cephalograptus cometa extrema* Bouček and Přibyl, 1941; Koren' & Rickards, p. 57, pl. 9, fig. 9; text-fig. 11 B, C.

**Holotype:** Specimen no. L30931 figured by Bouček and Přibyl (1941) on text-fig. 2 l; from the upper *convolutus* or lower *sedgwickii* Biozone, Aeronian (in according to the associated bedding-plane assemblage) of Wachtelberg bei Frankenberg, Germany.

**Material:** 14 complete and several incomplete flattened rhabdosomes.

**Diagnosis:** Rhabdosome acicular, composed of no more than five pairs of extremely elongated tubular thecae with apertures situated near distal extremity. Th<sup>1</sup> more than 16 mm long, inclined at c. 10° to the rhabdosome axis. The maximum dorso-ventral width of 2.15–3.15 mm is attained at the 1<sup>st</sup> thecal pair. The proximal end of the rhabdosome is slightly bulbous, commonly slightly curved. The sicula is obscured.

**Description:** The length of the mature rhabdosome with 6–10 thecae is 19.5–21 mm and th<sup>1</sup> is 16–18.4 mm long. The inclination of the ventral wall of th<sup>1</sup> attains 10–15° near the thecal aperture. The thecal apertures are 0.35–0.4 mm wide, normal to the thecal axis, occasionally slightly concave. The maximum dorso-ventral width of 2.15–3.15 mm is attained at the level of the apertures of the 1<sup>st</sup> thecal pair. The proximal end of the rhabdosome is commonly slightly curved. The early astogeny and sicula are obscured except in juvenile specimens (see text-fig. 5, fig. 7 B). Th<sup>1</sup> bends up at the level of sicular aperture and gives a bulbous appearance to the proximal end. Neither ancora nor virgella have been observed.

**Remarks:** The present material from the upper part of the *convolutus* Biozone presumably represents early populations assignable in *C. cometa extrema*. It may be distinguished from the later populations from the *sedgwickii* Biozone in having less elongated, more inclined thecae and in having more thecal pairs.



***Cephalograptus tubulariformis* (Nicholson, 1867)**

Pl. V, figs 3–5; pl. XX, fig. 6; text-fig. 5, figs 5 A–C

1867 *Diplograptus tubulariformis*; Nicholson, p. 109, pl. 7, figs 12, 13,  
1897 *Cephalograptus cometa* Geinitz; Perner, p. 12, pl. 10, figs 15, 16.  
1897 *Diplograptus (Cephalograptus) petalum* Elles, p. 206, pl. 13,  
figs 6–9.

1908 *Cephalograptus tubulariformis* (Nicholson), Elles & Wood, p. 287,  
pl. 32, figs 9a–d; text-fig. 198.

non 1941 *Cephalograptus tubulariformis* (Nicholson 1867), Bouček &  
Příbyl, p. 13, pl. 1, fig. 9; text-fig. 2 f–h.

1941 *Petalolithus folium* (Hisinger, 1837); Bouček & Příbyl, p. 7 (par-  
tium), pl. 1, fig. 7 (non 6); text-fig. 2 b (non a, c).

1965 *Cephalograptus tubulariformis* (Nicholson), 1867; Obut et al.,  
p. 37, pl. 2, figs 7–10.

non 1971 *Petalolithus (Ceph.) tubulariformis* (Nicholson, 1867);  
Schauer, p. 49, pl. 8, figs 5–6, pl. 9, figs 3–5.

1982 *Cephalograptus tubulariformis* (Nicholson), Lenz, pp. 24–25,  
figs 3 E, F; 14 E.

1990 *Cephalograptus tubulariformis* (Nicholson), Ge, pp. 77–78, pl. 8,  
fig. 8.

**Lectotype:** Designated by Bouček and Příbyl (1941); specimen no.  
NHM Q83 figured by Nicholson (1867, fig. 12) and refigured by  
Elles and Wood (1908) on pl. 32, fig. 9a; from the Birkhill Sha-  
les at Frenchland Burn, Scotland.

**Material:** 5 complete and 3 incomplete, flattened specimens.

**Description:** The wedge shaped rhabdosome reaches *c.* 16 mm in length. The maximum of 16 thecae have been observed in the present material. The sicula is poorly visible, but is at least partly exposed. A rudimentary ancora was found in one specimen. A partial septum appears to be developed in the distal part of the rhabdosome. The upwardly growing th<sup>1</sup> is 7.7–8.5 mm long, inclined at 25–35° to the rhabdosome axis. Distal thecae are inclined at 35–45°. The thecal inclination measured on the free ventral thecal walls is enhanced due to the remarkable ventral curvature of the thecae. The thecal aperture is 0.4–0.55 mm wide, perpendicular to the thecal axis. The dorso-ventral width is 3–3.5 mm at the th<sup>1</sup>–<sup>12</sup> apertures, 3.4–4.5 mm at th<sup>3</sup> and, in one specimen, reaches 5.6 at the last, 8<sup>th</sup> thecal pair. The 2TRD is 1.75–1.95 mm at th<sup>2</sup>. A 2TRD of 2.15 mm was measured at th<sup>7</sup> in one specimen.

**Remarks:** Further preparation of the specimen no L30934 assigned in *Petalolithus folium* by Bouček and Příbyl (1941, pl. 1, fig. 7; text-fig. 2 b) exposed a much elongated proximal end. Th<sup>1</sup> is at least 6.8 mm long and th<sup>12</sup> still longer. This specimen, from the *convolutus* Biozone (in the present sense), corresponds to *Cephalograptus tubulariformis*.

Family Retiolitidae Lapworth, 1873; emend. Mitchell 1987

**Genus *Pseudoretiolites* Bouček & Münch, 1944**

**Type species:** Original designation; *Retiolites perlatus* Nicholson,  
1868 from the Llandoverly of the Lake District, England.

**Diagnosis:** after Lenz and Melchin (1987).

***Pseudoretiolites perlatus* (Nicholson, 1868)**

Pl. VI, figs 1, 7–9; text-fig. 6, fig. 8

1868 *Retiolites perlatus*; Nicholson, p. 530, pl. 19, figs 21, 22.

1897 *Retiolites perlatus* Nichol.; Perner, p. 24, pl. 13, figs 44, 45.

1897 *Retiolites obesus* Lapw.; Perner, p. 25, pl. 13, figs 46–49, text-  
fig. 28.

1908 *Retiolites (Gladiograptus) perlatus* Nicholson; Elles & Wood,  
pp. 338–339, pl. 34, fig. 10 a–f; text-fig. 221 a–c.

1944 *Retiolites (Pseudoretiolites) perlatus* Nicholson 1868; Bouček &  
Münch, pp. 24–28, pl. 1, figs 4–7; text-figs 8 a–e, 9 c–e.

1968 *Pseudoretiolites perlatus* (Nicholson); Obut, Sobolevskaya &  
Merkureva, pp. 74–75, pl. 7, figs 6–9.

1974 *Retiolites perlatus perlatus* Nicholson, 1868; Hutt, p. 47, text-  
fig. 12, fig. 4.

1993 *Pseudoretiolites perlatus* (Nicholson, 1868); Loydell, pp. 61, 62;  
text-fig. 13, fig. 3 (see for further references).

**Material:** 28 complete and/or almost complete rhabdosomes and  
more fragments.

**Description:** Rhabdosome more than 40 mm long, widening rapidly at the proximal end. It widens from 1.5–1.8 mm at the 1<sup>st</sup> thecal pair to 4.1–4.8 mm at th<sup>5</sup>. The maximum width of 5.1–8.2 mm is attained at about th<sup>10</sup>. Thereafter some rhabdosomes still slightly widen, whilst others are parallel-sided. The sicular structure is rarely visible in the present material. The basket-like ancora is *c.* 1.2 mm wide. A thin but distinctive nema is involved in the obverse wall of the rhabdosome. The thecae are straight, but often fairly indistinct. Septal bars are represented by thin median lists. The reticulum is moderately fine, composed of sub-polygonal meshes having 0.25–0.6 mm in diameter. Apertural parts of the thecae are formed of finer, laterally elongate meshes, divided medially by a zig-zag list. The apertures are slightly introverted. Some specimens possess stomata which measure 0.8–1.0 mm in diameter. Proximal thecae incline at an angle of 60–70° to the rhabdosome axis, distal thecae incline at 50–60°. The 2TRD is 1.5–2.0 mm at th<sup>5</sup> and 1.9–2.3 mm (exceptionally 1.5 mm) distally. Distal thecae number 9–12 in 10 mm.

**Remarks:** Two different forms appear to be included in the material collected at Tmaň. Some specimens are rather narrow, having a maximum width of *c.* 5.2 mm, and densely packed thecae which number 10.5–12.5 in 10 mm. These rhabdosomes tend to have a higher angle of thecal inclination and more dense reticulum. This form matches well the type specimen and the material figured by Elles and Wood (1908). Other specimens attain a maximum width 6.1–8.2 mm. These have widely spaced thecae which number 9–10 in 10 mm. In Tmaň the two forms range in common through the *leptothea* and *convolutus* biozones but the narrow one has been also recorded in the underlying *simulans* Biozone at Hlánská Třebáň and Černošice.

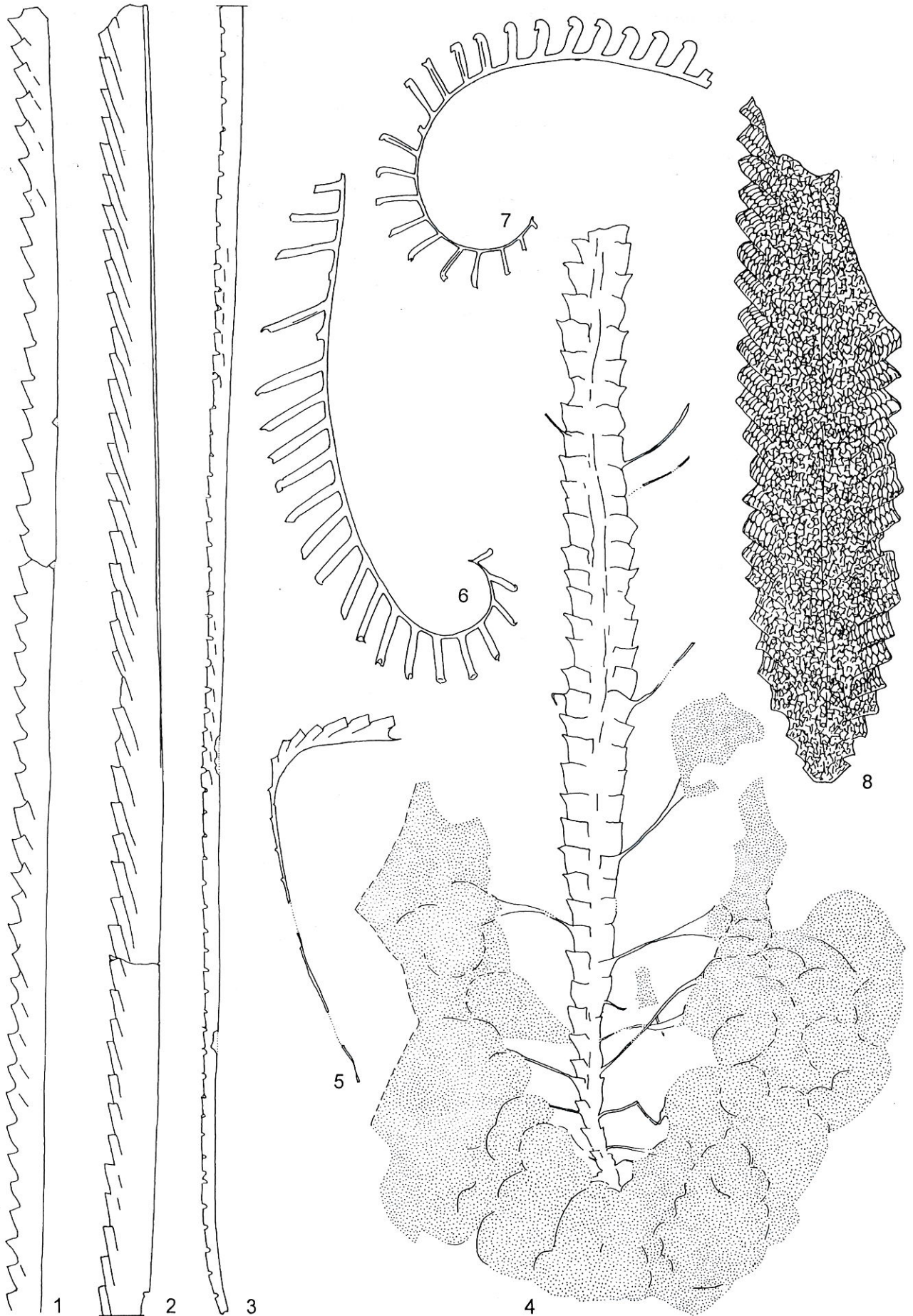
Superfamily Monograptacea Lapworth, 1873

Family Monograptidae Lapworth, 1873

**Genus *Pristiograptus* Jaekel, 1889**

**Type species:** Original designation; *Pristiograptus frequens* Jaekel, 1889 from the Silurian of Germany.

**Diagnosis:** after Hutt (1975).



***Pristiograptus regularis solidus* Přibyl, 1940a**

Pl. XI, figs 4, 7; text-fig. 7, figs 9 A, B

1940a *Pristiograptus regularis solidus* n. var.; Přibyl, pp. 6, 7; pl. 2, fig. 5.Holotype: Complete flattened specimen no. L31465 figured by Přibyl (1940a) on pl. 2, fig. 5; from the *convolutus* Biozone (mid-Aeronian) of Svätý Jiří near Tmaň, Bohemia.

Material: 7 flattened complete specimens.

**Diagnosis:** Pristiograptid with straight rhabdosome widening from 0.35 mm to 0.7–0.9 mm at th20. Apex of the *c.* 0.8 mm long sicula attains the level of the 1<sup>st</sup> thecal aperture. Proximal thecae incline at 15°, more distal thecae at *c.* 30°. The proximal thecae overlap for one-third their length, distal thecae for almost one-half. Thecal apertures broad, perpendicular to the rhabdosome axis. The thecae number *c.* 12.5 in the proximal 10 mm of the rhabdosome.

**Description:** The rhabdosome is straight, at least 30 mm long. It widens from 0.35 mm at th1, and 0.36–0.42 mm at th5, to 0.55–0.7 mm at th10. The present rhabdosomes are 0.7–0.9 mm wide at about th20. The sicula is probably 0.8 mm long and its apex attains the aperture of th1. Th1 originates just above a *c.* 0.18 mm wide sicular aperture provided with a short, tiny virgella. The thecae are simple, straight tubes inclined at *c.* 15° to the rhabdosome axis proximally and at 30° in the distal parts of the present rhabdosomes. The thecal apertures are perpendicular to the rhabdosome axis and occupy one-half of the rhabdosome width in the proximal thecae and two-fifths to one-third of the width distally. The proximal thecae overlap for one-third their length, the distal thecae for almost one-half their length. The 2TRD is 1.3–1.45 mm at th2 and gradually increases to 1.4–1.65 mm at th5 and 1.55–1.7 mm at about th20. The thecae number *c.* 12.5 in the proximal 10 mm of the rhabdosome.

**Remarks:** Though fully mature rhabdosomes are missing in the present material, these immature rhabdosomes may be distinguished from *P. regularis regularis* (Törnquist 1899) by their thecal inclination and overlap. The most proximal thecae of *P. regularis solidus* are inclined at 15° whilst the more distal thecae incline at *c.* 30°. *P. regularis regularis* show the opposite trend according to Törnquist (1899) and Hutt (1975). The thecae are less overlapping in *P. regularis solidus* and thecal apertures are perpendicular to the rhabdosome axis. *P. variabilis* Perner may be distinguished from *P. regularis solidus* by

its less tapering proximal part and less inclined thecae with narrower thecal apertures. *P. regularis solidus* is confined to the *leptothea* and *convolutus* biozones.

***Pristiograptus concinnus* (Lapworth, 1876)**

Pl. XI, fig. 3; text-fig. 6, fig. 1

1876 *Monograptus concinnus* sp. nov.; Lapworth, p. 320, pl. 11, figs 1 a–c.1911 *Monograptus concinnus* Lapworth; Elles & Wood, p. 368, pl. 36, figs 5 a–f; text-figs 240 a–d.1970 *Pristiograptus concinnus* (Lapworth, 1876); Rickards, p. 60, pl. 5, fig. 5.1975 *Pristiograptus concinnus* (Lapworth, 1876); Hutt, pp. 57, 58; pl. 12, figs 1, 2, 7, 8. (see for further synonymy).1988 *Pristiograptus concinnus* (Lapworth, 1876); Štorch, pp. 14, 16; pl. 6, figs 2, 3, 4; text-fig. 2B.1991 *Pristiograptus concinnus* (Lapworth, 1876); Loydell, pp. 680; pl. 2, fig. 4.

Material: 12 distal, although rather long fragments.

**Description:** The distal rhabdosome fragments are straight or weakly ventrally curved. The rhabdosome attains an almost uniform width of 1.3–1.4 mm, maintained through at least 10 cm of the distal portion. The tubular thecae have slightly convex ventral supragenicular walls, inclined at *c.* 30° to the rhabdosome axis, and slightly everted, occasionally concave apertures which occupy *c.* two-fifths of the rhabdosome width. The thecae overlap for one-third to one-half their length. They number 9–9.5 in 10 mm. The 2TRD is 2.1–2.2 mm.

**Remarks:** Infrequent distal fragments from the *leptothea* Biozone of Tmaň well agree with the previous descriptions of *P. concinnus* (listed in the present synonymy). This long ranging species have been already recorded in the *triangulatus-pectinatus* and *simulans* biozones in Bohemia (Štorch 1988, 1994).

**Genus *Coronograptus* Obut & Sobolevskaya, 1968; emend. Rickards (1976b)**Type species: Original designation; *Monograptus gregarius* Lapworth, 1876 from the Llandovery of Dobb's Linn, Scotland.

Diagnosis: after Rickards (1976b).

***Coronograptus maxiculus* Štorch, 1988**

Pl. VII, figs 1, 2; text-fig. 7, figs 6 A, B

1975 *Coronograptus gregarius gregarius* (Lapworth, 1876); Hutt, (partim), p. 64, pl. 14, fig. 2; text-fig. 15, figs 1, 2.

⇐

Fig. 6. 1 *Pristiograptus concinnus* (Lapworth); PŠ 775, part of longer fragment.2 *Pribylograptus leptothea* (Lapworth); PŠ 822, part of longer fragment.3 *Monoclimacis crenularis* (Lapworth); PŠ 697, part of longer specimen.4 *Dittograptus monstrosus* (Štorch); PŠ 61 (holotype).5 *Monograptus limatulus limatulus* Törnquist; PŠ 926/1.6 *Rastrites peregrinus* Barrande; BB 698.7 *Monograptus simulans* Pedersen; PŠ 740a.8 *Pseudoretiolites perlatus* (Nicholson); PŠ 861, wider form.Specimen on fig. 2 x4; other specimens x5. Specimens on figs 1, 2, 4, 7 from the *leptothea* Biozone, specimens on figs 3, 5, 6, 8 from the *convolutus* Biozone.

1988 *Coronograptus gregarius maxiculus* subsp. n.; Štorch, pp. 19, 20; pl. 12, fig. 5; text-fig. 2 H.

**Holotype:** Specimen no. PŠ 252 figured by Štorch (1988) on pl. 12, fig. 5 and text-fig. 2 H, refigured herein on pl. VII, fig. 1; from the lower part of the *leptotheca* Biozone (mid-Aeronian) of Svaty Jiří near Tmaň, Bohemia.

**Material:** 28 complete or almost complete flattened rhabdosomes and the collection described by Štorch (1988).

**Description:** The rhabdosome is composed of a 10–14 mm long, slightly dorsally curved sicula and a single, tube-like theca. The sicular aperture is straight or slightly concave, 0.3–0.35 mm wide, and possesses 0.3–0.4 mm long virgella with a broadened base. The sicular apex is often broken off. The single theca is 1.5–2.0 mm long and originates 1.5–3.1 mm from the sicular aperture. Its ventral wall is straight or weakly concave and slightly inclined (almost parallel to the rhabdosome axis). The aperture of the theca is 0.25 mm wide, normal to the rhabdosome axis. The maximum dorso-ventral width of the rhabdosome – 0.55–0.6 mm – is reached at the level of the thecal aperture.

**Remarks:** The last representative of the *gregarius* stem is confined to the *leptotheca* Biozone. In the lower part of its range *C. maxiculus* is accompanied still by *C. gregarius* from which it is easily distinguishable by its longer and straighter sicula with one single theca. Progressive increase in sicular size has been recorded in *C. gregarius* stem by Hutt (1975) and Bjerreskov (1975), yet without taxonomic statement. In English Lake District the giant siculae with single theca occur in *argenteus* Biozone (correlatable with Bohemian *leptotheca* Biozone).

### *Coronograptus gregarius* (Lapworth, 1876)

Pl. VII, figs 5, 6; text-fig. 7, figs 7 A–C

1876 *Monograptus gregarius*, sp.nov.; Lapworth, p. 317, pl. 10, figs 12 a–c.

1911 *Monograptus gregarius* Lapworth; Elles & Wood, p. 365, pl. 36, fig. 3 a–d; text-fig. 238 a, b.

1968 *Coronograptus gregarius gregarius* (Lapworth, 1876); Obut & Sobolevskaya (and Merkureva), p. 92, pl. 20, figs 1–6; pl. 21, fig. 1.

1970 *Monograptus gregarius* Lapworth, 1876; Rickards, p. 61, text-fig. 14, fig. 35; text-fig. 18, fig. 14 (see for further synonymy).

1975 *Monograptus gregarius* Lapworth, 1876; Bjerreskov, p. 46, pl. 6 F; text-fig. 15 A.

1975 *Coronograptus gregarius gregarius* (Lapworth, 1876); Hutt, p. 64, pl. 13, fig. 2; pl. 14, figs 1, 3; text-fig. 15, figs 3, 4.

1982 *Coronograptus gregarius gregarius* (Lapworth, 1876); Lenz, p. 52, pl. 20 B, D (?C); text-fig. 4 D, E (?O, Q).

1988 *Coronograptus gregarius gregarius* (Lapworth, 1876); Štorch, pp. 18–19, pl. 4, figs 1–3; text-fig. 2 I, J.

**Material:** 8 complete and 3 incomplete flattened rhabdosomes.

**Description:** The rhabdosome is dorsally curved throughout though the curvature is slightly accentuated distally. The longest rhabdosome collected measures 13 mm and possesses 11 thecae. The sicula is slightly dorsally curved, 6.0–7.3 mm long, having an aperture 0.25–0.3 mm wide and a virgella 0.3–0.4 mm long. The sicular apex attains *c.* the aperture of th3 in some specimens, in other two specimens the aperture of th4 and th6 respectively. Th1 is 1.6–2.7 mm long and originates 1.2–1.95 mm above the sicular aperture. More distal thecae are *c.* 2.0 mm long, simple tubes with slightly concave supragenicular ventral walls and expanded apertures. They overlap for one-third their length. The genicula are obscured by expanded thecal apertures. The dorso-ventral width is 0.55–0.65 at th1 and 0.6–0.75 mm at th3. The maximum width – 0.85 mm – was observed near the distal end of the most mature rhabdosome. The 2TRD of 2.1–2.6 mm measured at th2 is maintained throughout the whole length of the rhabdosome.

**Remarks:** The present material is from the lower part of the *leptotheca* Biozone and presumably represents the latest populations of *C. gregarius gregarius*. It may be distinguished from populations of *C. gregarius gregarius* from the *triangulatus-pectinatus* Biozone in having a longer sicula. Th1 also originates in a greater distance from the sicula aperture in the late populations. In Tmaň, *C. gregarius gregarius* occurs together with *C. maxiculus* which, however, ranges still higher, up to the top of the *leptotheca* Biozone.

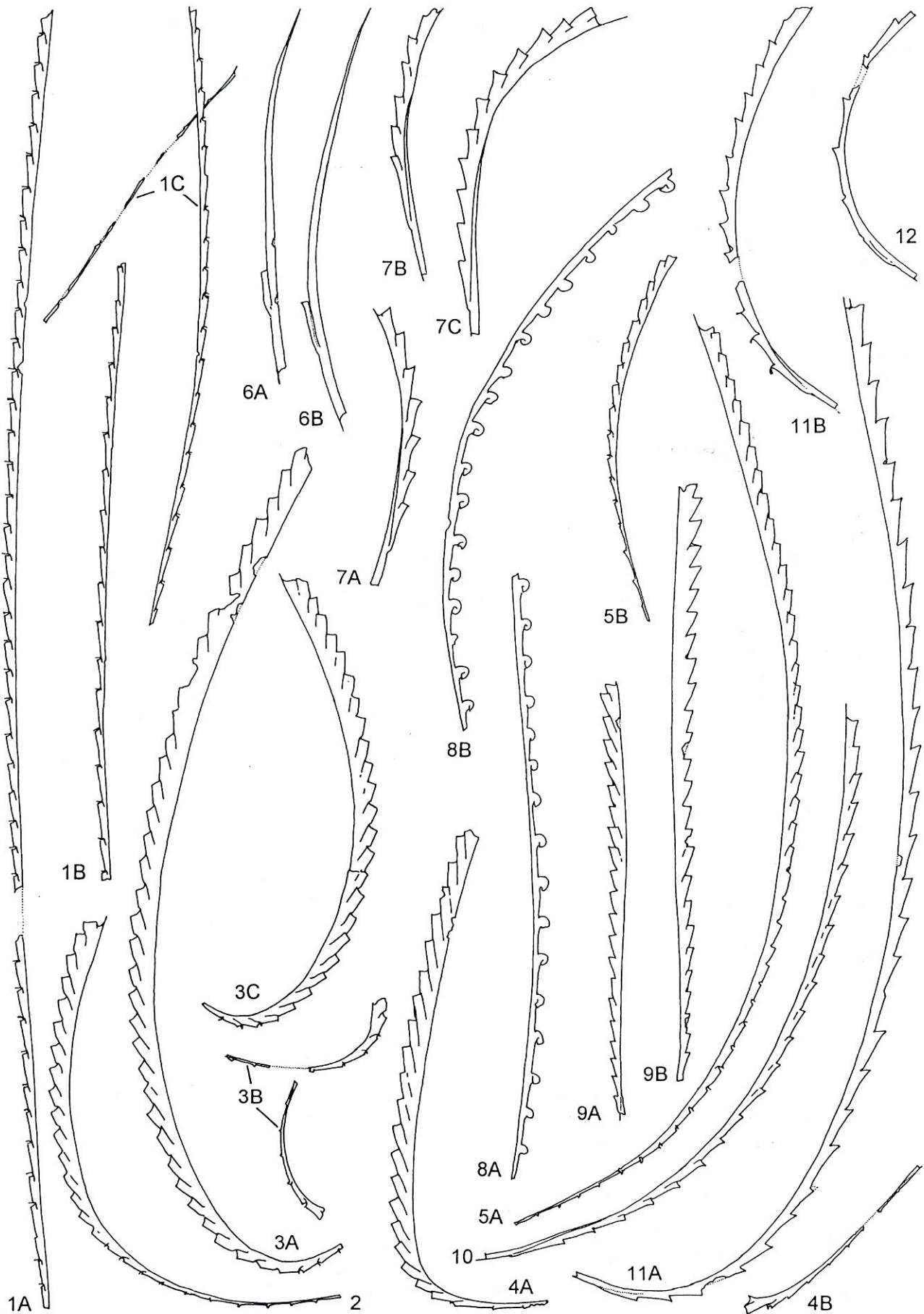
### Genus *Neolagarograptus* n. gen.

**Derivation of name:** The genus comprises several species morphologically similar, but evolutionarily unrelated, to the stratigraphically older genus *Lagarograptus* Obut & Sobolevskaya.

**Type species:** *Lagarograptus helenae* Štorch, 1988; from the middle Llandovery (*leptotheca* Biozone) of the Barrandian area, Bohemia.

- Fig. 7. 1 A–C *Monograptus respectabilis* n. sp.; 1 A – PŠ 768 (distal part, holotype), 1 B – PŠ 774, 1 C – PŠ 859 with sicular part. ⇨  
 2 *Monograptus havliceki* Štorch; PŠ 793.  
 3 A–C *Monograptus limatulus inopinus* Törnquist; 3 A – PŠ 808; 3 B – PŠ 859 (two juvenile rhabdosomes with sicular parts), 3 C – PŠ 710.  
 4 A, B *Monograptus limatulus limatulus* Törnquist; 4 A – PŠ 757, 4 B – PŠ 860 (juvenile rhabdosome with sicular portion).  
 5 A, B *Monograptus* aff. *imago* Zalasiewicz; 5 A – PŠ 808; 5 B – PŠ 722.  
 6 A, B *Coronograptus maxiculus* Štorch; 6 A – PŠ 764, 6 B – PŠ 754.  
 7 A–C *Coronograptus gregarius gregarius* (Lapworth); 7 A – PŠ 746, 7 B – PŠ 809; 7 C – PŠ 788.  
 8 A, B *Streptograptus* sp.; 8 A – PŠ 838/1, 8 B – PŠ 838/2.  
 9 A, B *Pristiograptus regularis solidus* Přibyl; 9 A – PŠ 766, 9 B – PŠ 447.  
 10 *Neolagarograptus helenae* (Štorch); PŠ 802.  
 11 A, B *Neolagarograptus impolitus* n. sp.; 11 A – PŠ 723, 11 B – PŠ 254b (holotype).  
 12 *Neolagarograptus* sp.; PŠ 234.

