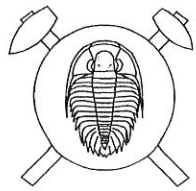
Pterygotid eurypterids (Arthropoda, Chelicerata) in the Silurian and Devonian of Bohemia



Pterygotidní eurypteridi (Arthropoda, Chelicerata) v českém siluru a devonu (Czech summary)

(3 text–figs., 6 plates)

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Representatives of the family Pterygotidae Clarke et Ruedemann, 1912 from the Ludlovian, Přídolian and Lochkovian strata of the Barrandian area, central Bohemia (Czech Republic) are reviewed and discussed: *Acutiramus bohemicus* (Barrande, 1872), *A. perneri* sp. n., *A.? nobilis* (Barrande, 1872), *Pterygotus barrandei* Semper, 1898, *P. kopaninensis* Barrande, 1872 and doubtful species *P. mediocris* Barrande, 1872 and *P.? blahai* Semper, 1898. Pterygotids show their maximum development in strata of Přídolian age and they tend to be concentrated in offshore dark platy limestone facies with anoxic bottom influences. They are constituents of marine faunas and exhibit the same environmental dependence as the coeval phyllocarid crustaceans of the fam. Ceratiocarididae.

The Silurian and Devonian deposits of the Barrandian area of central Bohemia contain marine eurypterids in strata of Wenlockian up to Lochkovian age. Particularly the family Pterygotidae is well represented and finds of the genus *Acutiramus* Ruedemann, 1935 belong to the relatively most common eurypterid remains found in the late Silurian and earliest Devonian strata.

Bohemian eurypterids were described for the first time by Barrande (1872) and later supplemented by Semper (1898) and Seemann (19O6). A thorough revision was made by Prantl and Přibyl (1948). Since their work only comments on distribution and stratigraphic occurrence (e.g.Chlupáč et al. 1972, Chlupáč in Kříž et al. 1986) have appeared with only a few systematic comments (Kjellesvig–Waering 1964).

The author had the opportunity to collect at most eurypterid localities of the Barrandian area since the mid–forties. The detailed biostratigraphic studies of Silurian and Devonian strata also offered new eurypterid materials. Valuable contributions also represented some older collections, especially those of F. J. Pecka, F. Hanuš and R. Růžička, deposited in the National Museum and not included in the revision by Prantl and Přibyl (1948).

The majority of the reference material is deposited in the collections of the National Museum, Prague (inventory numbers prefixed by L) and only a few specimens are housed at the Department of Geology and Paleontology, Charles University, Prague.

The terminology is adopted according to Stormer (1955), Waterston (1964) and Tollerton (1989). The drawings were made using transparent sheets which allowed to redraw outlines directly from the specimens. Dotted lines indicate in drawings secondary limits of organic remains (damages etc.).

A c k n o w l e d g e m e n t s . For a critical reading of the manuscript and valuable comments the author is indebted to V.P. Tollerton (Utica, USA). Dr. R. Horný, Dr. R. Prokop and Dr. V. Turek faciliated the study of materials deposited at the National Museum, Prague and also contributed by valuable suggestions.

Systematic part

Order Eurypterida Burmeister, 1843

Suborder Pterygotina Caster et Kjellesvig–Waering, 1964

Family Pterygotidae Clarke et Ruedemann, 1912

Genus *Acutiramus* Ruedemann, 1935

T y p e s p e c i e s : *Pterygotus cummingsi* Grote et Pitt, 1875 (synonyme *Pterygotus buffaloensis* Pohlman, 1881).

D i a g n o s i s : Prosoma subquadrate, free and fixed rami of chelicera with acute distal tips and large recurved terminal teeth. Teeth in proximal part of rami inclined anteriorly, some larger teeth of the fixed ramus commonly serrated. Metastoma obovate, cordate anteriorly, rather narrow. Genital appendages not segmented, type A spatulate or club–shaped, type B simple, lozenge–shaped or pyriform. Telson paddle–shaped, terminating in a short spine, margin serrated.

Acutiramus bohemicus (Barrande, 1872)

Pl.I, figs. 1–6.; pl. II, fig. 1; pl. IV, figs. 1, 2; pl. V, fig. 2; pl. VI, figs. 1–3; text–fig. 1

1872 *Pterygotus bohemicus* Barrande; Barrande p. 559, pl. 17, figs. 20–21.
– *Pterygotus* sp.; Barrande, p. 564, pl. 17, fig. 15.
– *Pterygotus comes* Barrande; Barrande, p. 560, pl. 17, figs. 22–24.
partim 1898 *Pterygotus bohemicus* Barrande; Semper, p. 73–76, pl. 12, fig. 8, text–fig. 5 (non text–fig. 6).
partim *Pterygotus Barrandei* nov. spec.; Semper, pl. 12, fig. 3 (non cetera)
1898 *Pterygotus nobilis* Barrande; Semper, pl. 12, fig. 9, text–fig. 7
1906 *Pterygotus bohemicus* Barrande; Seemann, p. 52–53, pl. 4, figs. 3, 4
– *Pterygotus fissus* nov. spec.; Seemann, p. 53–54, pl.4, fig. 5
– ?*Pterygotus nobilis* Barr.; Seemann, p. 5l, text–fig. 1.
1924 *Pterygotus bohemicus* Barrande; Diener, p. 11 (synonymy)
partim 1948 *Pterygotus (Acutiramus) bohemicus* Barrande; Prantl et Přibyl, p. 32–41, 84–92, pl. 1, figs. 1, 2, pl. 2, figs. 1, 2, pl. 3, figs. 1–4, 6, pl. 4, figs. 1–4, text–figs. 11–20, possibly also figs. 7,8.
1964 *Pterygotus (Acutiramus) bohemicus* (Barrande); Kjellesvig–Waering, p. 333, 340, 342, 343.
– *Pterygotus fissus* Semper; Kjellesvig Wearing, p. 332, 343, 344.

Holotype: incomplete coxa L23505 figured by Barrande (1872) on pl. 17, figs. 20, 21, preserved in relief in grey cephalopod limestone.
Locus typicus: Karlštejn.
Stratum typicum: Přídolí Formation, the lithology fully corresponds to the cephalopod limestone interval, beds Nos. 40–41 (Chlupáč et al. 1972) in the uppermost part of the Přídolí sequence, upper part of the *Monograptus transgrediens* Zone.

Known parts of the body: chelicerae, coxae and other segments of swimming and walking legs,incomplete metastoma,genital appendages of the type A,segments of opisthosoma (connected and isolated), incomplete telson.

Remarks: A description of most known parts of the body was presented by Prantl and Přibyl (1948). The new material. however,allows some supplements to be done.

Chelicera. Both cheliceral rami, in the pinched position, exhibit a strongly prolonged subquadrate outline.

The fixed ramus, only very gently tapering distally, shows teeth strongly differing in size and inclination. Teeth in the distal half of the teeth–bearing ramus are gently inclined posteriorly, while teeth in the proximal half are markedly inclined anteriorly. Six principal teeth strongly differ in size from the neighbouring ones (see text–fig. l). The large and broad terminal tooth dl, directed posteriorly, forms the prominent bluntly angulate and narrowed distal tip. Posteriorly, the following denticulation can be generally observed: 3 to 4 smaller teeth, principal tooth d2, 2–3 smaller teeth, principal tooth d3, 3 –4 smaller teeth, principal tooth d4 markedly larger than d3, inclined anteriorly and serrated on its posterior margin, 1–2 smaller teeth, the most prominent principal tooth d5 strongly inclined anteriorly,with prominent denticles on its posterior margin, 2–3 slender teeth, principal tooth d6 with serrated ant. and post. margins, a set of 4 or more slender and smaller teeth.

The free ramus with four principal teeth strongly differing in size. Terminal tooth is markedly recurved posteriorly and prolonged distally into bluntly angulate tip. Succeeding denticulation: a set of 4–5 perpendicular smaller teeth; perpendicular principal tooth d2; 2–3 perpendicular smaller teeth; strongly asymmetrical and most prominent principal tooth d3 with arcuate anterior and steeply sloping posterior margins;a set of 6–8 smaller teeth decreasing in size posteriorly, principal tooth d4 smaller than d1, d2 and d3 directed anteriorly, a row of teeth (7 or more) alternating in size, generally small. The proximal widened part of the free ramus bears a row of anteriorly directed slender teeth diminishing in size towards the joint with the fixed ramus. Teeth on both rami are longitudinally striated.