All specimens x5. Specimens on figs 1 A–C, 2, 3 A–C, 5 A, B, 6 A, B, 7 A–C, 8 A, B and 10 from the *leptotheca* Biozone, specimens on figs 4 A, B, 9 A, B, 11 A, B and 12 from the *convolutus* Biozone.



**Diagnosis:** Rhabdosome arcuately dorsally curved, slowly expanding in dorso-width, with a tendency to be parallel-sided. Sicula long, apex reaching a level between th1 and th3. The th1 originates high above the sicular aperture. Long and slender, pronouncedly geniculate thecae with slightly widened apertures, weak apertural excavations and, in some species, unpaired ventral apertural outgrowths. No genicular flanges are developed.

**Remarks:** *L. helenae*, *L. aff. tenuis*, and *L. sp.* described by Štorch (1988) from the later Aeronian (middle Llandovery) *convolutus* Biozone of Bohemia were arbitrarily included in *Lagarograptus* Obut & Sobolevskaya. However, recent amendment of the diagnosis of *Lagarograptus* given by Koren' and Bjerreskov (1997) clearly illustrated that these Bohemian taxa, redescribed herein, represent different evolutionary lineage which could be hardly involved in *Lagarograptus*. *Neolagarograptus* gen. n. may have evolved from some early coronograptids from which it differs in its slender, parallel-sided rhabdosome with more overlapping, strongly geniculate thecae and more everted thecal apertures. No genicular flanges are developed. Near the top of the *convolutus* Biozone, unpaired, triangular shaped ventral process is derived from the already ventrally widened apertural margin. The lineage culminated with its most robust representative *Neolagarograptus tenuis* (Portlock) in the lower part of the *sedgwickii* Biozone. *N. tenuis* has geniculate thecae with prominent ventral apertural lappets but without narrow apertural excavations or any genicular flanges or hoods.

#### ***Neolagarograptus helenae* (Štorch, 1988)**

Pl. VII, figs 3, 8; text-fig. 7, fig. 10

1988 *Lagarograptus helenae* sp. n.; Štorch, pp. 24, 26; pl. 12, fig. 3; text-fig. 4 D.

**Holotype:** Complete flattened specimen no. PŠ 274 figured by Štorch (1988, pl. 12, fig. 3; text-fig. 4 D) from the *leptotheca* Biozone (mid-Aeronian) of Svätý Jiří near Tmaň, Bohemia.

**Material:** 15 flattened, mostly complete specimens and more fragments.

**Description:** The rhabdosome is up to 30 mm long and has arcuate dorsal curvature. It widens from c. 0.35 mm at th1, and 0.42 mm at th5, to 0.5–0.55 mm at th20. The sicula is 4.6–5.1 mm long, terminated with a 0.2–0.25 mm wide aperture which possesses a short, tiny virgella. The sicular apex attains c. half-way between the apertures of th2 and th3. The thecae are long, tubular, having small but distinctive genicula, small apertural excavations and ventrally extended apertures perpendicular to the rhabdosome axis or, rarely, slightly introverted. Ventral apertural processes are missing even in well preserved specimens. The more distal thecae overlap for c. one-third their length. Apart from their steeply inclined subapertural parts the free supragenicular walls incline at about 5° to the rhabdosome axis. Th1 is 1.9–2.1 mm long and originates 1.1–1.5 mm above the sicular aperture. The 2TRD is 2.4–2.7 mm at th2, and

c. 2.2 mm at both th10 and th20. The thecae number 7.5–8.5 in the proximal 10 mm and 9–9.5 in 10 mm distally. **Remarks:** *N. helenae* is common in the *leptotheca* Biozone. It is well distinguished from *N. tenuis* Portlock by its more gracile rhabdosome, closely packed thecae and the regular dorsal curvature which is less accentuated proximally. The thecal apertures of *N. helenae* do not bear ventral apertural processes and the sicular apex reaches about half-way between th2 and th3 as opposed to the half-way between the th1 and th2 as in *N. tenuis*.

#### ***Neolagarograptus impolitus* n. sp.**

Pl. VII, figs 4, 7; text-fig. 7, figs 11 A, B

1988 *Lagarograptus* aff. *tenuis* (Portlock, 1843); Štorch, p. 22, pl. 2, fig. 3; text-fig. 4 C.

**Holotype:** Specimen no. PŠ 234 figured by Štorch (1988, pl. 2, fig. 3; text-fig. 4 C) and refigured herein on pl. VII, fig. 4; text-fig. 7, fig. 11 B; from the *convolutus* Biozone (mid-Aeronian) of Svätý Jiří near Tmaň, Bohemia.

**Material:** Three complete flattened specimens and several fragments.

**Diagnosis:** Rhabdosome with proximally accentuated dorsal curvature gradually widening from 0.4–0.45 mm at th1 to the maximum of 0.65 mm 45 mm from the proximal end. Sicula 3.5–4.0 mm long, apex attains the level of the 2<sup>nd</sup> thecal aperture. Geniculate thecae have weak apertural excavations. Thecal apertures slightly introverted with ventrally extended lips and, most proximally, small unpaired ventral lappets. Thecae number 7–8 in 10 mm proximally and 6.5–7 in 10 mm distally.

**Description:** The most mature of the rhabdosomes is 45 mm long, arcuate, and has proximally accentuated dorsal curvature. The dorso-ventral width gradually increases from 0.4–0.45 mm at th1 and 0.5–0.55 mm at th10 to the maximum of 0.65 mm attained 45 mm from the proximal end. The sicula is over 3.5 mm long, its apertural width is 0.2–0.25 mm. The sicular apex attains the aperture of th2. Th1 is 1.5–2.0 mm long. The elongate tubular thecae with distinctive genicula possess small apertural excavations and rather introverted apertures with ventrally extended lips. Small, unpaired ventral apertural lappets have been detected in the most proximal thecae. The thecae number 7–8 in 10 mm proximally (2TRD is 2.2–2.4 mm at th2) and 6.5–7 in 10 mm distally (2TRD is 2.6–2.9 mm).

**Remarks:** The present material originates from the *convolutus* Biozone. It is closely similar to *N. tenuis* except in having a shorter sicula (3.5–4.0 mm) and more densely packed proximal thecae (7–8 in 10 mm). And, no ventral apertural processes were recorded in the mesial and distal thecae of the present rhabdosomes which, however, may be regarded as possible ancestors of the widely recorded *N. tenuis* from the *sedgwickii* Biozone.

#### ***Neolagarograptus* sp.**

Text-fig. 7, fig. 12

1988 *Lagarograptus* sp.; Štorch, pp. 23, 24; pl. 2, fig. 2; text-fig. 4 B.  
Material: One complete, flattened, immature specimen.

Remarks: No new material has been found since the original description of the specimen given by Štorch (1988). This form was discovered in the upper part of the *convolutus* Biozone and may be easily distinguished by an extremely slender (0.4 mm wide), strongly dorsally curved rhabdosome. The supragenicular thecal walls are almost parallel to the rhabdosome axis except of ventrally extended subapertural parts.

**Genus *Pribylograptus* Obut & Sobolevskaya, 1966;**  
emend. Loydell (1991)

Type species: Original designation; *Monograptus incommodus*  
Törnquist, 1899 from the Llandovery of Sweden.  
Diagnosis: after Loydell (1991).

***Pribylograptus leptotheca* (Lapworth, 1876)**

Pl. IX, fig. 4; text-fig. 6, fig. 2

- 1876 *Monograptus leptotheca*; Lapworth, p. 352, pl. 12, fig. 4.  
1911 *Monograptus leptotheca* Lapworth; Elles & Wood, p. 371, pl. 37,  
fig. 2 a–d; text-fig. 242 a–c.  
1940 *Pristiograptus leptotheca* (Lapworth 1876); Přibyl, p. 6, pl. 2, figs  
6, 7.  
1970 *Monograptus leptotheca* Lapworth, 1876; pp. 68, 69; pl. 6, figs  
3, 4; text-fig. 14, fig. 37; text-fig. 16, fig. 2.  
1975 *Monograptus leptotheca* Lapworth, 1876; Bjerreskov, p. 51,  
pl. 7 F, G; text-fig. 16 C.  
1975 *Pribylograptus leptotheca* (Lapworth, 1876); Hutt, p. 73, pl. 16,  
figs 1–3, 7.  
1988 *Pribylograptus leptotheca* (Lapworth, 1876); Štorch, pp. 28, 29;  
pl. 6, fig. 1; text-fig. 2 C.  
1991 *Pribylograptus leptotheca* (Lapworth, 1876); Loydell, pp. 682,  
683; pl. 2, figs 5–10; pl. 3, figs 4, 5; text-fig. 1 A, B.

Material: Several flattened distal fragments.

Description: All the material is represented by straight, 1.8–2.0 mm wide distal fragments of the rhabdosomes which must have attained over 300 mm in length. In one fragment the uniform width of 1.9 mm is maintained along its 130 mm length. The thecae are long, much overlapping simple tubes with a low angle of inclination and simple apertures. Neither lateral apertural processes nor genicular hoods are developed in these distal fragments. The thecae number 10–10.5 in 10 mm.

Remarks: The present material from the lower part of the *convolutus* Biozone of Tmaň matches well both the classical description given by Elles and Wood (1911) and the recent description of isolated material from Sweden given by Loydell (1991). The latter author clearly demonstrates that the pribylograptid apertural morphology of the proximal part of the rhabdosome retreated gradually towards the distal part of the rhabdosome, being replaced by simple, pristiograptid-like apertures. Zalasiewicz (1996) warned that the Swedish isolated material described by Loydell (1991) differs from *Pr. leptotheca sensu* Rickards and Rushton (1972) in its proximal apertures

possessing triangular hoods and lacking lateral horns. He suggested that two taxa may be involved in *Pr. leptotheca*. However, poor preservation of the type material of *leptotheca* is not sufficient to say which one is the „true“ *leptotheca* of Lapworth (1876).

**Genus *Monoclimacis* Frech, 1897**

Type species: Original designation; *Graptolithus vomerinus* Nicholson, 1872, emend. Lapworth (1876); from the Llandovery of northern England.

Diagnosis: after Bulman (1970).

***Monoclimacis crenularis* (Lapworth, 1880)**

Pl. IX, fig. 2; text-fig. 6, fig. 3

- 1880 *Monograptus crenularis*; Lapworth, p. 153, pl. 4, figs 10a–e.  
1911 *Monograptus crenularis* Lapworth; Elles & Wood; pp. 414, 416;  
pl. 41, figs a, d, e (?b, c); text-fig. 343 a, b (?c–e).  
1940 *Monoclimacis crenularis* (Lapworth 1880); Přibyl, p. 11, pl. 2,  
figs 12, 13.  
1974 *Monoclimacis? crenularis* (Lapworth, 1880); Hutt, p. 56, pl. 9,  
figs 8–10; text-fig. 14, figs 1, 2.  
?1996 „*Monoclimacis*“ aff. *crenularis* (Lapworth); Zalasiewicz, p. 50;  
text-fig 4 A–D.

Material: 8 more or less complete flattened rhabdosomes and several fragments.

Description: The rhabdosome is straight except of a weakly dorsally curved proximal part. A maximum length of 95 mm was recorded. The sicula is not visible. Near the proximal end the rhabdosome is 0.4–0.45 mm wide. Thereafter the dorso-ventral width gradually increases to 1.2–1.4 mm, attained about 80–100 mm from the proximal end. The thecae are strongly geniculate, with dorsally facing, approximately semicircular apertural excavations and supragenicular walls parallel to the rhabdosome axis. The earliest thecae possess apertural hoods which, occasionally, are seen, though very small, even in distal thecae. The 2TRD is c. 1.8 mm near the proximal end of the rhabdosome and 1.85–2.05 mm distally. Thecae number 9–10.5 in 10 mm. No further details are seen in the present material.

Remarks: The Bohemian specimens were collected in the upper part of the *convolutus* Biozone. They match well the British material described by Elles and Wood (1911) and Hutt (1974) in a gradually widening, proximally dorsally curved rhabdosome and in thecal shape and spacing. The present rhabdosomes are often preserved in more or less scalariform view which implies an ovoid or sub-circular original cross section. This may explain the differences between the distal dorso-ventral width of the flattened Bohemian specimens (1.2–1.35 mm) and British material preserved in relief (0.8–1.0 mm). *Monoclimacis wachtelbergensis* Přibyl from the *sedgwickii* Biozone of Germany differs in having an even wider rhabdosome (1.4–1.6 mm) and widely spaced thecae (8.5–9.0 mm). The proximal part of the latter species is unknown.

## Genus *Monograptus* Geinitz, 1852 *sensu lato*

**Remarks:** *Monograptus* is used herein as a general label for those species whose precise generic assignment remains uncertain.

### *Monograptus limatulus limatulus* Törnquist, 1892

Pl. VIII, fig. 4; pl. X, fig. 7; pl. XX, figs 3, 6; text-fig. 6, fig. 5; text-fig. 7, figs 4 A, B

- 1892 *Monograptus limatulus* n. sp.; Törnquist, p. 9, pl. 1, fig. 6–8.  
 1897 *Monograptus limatulus* Törnquist; Perner; p. 19, pl. 13, fig. 9.  
 1899 *Monograptus limatulus* Törnquist; Törnquist, p. 14, pl. 2, figs 18–20.  
 1911 *Monograptus limatulus* Törnquist; Elles & Wood, pp. 390, 391; pl. 38, fig. 7 a, b, d (non c); text-fig. 259 a, b, ?c.  
 1941a *Pernerograptus limatulus* (Törnquist 1892); Přibyl (partim), pp. 5, 6; pl. 1, fig. 6 A, B; pl. 2, fig. 9 (non 8, 10).  
 1975 *Monograptus limatulus* Törnquist, 1892; Hutt, pp. 93, 94; pl. 15, figs 1, 2; text-fig. 23, figs 1–6.  
 1975 *Monograptus limatulus* Törnquist, 1892; Bjerreskov, pp. 53, 54; pl. 7 I; text-fig. 16 B.  
 1988 *Monograptus limatulus* Törnquist, 1892; Štorch, (partim), pp. 34–35, pl. 10, fig. 7 (non 1, 6), (non pl. 11, fig. 3); text-fig. 4 J, (non G, I).

**Material:** 33 complete or almost complete flattened rhabdosomes.

**Description:** The rhabdosome has a straight 7–11 mm long, thread-like proximal part. In the mesial part the rhabdosome suddenly widens and bends dorsally for 50–120°; the distal part is almost straight again, being c. 20–30 mm long. In one specimen a 0.8 mm long, slender sicula was observed. The 0.15–0.17 mm wide proximal portion of the rhabdosome is composed by 4–8 non-overlapping thecae terminated with more or less developed, but always small, hooks. The 2TRD is 2.5 mm at th3–th5. No further proximal details have been observed. In its mesial part the rhabdosome widens from 0.2–0.3 mm to 0.75–0.8 mm within 3–4 thecae. The proximal apertural hooks suddenly retreat, occasionally leaving small apertural hoods on 1–2 transitional thecae. The thecae become tubular, slightly geniculate, and overlap for one-half their length. The simple thecal apertures of the distal thecae are perpendicular to the thecal axes. The ventral supragenicular wall inclines at an angle of c. 20° to the rhabdosome axis. The distal part of the rhabdosome is 0.8–0.85 mm wide; distal thecae number 10.5–12.5 in 10 mm (2TRD is 1.7–1.9 mm).

**Remarks:** The rhabdosome slightly varies in both the general shape, length of the thread-like proximal part, and the mesial change of the thecal shape. It may be distinguished from *M. limatulus inopinus* and *M. havliceki* in having a straighter proximal portion, strong mesial dorsal curvature with rapid change of the thecal shape which encompass 3–4 thecae, in having small apertural hoods occasionally developed on 1–2 transitional mesial thecae, and in having a straightened distal portion. *M. limatulus limatulus* is confined to the *convolutus* Biozone.

### *Monograptus limatulus inopinus* Törnquist, 1899

Pl. VIII, figs 3, 5; text-fig. 7, figs 3 A–C

- 1899 *Monograptus inopinus* n. sp.; Törnquist, p. 10, pl. 1, figs 23–26.  
 1911 *Monograptus limatulus* Törnquist; Elles & Wood (partim), pp. 390, 391; pl. 38, fig. 7 c (non a, b, d); non text-fig. 259 a–c.  
 1941a *Pernerograptus limatulus* (Törnquist 1892); Přibyl (partim), pp. 5, 6; pl. 2, figs 8, 10 (non 9).  
 1988 *Monograptus limatulus* Törnquist, 1892; Štorch, (partim), pp. 34–35, pl. 10, figs 1, 6 (non 7), pl. 11, fig. 3; text-fig. 4 G, I (non J).  
**Holotype:** By monotypy. The specimen figured by Törnquist (1892) on pl. 1, figs 23–26, from the *folium* Biozone of Tomarp, Sweden.  
**Material:** 55 flattened rhabdosomes of which some are complete but the majority with the thread-like proximal parts broken off, 8 immature rhabdosomes composed of a sicula and several thecae.

**Diagnosis:** Arcuate rhabdosome with dorsal curvature accentuated near an almost straight proximal part composed of 4–6 axially elongated thecae. Sicula 0.5–0.6 mm long. Beginning with th4–6 the rhabdosome widens from 0.2 mm to 0.7–0.75 mm in the course of the next 6–7 thecae and then gradually to the maximum of 0.9 mm. The small apertural hooks of slender proximal thecae retreat leaving tiny apertural hoods over several transitional thecae. The slightly geniculate, pristiograptid distal thecae number c. 10.5 in 10 mm.

**Description:** The dorsal curvature of this arcuate, more than 50 mm long rhabdosome is strongly accentuated mesially. The proximal part of the rhabdosome is weakly dorsally curved, c. 5–6 mm long, composed of 4–6 elongated thecae with very small, hooked apertures. The sicula is 0.5–0.6 mm long, attaining just below the th1 aperture. The sicular aperture is 0.12 mm wide. The dorso-ventral width of the rhabdosome is 0.18–0.2 mm at th3. The 2TRD is 1.9–2.0 mm at th3. Beginning with th4–th6 the rhabdosome widens rapidly to 0.7–0.75 mm in the course of the next 6–7 thecae and bends for 120–180°. The proximal apertural hooks retreat, leaving small apertural hoods on several transitional thecae. The distal part of the rhabdosome is 0.9 mm wide and slightly but distinctly dorsally curved. Distal thecae are tubular, slightly geniculate, overlapping for one-half their length. They number c. 10.5 in 10 mm (2TRD is 1.8–1.9 mm). The simple apertures are straight, often slightly concave, perpendicular to the thecal axes. The ventral supragenicular walls incline at c. 25° to the rhabdosome axis.  
**Remarks:** *M. inopinus*, described by Törnquist (1892) from the *folium* Biozone of Sweden, was not reported subsequently although it was often represented among their figured specimens. No proximal end was preserved in the type material of *M. inopinus*. Törnquist (1892) stressed out that the distal fragments can be easily mistaken for the corresponding fragments of *M. limatulus*. The collection from Tmaň yields many specimens, from both the *leptothea* Biozone and the lower part of the *convolutus* Biozone, which compare well with the rhabdosome figured by Törnquist (1892) and also includes those which demonstrate the proximal development of this form. *M. limatulus inopinus* is regarded here as an older, possibly ancestral subspecies of *M. limatulus limatulus* from which it is distinguishable by its more dorsally curved rhabdosome, shorter and slightly curved proximal portion, more gradual change of the thecal form



and more gradual increase in the dorso-ventral width of the rhabdosome.

### *Monograptus havliceki* Štorch, 1988

Pl. VIII, figs 1, 2; pl. IX, fig. 3; text-fig. 7, fig. 2

1988 *Monograptus havliceki* sp. n.; Štorch, pp. 35–37, pl. 11, figs 1, 2; pl. 12, fig. 4; text-fig. 4 A, F.

**Holotype:** The specimen no. PŠ 269 figured by Štorch (1988, pl. 11, fig. 1; text-fig. 4 A) from the *leptotheca* Biozone (mid-Aeronian, originally middle *convolutus* Biozone) of Svatý Jiří near Tmaň, Bohemia.

**Material:** 32 more or less complete flattened rhabdosomes and many fragments.

**Description:** Rhabdosome is gently dorsally curved becoming almost straight distally. The longest, still incomplete specimen is 80 mm long. A proximal end with sicula has not yet been found. Very slender, elongated early thecae are terminated by small hooks which retreat rapidly, being replaced by small apertural excavations covered by apertural hoods. The dorso-ventral width of the rhabdosome is 0.22–0.3 mm at this level, 2TRD being 1.9 mm. Thereafter the rhabdosome gradually widens, attaining 0.6 mm after the next *c.* 10 thecae. These mesial thecae are geniculate and overlap for *c.* one-third their length. The ventral supragenicular walls incline at 5–10° to the rhabdosome axis. The apertures of monoclimalid appearance are placed in small apertural excavations and possess small apertural hoods composed of the dorsal thecal wall. The 2TRD is 1.6–1.8 mm in the mesial part of the rhabdosome. Thereafter the rhabdosome widens very gradually to a maximum width of 0.8–0.9 mm. The distal thecae are simple, slightly geniculated tubes with normal, straight apertures. They overlap for one-half their length. Ventral supragenicular walls incline at *c.* 10–15° to the rhabdosome axis. The distal thecae number 10.5–12.5 in 10 mm (2TRD is 1.65–1.85 mm).

**Remarks:** *M. havliceki* is common in the *leptotheca* Biozone. It belongs within the biform monograptid stem which originated from *M. chrysalis* Zalasiewicz or related taxa and gave rise to the specialized, extremely biform *M. limatulus* which is last representative. *M. havliceki* may be distinguished from *M. limatulus inopinus* and *M. limatulus limatulus* by its gradually widening rhabdosome, gradual change from hooked proximal thecae, across about 10 hooded monoclimalid thecae, to slightly geniculate almost pristiograptid distal thecae. The species differs from *Monoclimacis?* sp. (Hutt 1975) and *M. imago* Zalasiewicz in having a more robust rhabdosome with a gradual but distinctive change in thecal shape mesially, and slightly geniculated thecae distally.

### *Monograptus aff. imago* Zalasiewicz, 1992

Pl. VIII, fig. 6; text-fig. 7, figs 5 A, B

aff. 1975 *Monoclimacis?* sp.; Hutt, p. 57, pl. 13, fig. 1; text-fig. 13, figs 1, 2.

aff. 1992 *Monograptus imago* sp.nov.; Zalasiewicz, p. 782, fig. 1 o–w.

**Material:** 6 almost complete rhabdosomes and several fragments including proximal part.

**Description:** The rhabdosome attains more than 80 mm in length and is slightly dorsally curved throughout. The most proximal part with sicula has not been recorded. The proximal 6–8 thecae, as recorded in the present material, are very slender, elongated, parallel sided, terminated by small apertural hooks or hoods. The dorso-ventral width of the rhabdosome is 0.17 mm at this level, the 2TRD being 1.9 mm. The next 5–10 thecae are distinctly geniculate and have narrow apertural excavations of monoclimalid appearance, covered by rapidly retreating apertural hoods. The dorso-ventral width of the rhabdosome increases from 0.3 mm to 0.45 mm at this level. Thereafter the rhabdosome widens very slowly, attaining a maximum width of 0.6 mm (exceptionally 0.7 mm). Distal thecae are simple, geniculate tubes with normal, straight apertures. They overlap for one-third to two-fifths their length and number 11.5 in 10 mm (2TRD is *c.* 1.7 mm). Ventral supragenicular walls incline at 10° to the rhabdosome axis.

**Remarks:** The present material designated as *M. aff. imago* Zalasiewicz differs from closely related *Monoclimacis?* sp. (Hutt 1975) and *M. imago* Zalasiewicz in having a long and extremely slender (less than 0.2 mm wide) proximal end, more densely packed and, in the distal part of the rhabdosome, less geniculate thecae. *M. aff. imago* differs from *M. havliceki* in its narrower rhabdosome and more gradual change from slender hooked or hooded most proximal thecae, through hooded and geniculate monoclimalid mesial thecae to simple, slightly geniculate distal thecae. The latter two forms are being found together in the *leptotheca* Biozone at Tmaň but the stratigraphic range of *M. aff. imago* continues higher up to the lower part of the *convolutus* Biozone.

### *Monograptus respectabilis* n. sp.

Pl. XI, fig. 2; pl. XIX, fig. 1; text-fig. 7, figs 1 A–C

1988 *Monograptus?* sp.; Štorch, pp. 38, 39; pl. 1, figs 4, 5; text-fig. 4 K, L.

**Holotype:** The specimen no. PŠ 768 figured on text-fig. 7, fig. 1 A; from the *leptotheca* Biozone (mid-Aeronian) of Svatý Jiří near Tmaň, Bohemia.

**Material:** More than 50 more or less fragmentary flattened rhabdosomes.

**Diagnosis:** Rhabdosome slender, straight or weakly dorsally curved, very slowly widening from *c.* 0.1 mm to a maximum of 0.4 mm. Thecae elongate, weakly geniculate, terminated by straight, slightly everted apertures overhung by slender hoods. The thecae number 7.5–9 in 10 mm, overlap for one-sixth to one-fifth their length mesially, and for one-fourth to one-third distally. Ventral supragenicular walls incline at 4–8°. The thecal aperture takes *c.* two-fifths the rhabdosome width. **Description:** Fragments of slender, straight or weakly dorsally curved rhabdosomes, up to 60 mm long, have

been found, including one proximal end with an indistinct sicula. The sicular aperture is 0.1 mm wide and possesses a 0.25 mm long virgella. The rhabdosome gradually and very slowly widens from *c.* 0.1 mm to the maximum width 0.4 mm which is attained at least 80 mm from the proximal end. Details of the several most proximal thread-like thecae are unknown. The next thecae are elongate, slightly geniculate, terminated by straight, slightly everted apertures which are regularly overhung by slender hoods. The present material suggests that the apertural hoods are derived from the dorsal thecal wall. In the 0.28–0.32 mm wide fragments the thecae overlap for one-sixth to one-fifth their length. Ventral supragenicular walls incline at 4–6° to the rhabdosome axis. In the most distal fragments, 0.35–0.4 mm wide, the thecae incline at 5–8° and overlap for one-fourth to one-third their length. The thecal apertures occupy *c.* two-fifths the dorso-ventral width of the rhabdosome. The thecae number 7.5–9 in 10 mm throughout the entire length of the rhabdosome (2TRD is 2.1–2.9 mm).

**Remarks:** *Monograptus respectabilis* n. sp. may be distinguished from *Pristiograptus fragilis* Rickards, *Monograptus jonesi* Rickards and similar forms by its slightly geniculated, more overlapping thecae which possess a slit-like apertures covered by slender hoods. *M. respectabilis* n. sp. occurs in the *leptotheca* Biozone. In according to the thecal form it seems to be related to *M. limatulus*, *M. havliceki* and other hooded biform monograptids from which it may be easily distinguished by its almost straight and slender rhabdosome. *M. imago* Zalasiewicz differs from *M. respectabilis* by its more geniculate thecae and more robust, dorsally curved proximal portion of the rhabdosome which is 0.45 mm wide at th10.

### ***Monograptus dracocephalus* n. sp.**

Pl. XIII, fig. 6; text-fig. 8, figs 4 A–C

**Holotype:** The specimen no. PŠ 756 figured on pl. XIII, fig. 6; text-fig. 8, fig. 4 B; from the *leptotheca* Biozone (mid-Aeronian) of Svatý Jiří near Tmaň, Bohemia.

**Material:** 14 complete flattened rhabdosomes and many fragments.

**Diagnosis:** Rhabdosome slender, dorsally curved for *c.* 90° in its proximal part which encompasses 2–4 thecae, and generally straight more distally. Sicula 0.7–0.9 mm long, often ventrally curved, with a weak dorsal apertural lobe. Elongated, non-overlapping thecae low-triangular in profile, 0.35 mm high throughout the entire length of the rhabdosome. Proximal thecae with small apertural hooks terminated with tiny dorso-lateral spines; distal thecae without spines. 2TRD 1.9–2.9 mm at th2, distal thecae number 6.5–7 in 10 mm.

**Description:** The rhabdosome is slender, more than 20 mm long. It is dorsally curved for *c.* 90° in the proximal part which encompasses 2–4 thecae and generally straight more distally. The sicula is 0.7–0.9 mm long and, in many specimens, ventrally curved. Its apex attains one-

quarter to one-third up th1. The sicular aperture is 0.15–0.2 mm wide, simple or, in some specimens, provided with a weak dorsal lobe. The virgella is 0.25 mm long. Elongated and non-overlapping thecae are low-triangular in profile. The ventral walls of the proximal thecae incline at 10–12° and in distal thecae at 15–20° to the rhabdosome axis. The proximal thecae are terminated by small apertural hooks with short, probably paired spines which originate from the dorsal wall of the ventro-proximally facing aperture. The distal thecae have hooked, proximally facing apertures without spines. Th1 is 0.75–0.9 mm long and 0.3–0.35 mm high. The dorso-ventral width of the rhabdosome of *c.* 0.35 mm is maintained until the most distal thecae. The 2TRD is 1.9–2.9 mm at th2, and thereafter increases to 2.5–3.0 mm. The thecae number 6.5–7 in 10 mm in the straight distal part of the rhabdosome.

**Remarks:** Tiny rhabdosomes of *M. dracocephalus* n. sp., confined to the *leptotheca* Biozone and lower part of the *convolutus* Biozone, may be easily overlooked. The present species resembles *M. capis* Hutt in having a slender rhabdosome with isolated, low-triangular thecae. It may be distinguished, however, by its dorsally curved proximal part, ventrally curved sicula, and slightly spinose proximal thecae. *M. capis* has more expanded distal parts of the prothecae and more prominent apertural hooks.

### ***Monograptus mirus* Perner, 1897**

Pl. XIII, figs 1, 3, 4; text-fig. 8, figs 1 A, B

1897 *Monograptus mirus* Barr. MS; Perner, pp. 26, 27; pl. 12, figs 1, 2, ?3, non 4.

1944 *Spirograptus mirus* (Perner, 1897); Přibyl, p. 24.

**Lectotype:** Designated by Přibyl (1944); specimen no. L31165 figured by Perner (1897, pl. 12, fig. 1) from the *leptotheca* Biozone (mid-Aeronian) of Litohlavy near Beroun, Bohemia.

**Material:** More than 30, mostly incomplete or fragmentary specimens showing different parts of the rhabdosome.

**Diagnosis:** Rhabdosome slender, enrolled in a loose helical spiral with a somewhat straighter, irregularly curved distal portion. The second whorl measures 6–7 mm in diameter. The initial 3–4 thecae are situated on the dorsal side of the spiral, thereafter the rhabdosome axis twists gradually, bringing the thecae successively to both concave and convex sides. The thecae are isolated, having robust, rather expanded triangular prothecae and small, simply hooked metathecae with proximally facing apertures. The rhabdosome slowly widens from 0.2–0.3 mm proximally to 0.4–0.6 mm distally. Thecae number 7.5–10 in 10 mm.

**Description:** The slender rhabdosome is enrolled into a loose helical spiral. A maximum of 2.5 whorls have been recorded. The second whorl measures *c.* 6–7 mm in diameter. The distal portion of the rhabdosome irregularly curves and/or almost straightens. The small, *c.* 0.8 mm long sicula reaches about the level of the aper-

tural hook of th1. The initial 3–4 thecae are situated on the dorsal side of the spiral, thereafter the rhabdosome axis twists and gradually brings the thecae to the concave side of the spiral. Axial twisting of the rhabdosome continues until the distal portion of the rhabdosome is reached. The thecae are isolated, triangular in shape, having robust, rather expanded triangular prothecal parts and small, simply hooked metathecal parts with proximally facing apertures. Ventral prothecal walls are inclined at an angle of 30–40° to the rhabdosome. The rhabdosome widens from 0.2–0.3 mm at the level of th1 to 0.3–0.5 mm at th2, thereafter the dorso-ventral width (thecal height) very slowly increases to 0.4–0.6 mm distally. The 2TRD is 1.7–1.9 mm at th2, 1.6–1.8 mm at th5 and 1.9–2.1 at th10. Distal thecae number 7.5–10 in 10 mm (2TRD of 2.0–2.7 mm).

**Remarks:** *Monograptus mirus* Perner ranges from the *simulans* Biozone to the *convolutus* Biozone. Its stratigraphical range is similar to that of *Monograptus calamistratus* Churkin & Carter, 1970 and *Monograptus changyangensis* Sun which both have slender, spirally coiled rhabdosomes similar to *M. mirus*. *M. calamistratus* and *M. changyangensis*, however, may be distinguished from *M. mirus* by their spinose thecae which are almost regularly perpendicular to the spiral plane. The rhabdosome of *M. mirus* is even more slender, having a variably curved and/or straightened distal portion. *Torquigraptus involutus* (Lapworth) differs in its robust rhabdosome and laterally twisted thecal apertures. A possible successor to *M. mirus* – *Monograptus gemmatus* (Barrande) – has a similar, though less enrolled, proximal part of the rhabdosome, but a wider (0.85 mm) distal portion and less isolated, low-triangular distal thecae. Proximal and mesial thecae of *M. gemmatus* do not exhibit the remarkably expanded prothecal bases developed in *Monograptus mirus* Perner.

### *Monograptus capillaris* (Carruthers, 1867)

Pl. XIII, fig. 2; pl. XIX, fig. 6; text-fig. 8, fig. 3

1867 *Rastrites capillaris*, Carruthers, p. 368, pl. 2, fig. 10.

1868 *Rastrites capillaris* Carruthers, Carruthers, p. 126, pl. 5, fig. 16.

1913 *Monograptus gemmatus* (Barrande); Elles & Wood, pp. 436, 437; pl. 43, fig. 5 a–e; text-fig. 300 a–c.

1952 *Monograptus* (?subgen.) *capillaris* (Carruthers, 1868); Bouček & Přibyl, pp. 22, 23; text-fig. 4 d–f.

non 1953 *Diversograptus capillaris capillaris* (Carruthers, 1868); Bouček & Přibyl, pp. 496, 498, 499; pl. 1, figs 1–3; text-fig. 2, figs 7–12.

non 1993 *Paradiversograptus capillaris* (Carruthers, 1867); Loydell, pp. 145–147; text-fig. 23, figs 6, 11, 21; text-fig. 25, fig. 5.

1969 *Diversograptus? capillaris* (Carruthers); Strachan, pp. 198–200; text-fig. 6 a, b.

?1996 *Monograptus capillaris* Carruthers, 1867; Zalasiewicz, pp. 9, 11; text-fig. 4 N–Q.

**Material:** three complete rhabdosomes and several fragments.

**Description:** The rhabdosome is very slender, usually weakly dorsally curved. The sicula is *c.* 0.8 mm long and has a 0.12–0.15 mm wide aperture with a tiny vir-

gella. The non-overlapping thecae have thread-like prothecal parts and small, triangular metathecae. No apertural hooks or other details are visible on thecal apertures. The rhabdosome widens gradually from 0.15–0.2 mm at th1 to *c.* 0.25 mm at th5. Distally the rhabdosome maintains a width of 0.4–0.55 mm. The 2TRD is 2.3–3.0 mm at th2 and 2.65 mm at th5. Distal thecae number *c.* 7.5 in 10 mm.

**Remarks:** The present material match well the specimens figured by Elles & Wood (1913) and does not differ from the type material revised by Strachan (1969). In contrast to the specimens described from the upper *sedgwickii* and *linnaei* Biozones by Bouček and Přibyl (1953) and Loydell (1993) no diversograptid development was recorded in the present and Bouček and Přibyl's (1952) specimens from the *convolutus* Biozone. There is no reason to place this material in *Diversograptus* or *Paradiversograptus*. „*Paradiversograptus capillaris*“ from the *sedgwickii* and *linnaei* Biozones differs from the present material in clearly hooked thecae and a variously curved bipolar proximal end. The dorso-ventral width of the rhabdosome and thecal count in 10 mm are the same. *M. capis* may be easily distinguished from the present material by its markedly broadened distal parts of the prothecae and by prominent apertural hooks.

### *Monograptus paradenticulatus* Zalasiewicz, 1996

Pl. X, fig. 6; pl. XX, fig. 1; text-fig. 8, figs 7 A, B

1913 *Monograptus denticulatus* Törnquist, 1899; Elles & Wood, pp. 474–475, pl. 48, figs 2 a–f; text-fig. 330.

1958 *Monograptus denticulatus* Törnquist; Sudbury, pp. 509–510, pl. 21, figs 72, 73.

1970 *Monograptus denticulatus* Törnquist, 1899; Rickards, pp. 83–84, pl. 7, fig. 3; text-fig. 17, figs 5, 6.

1975 *Monograptus denticulatus* Törnquist, 1899; Hutt, p. 88, pl. 22, fig. 2; pl. 23, figs 1, 4.

1991 *Monograptus denticulatus sensu* Sudbury 1958; Loydell, pp. 684, 686; pl. 3, fig. 8.

1996 *Monograptus paradenticulatus* n. sp.; Zalasiewicz, pp. 11, 12; text-figs 4 R–S.

**Material:** 12 complete and some fragmentary specimens.

**Description:** The rhabdosome is *c.* 20 mm long (a maximum length of 40 mm was observed), dorsally curved, commonly fish-hook shaped in the proximal part. The apex of 0.7 mm long sicula attains the dorsal wall of the earliest metatheca. The first 4–6 thecae are slender, rastritiform, with small apertural hooks and wide interspaces. Th2 is 0.7 mm high and 0.15 mm thick, th5 is 1.0–1.2 mm high and 0.25–0.35 mm thick. Beginning with the th5 the metathecal tubes considerably broaden. Th10 is 1.1–1.2 mm high and 0.6 mm wide. Mesial and distal thecae are terminated by prominent apertural hooks with semicircular outlines and dorsally facing apertures. The thecal interspaces become less prominent but the metathecae are still isolated, without any overlap. The dorso-ventral width of the rhabdosome gradually increases to 1.35 mm at th20. The longest rhabdosome is

1.5 mm across 40 mm from the proximal end. The prothecal tubes are *c.* 0.1 mm wide in the proximal part of the rhabdosome, distally broaden to 0.2 mm at th10 and the maximum of 0.3 mm was observed in the most mature specimens. The 2TRD is 1.7–1.9 mm at th5, 2.1–2.3 mm at th10 and 2.6–2.7 mm at th30.

**Remarks:** *Monograptus paradenticulatus* Zalasiewicz is recorded from the lower part of the *leptotheca* Biozone at Tmaň. *Torquigraptus denticulatus* – the typical component of the *convolutus* Biozone assemblage – may be distinguished from *M. paradenticulatus* by its laterally twisted metathecae and less inclined 2–3 proximal thecae.

### *Monograptus simulans* Pedersen, 1922

Pl. XVI, fig. 4; text-fig. 6, fig. 7

1922 *Monograptus simulans* n. sp.; Pedersen, p. 21, figs 5 a–e.

1953 *Demirastrites pribyli* n. sp.; Bouček, p. 434; text-fig. 1.

1975 *Monograptus simulans* Pedersen, 1922; Bjerreskov, p. 79, fig. 23 E.

1980 *Demirastrites pribyli* Bouček, 1953; Štorch, pp. 307–308, pl. 1, figs 1, 2, ?3, 4, 5; pl. 2, figs 1, 2; text-fig. 1.

**Material:** 6 complete or nearly complete immature rhabdosomes, several distal fragments.

**Diagnosis:** Rhabdosome dorsally coiled in an open spiral. About ten proximal thecae typically rastritiform, with thread like prothecae and isolated slender metathecae *c.* normal to the rhabdosome and terminated with small apertural hooks. Thecal height 0.8 mm at th1, the maximum of 1.7–1.9 mm attained at th6–7. Between the th8 and th18, the thecae become more robust, with 0.2–0.25 mm wide prothecae and 0.5 mm wide metathecae with pronounced apertural hooks. Thecal height decreases to 1.4–1.5 mm, thecal interspaces narrow and thecal inclination decreases to 70°. The 2TRD is 1.5 mm at th2, 1.7–1.8 mm at th5, and 2.1–2.5 mm most distally.

**Description:** The rhabdosome is dorsally coiled in an open spiral and may have attained 100 mm in length. The slender sicula is 0.7–0.8 mm long. Its apex attains up the level of the first metatheca. About ten proximal thecae are typically rastritiform, with thread like, parallel-sided prothecae (*c.* 0.1 mm wide) and isolated slender metathecae 0.15–0.2 mm in diameter. Th1 is *c.* 0.8 mm high, th2 is 1–1.1 mm high, th5 is 1.5–1.6 mm

high. The maximum thecal height of 1.7–1.9 mm is attained at th6–7. Widely separated proximal thecae are inclined at an angle of 70–85° to the rhabdosome axis. The thecae terminate with small but significant apertural hooks with dorsally facing apertures. In the mesial part of the rhabdosome, between th8 and about th18, the thecae gradually change their outline and dimensions. The initial portion of the prothecal tube widens to 0.2–0.25 mm and the ventral prothecal wall inclines at *c.* 5° to the rhabdosome axis. The thecal hooks become more pronounced, metathecal tubes becoming more robust, 0.5 mm wide and the thecal height decreases to 1.4–1.5 mm. Thecal interspaces become narrower and the thecal inclination is *c.* 70°. The 2TRD is *c.* 1.5 mm at th2, 1.7–1.8 mm at th5, and slowly increases to 2.1–2.5 mm in the distal part of the rhabdosome.

**Remarks:** Bohemian specimens of *Monograptus simulans* have been described as a new species *Demirastrites pribyli* by Bouček (1953) and Štorch (1980). This species, which characterizes a distinct stratigraphic interval between the *Dem. pectinatus* and *M. convolutus* biozones, has been also used as an index fossil of the eponymous biozone by Bouček (1953), Kříž (1975), and Štorch (1980). Recent studies, however, has shown that the Bohemian material corresponds well to *Monograptus simulans* Pedersen in both its morphology and stratigraphical range. Štorch (1994) regarded *Dem. pribyli* Bouček, 1953 as a junior synonym of *M. simulans* Pedersen, 1922. Proximal fragments of *M. simulans* might be confused with some rastritids (namely *R. geinitzii*) from which it differs by a lesser thecal height and a distinct increase in the metathecal width which is observable from about the th6. *Rastrites orbitus* Churkin & Carter may be distinguished from *M. simulans* by its shorter proximal thecae (th5 is 1.1–1.2 mm long in *R. orbitus* as opposed to 1.6 mm in *M. simulans*), and uniform thecal appearance. A gradual change from slender rastritiform proximal thecae to robust distal thecae has not been observed in *R. orbitus*. *M. paradenticulatus* Zalasiewicz differs from *M. simulans* in its shorter thecae and a more rapid change from its few proximal rastritiform thecae to the robust, hooked distal thecae. Closely similar distal fragments may be distinguished by the lesser thecal height of *M. paradenticulatus* (1.35 mm).

Fig. 8. 1 A, B *Monograptus mirus* Perner; 1 A – PŠ 781, 1 B – PŠ 839 (proximal part and two distal fragments). ⇨

2 *Torquigraptus urceolinus* (Stein); PŠ 907.

3 *Monograptus capillaris* (Carruthers); BB 696 (proximal and distal fragments).

4 A–C *Monograptus dracocephalus* n. sp.; 4 A, B – PŠ 756 (holotype—complete specimen figured on fig. 4 B), 4 C – PŠ 825.

5 *Torquigraptus cf. valens* (Přibyl & Münch); PŠ 800.

6 A–C *Torquigraptus denticulatus* (Törnquist); 6 A – PŠ 917, 6 B – PŠ 855, 6 C – 858/2.

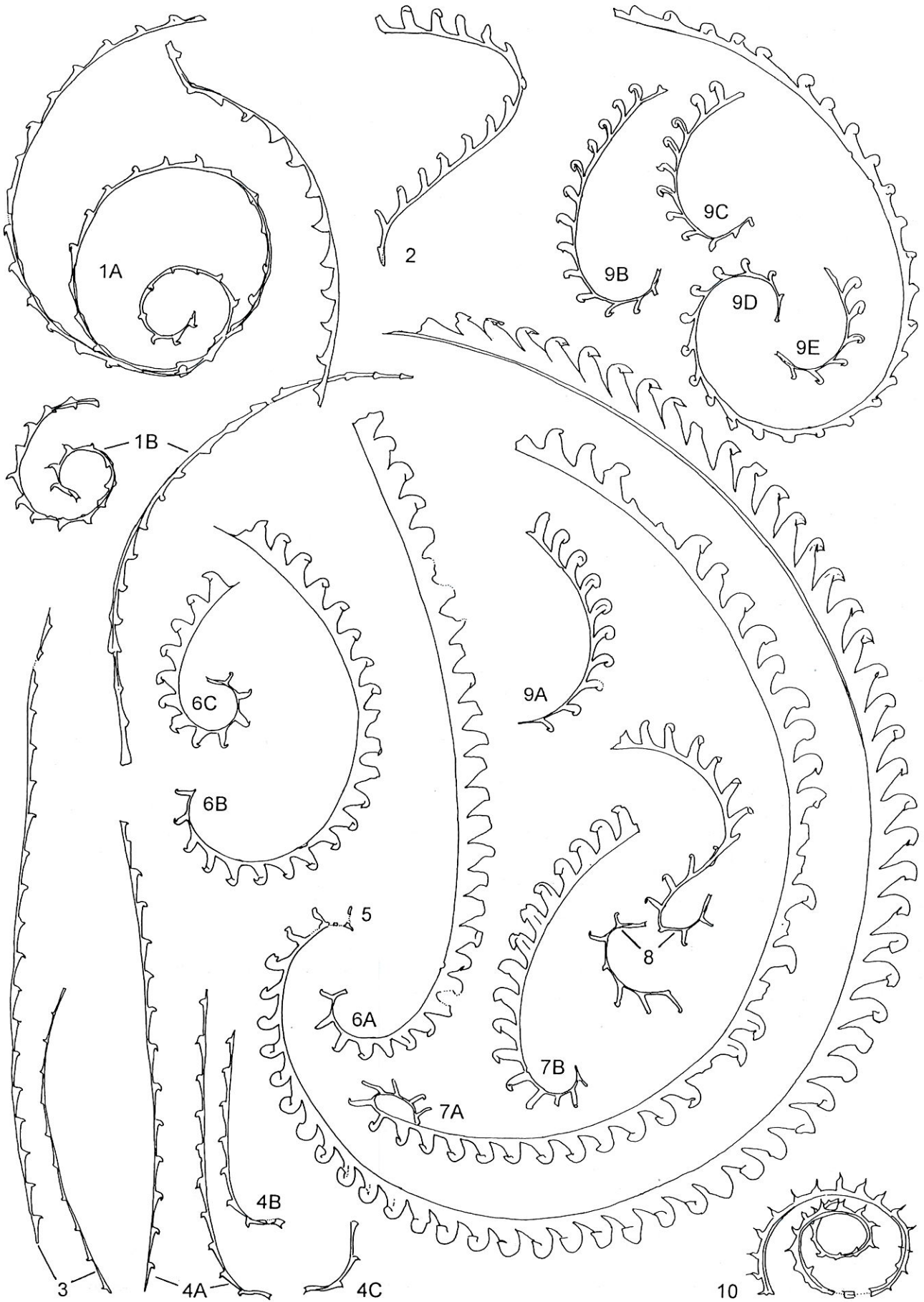
7 A, B *Monograptus paradenticulatus* Zalasiewicz; 7 A – PŠ 839, 7 B – PŠ 807.

8 *Torquigraptus? decipiens* (Törnquist); PŠ 716a.

9 A–E *Monograptus mirificus* n. sp.; 9 A, E – PŠ 761, 9 B, C – PŠ 795, 9 D – BB 693 (holotype).

10 *Spirograptus* sp.; PŠ 831.

All specimens x5. Specimens on figs 4 A–C, 5, 7 A, B, 9 A–E and 10 from the *leptotheca* Biozone, specimens on figs 1 A, B, 2, ?3, 6 A–C and 8 from the *convolutus* Biozone.



***Monograptus* sp. (aff. *simulans* Pedersen)**

Text-fig. 9, fig. 1

Material: Four incomplete specimens.

**Description:** The dorsally coiled rhabdosome attains 30–40 mm in length. The sicula is 0.8 mm long, attaining just above the dorsall wall of the first metatheca. The thecae are slender, hooked, rastritiform, separated by wide interspaces. The proximal thecae are perpendicular to the rhabdosome, distal thecae being inclined at *c.* 60°. Th2 is 0.75 mm high, th5 is 1.25 mm high and the maximum thecal height of 1.35 mm is attained at about th10. The 2TRD is 1.9 mm at th5, distally the 2TRD increases to *c.* 2.3 mm.

**Remarks:** This form differs from *L. richteri* (Perner) and *M. simulans* Pedersen in its shorter, distally less robust thecae. In contrast to the two latter species the apertural hooks persist in the distal thecae of *M.* sp. (aff. *simulans*). It may be also distinguished from *T.?* *decipiens* Törnquist by its more slender and less densely packed distal thecae. *M. mirificus* n. sp. and *T. cf. valens*, which both occur at the same level of the *leptotheca* Biozone, may be distinguished from *M.* sp. (aff. *simulans*) by their shorter, less isolated thecae with prominent hooks.

***Monograptus mirificus* n. sp.**

Pl. XVI, figs 2, 5; text-fig. 8, figs 9 A–E

**Holotype:** Specimen no. BB 693 figured on pl. XVI, fig. 5; text-fig. 8, fig. 9 D; from the *leptotheca* Biozone (mid-Aeronian) of Svätý Jiří near Tmaň, Bohemia.

**Material:** 32 specimens, more or less complete, including three mature rhabdosomes.

**Diagnosis:** The rhabdosome with its proximally accentuated dorsal curvature forms an open spiral composed of 1–2 whorls. Proximal thecae are isolated, rastritiform, narrow at the base, broadening at the level of the prominent apertural hook and inclined at 50–70°. Apertures face dorso-proximally. Towards the distal part of the rhabdosome the metathecae become more robust, separated by narrower interspaces and situated obliquely or perpendicularly to the spiral plane. Thecal height is 0.5 mm at th1, 0.85–0.95 mm at th10 and up to 1.3 mm most distally. The 2TRD is 1.6 mm at th2, 1.6–2.3 mm mesially and 2.6–2.7 mm distally.

**Description:** Although the majority of the material comprises immature, some 10–20 mm long rhabdosomes, several specimens exceed 60–80 mm in length. These form an open, probably planar spiral composed of one or two whorls. The dorsal curvature of the rhabdosome is accentuated proximally. The small, 0.6–0.75 mm long, slightly ventrally curved sicula has a 0.12 mm wide aperture with a short tiny virgella and a weak ventral lobe. The sicular apex attains the point of origin of the first metatheca. Isolated rastritiform thecae are terminated by prominent hooks which give the apertural part of the theca a characteristic nodular appearance. The metathecal tube is

narrow at the base and widens up to the level of the apertural hook. Proximal thecae are parallel to the spiral plane. Ventral walls of the slender, *c.* 0.1 mm wide prothecae incline at an angle of less than 5° to the rhabdosome axis. The metathecae of th1 and th2 are *c.* 0.5 mm long, inclined at 50–70° to the rhabdosome axis. The apertures face dorso-proximally, being partly covered by extended dorsal thecal walls. The following metathecae gradually become more robust, being separated by still narrower interspaces. Th5 is 0.75 mm high, th10 is 0.85–0.95 mm high. The apertures of the distal thecae face slightly laterally. The true dorso-ventral width of the distal part of the rhabdosome (*c.* 1.3 mm) is rarely seen as the mesial and distal thecae are oblique or even perpendicular to the spiral plane. Also some apertural details may be obscured by the oblique orientation of the distal thecae. The initial width of the distal prothecal tubes is 0.3 mm, exceptionally 0.4 mm in the most mature, 80 mm long specimen. The 2TRD is 1.6 mm at th2, 1.7–2.0 mm at th5, 1.6–2.3 mm at th10, and 2.6–2.7 mm most distally.

**Remarks:** *M. mirificus* n. sp. is common in the *leptotheca* Biozone. It is easily distinguished from *T. denticulatus* by its more isolated, gracile and typically arcuate metathecae, expanded at the level of the apertural hook expanded and never triangulate. The width of the metathecal tube increases rapidly in the proximal part of the rhabdosome in *T. denticulatus*. *M. paradenticulatus*, another species with a dorsally coiled rhabdosome and isolated, rather robust, hooked distal metathecae, has several slender, rastritiform proximal thecae. All its thecae are parallel to the plane of the rhabdosome spiral. Proximal portions of *M. mirificus* might be confused with *T. cf. valens* (Příbyl & Münch) which may be distinguished, however, by its less coiled proximal end and longer, laterally twisted mesial metathecae (th5 is 0.9 mm and th10 is 1.1 mm long). The distal parts of the two species are easily distinguishable. *M. mirificus* is more gracile distally and its thecae are oblique to perpendicular to the plane of the rhabdosome spiral. Prothecal bases of *M. mirificus* are narrower, and the metathecae are narrower, without a typical triangular outline.

**Genus *Torquigraptus* Loydell, 1993**

**Type species:** Original designation; *Graptolithus Proteus* var. *plana* Barrande, 1850; from the Llandovery of Bohemia.

**Diagnosis:** after Loydell (1993).

***Torquigraptus denticulatus* (Törnquist, 1899)**

Pl. X, fig. 8; pl. XIX, fig. 5; text-fig. 8, figs 6 A–C

1897 *Monograptus communis* Lapw.; Perner, p. 29, pl. 11, figs 18 a, b; pl. 12, fig. 20 (?5–9); text-fig. 14.

1899 *Monograptus denticulatus* n. sp.; Törnquist, p. 18, figs 19–23. non 1913 *Monograptus denticulatus* Törnquist, Elles & Wood, pp. 474, 475; pl. 48, fig. 2 a, b (?c–f); text-fig. 330.

1941 *Demirastrites denticulatus denticulatus* (Törnquist 1899); Příbyl & Münch, p. 10.

1946 *Demirastrites denticulatus denticulatus* (Törnquist) 1899; Příbyl, pp. 10–12, pl. 1, figs 1–4; text-fig. C 2.

non 1958 *Monograptus denticulatus* Törnquist; Sudbury, pp. 509–510, pl. 21, figs 72, 73; text-figs 4, 12.

1975 *Monograptus denticulatus* Törnquist, 1899; Bjerreskov, pp. 79–80; text-fig. 23 B, C.

non 1975 *Monograptus denticulatus* Törnquist, 1899; Hutt, p. 88, pl. 22, fig. 2; pl. 23, figs 1, 4.

1991 *Monograptus denticulatus* Törnquist, 1899; Loydell, text-fig. 3 A, B.

1996 *Torquigraptus denticulatus* (Törnquist); Zalasiewicz, pp. 5, 9; text-fig. 3 H, I.

**Material:** 8 complete and many incomplete and fragmentary rhabdosomes.

**Description:** The rhabdosome is 10–30 mm long, arcuate, with a proximally accentuated dorsal curvature. The sicula is small, 0.6–0.8 mm long and 0.15 mm wide

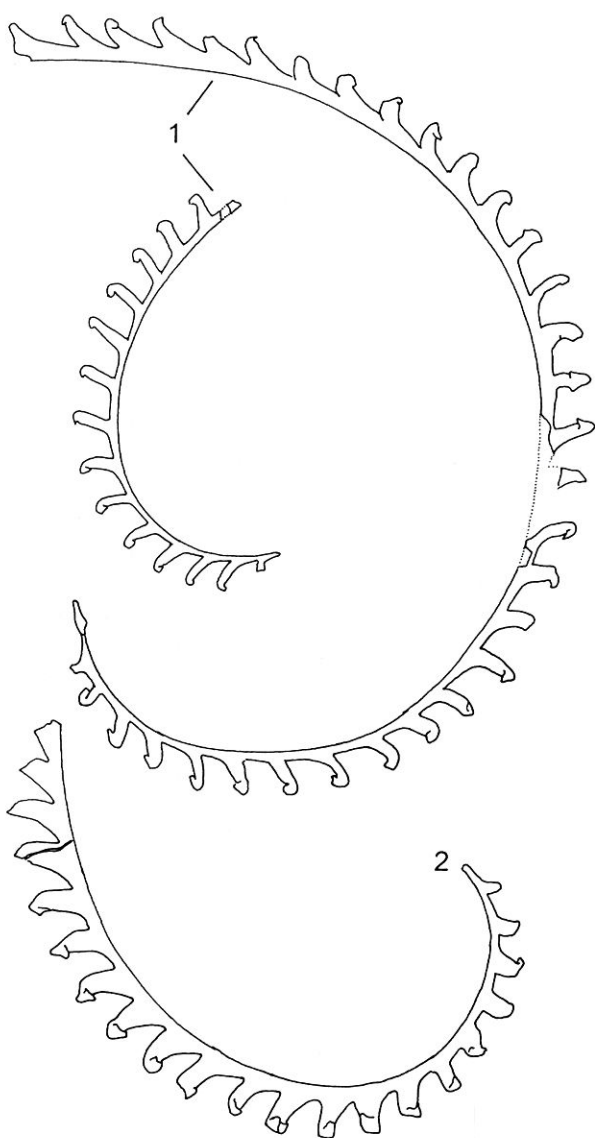


Fig. 9. 1. *Monograptus* sp. (aff. *simulans* Pedersen); PŠ 814.