Proximal parts of prosomal appendages. The specimen L30737 (pl. 4, fig. 1) preserves proximal parts of prosomal appendages in somewhat distorted position. It comes from the locality Kosoř–quarry S of Klapice (Přídolí Formation) which yielded numerous specimens of *A. bohemicus* but almost no other eurypterids.

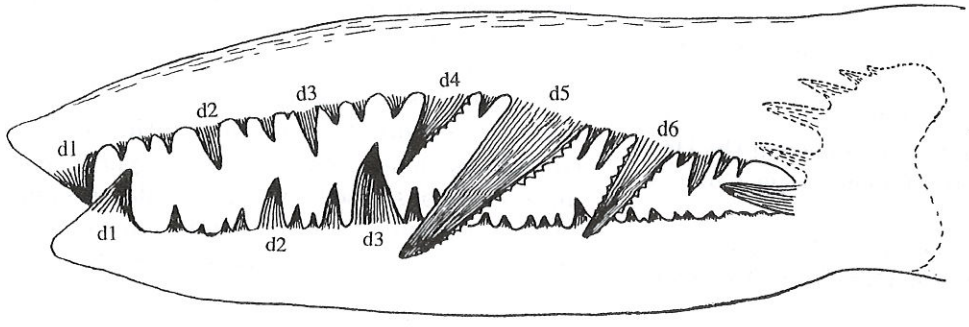

Fig. 1. Reconstructed chelicera of *Acutiramus bohemicus* made according to flattened specimens from Kosoř (quarry S of Klapice, Přídolí Formation), principal teeth designated dl to d6

The assignment to *A. bohemicus* is thus substantiated. Apart from somewhat uncertain parts of the doublure, the specimen shows in the right anterior sector part of a coxa with less prominent denticulation (6 distinct teeth observable), attributable to the first walking leg, shifted and turned in 180° from its original position. This is followed on the right and left sides by two or coxae in original position, partly covering each other. Their denticulation shows slender and narrower teeth (exact number obscurred by overlapping teeth of both coxae). The form of teeth and the preserved outline of coxa strongly resembles coxae assigned by Semper (1898) to *Pterygotus beraunensis* (pl. 12, figs. 5, 6) and by Prantl and Přibyl (1948) to *P. cobbi barrandei* (text–figs. 7, 8, pl. 5, fig. 2) and *Slimonia acuminata* (text–fig. 22, pl. 6, figs. 3, 6). By comparisson with L30737, it seems very probable that all these remains belong to *A. bohemicus* and represent coxae of walking legs.

The next pair of large coxae with prominent teeth fully agree with isolated coxae attributed by Prantl and Přibyl to swimming legs of *A. bohemicus* (1948, text–fig. 15, pl. 4, fig. 3). This interpretation may be correct but the fragmentary preserved teeth of a coxa on the left margin of L30737 suggest that only these last teeth belong to the swimming leg as the last prosomal appendage. Consequently, broad coxae with strong teeth as frequently found may belong either to the last walking, or to the swimming legs.

The specimen L30736 from the same locality (Kosoř, quarry S of Klapice) shows a similar but less complete arrangement of coxae (pl. 4, fig. 2): remnants of two coxae with slender teeth and attached segments of walking leg are followed posteriorly by a markedly larger coxa with stouter teeth, belonging either to the last walking, or to the swimming leg.

Metastoma. The specimen L30737 preserves also an incomplete metastoma which shows the arcuate anterior cordation and parabolical left shoulder, all pointing to a shape analogous as in *A. cummingsi* (comp. Clarke et Ruedemann 1912 on pl. 78, fig. 1, pl. 79, fig. 2, Copeland and Bolton, 1985, fig. 16B). This shape corresponds also to the incomplete isolated large metastoma L30747 from Lochkov which also exhibits the bluntly rounded posterior margin. The outline differs in both specimens from the metastoma L23 figured by Seemann (1906, pl. 4, fig. 8) and correctly assigned by Prantl and Přibyl (1948, p. 29, 82) to *Pterygotus barrandei* (on their pl. 3, fig. 2 incorrectly referred to *A. bohemicus*).

Other parts of the body. Prantl et Přibyl (1949) described incomplete swimming and walking legs, genital appendages of the A type, opisthosomal segments (including the pretelson) and incomplete telson which may be all with great probability ranged with *A. bohemicus*. The author also collected from the locality at Kosoř, quarry S of Klapice, four connected opisthosomal segments agreeing in sculpture and size with accompanying chelicerae and other parts of *A. bohemicus*. They represent most likely the second to fifth opisthosomal segments of a specimen of medium size (the sagittal lenth of preserved individual segments is around 65 mm).

Relationships. *A. bohemicus* is closely related to the North American and stratigraphically coeval species *A. cummingsi* (Grote et Pitt, 1875). This was well known to Seemann (1906), Clarke and Ruedemann (1912) and Prantl and Přibyl (1948) who all pointed to close affinity with *Pterygotus buffaloensis* Pohlman, 1881, later synonymised with *P. cummingsi* by Kjellesvig–Waering and Caster (1955). The differing features may be seen in details of denticulation of chelae, i.e. larger teeth between D1 and D3 on the free ramus and D1 to D4 on the fixed ramus, in the presence of the first anterior small tooth (before the prominent second tooth) on coxae of swimming legs (comp. Clarke and Ruedemann, 1912, text–fig. 72, pl. 78, fig. 2, pl. 79, fig. 1). However, the incomplete knowledge of other parts of the body in *A. bohemicus* does not exclude additional differences.

Taxonomy. In agreement with Prantl and Přibyl (1948), *Pterygotus fissus* Seemann, 1906 based on a fragmentary free cheliceral ramus L30 from Dlouhá hora, and the free ramus referred by Semper (1898, pl. 12, fig. 9) to *P. nobilis* Barrande are regarded as conspecific with *A. bohemicus*.

Pterygotus comes Barrande, 1872 (holotype by monotypy: ČE 1208 from Karlštejn) represents in agreement with interpretation by Semper (1898: 75) and Seemann (1906: 52) the isolated main principal tooth of the fixed cheliceral ramus of *A. bohemicus* (comp. pl. 6, figs 1, 2). The specimen is not flattened, shows the elliptical cross–section and on its posterior side a longitudinal row of broken denticles. The overal shape and the fine longitudinal striation fully agree with the the largest cheliceral tooth d5 of *A. bohemicus* whose holotype comes from the same locality and stratigraphic level as noted by Barrnade (1872). The phyllocarid nature of this specimen presumed by Prantl and Přibyl (1948) cannot be regarded as plausible.

Measurements. The holotype shows the length of teeth–bearing part of coxa 96 mm., corresponding parts of large coxae exhibit the length over 100 mm and the largest fragmen–

tary coxa L106 suggest the length of the gnathal part up to 120 to 130 mm. The largest remnants of cheliceras point to the length of fixed rami up to 300 mm.

The calculated dimensions of the total body based on reconstructions of *Acutiramus* by Clarke and Ruedemann (1912) and the largest known chelicerae and coxae of *A. bohemicus* point to the total length of the body without chelicerae around 230 to 250 cm. *A. bohemicus* is thus the largest fossil invertebrate of the Barrandian Paleozoic.

Occurrence. *A. bohemicus* is the most common Bohemian eurypterid. It occurs in the whole sequence of the Přídolí Formation starting with the Monograptus parultimus and M. ultimus Zones (localities Dlouhá hora, Kosov, Praha–Lochkov, "Orthoceras quarry", Zadní Kopanina–Desorts quarry), and ending with the uppermost part of the M. transgrediens Zone close below the Silurian–Devonian boundary. Main localities in the upper part of the Přídolí Formation are: Kosoř–quarry S of Klapice, Velká Chuchle–Žáks (=Eurypterid) quarry, Praha–Podolí, Praha–Malá Chuchle, Praha–Lochkov (quarries on the slope Višňovka). Radotín Valley (U topolů), Karlštejn–Budňany Rock, Klonk near Suchomasty etc.

Acutiramus perneri sp. n.

Pl. II, figs. 2–4; pl. III, figs. 1–6; pl. V, figs. 3–5

Holotype: chelicera L30739 preserved in dark grey calcareous shale, figured on pl. 3, fig. 4 and pl. 5, fig. 4. Paratypes: L68, L30557, L30653, L30740, L30741, L30742, L30743

Locus typicus: Kosoř, Černá rokle.

Stratum typicum: Radotín Limestone, upper Lochkovian, Monograptus hercynicus Zone.

Derivatio nominis: Named in honour of the Czech palaeontologist Jaroslav Perner. This name was used on the label by F. J. Pecka, the meritorious popularizer of geological sciences and collector of fossils who probably recognized the separate position of the species.