2. *Torquigraptus? decipiens* (Törnquist); PŠ 922.

All specimens x5. Rhabdosomes on fig. 1 from the *leptotheca* Biozone, rhabdosome on fig. 2 from the *convolutus* Biozone.

at the aperture. The sicular apex attains the level immediately below the point of origin of the first metatheca. The proximal 2–3 thecae are rastritiform, with slender prothecae and slender, isolated metathecae terminated by small, dorsally facing apertural hooks. Th1 is 0.6 mm high and the metatheca inclines at 70–80° to the rhabdosome. Th2 is 0.65–0.8 mm high. The following thecae become robust, high-triangular. Prothecal parts are reduced, apertural hooks twist and face laterally. Some apertures appear to have short, paired, ventro-lateral spine-like processes. Th5 is 0.8–0.95 mm high. The rhabdosome further widens attaining its maximum dorso-ventral width of 1.1–1.25 mm at c. th8–10. The 2TRD increases rapidly from 1.5–1.7 mm at th2 to 2.0–2.2 mm at th10. Distal thecae number 9.5–10 in 10 mm (2TRD is 2.1–2.2 mm).

**Remarks:** The present material matches well the descriptions and illustrations of *M. denticulatus* given by Törnquist (1899), Bjerreskov (1975) a.o. The true *T. denticulatus* indicates the upper part of the *convolutus* Biozone in Tmaň and elsewhere in the Barrandian area. The same stratigraphical range was recorded from Wales (Zalasiewicz 1996). Infrequent finds from the *sedgwickii* Biozone assigned to *T. denticulatus* by Bouček (1953) appear to have simply hooked thecae without lateral twisting.

#### *Torquigraptus? decipiens* (Törnquist, 1899)

Pl. XVI, fig. 3; text-fig. 8, fig. 8; text-fig. 9, fig. 2

1899 *Monograptus decipiens* n. sp.; Törnquist, pp. 20, 21; pl. 4, figs 9–14.

1913 *Monograptus decipiens* Törnquist; Elles & Wood, p. 469 (partim), pl. 47, fig. 3 a, b, e (non c, d); text-fig. 325 a (non b, c).

non 1941 *Demirastrites decipiens decipiens* (Törnquist, 1899); Přibyl & Münch, pp. 13, 14; text-fig. 1, fig. 6.

1958 *Monograptus decipiens* Törnquist, 1899; Sudbury, p. 510, pl. 21, figs 74, 75.

1970 *Monograptus decipiens* Törnquist, 1899; Rickards, p. 83, text-fig. 13, fig. 16; text-fig. 17, fig. 8; text-fig. 18, figs 3, 13.

1975 *Monograptus decipiens* Törnquist, 1899; Bjerreskov, pp. 80, 81; pl. 12 E.

1975 *Monograptus decipiens decipiens* Törnquist, 1899; Hutt, pp. 85, 87; pl. 21, figs 2–4; text-fig. 17, fig. 5; text-fig. 20.

1982 *Monograptus decipiens decipiens* Törnquist, 1899; Lenz, pp. 74–75; figs 6 F, N; 23 A, C, F.

**Material:** Two complete, immature rhabdosomes and more than 20 fragmentary specimens.

**Description:** The rhabdosome is 10–20 mm long, dorsally coiled in a helical spiral. One whorl was recorded in the present material. The sicula is 0.7–0.8 mm long and possesses a 0.1 mm wide aperture. The sicular apex attains up the point of origin of the ventral wall of the first metatheca. About eight proximal thecae are typically rastritiform, with thread like, parallel-sided prothecae and isolated slender metathecae 0.15–0.2 mm in diameter. The thecae are terminated by prominent, dorsally facing apertural hooks. Th1 is 0.55–0.65 mm high, th2 0.65–0.75 mm and th5 c. 0.8 mm. Th10 is 1.0–1.3 mm high and the maximum width is 1.4–1.6 mm in the di-

stal fragments. Widely separated proximal thecae are inclined at an angle of 70–85° to the rhabdosome axis. In the mesial part of the rhabdosome, beginning with *c.* th5, the thecae gradually change their outline and dimensions. The thecae become high-triangular in profile, the width of the metathecal tubes expands to 0.35–0.5 mm, the thecal inclination decreases to 70°, the apertural hooks retreat, the thecal interspaces become narrower, the apertural hooks twist so that the apertures face laterally. The 2TRD is *c.* 1.6 mm at th2, 1.7–1.9 mm at th5, and 2.0–2.4 mm in the distal part of the rhabdosome.

**Remarks:** *Monograptus decipiens* Törnquist is tentatively assigned to *Torquigraptus* with respect to its having laterally twisted apertures in mesial and distal thecae (see also Hutt 1975, pl. 21, fig. 4). *T.?* *decipiens* (Törnquist) is a typical component of the *convolutus* Biozone assemblage in Tmaň and elsewhere in the Barrandian. *Torquigraptus urceolinus* (Stein) which was found at the same level may be distinguished from *T.?* *decipiens* by its more isolated mesial thecae, while its metathecae are separated by wider interspaces. *T. urceolinus* has more delayed and gradual change from typically rastritiform proximal thecae to high triangular distal thecae.

#### ***Torquigraptus urceolinus* (Stein, 1965)**

Text-fig. 8, fig. 2

1913 *Monograptus urceolus*, Richter; Elles & Wood, pp. 470–471, pl. 48, fig. 1 a–d; text-fig. 326 a, b.

1965 *Monograptus urceolinus* sp. n.; Stein, pp. 185–186.

1996 *Torquigraptus urceolinus* (Stein); Zalasiewicz, p. 5, text-fig. 3 A G.

**Material:** Six incomplete specimens and more fragments.

**Description:** The rhabdosome is coiled in a loose, helical spiral. The thecae are isolated, rastritiform, but with laterally twisted apertures. The proximal end has not been found in the present material. Mesial and distal thecae are *c.* 1 mm high, the metathecal tubes being *c.* 0.35 mm wide, inclined at an angle of 60–70° to the rhabdosome axis. The 2TRD is 2.1–2.3 mm.

**Remarks:** *T. urceolinus* (Stein) may be distinguished from other, coeval species by its loose, helical spiral with widely spaced, isolated rastritiform thecae possessing small, laterally twisted apertural hooks. Its more isolated, non-triangular thecae serve to distinguish it from the otherwise similar *T.?* *decipiens* Törnquist. However, Stein (1965) based his new species on the material figured by Elles and Wood (1913) which exhibits triangular distal thecae close to *T.?* *decipiens* figured herein. I am aware that *T. urceolinus* may be just a preservational artefact and the junior synonym of *T.?* *decipiens*.

#### ***Torquigraptus cf. valens* (Přibyl & Münch, 1941)**

Pl. XI, fig. 6; text-fig. 8, fig. 5

*cf.* 1941 *Demirastrites decipiens valens* nov. var.; Přibyl & Münch, pp. 14, 15; pl. 1, fig. 11; text-fig. 1, fig. 8.

**Material:** Two nearly complete and four incomplete rhabdosomes.

**Description:** The mature rhabdosome is at least 80–100 mm long, coiled into an open, planar spiral with 1–2 whorls and a proximally accentuated dorsal curvature. The sicula and th1 are unknown but they probably closely resemble those of *M. mirificus* sp. n. The following proximal thecae are isolated, rastritiform, having thread-like, 0.1 mm wide prothecae and slender, widely separated metathecae which are terminated by prominent apertural hooks. The thecal apertures are laterally twisted and face dorso-proximally, being partly covered by coiled dorsal thecal walls. Thecal height is 0.9 mm at th5, 1.1 mm at th10 and 1.45 mm at th20. The 2TRD is 2.45 mm at th5 and 2.3 mm at th10. Distally the thecae gradually become less isolated, having prominent triangular outlines and small, laterally twisted apertural hooks. Th20 is 1.45 mm high, the maximum width of the rhabdosome – 1.9–2.3 mm – being attained at *c.* th30–35. Distal thecae have ventral metathecal walls inclined at 45–60°, 0.5–0.6 mm wide prothecae and a 2TRD of 2.2–2.6 mm.

**Remarks:** Rare finds of *T. cf. valens* (Přibyl & Münch, 1941) from the *leptothea* Biozone differ from the type material of „*Demirastrites*“ *valens* Přibyl & Münch from the *sedgwickii* Biozone of Thuringia in a more gracile proximal part of the rhabdosome with shorter metathecae. Distal parts look even more similar, the only differences being in the more prominent apertural hooks and lower thecal inclination of *T. cf. valens*. Both forms appear to have laterally twisted mesial and distal metathecae. On the other hand the proximal parts and immature rhabdosomes of *T. cf. valens* are very similar to *M. mirificus* n. sp. The two species may be easily confused as the proximal and mesial thecae have almost the same outline, and lateral twisting of the apertural hooks is not always recognizable in the mesial thecae of *T. cf. valens*. Distal portions of the present rhabdosomes, however, are easily distinguishable from those of *M. mirificus* by their broad prothecal tubes and robust, high-triangular metathecae with small, laterally twisted apertural hooks.

#### **Genus *Campograptus* Obut, 1949; emend. herein**

**Type species:** Original designation; *Monograptus convolutus* var. *communis* Lapworth, 1876, from the Llandovery of Scotland.

**Diagnosis:** Rhabdosome moderately to strongly dorsally curved proximally, becoming almost straight distally. Thecae triangular with no overlap, broad prothecal bases and simply hooked metathecae. The thecal hook involves both dorsal and ventral thecal wall. The nearly rounded apertures of proximal, mesial and, in some species even distal, thecae possess paired ventro-lateral, proximo-laterally directed spines. Several proximal thecae may be axially elongated.

**Remarks:** *Campograptus* Obut may be distinguished from otherwise similar *Stimulograptus* Přibyl & Štorch by its dorsally curved rhabdosome with laterally, rather than proximally, directed thecal apertural spines. Laterally



directed apertural spines are rarely seen in dorsally curved campograptids (see specimens figured by Štorch 1988, Melchin 1989, Loydell 1991 a.o.). In the straightened distal fragments preserved in scalariform view, however, prominent proximo-laterally to laterally directed spines are well exhibited (pl. 10, fig. 1). On the other hand, the scalariform orientation is rare in stimulograptid rhabdosomes due to their proximally or ventrally directed apertural spines.

### *Campograptus sanctgeorgensis* n. sp.

Pl. XII, figs 1, 3, 4; text-fig. 10, figs 2 A–C

**Holotype:** The specimen no. PŠ 769 figured on pl. XII, fig. 1; text-fig. 10, fig. 2 A; from the *leptotheca* Biozone (mid-Aeronian) of Svätý Jiří near Tmaň, Bohemia.

**Material:** 10 complete flattened specimens and a large number of incomplete and fragmentary rhabdosomes.

**Diagnosis:** Rhabdosome gently dorsally curved, gradually widening from 0.3–0.4 mm to the maximum of c. 1.3 mm attained 40–60 mm from the proximal end. Sicula 0.8–1.2 mm long, extending c. two-thirds up th1. Thecae non-overlapping, hooked, with proximally facing apertures. Proximal thecae axially elongated, low triangular; distal thecae become higher triangular, provided with robust apertural hooks. Paired ventro-lateral apertural spines appear in proximal and mesial thecae. The 2TRD is 2.1–2.6 mm at th2, distal thecae numbering 8–8.5 in 10 mm.

**Description:** The rhabdosome is more than 120 mm long and dorsally curved throughout. The sicula is 0.8–1.2 mm long and its apex extends c. two-thirds up th1. The sicular aperture is 0.25 mm wide, possessing a weak dorsal lobe and short virgella. Hooked thecae lack overlap. Proximal thecae are elongated, low triangular, with proximally facing apertures. Their ventral walls incline at an angle of 5–15° to the rhabdosome axis. Paired ventro-lateral apertural spines are developed in both proximal and mesial thecae. The 2TRD is 2.1–2.6 mm at th2. The rhabdosome slowly widens from 0.3–0.4 mm at th1 to 0.6–0.7 mm at th10 and, thereafter, to the maximum of 1.3–1.35 mm which is attained 40–60 mm from the proximal end. Distal thecae become higher triangular, provided with robust, proximally facing apertural hooks of semicircular outline. Ventral thecal walls of the distal thecae incline at 30–40° to the rhabdosome. Distal thecae number 8–8.5 in 10 mm (2TRD is 2.2–2.3 mm).

**Remarks:** Distal fragments of this species can be easily mistaken by *C. lobiferus lobiferus*. They may be distinguished, however, by their broader, more triangular profile. *C. communis*, *C. millepeda*, and *C. clingani* are dorsally curved with a proximally accentuated curvature. Proximal parts of their rapidly widening rhabdosomes are more robust. This species may resemble *M. intermedius* Carruthers the type material of which (lectotype no. BM (NH) Q.88 designated by Strachan 1969), however, is poorly preserved. The distal part of *C. sanctgeorgen-*

*sis* has a greater dorso-ventral width and more densely packed thecae.

### *Campograptus millepeda* (McCoy, 1850)

Pl. XI, figs 1, 5; text-fig. 10, figs 5 A–D

1850 *Graptolites millepeda* M. Coy, p. 270.

1913 *Monograptus millepeda* (M. Coy); Elles & Wood, pp. 465, 466; pl. 46, fig. 10 a–d; text-fig. 323 a–c.

1968 *Campograptus curtus* Obut & Sobolevskaya sp. nov.; Obut et al., p. 104, pl. 25, figs 7, 8.

1975 *Monograptus millepeda* (McCoy, 1850); Hutt, pp. 96, 97; pl. 22, figs 1, 5; text-fig. 19, fig. 4. (see for further synonymy).

1978 *Oktavites spinatus*; Ni, pp. 411, 412; pl. 3, fig. 20; text-fig. 5, figs 1, 2.

1982 *Monograptus millepeda* (McCoy, 1850); Lenz, p. 88, pl. 7, figs M, O; pl. 25, figs D, G, H.

1988 *Campograptus millepeda* (McCoy, 1850); Štorch, pp. 41, 42; pl. 9, fig. 2; pl. 10, fig. 4; text-fig. 6 C, D.

1991 *Monograptus millepeda* (M. Coy, 1850); Loydell, pp. 686, 687; pl. 3, figs 9, 11, 14, 15.

**Material:** 12 complete, mostly immature rhabdosomes and more fragments.

**Description:** The rhabdosome is dorsally curved throughout though the curvature is accentuated proximally. The longest specimen measures 36 mm. The robust sicula is 0.7–0.85 mm long and its apex attains the top of th1. Th1 originates just above the 0.3–0.4 mm wide, rather concave sicular aperture. Non-overlapping thecae are high-triangular throughout the rhabdosome and possess prominent apertural hooks of semicircular profile. Thecal apertures face proximally to dorso-proximally. Paired ventral apertural spines revealed in the proximal thecae (Loydell 1991) are rarely discernible in the present material. The rhabdosome widens from the initial width 0.5–0.6 mm at th1 to 0.9–1.0 mm at th5. The maximum dorso-ventral width of 1.1–1.3 mm is attained at th7–th10. The 2TRD is 1.15–1.35 mm at th2, 1.55–1.7 mm at th5, and 1.8–2.0 mm at th10. Proximal thecae are densely packed whilst the distal thecae number 10–11 in 10 mm.

**Remarks:** The proximal development, thecal shape and spinose apertures refer *C. millepeda* and other so called campograptids to one common group which, later on, gave rise to stimulograptids. *C. millepeda* ranges from the upper part of the *simulans* Biozone to the *leptotheca* Biozone, being replaced higher up by *C. clingani*.

### *Campograptus clingani* (Carruthers, 1867)

Pl. X, figs 2, 5; pl. XIX, fig. 8; text-fig. 10, figs 4 A, B

1867 *Graptolithus Clingani*; Carruthers, p. 369, pl. 2, fig. 8.

non 1897 *Monograptus Clingani* Carr.; Perner, p. 38, pl. 11, figs 14–17, 21.

1913 *Monograptus Clingani* (Carruthers); Elles & Wood, p. 463, pl. 46, fig. 11 a–f; text-fig. 322 a, b.

1969 *Monograptus clingani* (Carruthers); Strachan, p. 195, pl. 5, figs 1–5.

1975 *Monograptus clingani* (Carruthers, 1867); Bjerreskov, pp. 67, 68; text-fig. 20 E.

1975 *Monograptus clingani* (Carruthers, 1867); Hutt, p. 82, pl. 23, figs 5–7; text-fig. 19, fig. 9 (see for further synonymy).

1982 *Monograptus clingani* (Carruthers, 1867); Lenz, p. 65, pl. 5 U, V; pl. 21 E, K.

1988 *Campograptus clingani* (Carruthers, 1867); Štorch, pp. 42, 43, pl. 9, figs 2, 3, 5; text-fig. 6 A, B.

**Material:** 24 more or less complete rhabdosomes.

**Description:** The rhabdosome is dorsally curved throughout its entire length, though its curvature is accentuated proximally. A maximum length of 23 mm was observed in the present material. The blunt proximal end possesses a prominent, 1.0–1.1 mm long sicula, reaching slightly below the dorsal wall of th1. The sicular aperture is 0.25 mm in diameter. The thecae have broad prothecal bases, and slender, proximally facing hooked metathecae. Ventro-lateral apertural spines are occasionally visible. The ventral thecal wall is parallel or inclined at a very low angle to the rhabdosome axis. The metathecal hook occupies *c.* one-third to two-fifths the rhabdosome width which increases from 0.6–0.8 mm at th1 to 1.3–1.4 mm at about th10. The latter width is maintained until the distal end of the rhabdosome. The 2TRD is *c.* 1.4 mm at th2, and *c.* 1.8 mm at th10. The distal thecae number 10–10.5 in 10 mm.

**Remarks:** *C. clingani* may be well distinguished from the other similar, dorsally curved monograptids by its robust proximal end and hooked thecae with broad prothecal bases, and ventral thecal walls almost parallel to the rhabdosome. The isolate, hooked metathecal part occupies just one-third to two-fifths the rhabdosome width. *C. clingani* is confined to the *convolutus* Biozone.

#### ***Campograptus obtusus* (Rickards, 1970)**

Pl. X, figs 3, 4; text-fig. 10, figs 3 A, B

1970 *Monograptus communis obtusus* subsp. nov.; Rickards, pp. 85, 86; pl. 8, fig. 4; text-fig. 18, fig. 12.

?1989 *Monograptus communis obtusus* Rickards, Melchin, fig. 10 Q, S.

**Material:** 7 complete and more incomplete rhabdosomes.

**Description:** The rhabdosome is more than 55 mm long and has a proximally accentuated dorsal curvature and an almost straight distal part. The proximal end is markedly robust. The prominent sicula is 0.8–1.1 mm long, attaining *c.* the dorsal wall of th1. The sicular aperture is 0.25–0.3 mm in diameter and possesses a dorsal apertural lobe and a tiny virgella. The thecae have broad prothecal bases, connected through broad common canal, and hooked, proximally to dorso-proximally facing metathecae. Ventro-lateral apertural spines are often visible.

The ventral wall of the proximal thecae inclines at 20° to the rhabdosome axis. In the distal thecae the angle of inclination increases to 45°. The rhabdosome widens from 0.55–0.65 mm at th1 to 0.85–0.95 mm at th5, and 1.1–1.25 mm at th10. Thereafter, the maximum distal width 1.2–1.5 mm is slowly attained. The 2TRD is *c.* 1.4 mm at th2, 1.8–1.9 mm at th10 and 2.2–2.4 mm most distally. The distal thecae number 8.5–9 in 10 mm.

**Remarks:** This species was described by Rickards (1970) from the *sedgwickii* Biozone of Britain as the latest subspecies of *C. communis*. The type material is preserved in full relief, which may explain its markedly smaller dorso-ventral width in comparison with the flattened Bohemian material coming from the upper part of the *convolutus* Biozone of Tmaň. *C. obtusus* may be distinguished from *C. communis* by its robust proximal end without slender, axially elongated most proximal thecae. The characteristic, robust proximal end suggests that the present material belongs in *C. obtusus*. The proximal part of *C. obtusus* may be confused with less robust rhabdosome of *C. clingani* which has, however, still broader prothecae, slender hooked metathecae and ventral thecal walls parallel or sub-parallel to the rhabdosome.

#### ***Campograptus cf. communis* (Lapworth, 1876)**

Pl. XII, figs 2, 5; text-fig. 10, figs 1 A, B

*cf.* 1876 *Monograptus convolutus* Hisinger, sp. var. (a) *communis*; Lapworth, p. 358, pl. 13, fig. 4 a (non b).

*cf.* 1913 *Monograptus communis* (Lapworth); Elles & Wood, pp. 480, 481; pl. 49, fig. 1 a, c (non b, d, e); text-fig. 336 a (non b).

*cf.* 1958 *Monograptus communis communis* Lapworth; Sudbury, pp. 520–522, pl. 23, figs 97–101; text-figs 18, 20.

*cf.* 1970 *Monograptus communis communis* Lapworth, 1876; Rickards, pp. 84, 85; pl. 6, fig. 7; text-fig. 17, figs 1, 19, (?9).

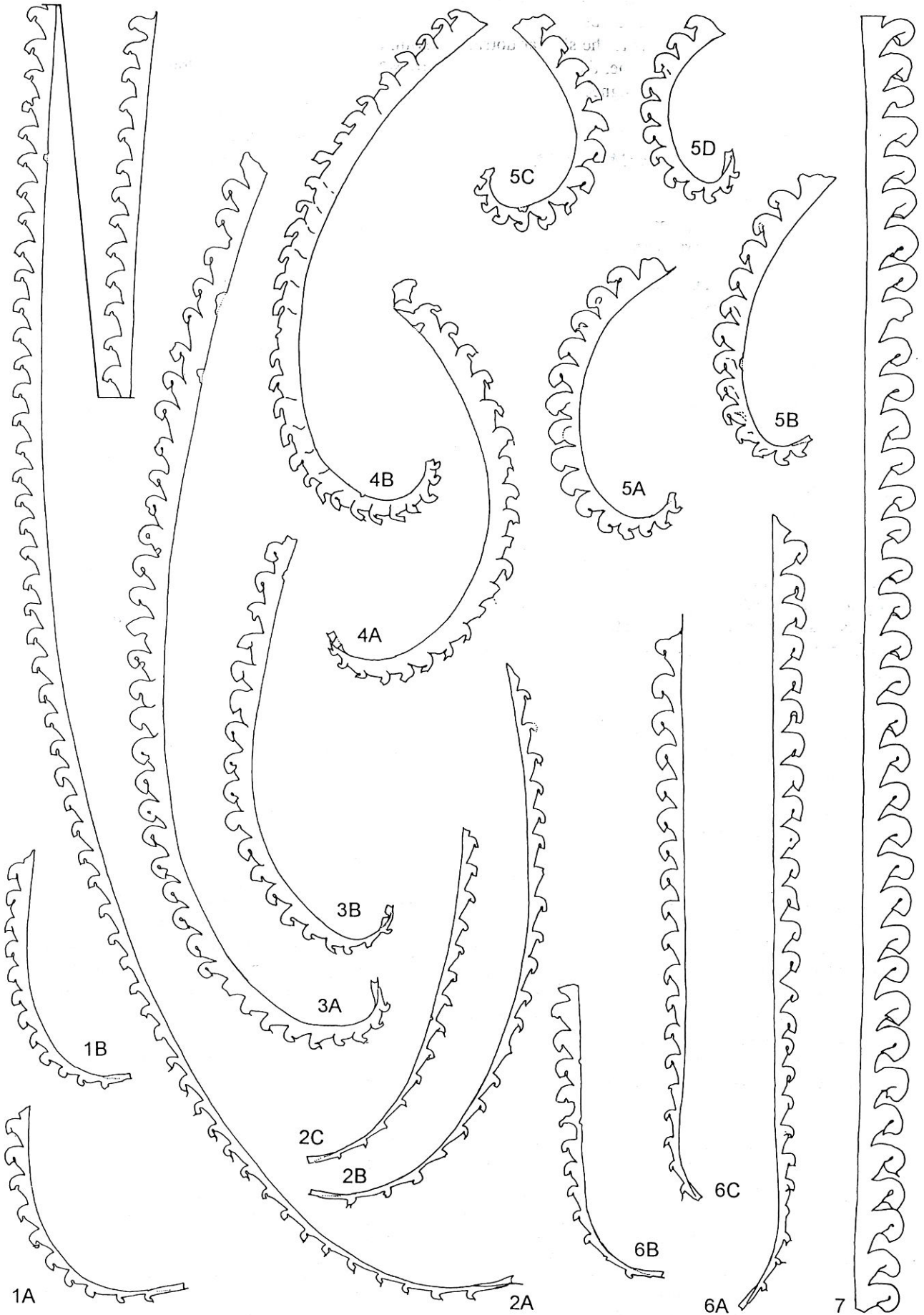
*cf.* 1991 *Monograptus communis communis* Lapworth, 1876; Loydell, pp. 683, 684; pl. 3, figs 6, 10.

**Material:** Three immature rhabdosomes.

**Description:** The present material comprises immature, *c.* 10 mm long, dorsally curved specimens. The sicula is 1.0–1.1 mm long and reaches about three-quarters up th1. The sicular aperture is 0.2–0.25 mm wide. The rhabdosome is 0.4–0.45 mm wide at th1–2 and 0.85–0.9 mm wide at th10. The thecae are hooked and triangular in profile. No apertural spines are visible. The 2TRD is 1.7–2.1 mm.

**Remarks:** The present rhabdosomes may be distinguished from *C. millepeda* by their widely spaced, more elongated and low-profile proximal thecae. On the other hand,

Fig. 10. 1 A, B *Campograptus cf. communis* (Lapworth); 1 A – PŠ 737, 1 B – PŠ 794. ⇨  
 2 A–C *Campograptus sanctgeorgensis* n. sp.; 2 A – 769 (holotype), 2 B – PŠ 836, 2 C – PŠ 782.  
 3 A, B *Campograptus obtusus* (Rickards); 3 A – PŠ 856, 3 B – PŠ 840.  
 4 A, B *Campograptus clingani* (Carruthers); 4 A – PŠ 250a, 4 B – PŠ 919.  
 5 A–D *Campograptus millepeda* (McCoy); 5 A – PŠ 803, 5 B – PŠ 786, 5 C – PŠ 807, 5 D – PŠ 773.  
 6 A–C *Campograptus lobiferus lobiferus* (McCoy); 6 A – PŠ 817, 6 B – PŠ 726, 6 C – PŠ 825.  
 7 *Campograptus lobiferus harpago* Törnquist; PŠ 751.  
 All specimens x5. Specimens on figs 1 A, B, 2 A–C, 5 A–D and 6 A–C from the *leptotheca* Biozone, specimens on figs 3 A, B, 4 A, B and 7 from the *convolutus* Biozone.



this form is more dorsally curved and rapidly widening than *C. sanctgeorgensis* n. sp. and resembles rather *C. lobiferus lobiferus*. In according to the similar dorsal proximal curvature of the rhabdosome, thecal shape and dimensions it may be tentatively assigned to *C. communis* Lapworth.

### *Campograptus lobiferus lobiferus* (McCoy, 1850)

Pl. XII, figs 7, 8; text-fig. 10, figs 6 A–C

1850 *Graptolites lobiferus*; M. Coy, p. 270.

1897 *Monograptus lobiferus* M. Coy; Perner, p. 32, pl. 10, fig. 19; text-fig. 16.

1913 *Monograptus lobiferus* (M. Coy); Elles & Wood, p. 448, pl. 45, fig. 1 a–f; text-fig. 308 a–e.

1975 *Monograptus lobiferus* (M. Coy); Hutt, p. 94, pl. 18, figs 1, 3; pl. 19, fig 6; text-fig. 24, fig. 4 a, b (see for further references).

1988 *Monograptus lobiferus* (McCoy, 1850); Storch, pp. 37, 38; pl. 12, figs 1, 2, 6; text-fig. 4 E, M.

**Material:** over 100 more or less complete flattened rhabdosomes, including many proximal ends and very distal portions.

**Description:** The rhabdosome is more than 100 mm long, dorsally, or slightly doubly, curved in its most proximal part and straight distally. The sicula is c. 1 mm long, its apex attaining the mid-point or dorsal wall of th1. The sicular aperture is 0.2–0.25 mm wide and possesses a tiny virgella. The thecae are triangular, isolated, terminated with lobate apertural hooks. The thecal apertures possess short, paired, lateral, laterally directed spines which are particularly well seen in the scalariform preservation of the rhabdosome. The proximal thecae are low-triangular and have dorso-proximally facing apertures. Th1 is 0.4–0.45 mm high, th5 is c. 0.7 mm high, and th10 is 0.85–0.95 mm high. Distalwards the thecae become much higher and appear to be densely packed. The apertures face dorsally in the distal thecae. The rhabdosome widens to 1.2–1.3 mm at th20. The most distal fragments are up to 2.6 mm wide, having about 8 thecae in 10 mm. The 2TRD gradually increases from 1.9–2.1 mm at th2 to 2.45–2.55 mm at th20.

**Remarks:** Material collected in the *leptotheca* Biozone fits well the type specimen refigured by Elles and Wood (1913) and the material described from Britain and Scandinavia. The specimens collected from the *convolutus* Biozone differ in having longer, rather dorsally than proximally facing recurved parts of the metathecae, and may be assigned to *C. lobiferus harpago* Törnquist.

### *Campograptus lobiferus harpago* Törnquist, 1899

Pl. X, fig. 1; pl. XII, fig. 6; text-fig. 10, fig. 7

1899 *Monograptus harpago* n. sp.; Törnquist (pars), pp. 16, 17; pl. 3, figs 3, 7 (?4, 5, 6, 10), (non 11).

1975 *Monograptus lobiferus harpago* Törnquist, 1899; Bjerreskov, p. 67, pl. 10 E, fig. 20 A.

**Material:** Over 50 flattened specimens, mostly fragmentary, some in scalariform view.

**Description:** The rhabdosome is at least 150 mm long. It is slightly dorsally or even doubly curved proxi-

mally and straight distally. The sicula is 1–1.2 mm long, its apex attaining the top of th1. The thecae are isolated, terminated with tightly lobate apertures which possess prominent, paired, c. 0.4 mm long, lateral, laterally directed spines. The spines are particularly well seen when the rhabdosome is preserved in scalariform view. The proximal thecae are low-triangular, with dorso-proximally facing apertures. Th1 is c. 0.4 mm high, th5 0.5–0.6 mm high, and th10 is 0.8–0.9 mm high. Distal thecae are much higher, isolated, and have rather long recurved apertural lobes, tightly adpressed to the early portion of the metathecae. The apertures face dorsally. The distal fragments of the rhabdosomes are up to 2.3 mm wide. Distal thecae number c. 8 in 10 mm.

**Remarks:** *C. lobiferus harpago* occurs in the *convolutus* Biozone. It may be distinguished from *C. lobiferus* by its tightly recurved, longer and more prominent apertural lobes and stiff, lateral and laterally directed apertural spines. Proximal parts of the two species are distinguishable solely by the prominent apertural spines of *C. harpago*. Scalariform preservation of the rhabdosomes of *C. harpago* is rather common, being predetermined by these lateral spines. *M. knockensis* Elles & Wood has similar thecae which, however, are more isolate, being terminated by even longer recurved portions. No apertural spines have been so far recorded in *M. knockensis*.

### Genus *Streptograptus* Yin, 1937; emend. Loydell, 1990

**Type species:** Proposed by Loydell & Chen 1991; *Graptolithus plumosus* Baily, 1871 from the Llandovery of Northern Ireland.

**Diagnosis:** after Loydell (1993).

### *Streptograptus* sp.

Pl. XIII, fig. 5; pl. XIX, fig. 4; text-fig. 7, figs 8 A, B

**Material:** four fragmentary flattened rhabdosomes.

**Description:** The present material is represented by weakly ventrally curved or almost straight distal fragments which are c. 20 mm long and 0.6–0.8 mm wide. The long prothecae are parallel sided and 0.2–0.25 mm wide. Coiled, high-profile, dorsally facing metathecae of streptograptid appearance comprise c. two-fifths to one-third of the rhabdosome width. No further details of thecal apertures are visible. The thecae number 7–8 in 10 mm (2TRD of 2.3–3.0 mm).

**Remarks:** Rare, ventrally curved distal fragments with coiled streptograptid thecae do not match any species described from the mid-Aeronian deposits. The single fragment of *Monograptus* sp. 1 described by Hutt (1975) from the *magnus* Biozone of England represents a more gracile form with more densely packed thecae of higher profile. It may be regarded as either the ancestor of the *M. knockensis* stem (Hutt 1975) or as an early form giving rise to streptograptids. *Streptograptus?* sp. figured by Zalasiewicz (1996) from the upper *convolutus* Biozone of Wales has a more slender rhabdosome with smaller metathecae and inclined ventral prothecal walls.

### Genus *Spirograptus* Gürich, 1908

Type species: *Graptolithus turriculatus* Barrande, 1850 from the Llandoverly of Bohemia. Subsequently designated by Bulman (1929).  
Diagnosis: after Loydell et al. (1993).

#### *Spirograptus* sp.

Pl. IX, fig. 1; text-fig. 8, fig. 10

Material: one incomplete, flattened specimen.

Description: The rhabdosome is tightly enrolled in a low-conical spiral composed of a little more than two whorls. The sicula and first theca are not preserved. Low-triangular, non-overlapping thecae are terminated with spinose, probably asymmetrical apertures. One of the paired apertural spines is short and the second is 0.3–0.35 mm long. The thecae are generally oblique to perpendicular to the plane of spiral so that the thecal height is rarely visible. It appears to be 0.6 mm in the proximal whorl and, at maximum, 0.7 mm near the distal end of the rhabdosome. The 2TRD is 1.35–1.5 mm proximally and *c.* 1.7 mm distally.

Remarks: *Spirograptus* sp. was found in the *leptotheca* Biozone. It resembles *M. calamistratus* in its spiral shape, thecal orientation and spinosity. It is left in open nomenclature until better preserved and more complete material is available.

### Genus *Rastrites* Barrande, 1850

Type species: *Rastrites peregrinus* Barrande, 1850 from the Llandoverly of Bohemia. Subsequently designated by Hopkinson (1869).

Diagnosis: Rhabdosome with thread-like prothecae and straight, completely isolated tubular metathecae. The initial thecae are inclined at an angle of less than 90° to the rhabdosome axis, the distal thecae are perpendicular or pendent, inclined at higher angle. Slightly hooked apertures face proximally, lateral apertural walls are often terminated by ventrally projected, paired, triangular or horn-like processes.

#### *Rastrites peregrinus* Barrande, 1850.

Pl. XIV, figs 2, 4, 9; pl. XV, fig. 7; text-fig. 6, fig. 6; text-fig. 11, figs 3 A, B

1850 *Rastrites peregrinus*; Barrande, p. 67, pl. 4, fig. 6.

1897 *Rastrites peregrinus* Barr.; Perner, pp. 14, 15; pl. 13, fig. 33, 34; text-fig. 6.

1914 *Monograptus (Rastrites) peregrinus* (Barrande); Elles & Wood, (pars), pp. 488, 489, pl. 50, fig. 1 b, c (non a, b), non text-fig. 343.

1941b *Rastrites peregrinus peregrinus* Barrande; Pfißl, pp. 4–6, pl. 1, figs 8, 9; pl. 2, fig. 8; pl. 3 fig. 13; text-figs 5, 6.

?1967 *Rastrites cf. hybridus hybridus* Lapw.; Schauer, p. 178, pl. 3, figs 1, 2

1967 *Rastrites hybridus hybridus* Lapw.; Schauer, pl. 3, pp. 177–178, pl. 3, figs 3–5, ?6.

1967 *Rastrites peregrinus peregrinus* Barrande; Schauer, p. 176, pl. 2, figs 5–7.

1975 *Rastrites peregrinus peregrinus* Barrande, 1850; Bjerreskov, p. 83, pl. 13 A.

?1991 *Rastrites peregrinus* Barrande, 1850: Loydell, p. 687, pl. 3, figs 12, 13.

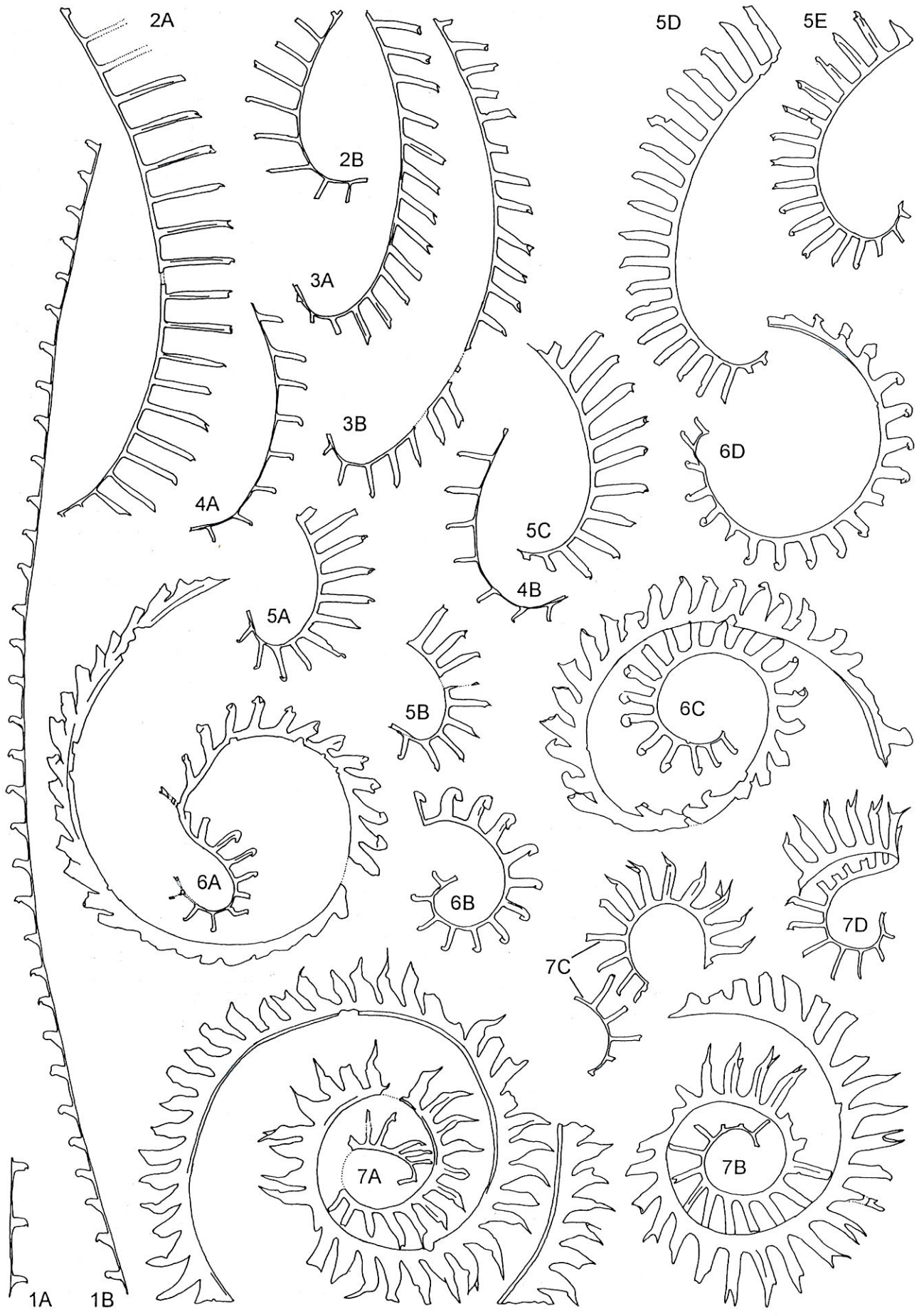
Lectotype: Designated herein; specimen no. L27594, left one of the two specimens figured by Barrande (1850, pl. 4, fig. 6), from the *convolutus* Biozone (mid-Aeronian) of Libomyšl, Bohemia.

Remarks: The specimen figured on the right side of the Barrande's fig. 6 (no L30073) originates from Bykoš.

Material: over 200 complete or almost complete flattened rhabdosomes.

Diagnosis: The rhabdosome is fish-hook shaped with a tightly curved proximal end. The sicular apex reaches *c.* one-third the distance between th1 and th2. The rastritiform thecae have thread-like prothecae and long, isolated, tubular metathecae. The slightly hooked apertures possess short, paired, ventro-proximally directed lateral processes. Th1–th3 incline at 45–60° to the rhabdosome, the next theca is *c.* perpendicular, the more distal thecae are inclined at 100–130°. Th1 is 0.75–0.9 mm long, th3 1.0–1.25 mm, and distal thecae are 1.6–2.2 mm long. The 2TRD is 1.5–2.0 mm proximally and 2.0–2.4 mm distally.

Description: The fish-hook shaped rhabdosome attains a maximum length of about 25 mm. The dorsal curvature is accentuated in its proximal part. The small sicula is 0.7–0.85 mm long and the apex reaches *c.* one-third the distance between the metathecae of th1 and th2. The sicular aperture is *c.* 0.15 mm wide. The typically rastritiform thecae have thread-like prothecae and long, isolated, tubular metathecae with slightly broadened bases. The thecae are terminated by slightly hooked, ventro-proximally facing apertures possessing paired, 0.25–0.35 mm high, lateral, ventro-proximally directed horn-like processes. Proximal thecae have *c.* 0.07 mm wide prothecae and 0.2 mm wide metathecae, while distal thecae have 0.13–0.18 mm wide prothecae and 0.3–0.35 mm wide metathecae, terminated by slightly hooked apertures. The earliest 2–3 thecae are inclined to the rhabdosome axis at an angle of 45–60°. The next theca is *c.* perpendicular, whilst the more distal thecae become pendent, being inclined at 100–130° to the rhabdosome axis. This must have resulted in a generally uniform direction of the metathecae in the water-column. Th1 is 0.75–0.9 mm long, th2 is 0.95–1.2 mm long, th3 1.0–1.25 mm, and th5 1.3–1.75 mm. Distal metathecae are 1.6–2.15 mm (exceptionally 2.4 mm) long. The 2TRD is 1.45–1.7 mm at th2, 1.5–1.95 mm at th3, 1.6–2.1 mm at th5, 1.95–2.4 at th10, and 2.1–2.4 mm at th20. The great variability in the length and spacing of the metathecae is similar to that recorded by Štorch and Loydell (1992) in the *Rastrites linnaei* Group.  
Remarks: *R. peregrinus* Barrande is a dominant component of the *convolutus* Biozone assemblage in the Barrandian area of Bohemia. It is probably the ancestor of *R. hybridus* (Lapworth) from which it may be distinguished by its more tightly curved proximal end, slightly longer and less densely packed thecae and more hoo-



ked thecal apertures. Intraspecific variation in rastritid graptolites, however, is such that it is very difficult to separate the two species and further examinations of large collections of *R. hybridus* may show that it is just a junior synonym of *R. peregrinus*. *R. longispinus* (Perner) and *R. geinitzii* (Törnquist) clearly differ from *R. peregrinus* by their rather arcuate than fish-hook shaped rhabdosome and longer thecae which are almost perpendicular to the rhabdosome axis.

### ***Rastrites approximatus* Perner, 1897**

Pl. XIV, figs 1, 3, 8; pl. XV, figs 1, 5; text-fig. 11, figs 5 A–E

1897 *Rastrites peregrinus* var. *approximatus*; Perner, pp. 15, 16; pl. 13, figs 36–39, 42, 43 (non 40).

1941b *Rastrites approximatus approximatus* Perner, 1897; Přibyl, pp. 7, 8; pl. 1, figs 6, 7; pl. 2, figs 9, 10.

non 1967 *Rastrites approximatus approximatus* Perner, 1897; Schauer, p. 177, pl. 3, figs 11–13.

**Lectotype:** Designated by Přibyl (1948); specimen no. L31275 figured by Perner (1897, pl. 13, fig. 36) from the *leptothea* Biozone (mid-Aeronian) of Bykoš, Bohemia.

**Material:** over 100 complete flattened specimens.

**Diagnosis:** Rhabdosome arcuate, 10–20 mm long, the dorsal curvature being proximally accentuated. The typically rastritid thecae are terminated by slightly hooked apertures with small, weakly proximally curved, triangular lateral processes. Proximal metathecae are slender, distal metathecae being 0.35–0.42 mm wide. The 1<sup>st</sup> metatheca is 0.7–0.8 mm long, inclined at 50–65°. Beginning with the 1.2–1.4 mm high th3 the thecae become almost perpendicular to the rhabdosome. The maximum thecal height of 1.8–2.5 mm is attained at *c.* th10. The 2TRD is 1.2–1.4 mm most proximally and 1.3–1.8 mm distally.

**Description:** The arcuate, 10–20 mm long rhabdosome, the dorsal curvature of which is accentuated proximally, possesses typical rastritid thecae with thread-like prothecae and isolated, tubular metathecae. The sicula is 0.75–0.85 mm long with its apex attaining above the point of origin of the second protheca. The sicular aperture is 0.12–0.15 mm wide. The metatheca of th1 is 0.7–0.8 mm long, inclined at 50–65° to the rhabdosome axis, th2 is 0.95–1.1 mm long, having almost the same angle of inclination. Beginning with the 1.2–1.4 mm high th3 the thecae become almost perpendicular (inclined at 70–90°) to the rhabdosome axis. Th5 is 1.5–1.8 mm high; the maximum thecal height (or length) of 1.8–2.4 mm

(exceptionally 2.5 mm) is attained at about th10. The thecae are terminated by slightly hooked, proximally facing apertures which possess paired, highly triangular (0.25–0.35 mm high), weakly proximally curved lateral processes. Proximal thecae have 0.05–0.07 mm wide prothecae and 0.12–0.16 mm wide metathecae, distal thecae have 0.13–0.15 mm wide prothecae and 0.35–0.42 mm wide metathecae. The 2TRD is 1.2–1.35 mm (exceptionally 1.5 mm) at th2, the same value at th3, 1.2–1.5 mm at th5, 1.3–1.8 mm at th10, and 1.4–1.8 mm at th20. The considerable variability in the length and spacing of the thecae corresponds to that of the other rastritids (see Štorch and Loydell 1992).

**Remarks:** In the Barrandian area *R. approximatus* Perner – a major component of the *leptothea* Biozone assemblage – ranges up to the lower part of the *convolutus* Biozone. It may be distinguished from *R. peregrinus* by its longer, slightly wider, and more densely spaced thecae which are rather normal than pendent to the rhabdosome axis in the distal part of the rhabdosome. *R. longispinus* Perner is distinguished from *R. approximatus* by its greater thecal height and lesser thecal width, particularly in the mesial part of the rhabdosome, and in the more widely spaced thecae which are usually normal to the rhabdosome. Distal fragments of *R. longispinus* are almost straight in contrast to the regularly arcuate distal parts of *R. approximatus*.

### ***Rastrites geinitzii* Törnquist, 1907**

Pl. XVI, figs 6, 7; text-fig. 11, figs 2 A, B

1907 *Rastrites approximatus* Perner, var. *Geinitzi* n.v.; Törnquist, p. 9, 10; pl. 1, figs 32–41.

?1914 *Monograptus (Rastrites) approximatus*, var. *Geinitzii* (Törnquist); Elles & Wood, p. 492, pl. 50, fig. 5 a–d; text-fig. 347 a, b.

1967 *Rastrites approximatus geinitzii* Törnquist 1907; Schauer, p. 177, pl. 4, figs 1, 2.

**Material:** 5 incomplete flattened specimens and more fragments.

**Description:** In the present, mostly fragmentary specimens the dorsally curved rhabdosome exceeds 30 mm in length. Details of the small sicula are not visible. Apertural parts of the two initial thecae are broken off in the present fragments. The following metathecae are terminated by slightly curved, ventro-proximally facing apertures with paired lateral, high-triangular, ventro-proximally directed processes. The proximal metathecae are 0.15–0.2 mm wide, perpendicular to the rhabdosome axis. Th3

↩

Fig. 11. 1 A, B *Rastrites spina* (Richter); 1 A – PŠ 912 (distal fragment), 1 B – PŠ 907.

2 A, B *Rastrites geinitzii* Törnquist; 2 A – BB 699, 2 B – 852/1.

3 A, B *Rastrites peregrinus* Barrande; 3 A, B – PŠ 724.

4 A, B *Rastrites* cf. *erectus* Hutt; 4 A – PŠ 519b, 4 B – PŠ 845a.

5 A–E *Rastrites approximatus* Perner; 5 A – PŠ 765, 5 B – PŠ 829, 5 C – PŠ 719, 5 D – PŠ 712a, 5 E – PŠ 829.

6 A–D *Lituigraptus richteri* (Perner); 6 A – PŠ 759, 6 B – PŠ 765, 6 C – PŠ 528, 6 D – PŠ 749.

7 A–D *Lituigraptus convolutus* (Hisinger); 7 A – PŠ 748, 7 B – BB 697, 7 C, D – PŠ 724.

All specimens x5. Specimens on figs 2 A, B, 5 A–E and 6 A–D from the *leptothea* Biozone, specimens on figs 1 A, B, 3 A, B, 4 A, B and 7 A–D from the *convolutus* Biozone.

is 1.7 mm high, and th5 is 1.8–2.1 mm high. The thecal height further increases to 2.2–2.9 mm at th10 and 3.0–3.2 mm at th20. The most distal thecae are 0.3–0.35 mm wide. The 2TRD is 1.7 mm at th2, 1.6–2.0 at th5, c. 1.8 mm at th10, and further increases to 3.0–3.8 mm in the most distal fragments.

**Remarks:** *R. geinitzii* Törnquist occurs in the lower part of the *leptotheca* Biozone in Tmaň. It differs from *R. approximatus* in having longer, widely spaced thecae. It closely resembles *R. longispinus* which, however, appears to have hooked thecae without prominent triangular apertural processes.

### ***Rastrites* cf. *erectus* Hutt, 1975**

Pl. XIV, fig. 5; pl. XV, figs 2–4, 6

cf. 1914 *Monograptus (Rastrites) fugax* (Barrande); Elles & Wood, p. 493 (pars), pl. 50, fig. 7 b, (non a, c, d); text-fig. 348.

cf. 1975 *Rastrites hybridus erectus* subsp. nov.; Hutt, pp. 114, 115; pl. 26, figs 2, 5; text-fig. 26, figs 10–12.

**Material:** 12 complete or almost complete specimens and several fragments.

**Description:** The rhabdosome is c. 10 mm long, dorsally curved proximally and almost straighten distally. The sicula is 0.75–0.85 mm long having a 0.1–0.12 mm wide aperture. The sicular apex attains c. one-third the distance between th1 and th2. The thecae have thread-like prothecal parts and rather robust, c. 0.2–0.25 mm wide metathecal parts. Like in other coeval rastritids, the tiny thecal aperture has paired lateral processes. The dorsal wall of the metatheca, however, is projected in a lip which overhangs the aperture and gives the aperture a rather hooked appearance. The metatheca of th1 is 0.6–0.7 mm long and inclined at 55–70° to the rhabdosome. Th2 is 0.7–0.8 mm long, inclined at 50–55°, th3 is 0.8–0.95 mm long, inclined at 60–90°. The following metathecae are longer and perpendicular and, thereafter, pendent (inclined at 90–110°). Thecal height is 0.95–1.2 mm at th5 and 1.35–1.4 mm at th10. The 2TRD is 2.2 mm at th2 (extremes 1.9 and 2.3 mm respectively). The 2TRD increases to 2.5–2.6 mm from th3.

**Remarks:** The present material differs from the specimens figured by Hutt (1975) in having longer and more gracile thecae and a less straight distal part of the rhabdosome. With respect to the intraspecific variability observed in other rastritids (Štorch and Loydell 1992), however, it may be tentatively assigned to *R. erectus* Hutt until further, more complete material is available.

### ***Rastrites spina* (Richter, 1853)**

Pl. XIX, fig. 2; text-fig. 11, figs 1 A, B

1853 *Monograptus spina*; Richter, p. 462, pl. 12, figs 32, 33.

1912 *Rastrites spina*, Richter, Eisel, p. 4, pl. 1, figs 3–5, 7, 9.

1914 *Monograptus (Rastrites) fugax* (Barrande); Elles & Wood, p. 493 (pars), pl. 50, figs 7 a, d (non b, c and text-fig. 348).

1942 *Rastrites spina* (Richter, 1853); Přibyl, p. 5, pl. 1, figs 20, 21.

non 1967 *Rastrites spina* (Richter, 1853); Schauer, p. 179, pl. 4, figs 8–10.

1970 *Rastrites spina* (Richter, 1853); Rickards, p. 97; text-fig. 17, figs 24, 25.

1975 *Rastrites spina* (Richter, 1853); Hutt, p. 116; text-fig. 26, fig. 6.

**Material:** One long and several small flattened distal fragments.

**Description:** The proximal part of the rhabdosome has not been found. The longest of distal fragments measures 50 mm. The thecae have long, thread-like prothecae and robust, 0.5–0.75 mm high metathecae. The metatheca is either perpendicular or inclined at c. 80° to the rhabdosome axis. The proximo-ventrally facing aperture is covered by an overhanging lip formed of the dorsal thecal wall. It gives the aperture a hooked appearance. The 2TRD is 2.4–2.7 mm. In one fragment, presumably belonging to the distal portion of a very long specimen, the 2TRD is 4.6 mm. The thecae number 9 (exceptionally 4.3) in 10 mm.

**Remarks:** *R. spina* is tentatively assigned to *Rastrites* despite its robust metathecae with broadly hooked apertures. Rare specimens from the *convolutus* Biozone of Tmaň match well those from Germany figured by Přibyl (1942) and those from England figured by Rickards (1970) and Hutt (1975). Other rhabdosomes from Germany assigned to *R. spina* by Schauer (1967), Kirste (1919) a.o. with higher metathecae (up to 1.2 mm) may represent different species.

### **Genus *Lituigraptus* Ni, 1978; emend. herein**

**Type species:** *Prionotus convolutus* Hisinger, 1837 from the Llandovery of Sweden. Subsequently designated herein.

**Diagnosis:** Dorsally enrolled spiral rhabdosome, distally the rhabdosome axis gradually twists and the thecae may be situated ventrally or perpendicular to the spiral plane. Proximal thecae rastritiform, with thread-like prothecae and straight, tubular metathecae with hooked apertures. Mesially the thecae gradually become high triangular; apertural hooks gradually retreat being substituted by prominent paired, ventrally or ventro-proximally directed, lateral processes.

**Remarks:** *Lituigraptus* Ni, 1978 may be distinguished from *Rastrites* Barrande, 1850; *Stavrites* Obut & Sobolevskaya, 1968 and other taxa having rastritiform proximal thecae by markedly biform metathecae. The proximal thecae of *Lituigraptus* are slender, with simply hooked apertures, distally the basal part of the metathecae broadens and the dorsal wall of the thecal hook retreats whilst the lateral apertural walls project in prominent paired, triangular to horn-like processes. When the thecae are oriented normal to the bedding plane after the burial of the rhabdosome both lateral processes are seen giving the aperture a characteristic horned appearance. Otherwise just a single horn is exposed. Ni (1978) erected *Lituigraptus* as a new subgenus of the genus *Rastrites* Barrande and designated *R. (Lituigraptus) glomeratus* Ni as a type species. However, *R. (Lituigraptus) glomeratus* Ni, 1978 is considered herein a junior synonym of *Lituigraptus convolutus* (Hisinger, 1837) which is thus designated



a type species of *Lituigraptus*. In addition to the two species described below, *Rastrites phleoides* Törnquist is included in *Lituigraptus*.

### *Lituigraptus convolutus* (Hisinger, 1837)

Pl. XVIII, figs 1–4; pl. XIX, fig. 3; text-fig. 11, figs 7 A–D

- 1837 *Prionotus convolutus*; Hisinger, p. 114, pl. 35, fig. 7.  
 1892 *Monograptus convolutus* His.; Törnquist, pp. 30–34, pl. 1, figs 5–11.  
 1897 *Monograptus convolutus* His.; Perner, pp. 23, 24, pl. 12, figs 27, 28, 30 (?29); pl. 13, fig. 41; text-fig. 10.  
 1913 *Monograptus convolutus* (Hisinger); Elles & Wood, pp. 467–469, pl. 47, fig. 1 a–d; text-fig. 324 a, b.  
 1941 *Demirastrites convolutus* (Hisinger, 1837); Přibyl & Münch, pp. 13–15, pl. 1, figs 9, 10; pl. 3, figs 7–9; text-fig. 1.  
 non 1975 *Monograptus convolutus* (Hisinger, 1837); Bjerreskov, p. 81, pl. 12 D; text-fig. 23 F.  
 1975 *Monograptus convolutus* (Hisinger, 1837); Hutt, pp. 83, 84; pl. 19, fig. 3; pl. 25, fig. 3; text-fig. 22, figs 2, 6. (see for further synonymy).  
 1978 *R. (Lituigraptus) glomeratus* subgen. et sp. nov.; Ni, p. 414, pl. 4, figs 6, 7, 14.  
 1982 *Monograptus convolutus* (Hisinger, 1837); Lenz, pp. 69, 70; figs 6 B, 22 A, F.