Material: 15 chelicerae flattened in bedded limestones or calcareous shales. Operculum with genital appendage, coxae and diverse isolated parts of segments probably conspecific.

Diagnosis. Species related to *A. bohemicus* differing from it in slender chelicerae with narrower, more acutely–angled distal tips of chelae, with shorter and less prominent teeth on both cheliceral rami. Denticles on the principal teeth d5 and d6 weaker.

Remarks. All former authors, including Prantl and Přibyl (1949) and Chlupáč (lists of fossils 1953, 1972, discussion in Kříž et al. 1986), included this species in *A. bohemicus*. Though the overall plan of denticulation of chelicerae is analogous, the differences stated in the diagnosis allow a distinction. The longitudinal striation of teeth and fine longitudinal ridges near the outer margins of fixed cheliceral rami are analogous in *A. bohemicus* and *A. perneri* and probably are common also in other representatives of the genus. Consequently, they cannot be regarded as specific diagnostic features. The distally prolonged and narrowly acute–angled tips of cheliceral rami distinguish *A. perneri* from *A. macrophthalmus* (Hall, 1859), *A. cummingsi* (Grote et Pitt, 1875) and *A. floweri* (Kjellesvig–Waering et Caster, 1955) which all derive from older, Silurian strata.

Although *A. perneri* is based on chelicerae, some other parts of the body, namely incomplete opisthosomal segments, coxae and diverse fragments found in the same beds belong to this species.

Remarkable is the operculum L30741 (pl. 2, fig. 3) with the genital appendage of the type B in position. The genital appendage of total length 61 mm shows a rather long proximal hastate portion with scale sculpture in anterior sector. The overall shape is pyriform, the maximum breadth in the posterior third equals to 39 mm. The posterior margin is gently bilobed. Due to flattening, the thickened areas of attachment in lateral marginal parts and the flanges are indicated by darker cuticle, and the same concerns the arcuate area in the posterior half of the appendage which represents the posterior margin of the dorsal structure. The central part of the appendage shows irregular circular asymmetrically placed sculptures which are probably a result of fossilisation, though epibionts cannot be excluded. The genital appendage is typically unsegmented and differences in expressiveness of its individual parts are caused by different thickness of the cuticle accentuated by compaction. Opercular plates adjoining the anterior hastate portion of the genital appendage are divided by a suture which is generally longer than that of *Erettopterus* figured by Waterston (1964).

Measurements. The holotype exhibits the preserved length of the incomplete chelicera 190 mm with the teeth–bearing part of the fixed ramus 141 mm , the maximum length of the main tooth d5 equal to 33 mm. The smallest chelicera L69 has the length of the teeth–bearing part of the fixed ramus 60 mm, that of the free ramus 56 mm. The largest specimen L30743 exhibits the preserved length of chelicera 227 mm, the teeth–bearing part of the fixed ramus 180 mm. The maximum total length of the body calculated according to measurements of chelicerae is estimated to 140 to 160 cm.

Occurrence. Most of the material comes from Kosoř–Černá rokle, old quarries on both sides of the valley, upper Lochkovian, Monograptus hercynicus Zone. Dacryoconarid tentaculites preserved in the same slabs of rocks point to the Zones with Homoctenowakia bohemica and Paranowakia intermedia. The occurrence in the lower Lochkovian Monograptus uniformis Zone is demonstrated by the find of chelicerae (L30557, pl. 3, figs. 2, 3, pl. 5, fig. 5) from the dendroid–bearing layers at Lejškov near Suchomasty. The fragmentary remains from other Lochkovian localities reported e.g. in Chlupáč et al. (1972) belong probably to this species too.

Acutiramus? nobilis (Barrande, 1872)

Pl. VI, fig.4

1872 *Pterygotus nobilis* Barrande; Barrande, p. 663, pl. 18, figs. 10, 11.
non *Pterygotus nobilis* Barrande; Semper, p. 76–77, text–fig. 7 (indeterminable) pl. 12, fig. 9 (= *Acutiramus bohemicus*).
non *Pterygotus nobilis* Barrande; Seemann, p. 51, text–fig. 1 (= probably *A. bohemicus*).
1964 *Pterygotus (Acutiramus) nobilis*; Kjellesvig–Waering, p. 333, 341, 344.

Holotype (by monotypy): posterior part of a free cheliceral ramus L56 preserved in full relief in grey fine–grained bioclastic limestone. Figured by Barrande (1872, pl. 18, figs. 10, 11), refigured here on pl. 6, fig. 4.
Locus typicus: Koledník.
Stratum typicum: Kopanina Formation (Ludlow), the Ananaspis fecunda Biozone (demonstrated by remnants of associated proetid trilobites).

Remarks. The available proximal part of the free ramus is distinguished by small teeth of three dimensions alternating in size. The lengths of individual teeth in proximal direction are as follows (in mm): 4.7, 2.7, 2.3, 3.9, 2, 1, 4.3, 2.8, 1, 2.1, 1, 3 and further very small teeth broken off. Barrande's (1872) figure on pl. 18 is idealized in the length of teet.

The holotype is not sufficient for species characteristics. The slender form of the ramus and the denticulation may point to *Acutiramus*, though the decissive distal termination of the ramus is lacking. The weak denticulation and the difference in the occurrence do not justify the identification with *A. bohemicus* inferred by Prantl and Přibyl (1948).

The incomplete preservation of the holotype and the difference in stratigraphic occurrence make the assignment of cheliceral rami figured by Semper (1898, text–fig. 7) and Seemann (1906, text–fig. 1) uncertain. These should be so far left in the open nomenclature only.

Genus *Pterygotus* Agassiz, 1844

Type species: *Pterygotus anglicus* Agassiz, 1844

Diagnosis: Prosoma subtrapezoidal, free ramus of chelicera terminates in a prominent curved tooth, rounded distally, teeth curved posteriorly,larger teeth not serrated. Metastoma subcircular or oval, cordate anteriorly, wide. Genital appenadeges unsegmented, as in *Acutiramus*. Telson paddle–shaped, terminated by a short spine (comp. Waterston 1964: 29).

Pterygotus barrandei Semper, 1898

Pl. VI, figs. 5, 6; text–fig. 2

1898 *Pterygotus Barrandei* nov. spec., Semper, p. 78–80, pl. 12, (doubtful: pl. 12, figs. 2–4, text–figs. 10, 11).
1906 *Pterygotus Barrandei* Semper; Seemann, pl. 4, figs. 1, 2.
– *Pterygotus* sp.; Seemann, p. 55, pl. 4, fig. 8
1912 *Pterygotus Barrandei* Semper; Clarke et Ruedemann, p.
1924 *Pterygotus Barrandei* Semper; Diener, p.10.
1935 *Pterygotus (Curviramus) barrandei* Semper; Ruedemann, pl. 1, fig.7.
1948 *Pterygotus (Pterygotus) cobbi barrandei* Semper; Prantl et Přibyl, p. 26–30, 80–83, text–figs. 4, 6 (non 7, 8), pl. 1, fig. 1, pl. 3, fig. 2, possibly pl. 7, figs. 1, 2.
1961 *Pterygotus (Pterygotus) barrandei* Semper; Kjellesvig–Waering, p. 818.
1964 *Pterygotus (Pterygotus) barrandei* Semper; Kjellesvig–Waering, p. 332, 342, 344.
1964 *Pterygotus (Pterygotus) barrandei* Semper, Waterston, p. 9, 22, 25, 27.

Lectotype (designated by Prantl et Přibyl, 1948): incomplete fixed cheliceral ramus figured by Semper (1898) on pl. 12, fig. 1.
Locus typicus: Dlouhá hora.
Stratum typicum: Přídolí Formation.
Material: 10 incomplete chelicerae, metastoma, assignment of other parts doubtful (genital appendages of the type A, coxae).

Remarks. The lectotype figured by Semper (1898, pl. 12, fig. 1) represents the distal part of the free cheliceral ramus distinguished by the long and curved terminal tooth followed in proximal direction by 7 incomplete teeth alternating in size.