**Material:** 11 complete and more than 30 incomplete and fragmentary rhabdosomes.

**Description:** The mature rhabdosome is enrolled in a wide, probably low-conical spiral composed of at least 4 whorls. The most distal portion of the rhabdosome becomes almost straight. The length of some straight distal fragments is more than 60 mm. The thecae are situated on the convex side of the spiral. The sicula is 0.75–0.8 mm long, slightly dorsally curved, its apex attaining the dorsal wall of the th1. The sicular aperture is 0.12 mm wide. The proximal thecae are rastritiform, with thread-like prothecae and slender, isolated metathecae perpendicular to the rhabdosome. Proximal metathecae are terminated by small hooks with small, paired lateral apertural processes. Th1 is 0.6–0.8 mm high, th2 is 0.8–1.2 mm high and th5 is 1.3–1.55 mm high. The metathecal tube of th1 is 0.1 mm wide, and 0.17–0.2 mm wide at th2. The following thecae become broader and higher, separated by less prominent interspaces. The thecal apertures are no longer hooked but possess prominent paired lateral apertural processes growing out from the lateral walls of the metatheca. The rhabdosome widens to 1.8–1.95 mm at th10 and 2.0–2.45 mm at th20 (the rhabdosome width corresponds to the thecal height). The maximum width of 2.6–2.7 mm is attained at the 3<sup>rd</sup> whorl of the rhabdosome spiral. The maximum dorso-ventral width of 3.4 mm was recorded in some isolated distal fragments of the rhabdosome. The metathecal tubes are 0.25–0.35 mm wide at th10 and c. 0.4 mm wide at th20. Distal metathecae are 0.5–0.7 mm wide, inclined at 60–70° to the rhabdosome, and separated by rather narrow interspaces. Their common canal widens to 0.7 mm. The 2TRD is 1.0–1.5 mm at th2, 1.0–1.25 mm at th5, 1.1–1.4 mm at th10 and c. 1.35 mm at th20. In the distal part of the rhabdosome the thecae number 9.5–11 in 10 mm (2TRD of 1.8–2.1 mm).

**Remarks:** *L. convolutus* (Hisinger) is a common, zonal index fossil in Bohemia. It may be distinguished from its likely ancestor *L. richteri* (Perner) by its longer and more slender proximal and mesial thecae which more rapidly change from hooked to those possessing prominent ventrally projected lateral horns. Further suppression of hooked thecae possibly gave rise to *L. phleoides* (Törnquist) in the lower *sedgwickii* Biozone. It may be distinguished from *L. convolutus* by its having longer, more isolated rastritiform thecae with paired lateral apertural horns throughout almost the whole rhabdosome. On the other hand, the specimens from the *leptothea* Biozone (corresponding to the lower part of the *convolutus* Biozone of some stratigraphical schemes – e.g. Bouček 1953, Bjerreskov 1975, Štorch 1994) with generally shorter and more robust thecae, which have been assigned to *M. cf.* or aff. *convolutus* or to *M. convolutus* itself, belong to *L. richteri*.

### *Lituigraptus richteri* (Perner, 1897)

Pl. XVI, fig. 1; pl. XVII, figs 1–7; pl. XVIII, fig. 5; text-fig. 11, figs 6 A–D

- 1897 *Rastrites Richteri* n. sp.; Perner, p. 16, pl. 13, fig. 24 a, b.  
 1941 *Rastrites richteri* Perner, 1897; Přibyl, p. 9, pl. 1, fig. 7; pl. 2, figs 4–6; text-fig. 1.  
 1967 *Rastrites richteri* Perner 1897; Schauer, p. 177, pl. 4, figs 5–7.  
 1980 *Demirastrites* aff. *convolutus* (Hisinger, 1837); Štorch, pl. 2, fig. 3.  
 1996 *Monograptus* aff. *convolutus* (Hisinger), Zalasiewicz, text-fig. 6 I, J, L.  
 1996 *M. convolutus?*, Zalasiewicz, text-fig. 6 K.

**Lectotype:** Designated by Přibyl (1948); figured by Perner (1897, pl. 13, fig. 24 a) and refigured by Přibyl (1941) on pl. 2, fig. 6. Specimen no L27492 from the *leptothea* Biozone at Loděnice, Bohemia.

**Material:** 18 complete, mature rhabdosomes and over 150 fragmentary and/or immature specimens.

**Diagnosis:** Rhabdosome dorsally coiled in an open, low conical spiral composed of c. 3 whorls. Proximal and mesial thecae rastritid, perpendicular to the rhabdosome, situated on the convex side of the spiral. The conspicuous, dorsally facing apertural hooks slowly retreat between th10 and th20, being substituted by lateral, triangular apertural processes early in the 2<sup>nd</sup> whorl. Th1 is 0.7 mm high, th2 0.8–1.2 mm, and th20 1.65–1.85 mm. Distal thecae are robust, inclined at c. 60°, separated by narrow interspaces. The dorso-ventral width is 1.8–2.2 mm in the late 2<sup>nd</sup> whorl, and up to 2.5–3.0 mm in the straight distal portion. The 2TRD is 1.2–1.7 mm at th2–th3, 1.5–2.0 mm at th10, c. 1.35 mm at th20. Most distal thecae number 7–10 in 10 mm.

**Description:** The mature rhabdosome is about 100 mm long, and was more or less regularly dorsally coiled in a low conical spiral (max. 3 whorls). In the proximal and mesial parts of the rhabdosome the thecae are situated on the convex side of the spiral. More distally the rhabdosome axis is gradually twisted and the thecae become perpendicular to the spiral plane and then ventrally situated. Late mature rhabdosomes possess distal parts

which are straight, slightly ventrally curved, and several centimetres long. The sicula is 0.7–0.8 mm long, its apex attaining the level above the dorsal wall of th1. The proximal 6–8 thecae have slender prothecal parts and rastritiiform isolated metathecae perpendicular to the rhabdosome. Conspicuous, rounded thecal apertural hooks terminate with dorsally facing apertures. Th1 is *c.* 0.7 mm high, th2 is 0.8–1.2 mm high and th5 is 1.0–1.4 mm high. The metathecal tube of th1 is 0.15 mm wide, that of the th5 is 0.2–0.3 mm wide. The following metathecae elongate slowly, being 1.4–1.6 mm high and *c.* 0.4 mm broad at th10 and 1.65–1.85 mm high and 0.5–0.55 mm broad at th20. The thecae are separated by less and less prominent interspaces. The apertural hook gradually retreats between th10 and th20. In the early 2<sup>nd</sup> whorl the hooked aperture is gradually substituted by short, paired lateral apertural processes. Paired lateral apertural processes are well developed in the 3<sup>rd</sup> whorl of the rhabdosome spiral as well as in its straightened distal part. The rhabdosome slowly widens to 1.8–2.2 mm in the late 2<sup>nd</sup> whorl and the maximum width of 2.5–3.0 mm was recorded in straight distal portions. Distal metathecae are 0.6–0.8 mm wide, inclined at 60° to the rhabdosome, and separated by rather narrow interspaces. Their common canal widens to 0.6–0.7 mm. The 2TRD is 1.2–1.7 mm at th2, 1.2–1.6 mm at th5, 1.5–2.0 mm at th10 and *c.* 1.35 mm at th20. In the 3<sup>rd</sup> whorl and the straight distal part of the rhabdosome the thecae number 7–10 in 10 mm (2TRD of 2.0–2.9 mm).

**Remarks:** Perner (1897) described *R. richteri* on the basis of fragmentary rhabdosomes. Both illustrated specimens are mesial fragments. Přibyl (1941) figured another but still of mesial fragments. A number of well preserved, often complete rhabdosomes from Tmaň brought an entirely new insight to this rather mysterious taxon. The species does not belong to *Rastrites* Barrande due to its bifurcated thecae which are hooked proximally and provided with lateral apertural processes distally. Herein the species is assigned to *Lituigraptus* Ni being a possible praecursor of *Lituigraptus convolutus* (Hisinger). *L. richteri* may be distinguished from *L. convolutus* by its generally shorter and more robust thecae which are hooked in the proximal and mesial part of the rhabdosome and possess shorter, less well developed lateral apertural processes in the distal part of the rhabdosome. The rhabdosome width is more slowly increasing, the thecal interspaces wider and the 2TRD higher in *L. richteri* (Perner) than in *L. convolutus*. The present material match well the specimens illustrated by Štorch (1980) and Zalasiewicz (1996) as *Monograptus* aff. *convolutus*. In Barrandian *L. richteri* is a typical component of the *leptotheca* Biozone and overlaps little, if at all, with *L. convolutus*.

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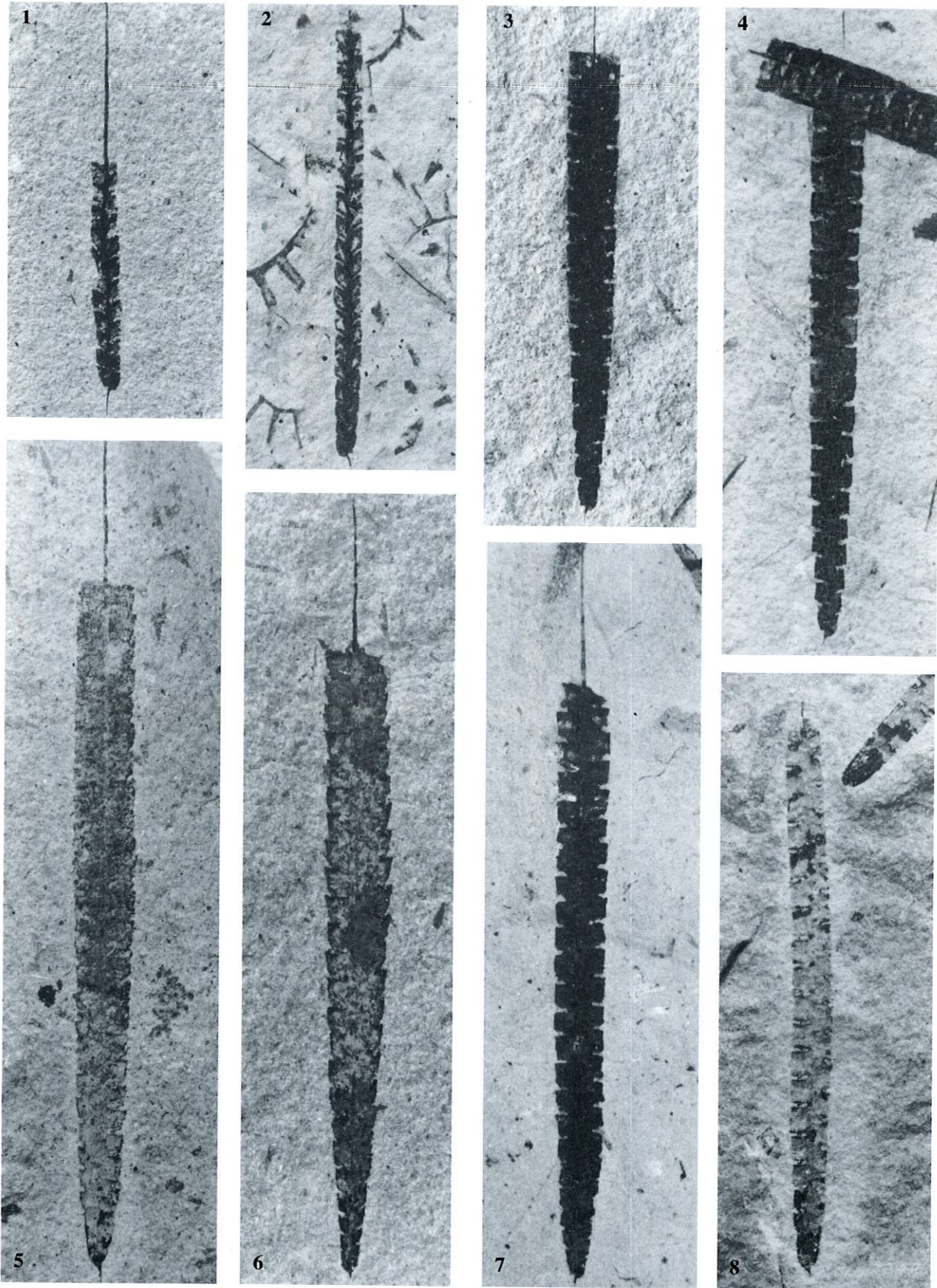
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### Graptoliti zón *Pribylograptus leptotheca* a *Lituigraptus convolutus* z Tmaně (silur, Barrandien)

Souhrnné zpracování bohaté a dobře zachovalé graptolitové fauny středního Llandovery (stupeň Aeron) z klasické lokality v polích u kostelíka Svatého Jiří severovýchodně od Tmaně (okres Beroun). Celkem bylo zjištěno 60 druhů a poddruhů planktonických graptolitů. Kvantitativní analýza objemových vzorků z různých částí vrstevního sledu ukázala, že ve společenstvech vysoce převládají co do počtu jedinců i druhů rhabdosomy jednořadých rastritidních forem s izolovanými tékami. V systematické části studie je popsán nový rod *Neolagarograptus* a 7 nových druhů (*Normalograptus? inornatus*, *Petalolithus krizi*, *Neolagarograptus impolitus*, *Monograptus respectabilis*, *M. dracocephalus*, *M. mirificus* a *Campograptus sanctgeorgensis*). Deset druhů bylo vzhledem k nedostatečnému materiálu ponecháno v otevřené nomenklatuře, 23 taxonů je nových pro český silur. Systematická revize fauny umožnila zpřesnění biostratigrafického členění a korelace středního llandovery Barrandienu. Biozóna *L. convolutus* (zóna rozsahu) byla redefinována a v intervalu odpovídajícím původně spodní části této biozóny byla definována nová biozóna *Pr. leptotheca* (intervalová zóna prvního výskytu).

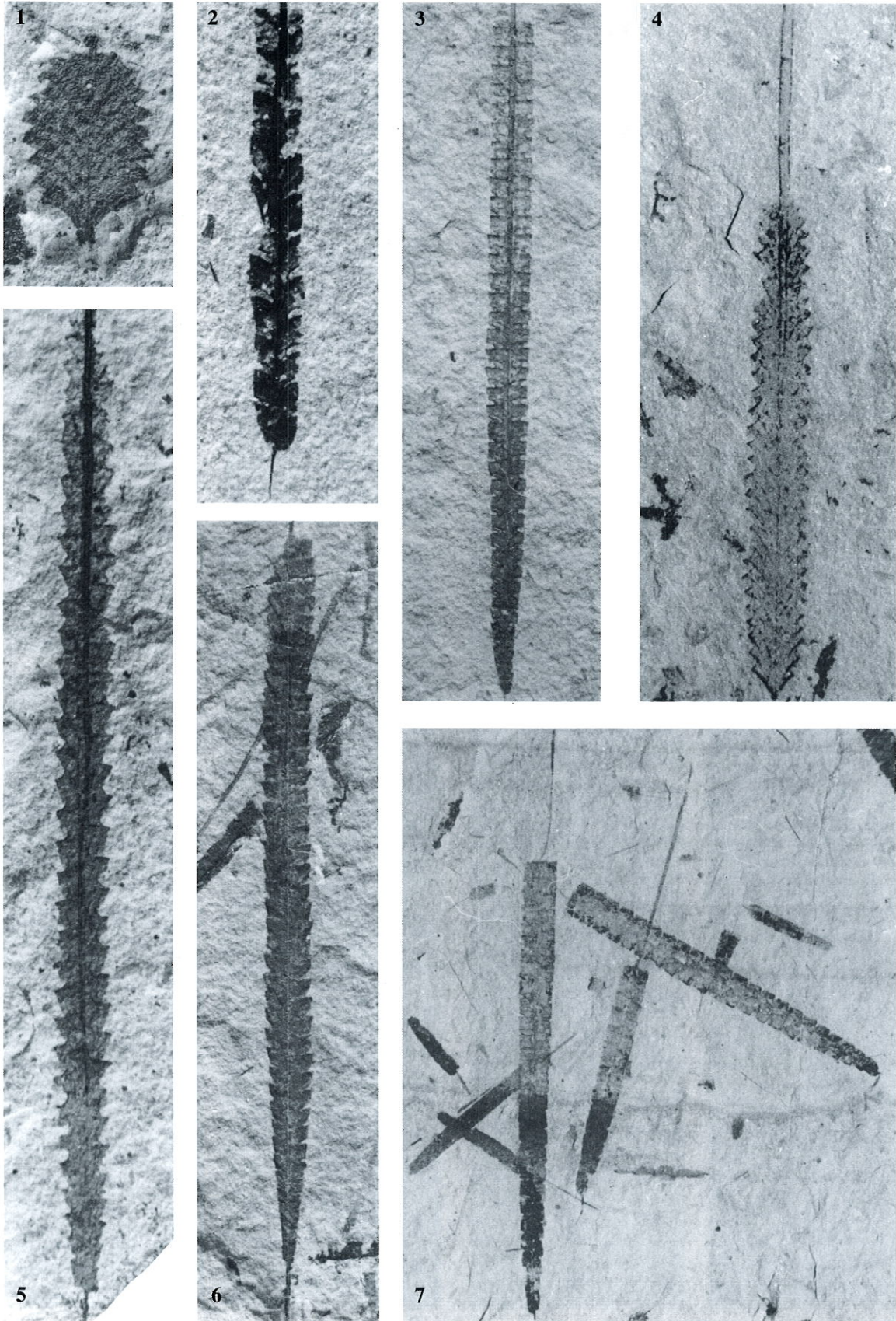
P. Št o r c h: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. I)



1, 2 *Metaclimacograptus hughesi* (Nicholson); 1 – PŠ 743, 2 – PŠ 736.  
 3, 4, 75, 7 *Normalograptus inornatus* n. sp.; 3 – PŠ 770, 4 – PŠ 739,  
 75 – PŠ 779, 7 – PŠ 742 (holotype).  
 6 – *Neodiplograptus thuringiacus* (Kirste); PŠ 789.  
 8 – *Metaclimacograptus bohemicus* (Perner); PŠ 832.

All specimens x5. Specimens on figs 1–4, 7 from the *leptotheca* Biozone, specimens on figs 5, 6 from the *convolutus* Biozone.  
 All specimens from the field 500 m SE of Svätý Jiří Church, E of Tmaň.  
 All photographs taken by the author.

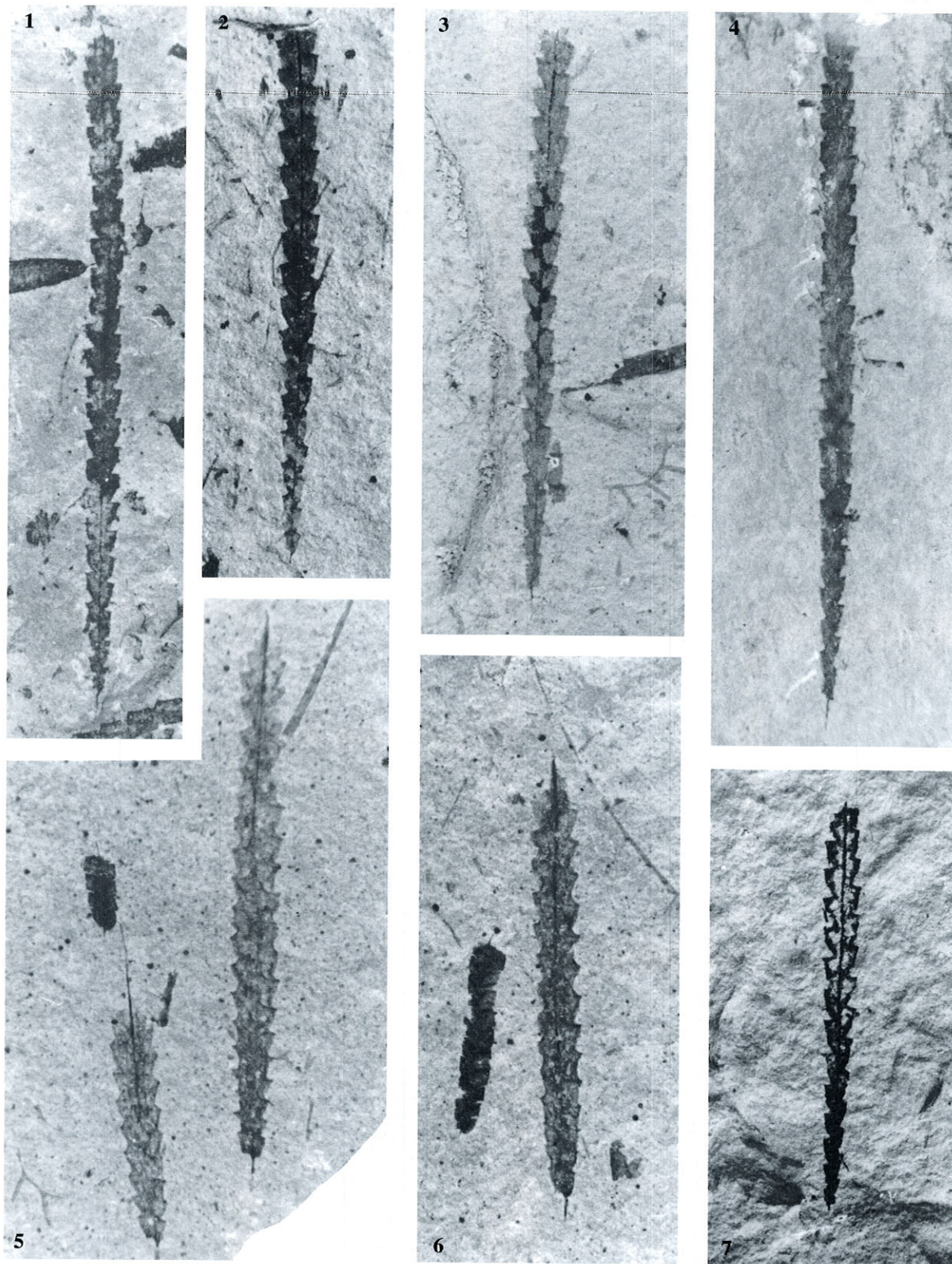
P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. II)



1 *Petalolithus* cf. *ovatoelongatus* (Kurck); PŠ 746.  
 2 *Metaclimacograptus hughesi* (Nicholson); 1 – PŠ 743.  
 3, 7 *Normalograptus inornatus* n. sp.; 3 – PŠ 849, 7 – PŠ 777.  
 4 *Petalolithus praecursor* Bouček & Přibyl; PŠ 762.

5 *Normalograptus? nikolayevi* (Obut); PŠ 753.  
 6 *Neodiplograptus thuringiacus* (Kirste); PŠ 828.  
 Figs 3, 4, 6, 7 x3; figs 1, 5 x5; fig. 2 x10. All specimens from the *leptotheca* Biozone.

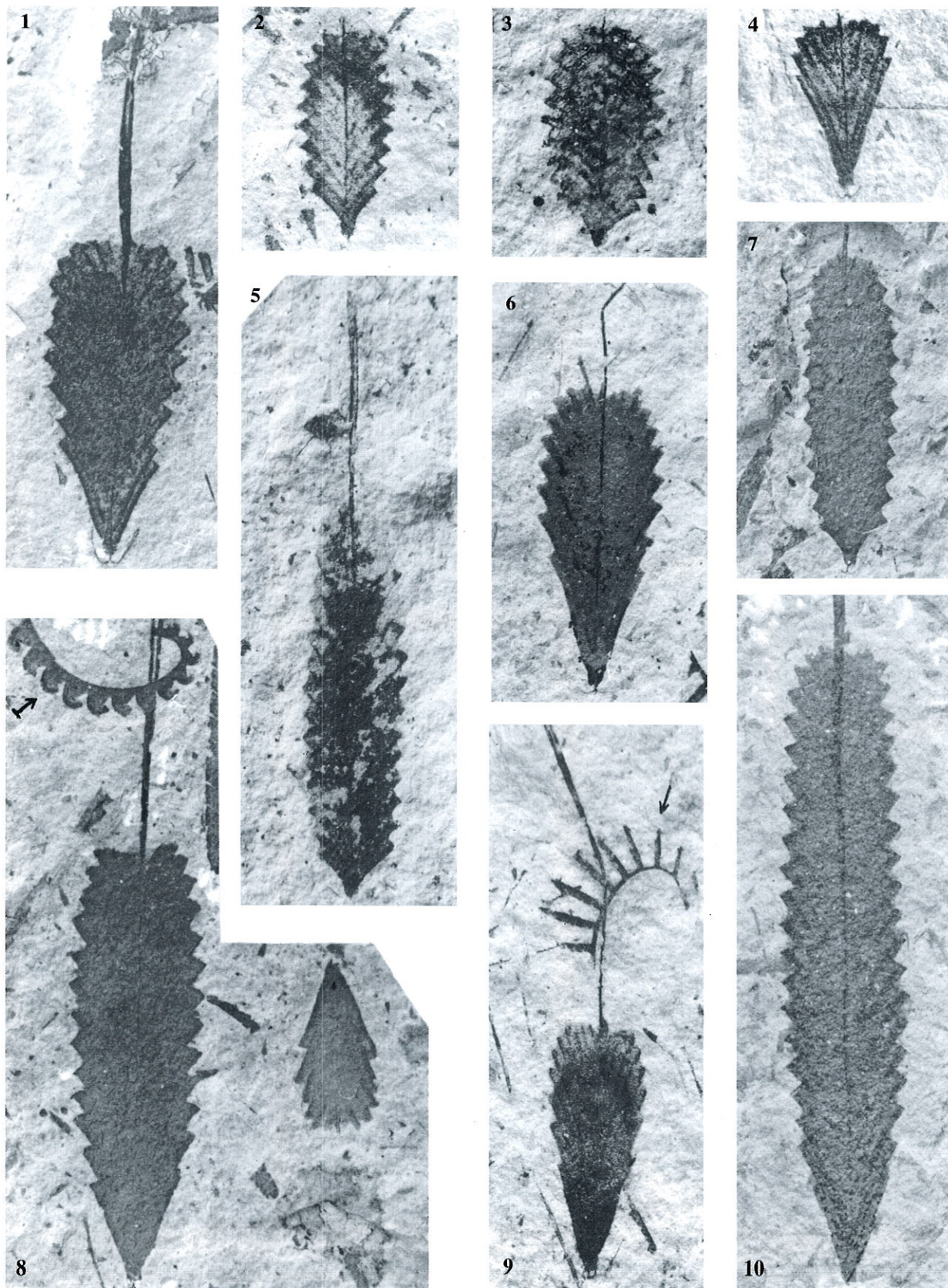
P. Št o r c h: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. III)



1-4, 7 *Glyptograptus tamariscus tamariscus* (Nicholson); 1 - PŠ 778,  
2 - PŠ 714, 3 - PŠ 713/1, 4 - PŠ 734, 7 - PŠ 713/2.

5, 6 *Normalograptus? nikolayevi* (Obut); 5, 6 - PŠ 799.  
All specimens x5; all from the *leptotheca* Biozone.

P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. IV)



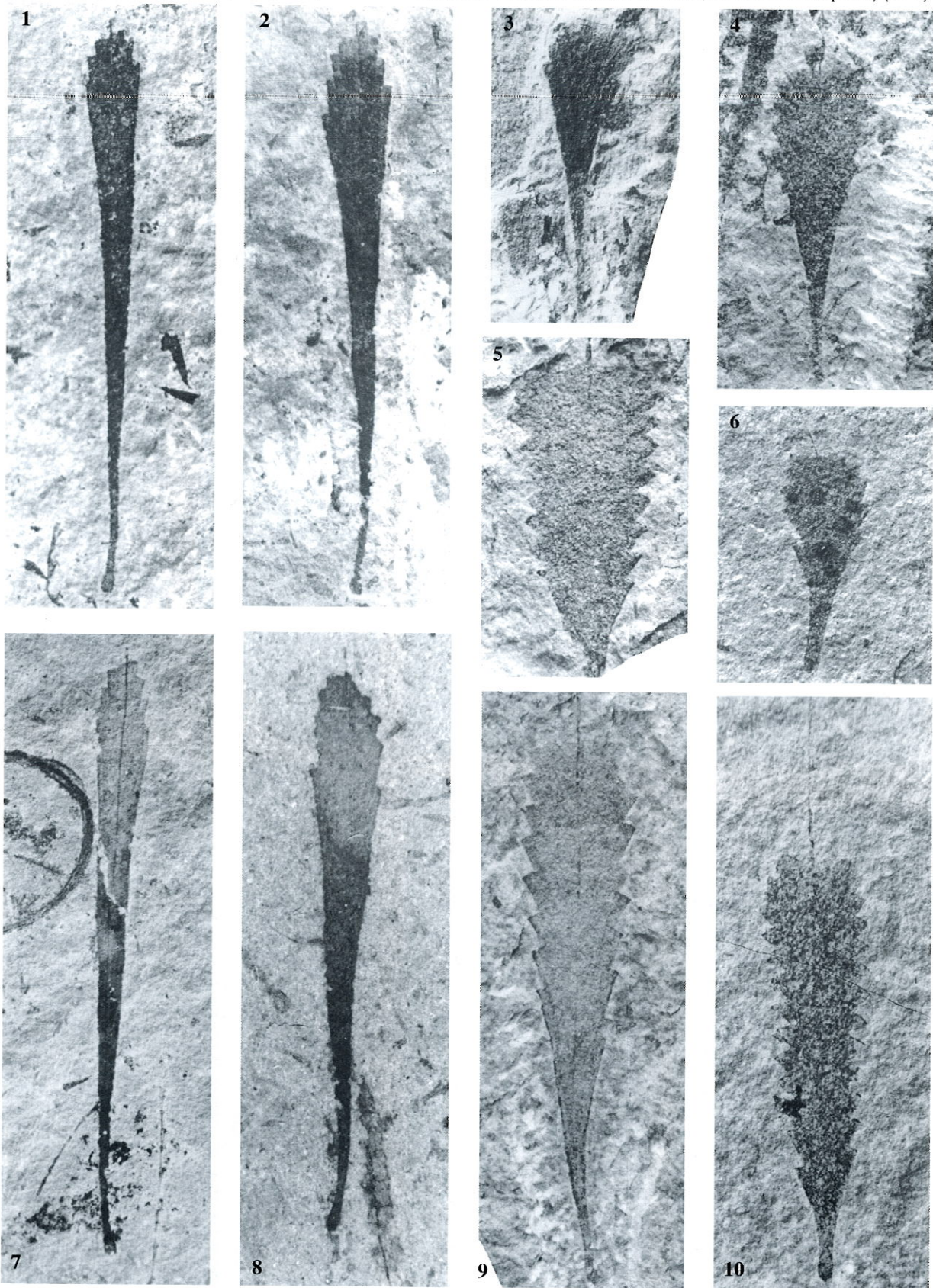
1, 4, 6, 8–10 *Petalolithus folium* (Hisinger); 1 – PŠ 821, 4 – PŠ 730,  
6 – PŠ 804/1, 8 – PŠ 773 [with *Campograptus millepeda* (McCoy), t→],  
9 – PŠ 804/2 (with *Rastrites approximatus* Perner, →), 10 – BB 697.  
2, 5, 7 *Petalolithus praecursor* Bouček & Přibyl; 2 – PŠ 801/1,

5 – PŠ 711/2, 7 – PŠ 801/2.