The more complete chelicera L01 figured by Seemann (1906) on pl. 4, fig. 1 and refigured by Clarke and Ruedemann (1912) and Prantl and Přibyl (1948, text–fig. 4, pl. 1, fig. 1) exhibits the fixed and free rami in situ. The fixed ramus is distally terminated by a smaller vertical tooth with arcuate distal outline. This terminal tooth is backwards followed by sets of smaller teeth and three markedly more prominent and gently backwards curved principal teeth from which the second is the largest. The free ramus is marked

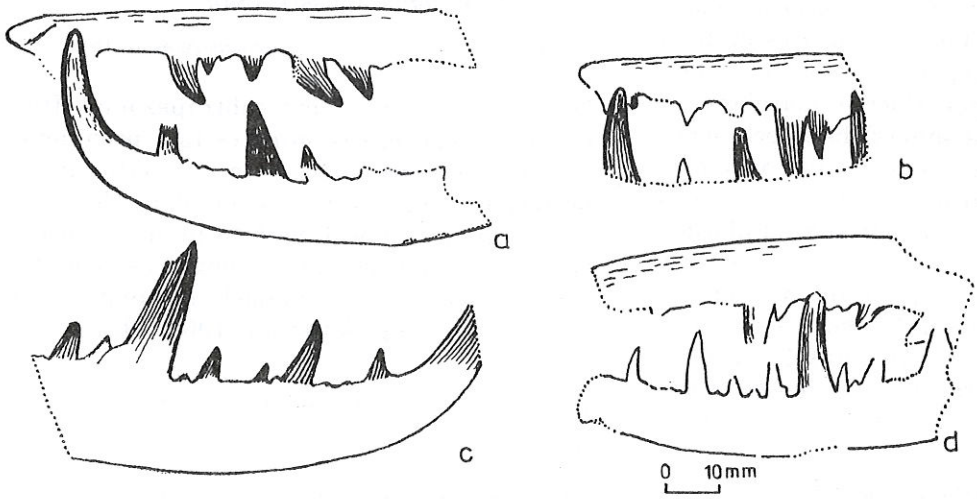

Fig. 2. Fragmentary chelicerae of *Pterygotus barrandei*. a – L30775, Velká Chuchle, b – L30734, Praha–Podolí, c – L67, Praha–Podolí, d – L30735, Praha–Podolí. All specimens flattened

by the characteristically curved and very prominent terminal tooth, followed by sets of smaller and five more prominent main teeth from which the fourth is the largest (small teeth are incompletely preserved or obscure in the distal portion of the chela).

Other available specimens preserve the fixed ramus in four cases: in L30775 (text–fig. 2a) the ramus seems to be angulate or narrowly curved distally but the terminal tooth is broken off; in L30734 the terminal tooth is rather short and directed gently backwards, the distal tip of the ramus being narrowly rounded (cp. text–fig. 2b). The subsequent backwards following teeth seem to alternate in size as in the Seemann's specimen L01 with a gentle backward curvature.

The free ramus is best preserved in L65 (pl. 6, fig. 6): generally more prominent and anteriorly directed but gently posteriorly curved teeth alternate with sets of smaller teeth of unequal size (comp. also L84, pl.6, fig.5). Teeth in both cheliceral rami are narrower than in *Acutiramus bohemicus* and secondary denticles are not developed on principal teeth. The fine longitudinal striation of teeth and less regular and discontinuous fine lingitudinal ridges near the outer margin of the fixed ramus (observable in L84, L30735, L30734) are analogous as in *A. bohemicus* and *A. perneri*.

The metastoma L23 figured by Seemann (1906, pl. 4, fig. 8) was correctly referred to this species by Prantl and Přibyl (1948, p. 28, 81), though its figure on pl. 3, fig. 2 was erroneously reported under *A. bohemicus*. The assignment of other parts, namely coxae and genital appendages, as provided by Prantl and Přibyl (1948, text–figs. 7–10 , pl. 5, fig. 2, pl. 7, figs. 1, 2) is not directly evidenced.

Relations. As pointed out by Semper (1898), Clarke and Ruedemann (1912), Prantl and Přibyl (1948) and Kjellesvig–Waering (1964), *P. barrandei* is closely related to *P. cobbi* Hall, 1859. The latter species is based on free ramus depicted by Hall (1859, pl. 83B, fig.4), later supplemented by a better specimen figured by Clarke and Ruedemann (1912, pl. 77, fig. 6). In spite of a close similarity and coeval occurrence in strata of Přídolian age, both taxa could be hardly regarded as conspecific: teeth on the free ramus are in the Bohemian specimens more markedly directed anteriorly and the largest tooth is longer than in *P. cobbi*. *P. lightbodyi* Kjellesvig–Waering, 1961 from the upper Ludlow of England has both terminal teeth on cheliceral rami markedly curved and other principal teeth longer. *P. floridanus* Kjellesvig–Waering, 1950 from the Lochkovian (?) of Florida may be allied but its fragmentary preservation hinders a more objective comparison.

Measurements. The largest chelicera L01 shows the preserved incomplete length 127 mm, the length of the largest tooth d3 on the free ramus being 30 mm. The length of the best preserved free ramus L65 is 103 mm. The average dimensions of *P. barrandei* are smaller than in *A. bohemicus*. The total body length calculated according to the reconstruction of *P. anglicus* presented by Woodward (1866) and Stormer (1955) averages to 130 cm in largest Bohemian specimens.

Occurrence. *P. barrandei* is a rare species known from the lower Přídolian Monograptus ultimus Zone (Dlouhá hora) and reaching its acme in the upper Přídolian Monograptus transgrediens Zone (most specimens derive from Praha–Podolí=Dvorce, rare finds from Velká Chuchle, Žák's quarry).

Pterygotus kopaninensis Barrande, 1872

Pl. V, fig. 1; text–fig. 3

1872 *Pterygotus kopaninensis* Barrande; Barrande, p. 562, pl. 18, fig. 8.
1898 *Pterygotus kopaninensis* Barrande; Semper, p. 86.
1924 *Pterygotus kopaniensis* Barrande; Diener, p. 12.
1948 *Pterygotus (Acutiramus) bohemicus* (Barrande, 1872); Prantl et Přibyl, p. 32, 37, 84, 89 (discussion of *Pterygotus kopaninensis* in synonymy of *P. bohemicus).*
1964 *Erettopterus (Erettopterus) kopaninensis* (Barrande); Kjellesvig–Waering, p. 333, 339, 343.

Holotype (by monotypy): incomplete fixed cheliceral ramus L1396 (former Nr. ČE1219) figured by Barrande (1872) on pl. 18, fig. 8, preserved in grey biomicritic limestone.
Locus typicus: Zadní Kopanina.
Stratum typicum: Kopanina Formation (Ludlow).

Description. The holotype represents the distal part of the fixed cheliceral ramus with teeth partly preserved in relief, total length 43 mm. The ramus gently tapers to the distal rounded tip which, however, is obscured by the fragment of the distal part of the free ramus shifted in contact with the tip of the fixed ramus (this feature caused the seeming strong backward curvature of the terminal tooth depicted in Barrande's figure).From the distal termination backwards, the following teeth on the fixed ramus may be observed (lengths in mm): 1.0, 1.4, 0.4, 1.0, 4.5, 2.2, 0.5, 2.0, 1.0, 3.0, 1.8, 2.0, 5.0, (incomplete), 2.8, 1.0, 1.0, 2.0, 1.0, 2.0. The maximum height of the ramus without teeth is 7.6 mm. Teeth are conical, with marked longitudinal striation.The fragment of the free ramus in contact with the fixed one shows the broken terminal tooth and the subsequent smaller incompletely exposed tooth, partly overlapped by the fixed ramus.

The surface of the fixed ramus shows a distinctive sculpture consisting of rather short elliptical and dark maculae (short scaly ridges). The marked oblique folding of the ramus is evidently caused by secondary deformation during the fossilisation process.

Remarks. The peculiar hook–like termination of the ramus shown in Barrande's (1872) drawing evidently influenced Kjellesvig–Waering (1964) in assignment of this species to *Erettopterus.* This feature, however,was caused by the connection with the remnant of the free ramus, as stated above. The form of the pincer and its denticulation point to *Pterygotus* s. str. The characteristic sculpture of maculae shows some analogy with longitudinal sculptures on fixed rami of other pterygotids though its marked development may belong the distinctive features of the species.

Occurrence. So far known from the type locality only. The rock preserving the holotype is a grey biomicrite which contains numerous remains of the trilobite *Raphiophorus rouaulti* (Barrande), a cranidium of *Leonaspis* and a fragment of a harpetid trilobite. Associated are also *Cardiola* sp., *Monograptus* and several other indeterminable fossils. Owing to this assemblage,the specimen evidently derives from the Kopanina Formation (Ludlow), according to oral communication by Dr. J. Kříž most likely the *Monograptus chimaera* or *M. fritschi linearis* Zone.

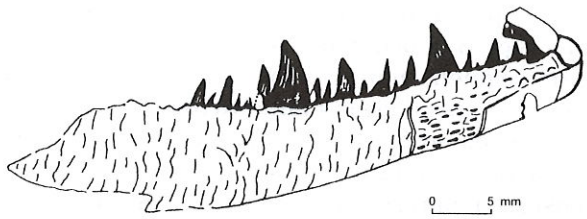

Fig. 3. *Pterygotus kopaninensis,* holotype: incomplete fixed and fragmentary free ramus of chelicera (transverse secondary wrinckles schematised)

Doubtful pterygotid species

Pterygotus ? mediocris Barrande, 1872

Pl. VI, fig. 7

1872 *Pterygotus mediocris* Barrande; Barrande, p. 552, pl. 18, fig. 9.
1898 *Pterygotus mediocris* Barrande; Semper, p. 87.
1906 *Pterygotus bohemicus* Barrande; Seemann, p. 52.
1924 *Pterygotus mediocris* Barrande; Diener, p. 12.
1948 *Pterygotus (Acutiramus) bohemicus* (Barrande); Prantl and Přibyl, p. 38, 89.
1964 *Pterygotus (Acutiramus) bohemicus* (Barrande); Kjellesvig–Waering, p. 343.

Holotype (by monotypy): incomplete coxa L29 (former Nr. ČE1217) preserved in semirelief in limestone.
Locus typicus: Praha–Lochkov.
Stratum typicum: Kopanina Formation (Ludlow).

Remarks. The holotype is a gently flattened and secondary folded gnathal part of coxa with twelve preserved teeth gradually diminishing posteriorly. The specimen is not sufficient for species identification, it, however, shows no substantial differences from *Acutiramus bohemicus* with which it may be conspecific as presumed by Seemann (1906) and Prantl and Přibyl (1948).
Occurrence. The grey biomicritic cephalopod limestone with aligned orthocone nautiloid shells points to the uppermost part of the Kopanina Formation as developed at the type locality.

Pterygotus? blahai Semper, 1898

1898 *Pterygotus blahai* nov. spec.; Semper, p. 82–84, text–fig. 13.
1924 *Pterygotus blahai* Semper; Diener, p. 11.
1948 *Pterygotus (?Pterygotus) blahai* Semper; Prantl and Přibyl, p. 30–31, 83–84, pl. 3, fig. 5.
1964 *Pterygotus (Pterygotus?) blahai* Semper; Kjellesvig–Waering, p. 342, 344.

Holotype (by monotypy): Specimen figured by Semper (1898) on text–fig. 13 (not available).
Locus typicus: Praha–Lochkov. Višňovka.
Stratum typicum: Přídolí Formation.

Remarks. According to Semper's (1898, p. 83) figure, the holotype represents the incomplete operculum with the genital appendage of the type B in original position, and a fragmentary segment in proximity. The lozenge–shaped genital appendage is similar to that of *A. perneri* as figured on pl. 2, fig. 3 but the posterior part is narrower and simply rounded, without bilobed posterior margin. The Semper's figure shows thickened lateral areas of attachment and posterolateral flanges.

The figured specimen is not sufficient for identification of species but it is very probable that it might be conspecific with *Acutiramus bohemicus* which occurs rather commonly at the type locality of *P.? blahai.* As stated by Semper (1898), the holotype was deposited in the private collection of Mr. V. Blaha in Radotín. Its later depository is unknown and the specimen was not available to Prantl and Přibyl (1948), being probably lost.

Prantl and Přibyl (1948, pl. 3, fig. 5) referred to *P. blahai* a fragmentary large opisthosomal segment L46 from Velká Chuchle, distinguished by sculpture of large scales. The assignment of this specimen to *P.? blahai* is doubtful.
Occurrence. According to Semper (1898), the type specimen derives from the locality Višňovka near Praha–Lochkov where it was found in the dark limestone rich in orthoceratids, i.e.in rocks corresponding to the Přídolí Formation which are exposed in the "Marble quarry" at Praha–Lochkov and in its vicinity called Višňovka (comp. Kříž et al. 1986).

Distribution and environment of Bohemian pterygotids

Silurian and early Devonian pterygotids occur in the Barrandian in typical marine strata and are associated with richly diversified and common marine fossils.

The Ludlovian pterygotids contained in the Kopanina Formation are rare and fragmentary. Their oldest remains derive from richly fossiliferous biomicrites with common trilobites which belong to the Biozone *with Encrinuraspis beaumonti,* i. e. to the *Monograptus chimaera* and–or *M. fritschi linearis* graptolite Zones. Also found here are *Pterygotus kopaninensis* Barr. and some indeterminable remains. Somewhat younger, mostly bioclastic limestones of the *Ananaspis fecunda* Biozone yielded the insufficiently known *Acutiramus ? nobilis* Barr.

The overlying limestones of the *Prionopeltis archiaci* Biozone contain a little more abundant fragments of pterygotids, which, however, are mostly not determinable. Also the holotype of *Pterygotus? mediocris* Barr. and fragments found in the cephalopod ("Orthoceras") limestones near Prague (localities near Praha–Lochkov, especially the " Orthoceras quarry", interval 5 in Kříž et al. 1986 as example) belong in this stratigraphic interval.

The base of the overlying Přídolí Formation (Přídolian), i. e. the graptolite Zones with *Monograptus parultimus* and *M. ultimus* are distinguished by a sudden and marked increase in abundance of pterygotids. The rather common *Acutiramus bohemicus* (Barr.) occurs both in finely bioclastic grey limestones with common trilobites of the *Prionopeltis striata* and *Scharyia nympha* Assemblage, or in darker fine–grained bioclastic limestones rich in graptolites known from localities with condensed sedimentation at Prague (the locality *"Orthoceras"* Quarry, with crowded pterygotid remains close above the base of the Přídolí Formation). Though *Acutiramus* dominates, *Pterygotus barrandei* is also present as a rare component of the fauna (Dlouhá hora).

The markedly increasing frequency of pterygotids and other eurypterids at the base of Přídolí may be confined to effects of the Basal Přídolian Event (Chlupáč and Kukal 1988) which was manifested in the Barrandian by deepening and marked decrease of facies diversity.

Most of the instructive and determinable remains of pterygotids derive from the higher part of the Přídolí Formation which corresponds to the graptolite Zones with *Monograptus lochkovensis* to *M. transgrediens.* Pterygotids are here strictly confined to a distinctive facies of dark platy bituminous, mostly fine–grained limestones alternating with shaly limestones and calcareous shales. This facies with dominant laminated pelagic limestones and subordinate calcareous turbidites is distributed seawards from the light bioclastic limestones with rich benthos confined to shoals of the former volcanic elevations (cp. facies distribution in Horný 1962, Havlíček and Štorch 1990).

Pterygotids occur rather frequently in dark limestones and shale interbeds and their remains are accompanied by common nautiloids, phyllocarids, graptolites, thin-shelled bivalves, less diversified gastropods, pelagic crinoids (*Scyphocrinites*), ostracods, less frequent brachiopods etc. Pterygotids are found even as articulated large parts of bodies which suggest that even complete exoskeletons are present. The mode of occurrence point to autochthoneity of eurypterid remains. Localities of this kind are concentrated in the south-eastern limb of the Silurian area between Prague and Suchomasty, typical examples being Praha–Podolí, Praha–Velká Chuchle, Kosoř–quarry S of Klapice, Praha–Lochkov–Marble quarry, Budňany Rock at Karlštejn, and Klonk near Suchomasty.

The Silurian–Devonian boundary does not show any marked impact on pterygotids: *Acutiramus perneri* sp. n. in the Lochkovian can be regarded as a direct descendant of the Silurian *A. bohemicus* (Barr.) and the non-pterygotid eurypterids are analogous (*Slimonia, Paracarcinosoma*). Though pterygotid remains are rather uncommon in the lower Lochkovian *Monograptus uniformis* Zone (Lejškov and Klonk near Suchomasty as examples), the classic upper Lochkovian localities at Kosoř Černá rokle yielded instructive finds of *Acutiramus perneri* sp. n. accompanied by other rare eurypterids.

The facies of sediments is analogous as in the Přídolí: the Lochkovian Radotín Limestone is marked by dark bituminous platy limestones with subordinate calcareous shale interbeds, and the associated fauna consists of locally richly diversified nautiloids, large thin-shelled bivalves, brachiopods, gastropods, hyolithids and trilobites (Chlupáč et al. 1972, 1985). Pelagic elements are represented by dacryoconarid tentaculites, conodonts, chitinozoans and locally common phyllocarids of the *Ceratiocaridid–Aristozoid* Assemblage (Chlupáč 1994). The same localities yielded also peculiar fish fauna with *Holopetalichthys kosorensis* (Gross), *Kosoraspis peckai* Gross, *Machaeracanthus* and some other undescribed forms.