3 *Petalolithus* cf. *ovatoelongatus* (Kurck); PŠ 811.  
All specimens x5; all from the *leptotheca* Biozone.



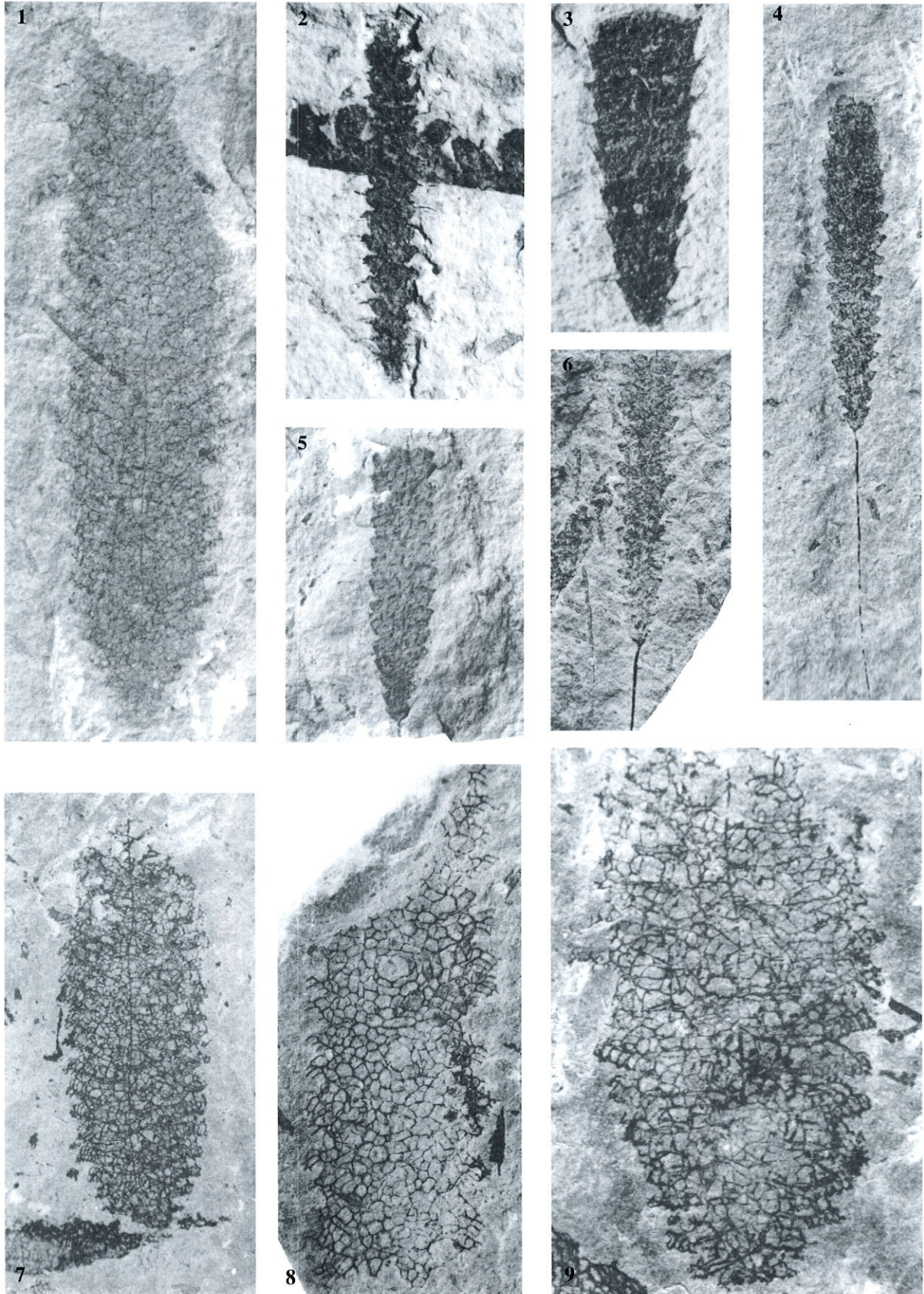
P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. V)



1, 2, 7, 8 *Cephalograptus cometa extrema* Bouček & Přibyl; 1 – PŠ 798, 2 – PŠ 797, 7 – PŠ 812, 8 – PŠ 813 [transitional form to *C. cometa cometa* (Geinitz)].  
3–5 *Cephalograptus tubulariformis* (Nicholson); 3 – PŠ 846/1, 4 – PŠ 846/2, 5 – PŠ 833/1 (proximal end broken off).

6, 10 *Petalolithus krizi* n. sp.; 6 – PŠ 781, 10 – PŠ 796 (holotype).  
9 *Cephalograptus cometa cometa* (Geinitz); PŠ 835.  
All specimens x5; all from the *convolutus* Biozone.

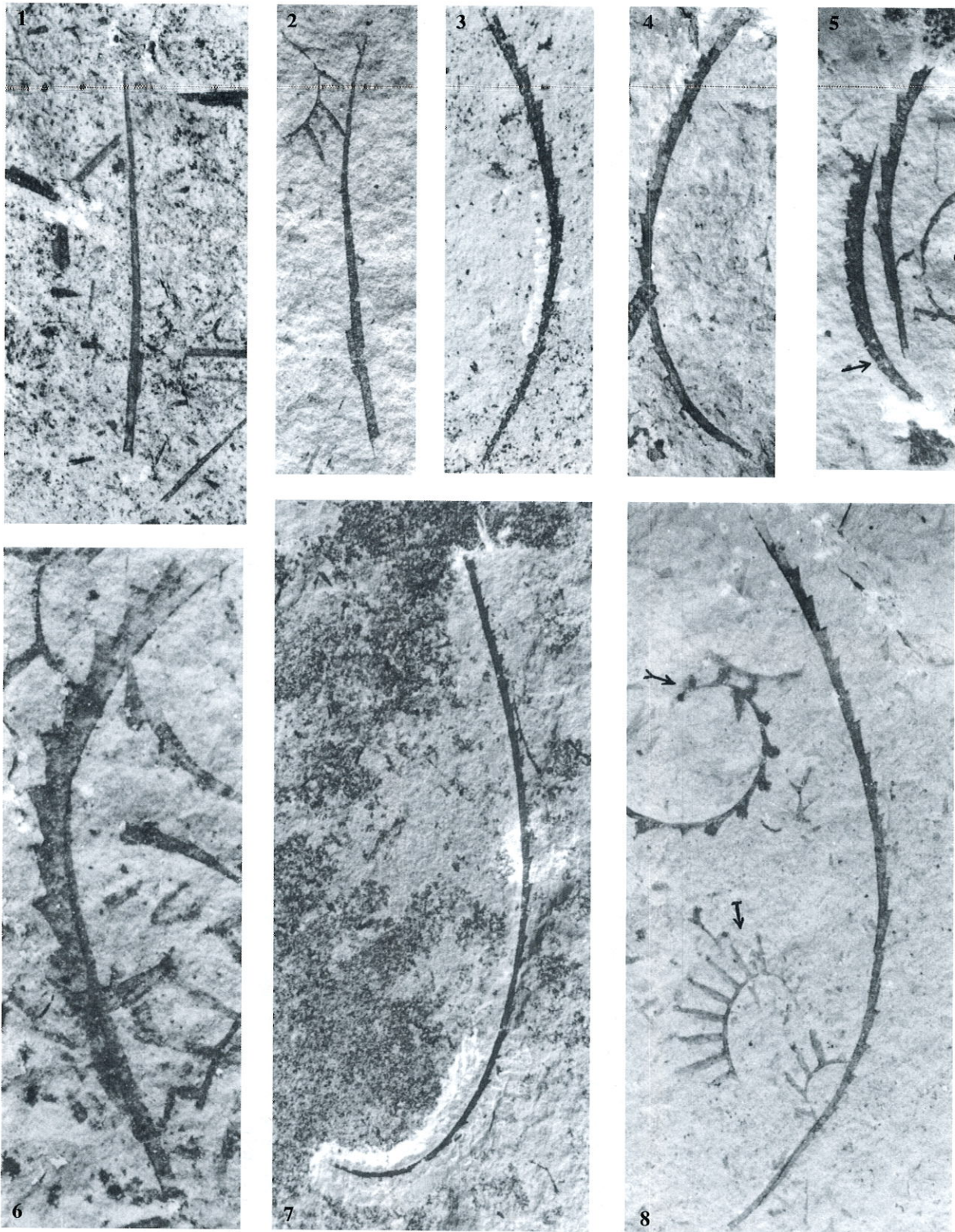
P. Š t o r c h : Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. VI)



1, 7-9 *Pseudoretiolites perlatus* (Nicholson); 1 - PŠ 861 (wider form), 7, 9 - PŠ 755, 8 - PŠ 780 (narrower form with prominent stomata).  
2 *Pseudorthograptus insectiformis* (Nicholson); PŠ 201.  
3 *Rivagraptus sentus* Koren' & Rickards; PŠ 784/2.

4, 75, 6 *Rivagraptus bellulus* (Törnquist); 4 - PŠ 787, 75 - PŠ 830, 6 - PŠ 857/1.

Figs 1, 2, 4-8 x5; figs 3, 9 x10 Specimens on figs 2, 5 from the *leptotheca* Biozone, specimens on figs 1, 3, 4, 6-9 from the *convolutus* Biozone.

P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. VII)

1, 2 *Coronograptus maxiculus* Štorch; 1 – PŠ 252 (holotype), 2 – PŠ 764.  
 3, 8 *Neolagarograptus helenae* (Štorch); 3 – PŠ 741, 8 – PŠ 802 (with  
*Rastrites approximatus* Perner,  $\rightarrow$ ) and *Monograptus mirificus* n. sp.,  $\rightarrow$ ).  
 4, 7 *Neolagarograptus impolitus* n. sp.; 4 – PŠ 234 (holotype), 7 – PŠ 723.

5, 6 *Coronograptus gregarius gregarius* (Lapworth); 5 – PŠ 809 (with  
*Monograptus havliceki* Štorch,  $\rightarrow$ ), 6 – PŠ 788.

Fig. 7 x3; figs 1–5, 8 x5; fig. 6 x10. Specimens on figs 1–3, 5, 6, 8 from the  
*leptotheca* Biozone, specimens on figs 4, 7 from the *convolutus* Biozone.

P. Št o r c h : Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. VIII)



1, 2 *Monograptus havliceki* Št orch; 1 – PŠ 760 (with *Monograptus respectabilis* n. sp., ↗ and *Streptograptus* sp. →), 2 – PŠ 793.

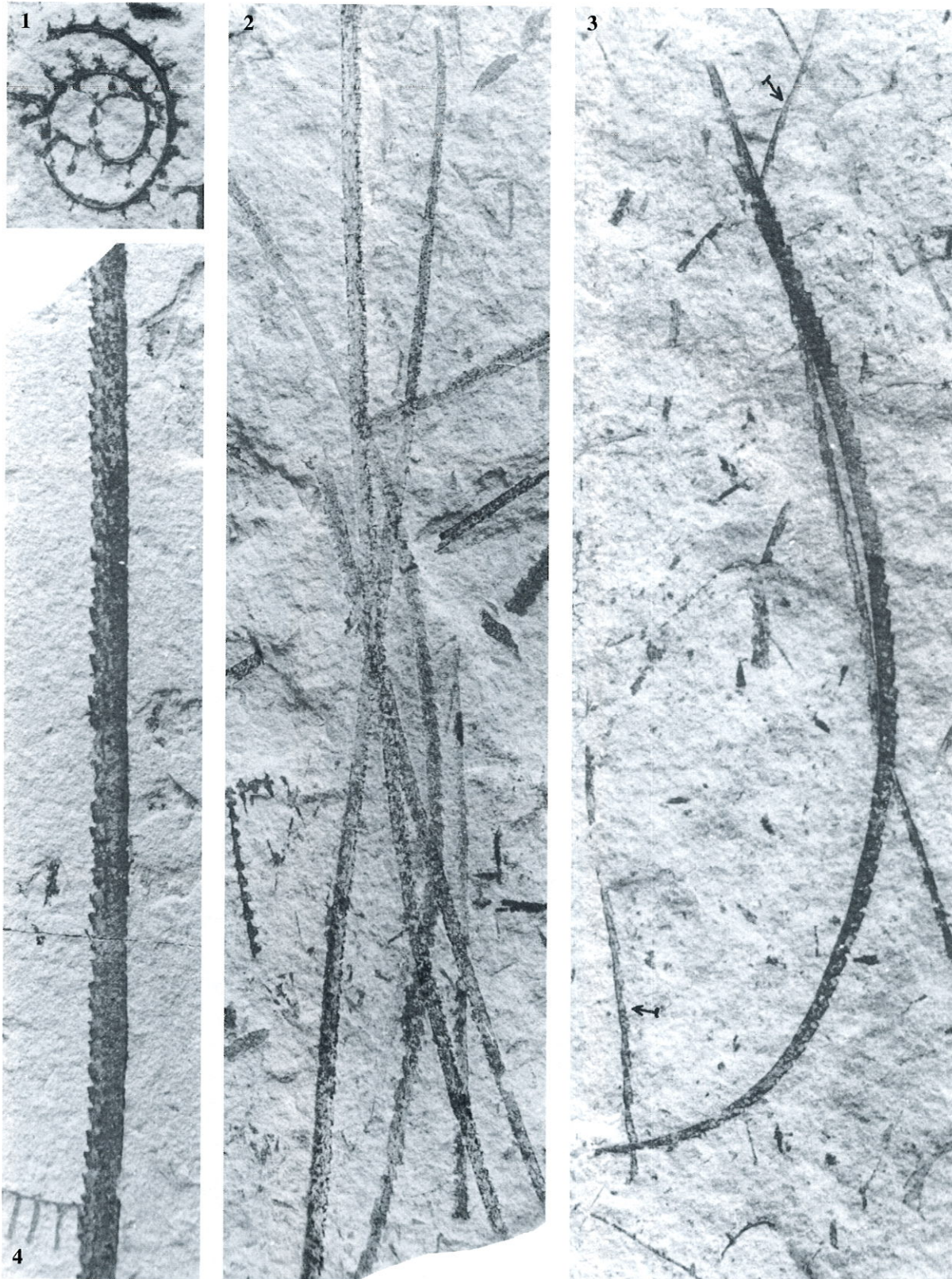
3, 5 *Monograptus limatulus inopinus* Törnquist; 3 – PŠ 270/1, 5 – PŠ 808.

4 *Monograptus limatulus limatulus* Törnquist; PŠ 757.

6 *Monograptus* aff. *imago* Zalasiewicz; PŠ 806 (with distal portion of *Monograptus respectabilis* sp. n., ↗).

All specimens x5. Specimens on figs 1–3, 5, 6 from the *leptotheca* Biozone, specimen on fig. 4 from the *convolutus* Biozone.

P. Š t o r c h : Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. IX)



1 *Spirograptus* sp.; PŠ 831.

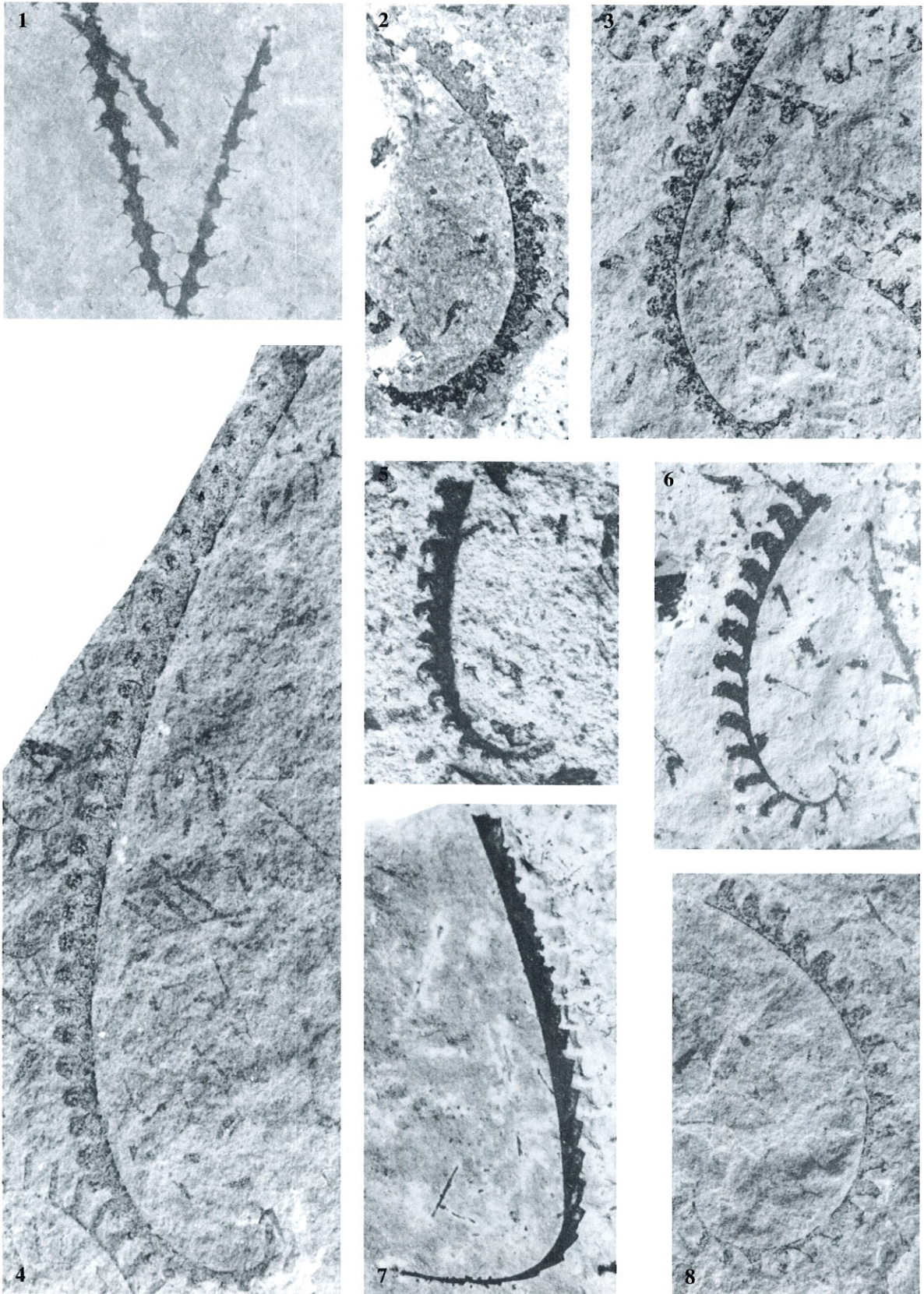
2 *Monoclimacis crenularis* (Lapworth); PŠ 697.

3 *Monograptus havliceki* Štorch; PŠ 768 (with *Monograptus respectabilis* n. sp. ↳)

4 *Pribylograptus leptotheca* (Lapworth); PŠ 822.

Figs 2, 4 x3, figs 1, 3 x5 Specimens on figs 1, 3, 4 from the *leptotheca* Biozone, specimen on fig. 2 from the *convolutus* Biozone.

P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. X)



1 *Campograptus lobiferus harpago* Törnquist; PŠ 271 (scalariform view showing laterally directed apertural spines).

2, 5 *Campograptus clingani* (Carruthers); 2 – PŠ 250a, 5 – PŠ 221.

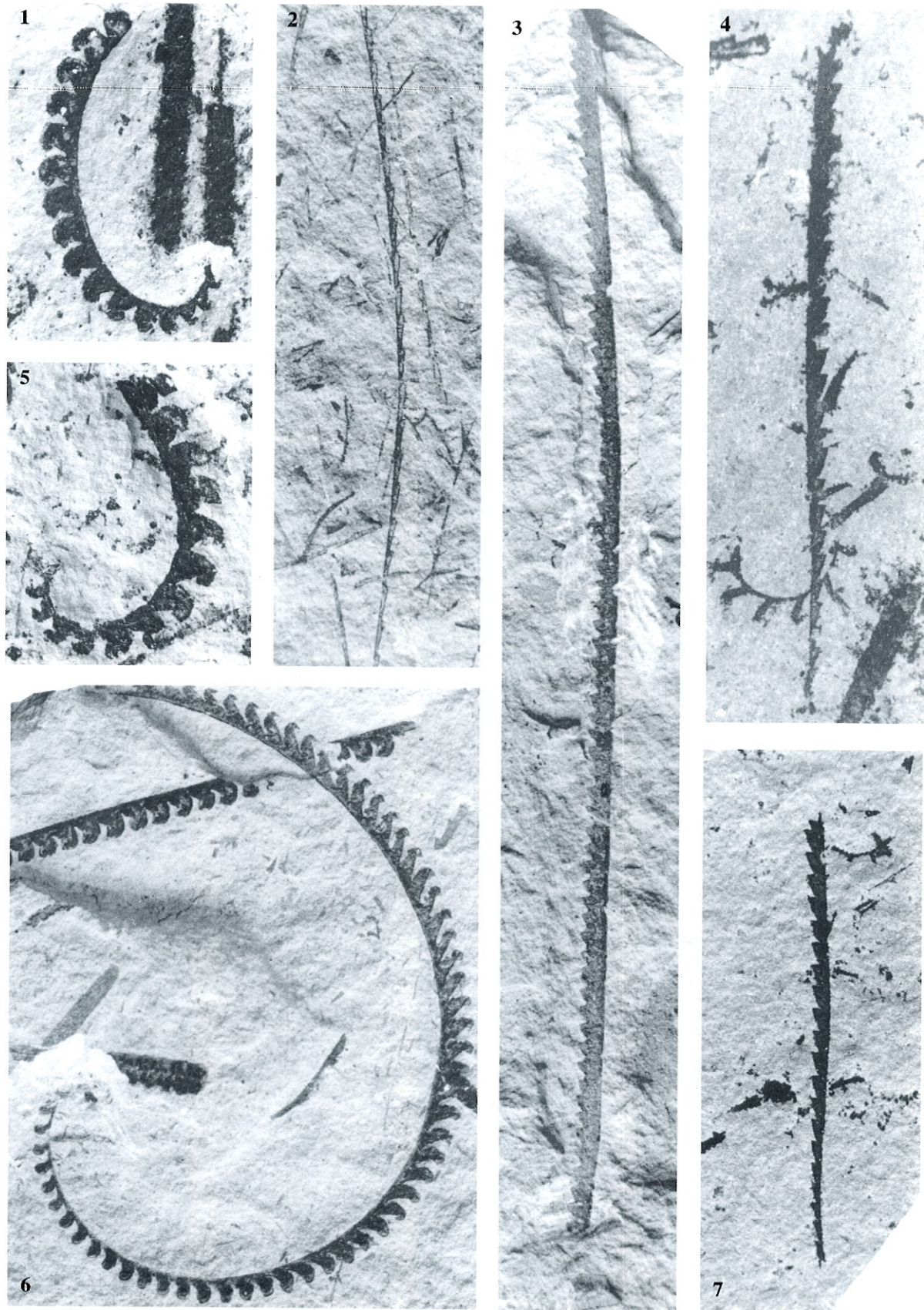
3, 4 *Campograptus obtusus* (Rickards); 3 – PŠ 840, 4 – PŠ 856.

6 *Monograptus paradenticulatus* Zalasiewicz; PŠ 807.

7 *Monograptus limatulus limatulus* Törnquist; PŠ 232.

8 *Torquigraptus denticulatus* (Törnquist); PŠ 855.

All specimens x5. Specimen on fig. 6 from the *leptotheca* Biozone, other specimens from the *convolutus* Biozone.

P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XI)

1, 5 *Campograptus millepeda* (McCoy); 1 – PŠ 803, 5 – PŠ 807.  
 2 *Monograptus respectabilis* n. sp.; PŠ 859.  
 3 *Pristiograptus concinnus* (Lapworth); PŠ 775.  
 4, 7 *Pristiograptus regularis solidus* Přibyl; 4 – PŠ 747, 7 – PŠ 766.

6 *Torquigraptus* cf. *valens* (Přibyl & Münch); PŠ 800.  
 Fig. 3, 6 x3, figs 1, 2, 4, 7 x5, fig. 5 x10 Specimens on figs 1–3, 5, 6 from the *leptotheca* Biozone, specimens on figs 4, 7 from the *convolutus* Biozone.

P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XII)

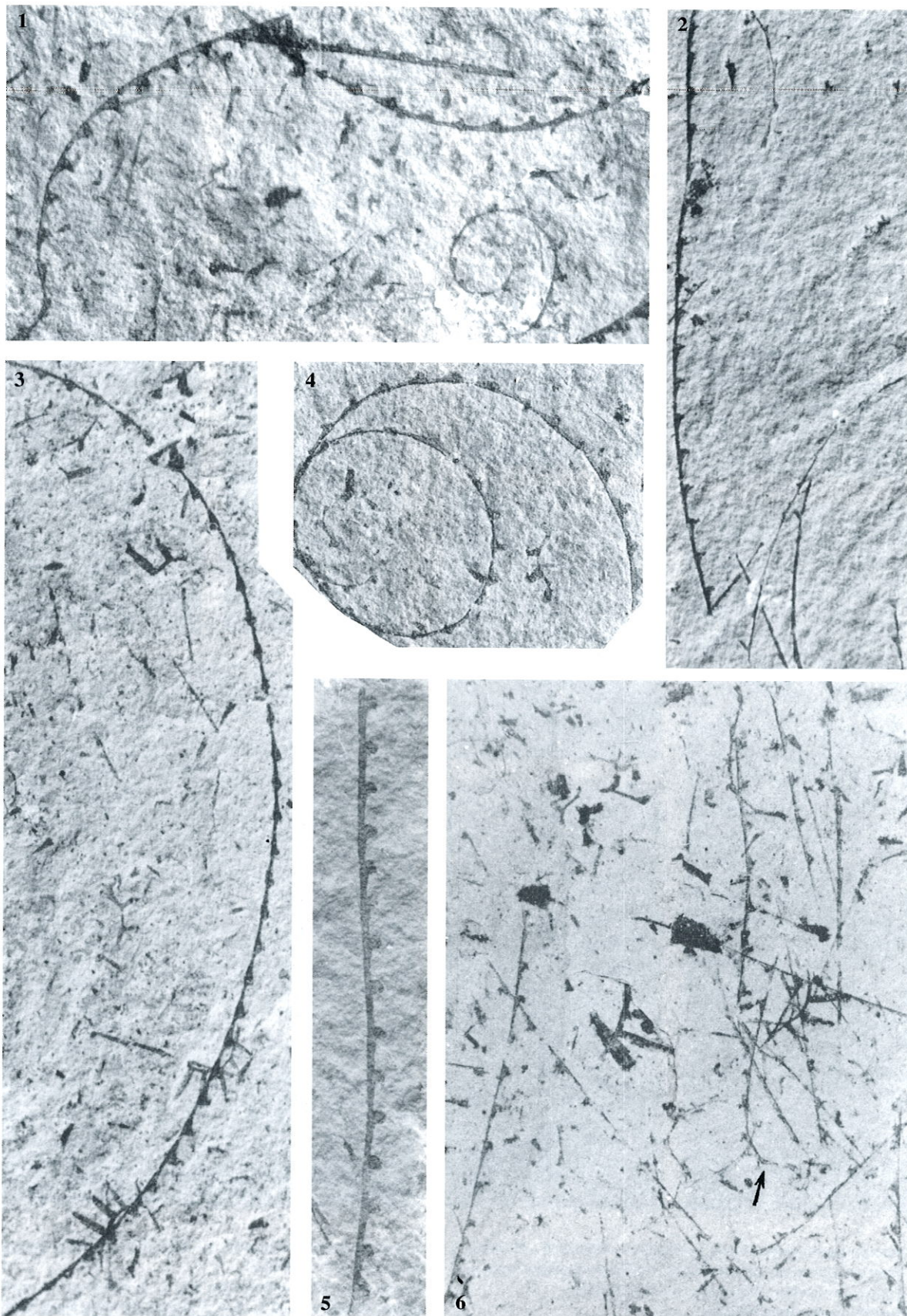


1, 3, 4 *Campograptus sanctgeorgensis* n. sp.; 1 – PŠ 769 (holotype), 3 – PŠ 782, 4 – PŠ 836.  
2, 5 *Campograptus* cf. *communis* (Lapworth); 2 – PŠ 794, 5 – PŠ 737.  
6 *Campograptus lobiferus harpago* Törnquist; PŠ 271 (scalariform of the distal fragment).