The area of distribution of the pterygotid-bearing Radotín Limestone corresponds to that of the Přídolian platy limestones between Prague and Suchomasty. (cp. Chlupáč et al. 1972, 1992).

To summarize, pterygotids in the Barrandian belong to constituents of typical marine faunas. They are concentrated in facies of dark bituminous platy limestones with shale interbeds which represent offshore facies deposited seawards from shallow-water light bioclastic limestones. The sediments enriched in pterygotids show influence of anoxic conditions and impoverished benthic life but the general litho- and biofacies point to offshore, pelagic environment of normal salinity.

The occurrences of pterygotids in the late Silurian and early Devonian of the Barrandian are in agreement with conclusions of Kjellesvig-Waering (1961, 1964) on the marine life habit of pterygotids. The Barrandian exhibits no brackish or hypersaline facies in the time-span Silurian–early Devonian, and, consequently, the suspected tolerance of pterygotids to salinity values as presumed e.g. by Stormer (1976) and discussed by Selden (1984) cannot be tested here.

The distribution of pterygotids shows a marked analogy with that of phyllocarids, namely their *Ceratiocaridid* and mixed *Ceratiocaridid–Aristozoid* Assemblages. It seems that the life conditions were the same or at least analogous for both these animal groups. Pterygotid eurypterids are significant and characteristic components of Bohemian late Silurian and earliest Devonian faunas, and, owing to their gigantism, they were the largest animals which inhabited the Bohemian seas of that time.

Translated by the author

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Pterygotidní eurypteridi (Arthropoda, Chelicerata) v českém siluru a devonu

Zástupci čeledi Pterygotidae Clarke et Ruedemann, 1912 jsou v českém siluru a devonu (ludlow–lochkov) zastoupeni druhy *Acutiramus bohemicus* (Barrande, 1872), *A. perneri* sp.n., *A nobilis* (Barrande, 1872), *Pterygotus barrandei* Semper, 1898, *P. kopaninensis* Barrande, 1872 a pochybnými, nedostatečně charakterizovanými druhy *Pterygotus mediocris* Barrande, 1872 a *P.? blahai* Semper, 1898. Maximální rozvoj pterygotidů spadá do vrstev přídolského stáří, přičemž jejich nejpočetnější nálezy jsou omezeny na pelagické facie deskovitých vápenců s vložkami vápnitých břidlic, jež vykazují anoxické vlivy.

Pterygotidi jsou typickými složkami mořských faun a jejich závislost na faciích je analogická s phyllocaridními korýši čeledi Ceratiocarididae. Podle nálezů izolovaných částí byla propočtena délka celých jedinců u druhu *Acutiramus bohemicus* až na 230–250 cm, takže se jednalo o největší bezobratlé živočichy známé z paleozoika Barrandienu.

Explanation of plates V and VI

Plate V

1 – *Pterygotus kopaninensis* Barrande, incomplete cheliceral ramus L1396, holotype, Kopanina Formation, Zadní Kopanina, x1.95;

2 – *Acutiramus bohemicus* (Barrande), gnathal part of flattened coxa, L30655, Praha – Velká Chuchle, x0.85;

3–5 – *Acutiramus perneri* sp.n., Lochkov Formation: 3 – chelicera L30653, Kosoř, x0.83; 4 – chelicera L30639, holotype, Kosoř, x0.71; 5 – chelicera L30557, Lejškov, x0.93

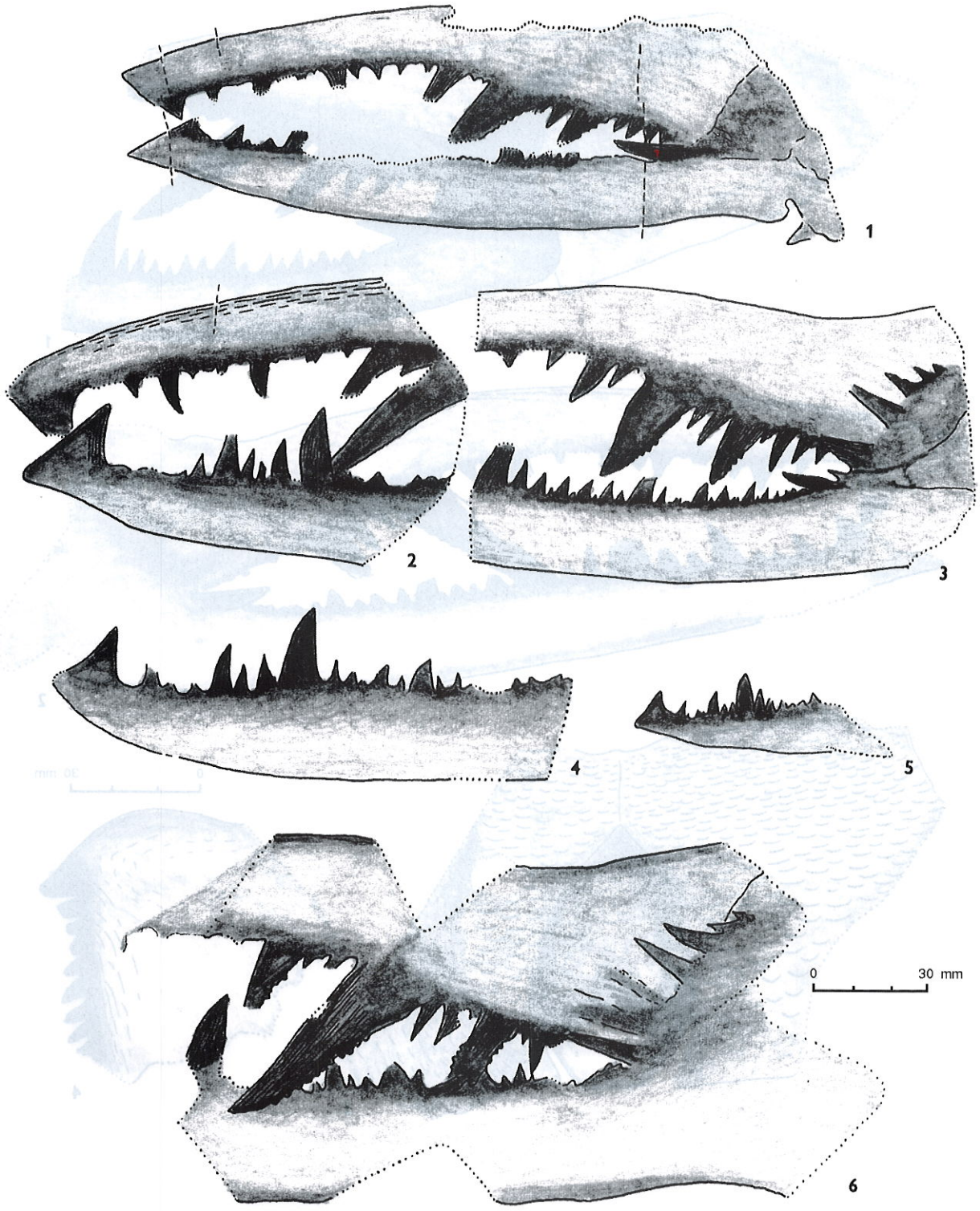
Plate VI

1–3 *Acutiramus bohemicus (*Barrande), Přídolí Formation, Karlštejn: 1, 2 – isolated main tooth d5 from the fixed cheliceral ramus in lateral (1) and posterior (2) views, holotype of *Pterygotus comes* Barrande (1872, pl. 17, figs. 22, 23), x1.6; 3 – gnathal part of coxa in relief, L23505, lectotype figured by Barrande (1872, pl. 17, figs. 20, 21), x0.70;

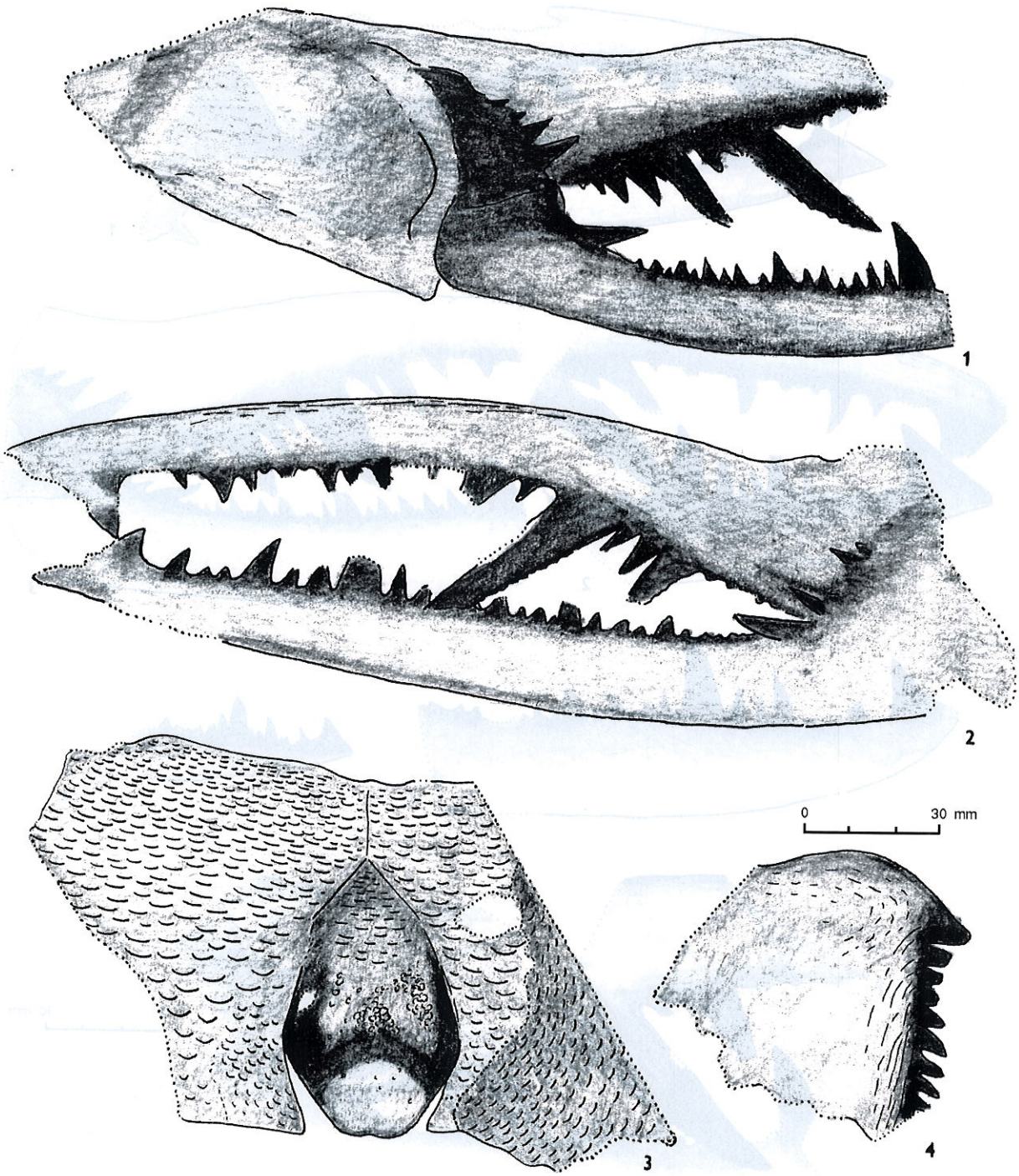
4 – *Acutiramus nobilis* (Barrande), incomplete free cheliceral ramus L56, holotype, Kopanina Formation, Koledník, x0.95;

5–6 *Pterygotus barrandei* Semper, Přídolí Formation, Praha–Podolí: 5 – chelicera L84, x0.94; 6 – chelicera L65, x0.84;

7 – *Pterygotus mediocris* Barrande, gnathal part of coxa L29, holotype, Kopanina Formation, Praha–Lochkov, x1.30

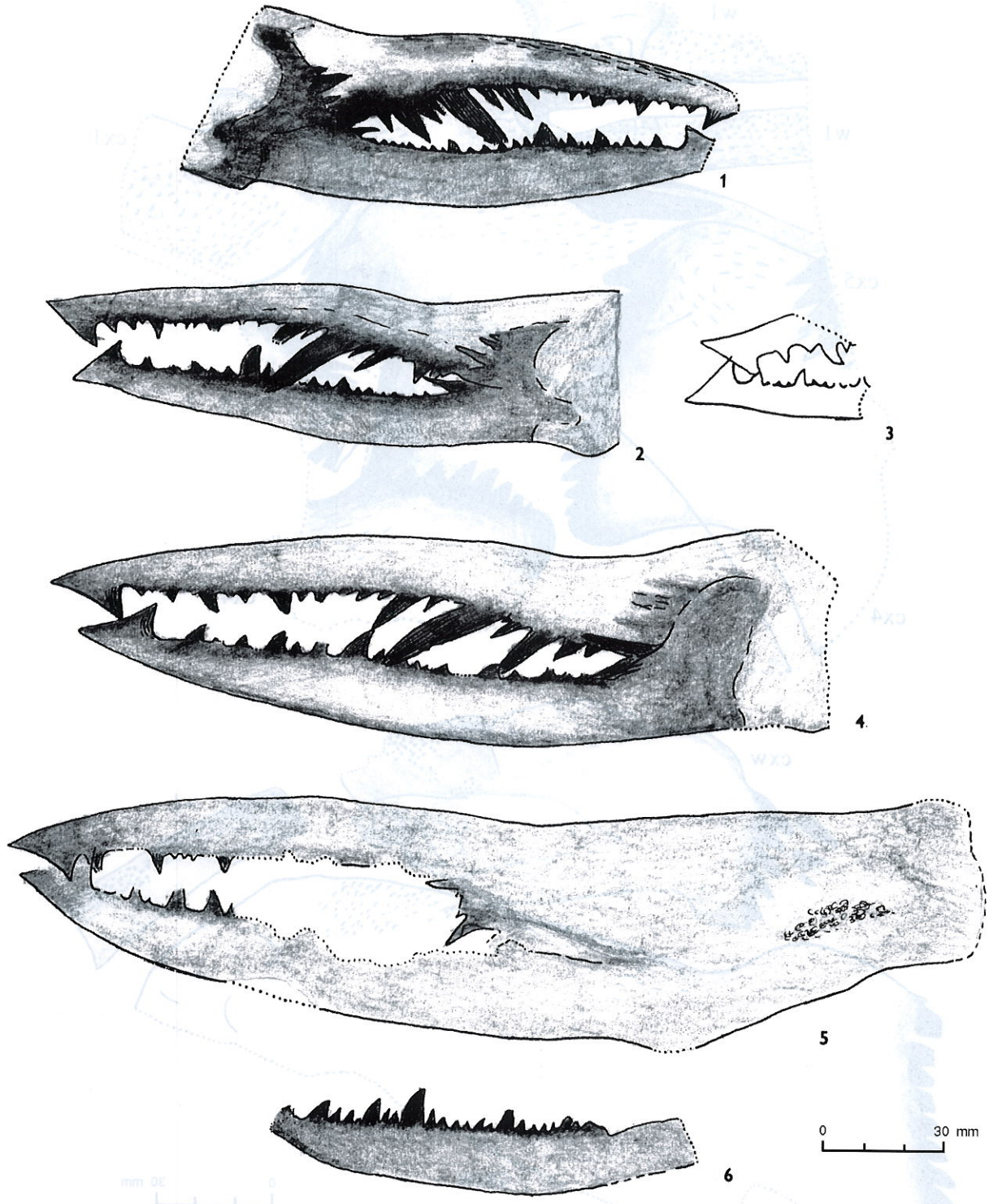


Acutiramus bohemicus (Barrande), Přídolí Formation
1 – chelicera PF00019, Velká Chuchle; 2 – distal part of chelicera L30676, Kosoř, quarry S of Klapice; 3 – incomplete chelicera L30654, the same locality; 4 – distal part of the free cheliceral ramus L30677, the same locality; 5 – incomplete free cheliceral ramus of a smaller specimen L30656, Praha–Podolí; 6 – one of the largest incomplete chelicerae, L30738, Kosoř