7, 8 *Campograptus lobiferus lobiferus* (McCoy); 7 – PŠ 718, 8 – PŠ 825.  
Fig. 1 x3, figs 2–8 x5. Specimens on figs 1–5, 7, 8 from the *leptotheca* Biozone, specimen on fig. 6 from the *convolutus* Biozone.



P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XIII)



1, 3, 4 *Monograptus mirus* Perner; 1 – PŠ 839, 3 – PŠ 785, 4 – PŠ 781.  
2 *Monograptus capillaris* (Carruthers); BB 696.  
5 *Streptograptus* sp.; PŠ 838/1.

6 *Monograptus dracocephalus* n. sp.; PŠ 756 (holotype designated by →).  
All specimens x5. Specimens on figs 1, 3, 5, 6 from the *leptotheca* Biozone, specimen on figs 2, 4 from the *convolutus* Biozone.

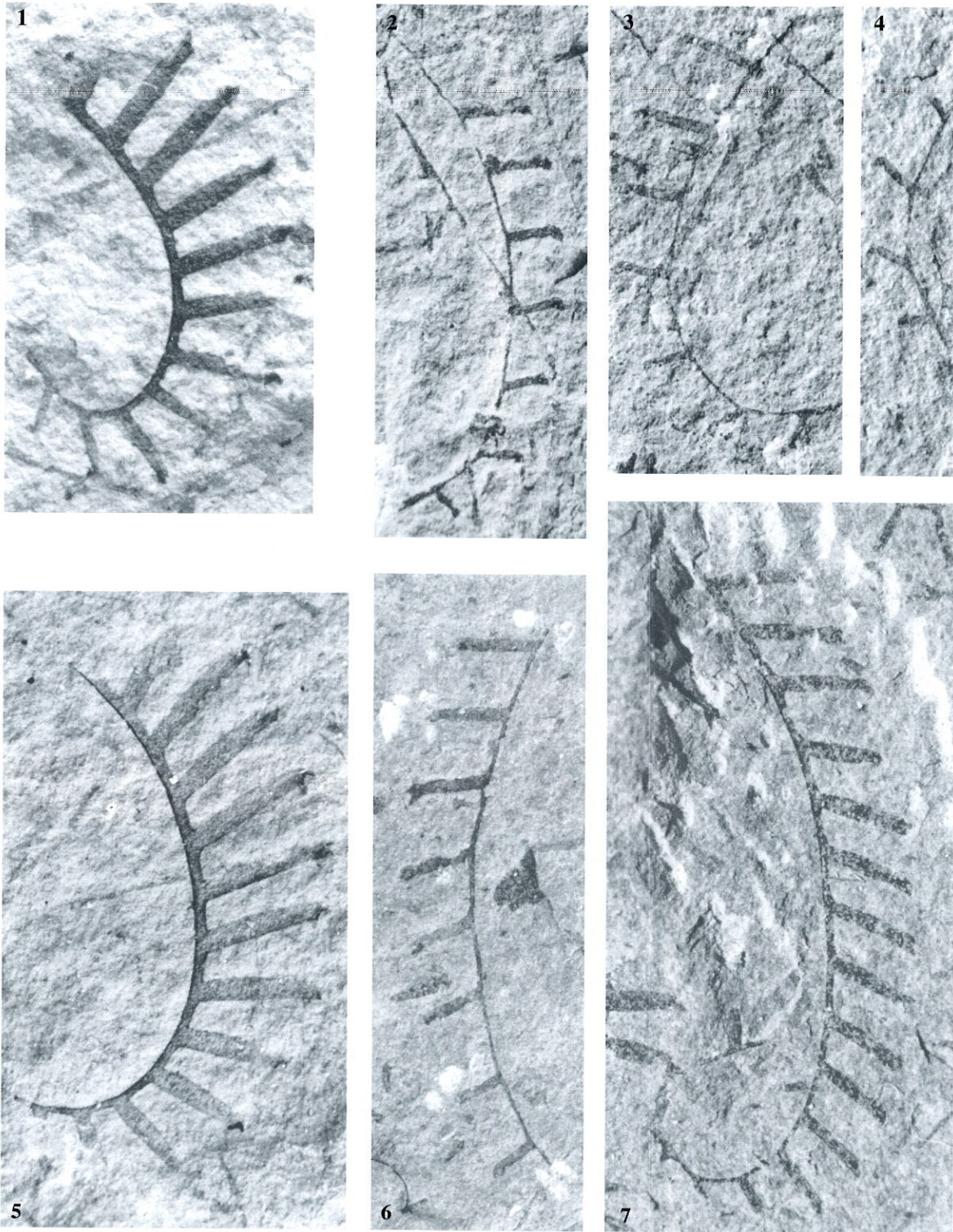
P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XIV)



1, 3, 8 *Rastrites approximatus* Perner; 1 – PŠ 824, 3 – PŠ 829, 8 – PŠ 712a.  
2, 4, 9 *Rastrites peregrinus* Barrande; 2, 9 – PŠ 724 [with distal portion of *Lituigraptus convolutus* (Hisinger), ↳], 4 – BB 698.  
5 *Rastrites* cf. *erectus* Hutt; PŠ 720.

6, 7 *Rastrites geinitzii* Törnquist; 6 – BB 699 [with *Lituigraptus richteri* (Perner), >>], 7 – PŠ 852/1.

All specimens x5. Specimens on figs 1, 3, 6–8 from the *leptotheca* Biozone, specimens on figs 2, 4, 5, 9 from the *convolutus* Biozone.

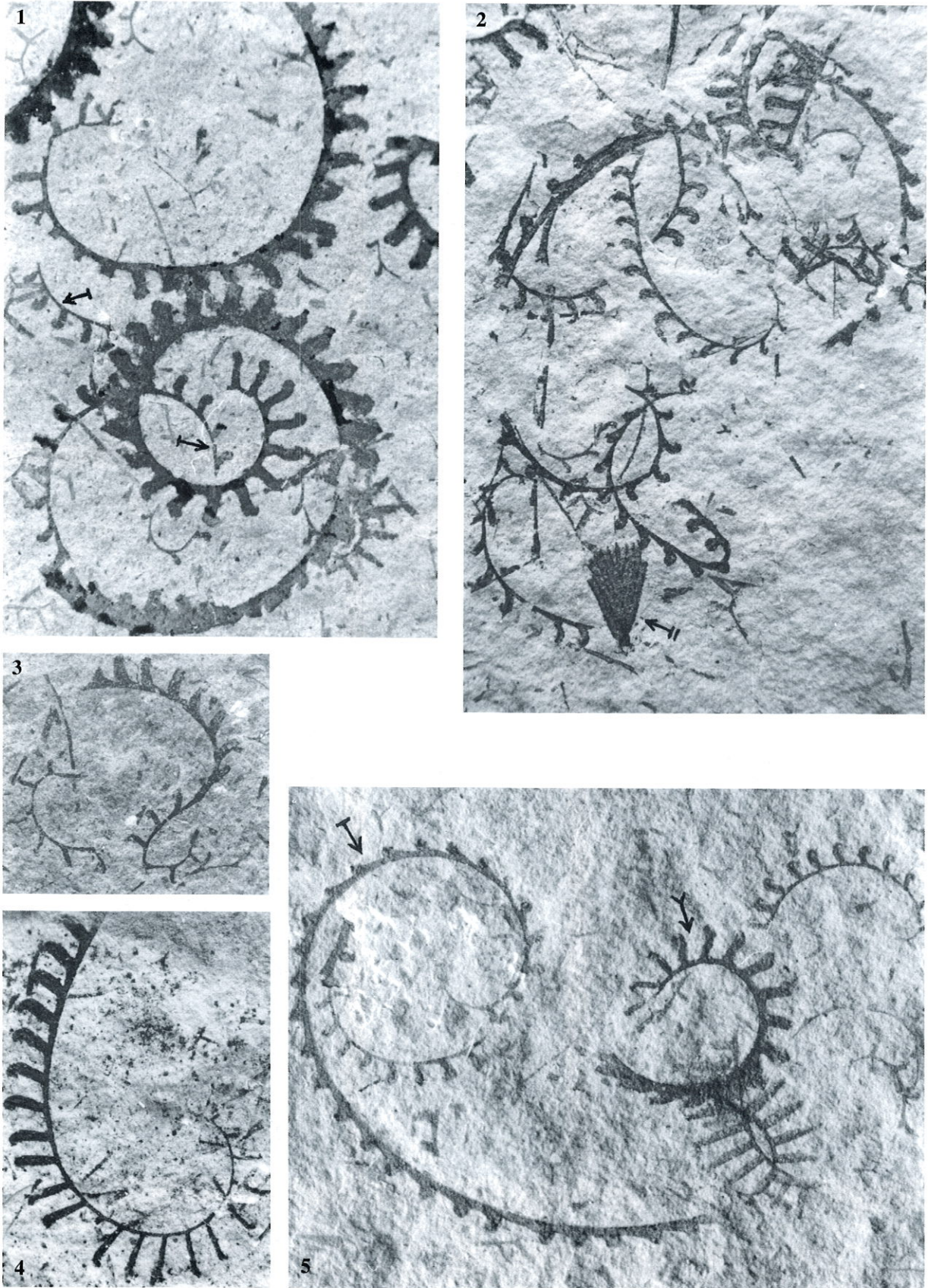
P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XV)

1, 5 *Rastrites approximatus* Perner; 1 – PŠ 765, 5 – PŠ 719.  
2–4, 6 *Rastrites cf. erectus* Hutt; 2 – PŠ 519b, 3 – PŠ 845a, 4 – PŠ 860, 6 – PŠ 720.

7 *Rastrites peregrinus* Barrande; PŠ 724.

All specimens x10. Specimens on figs 1, 5 from the *leptotheca* Biozone, specimens on figs 2–4, 6, 7 from the *convolutus* Biozone.

P. Št o r c h: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XVI)



1 *Lituigraptus richteri* (Perner); PŠ 805 (with *Monograptus mirificus* n. sp., I→).

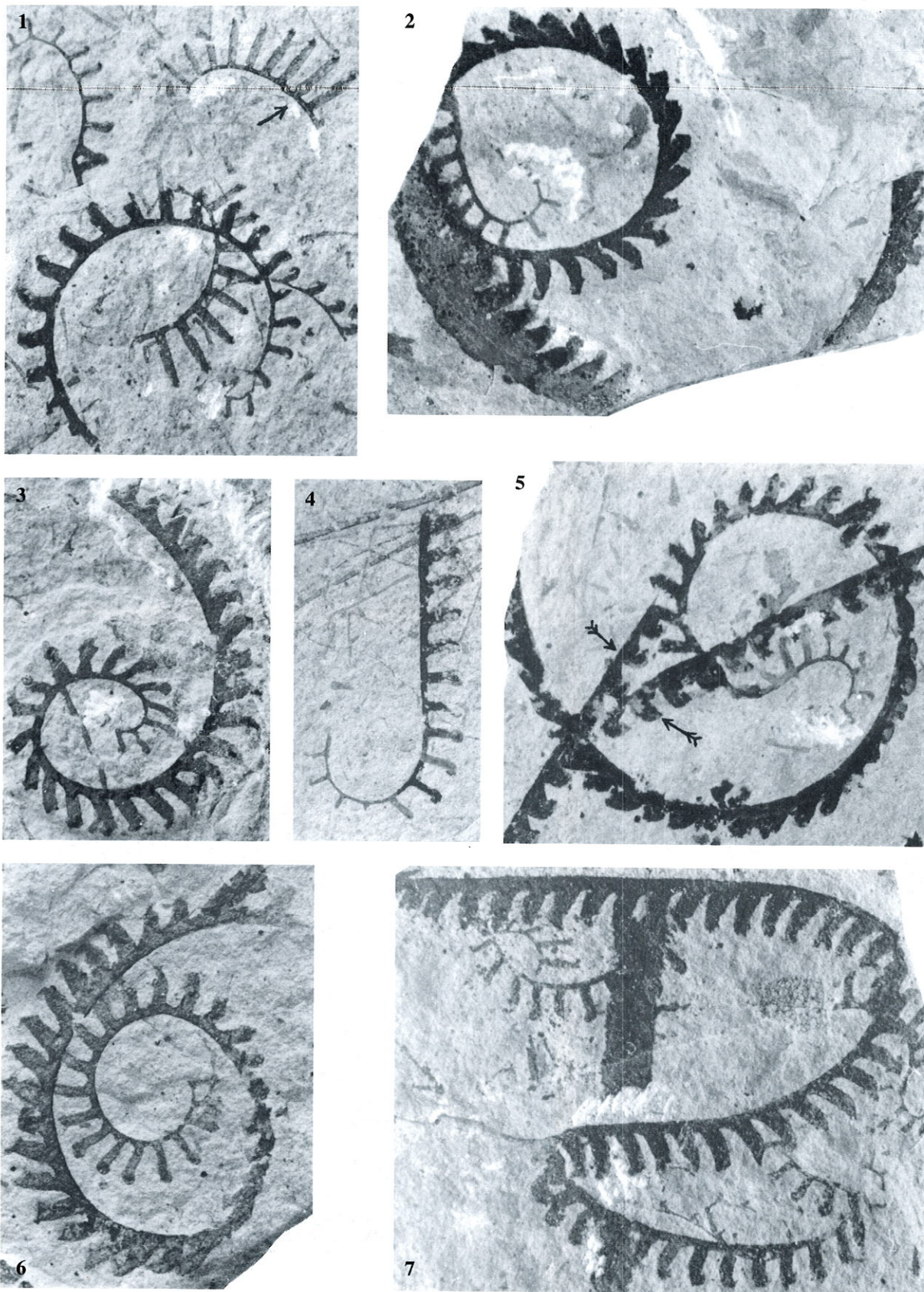
2, 5 *Monograptus mirificus* n. sp.; 2 – PŠ 795 [with *Petalolithus folium* (Hisinger), II→], 5 – BB 693 [holotype, ←I with *Lituigraptus richteri* (Perner), ←<].

3 *Torquigraptus? decipiens* (Törnquist); PŠ 716a.

4 *Monograptus simulans* Pedersen; PŠ 740a.

All specimens x5. Specimens on figs 1, 2, 4, 5 from the *leptotheca* Biozone, specimen on fig. 3 from the *convolutus* Biozone.

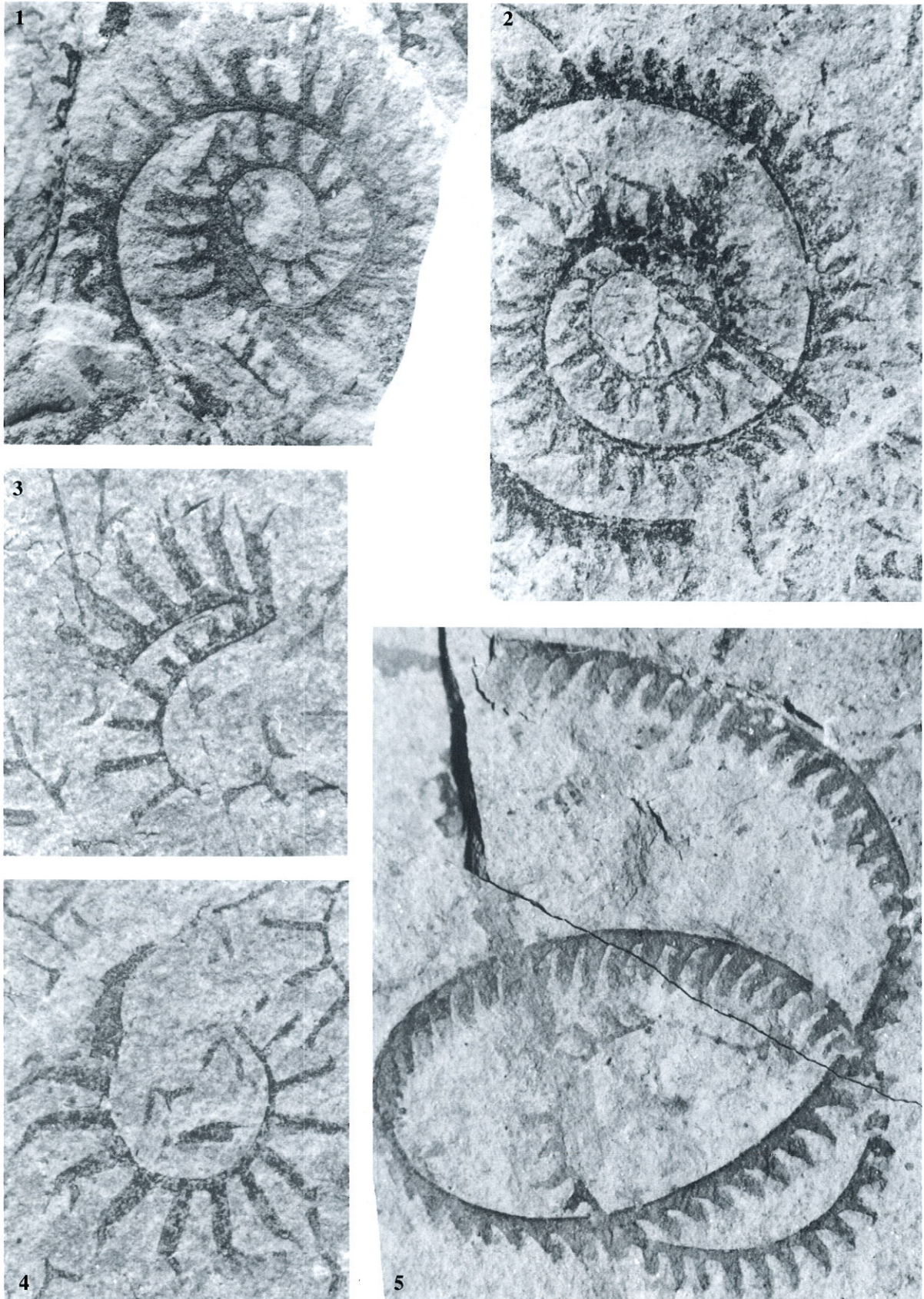
P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XVII)



1-7 *Lituigraptus richteri* (Perner); 1 - PŠ 749 (with *Rastrites approximatus* Perner, ←), 2 - PŠ 715, 3 - PŠ 728, 4 - PŠ 739, 5 - PŠ 759 [with

*Campograptus lobiferus lobiferus* (McCoy), ←←], 6 - PŠ 528, 7 - PŠ 810/2. All specimens x5; from the *leptotheca* Biozone.

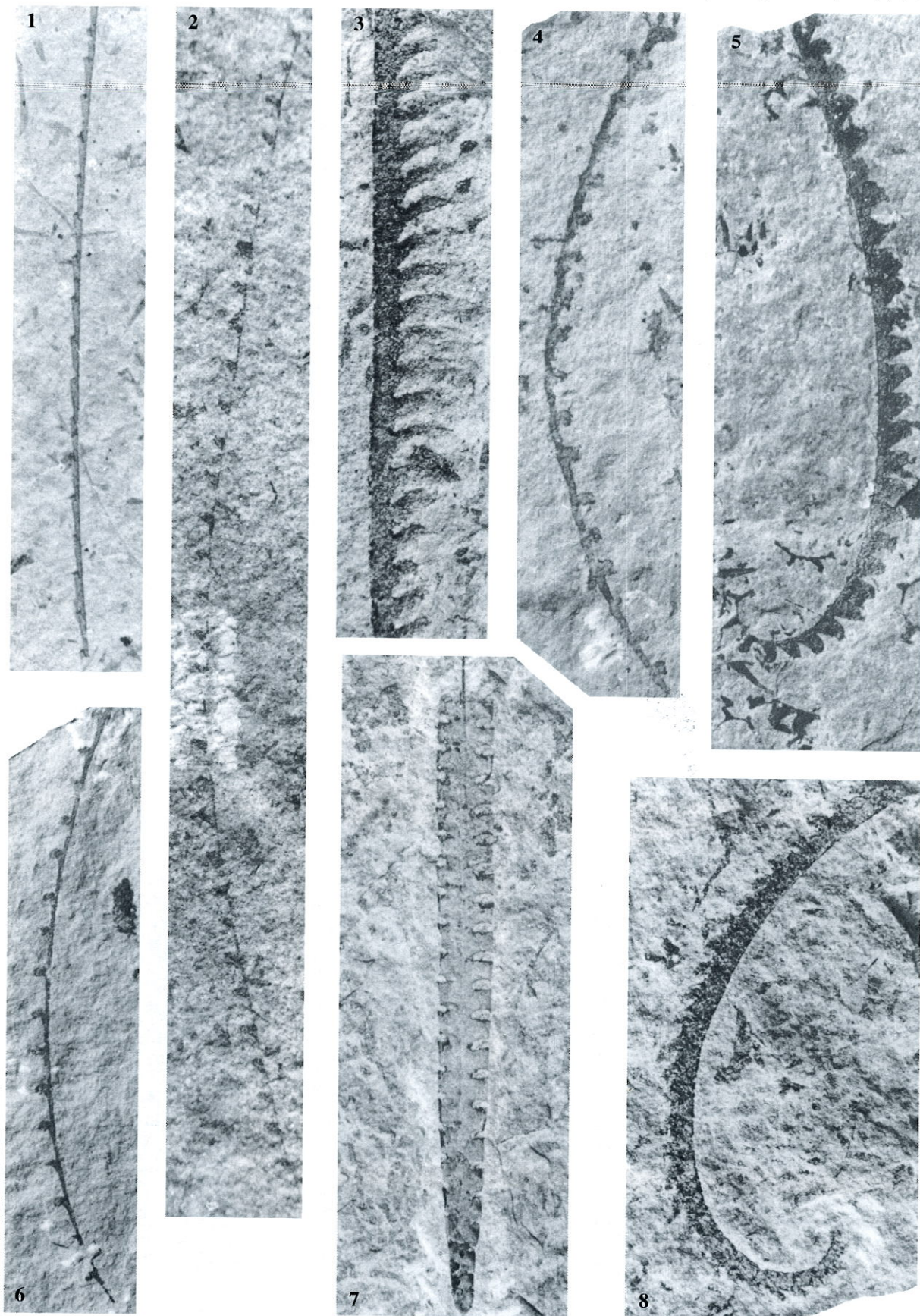
P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XVIII)



1–4 *Lituigraptus convolutus* (Hisinger); 1 – BB 695, 2 – PŠ 748, 3, 4 – PŠ 724.

5 *Lituigraptus richteri* (Perner); PŠ 810/1.

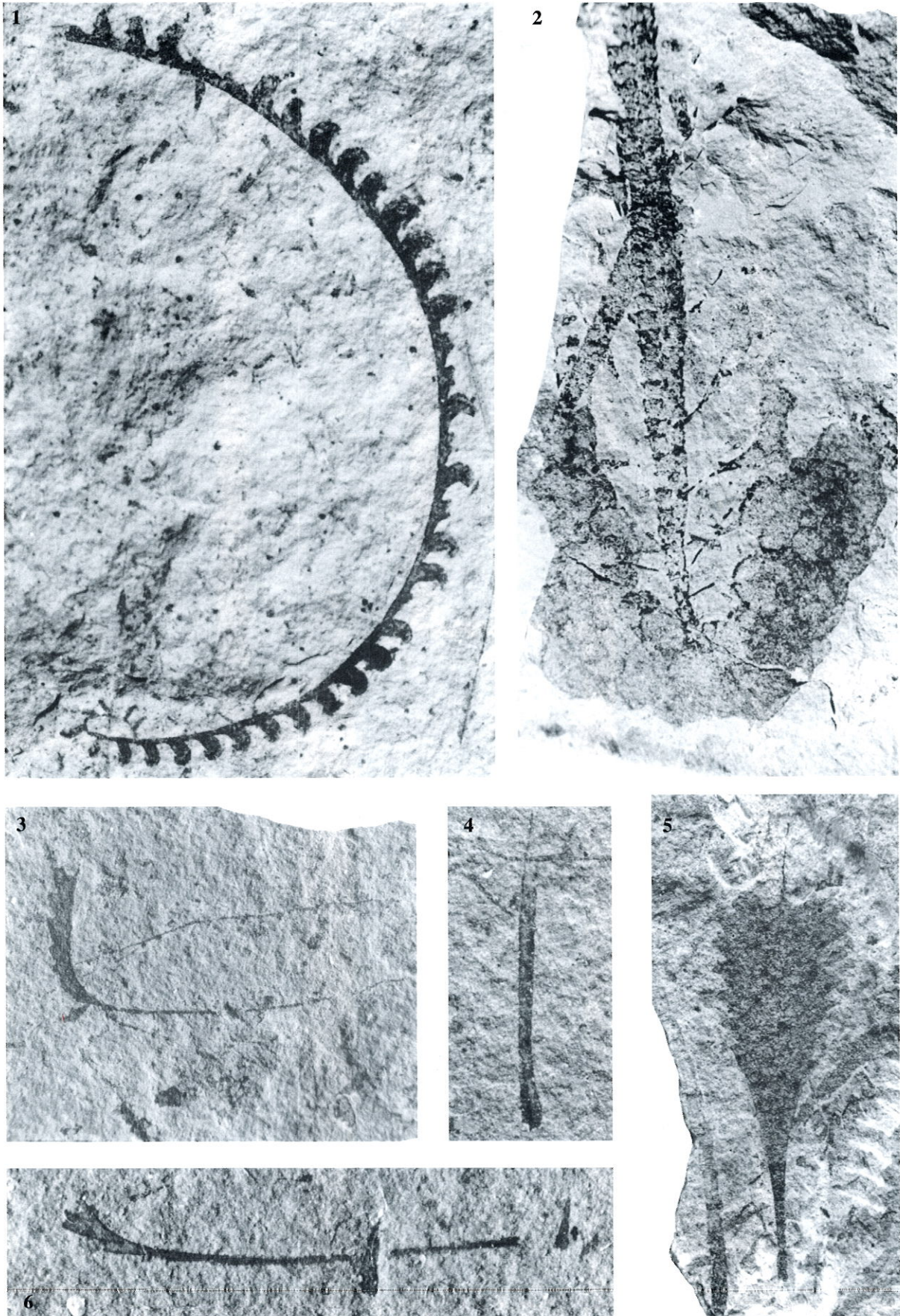
Figs 1, 2, 5 x5, figs 3, 4 x10. Specimens on figs 1–4 from the *leptotheca* Biozone, specimen on fig. 5 from the *convolutus* Biozone.

P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XIX)

- 1 *Monograptus respectabilis* n. sp.; PŠ 774.  
 2 *Rastrites spina* (Richter); PŠ 907.  
 3 *Lituigraptus convolutus* (Hisinger); PŠ 925.  
 4 *Streptograptus* sp.; PŠ 838/2.  
 5 *Torquigraptus denticulatus* (Törnquist); PŠ 917.

- 6 *Monograptus capillaris* (Carruthers); PŠ 924.  
 7 *Normalograptus inornatus* n. sp.; PŠ 911.  
 8 *Campograptus clingani* (McCoy); PŠ 919.  
 All specimens x5. Specimens on figs 1, 4 from the *leptotheca* Biozone,  
 specimens on figs 2, 3, 5, 7, 8 from the *convolutus* Biozone

P. Štorch: Graptolites of the *Pribylograptus leptotheca* and *Lituigraptus convolutus* biozones of Tmaň (Silurian, Czech Republic) (Pl. XX)



1 *Monograptus paradenticulatus* Zalasiewicz; PŠ 839.  
 2 *Dittograptus monstrosus* (Štorch); PŠ 61.  
 3, 6 *Monograptus limatulus limatulus* Tömquist; 3 – PŠ 926/1, 6 – PŠ 860.  
 4 *Cephalograptus cometa extrema* Bouček & Přibyl; PŠ 860 (juvenile specimen).

5 *Cephalograptus tubulariformis* (Nicholson); PŠ 920/1.  
 Fig. 1 x3, figs 1, 3, 5 x5, figs 4, 6 x10. Specimens on figs 1 and 2 from the *leptotheca* Biozone, specimens on figs 2–6 from the *convolutus* Biozone.