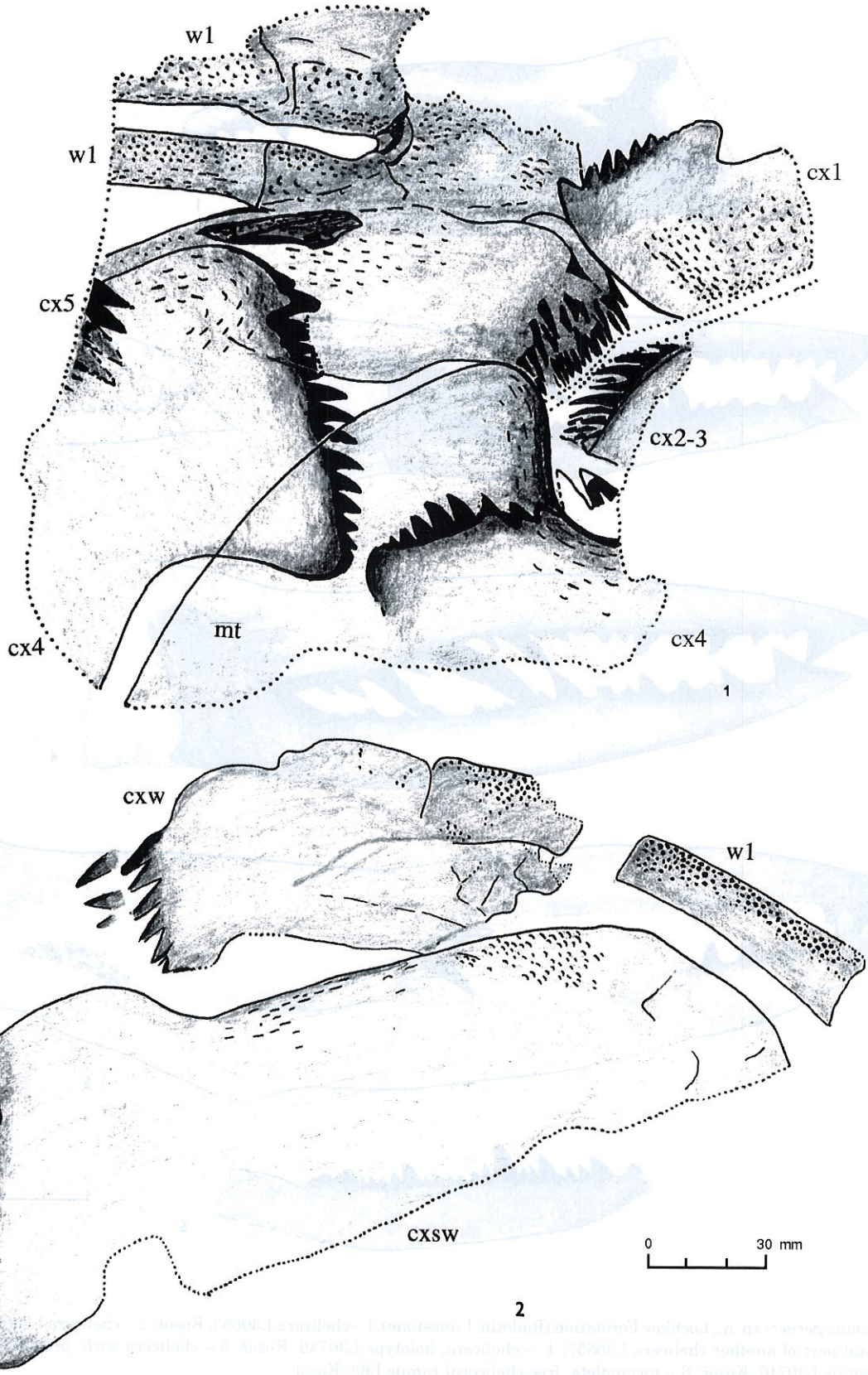


1 – *Acutiramus bohemicus* (Barrande), proximal parts of cheliceral rami L98, Přídolí Formation, Praha–Velká Chuchle; 2–4 *Acutiramus perneri* sp. n., Lochkov Formation (Radotín Limestone), Kosoř–Černá rokle: 2 – large chelicera L30743; 3 – operculum with the genital appendage, type B, L30741; 4 – incomplete coxa L30742

Ivo Chlupáč: Pterygotid eurypterids (Arthropoda, Chelicerata) in the Silurian... (Pl. III)

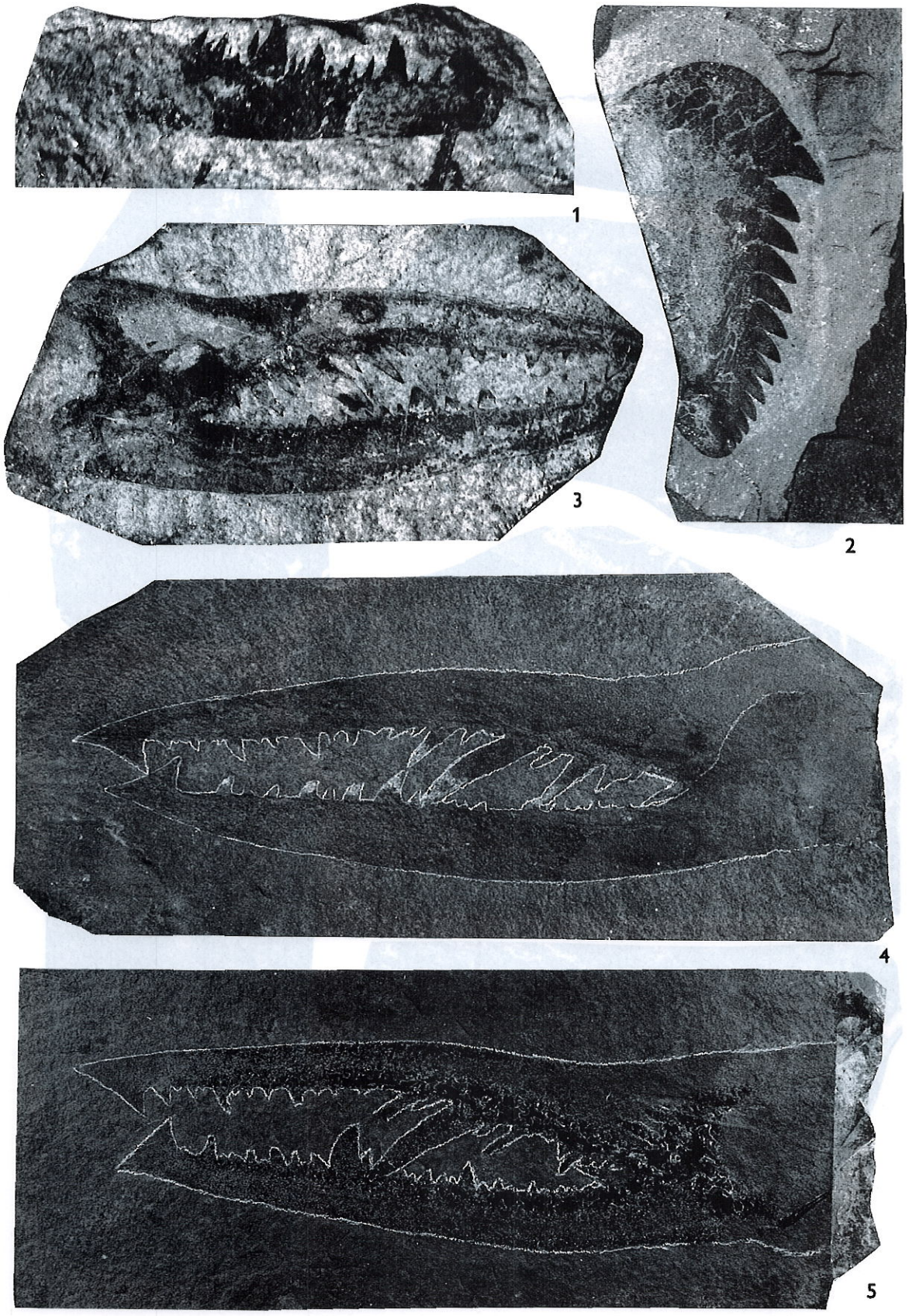


Acutiramus perneri sp. n., Lochkov Formation (Radotín Limestone): 1 – chelicera L30653, Kosoř; 2 – chelicera L30557, Lejškov; 3 – distal part of another chelicera L30557; 4 – chelicera, holotype L30739, Kosoř; 5 – chelicera with proximal part of the fixed ramus L30740, Kosoř; 6 – incomplete free cheliceral ramus L68, Kosoř



Acutiramus bohemicus (Barrande), Přídolí Formation, Kosoř, quarry S of Klapice: 1 – prosomal appendages, ventral side, L30737: cxl – coxa of the first walking leg, cx2–3 coxae of the second and third walking legs, cx4 – coxae of the last walking leg, cx5 – coxa of the swimming leg, wl – proximal parts of walking legs, mt – metastoma; 2 – coxae of walking legs (cxw), segment of a walking leg (wl) and the coxa of the swimming leg (cxsw), L30736

Ivo Chlupáč: Pterygotid eurypterids (Arthropoda, Chelicerata) in the Silurian... (Pl. V)



(for explanation see page 156)

Ivo Chlupáč: Pterygotid eurypterids (Arthropoda, Chelicerata) in the Silurian... (Pl. VI)

(for explanation see page 156)