



## A NEW SILURIAN XIPHOSURAN FROM PODOLIA, UKRAINE, USSR

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**ABSTRACT.** A single incomplete specimen of a xiphosuran, *Pasternakevia podolica* gen. et sp. nov., from the Ludlow Series of Podolia, Ukraine, USSR, is described. It has a smooth, spatulate carapace and rounded genal cornua. The opisthosoma bears nine free tergites (second to tenth); the first tergite is reduced and hidden beneath the carapace. The tergites have a broad axial region and small pleurae; the second tergite is hypertrophic. Telson and appendages are not preserved. *P. podolica* resembles *Pseudoniscus Nieszkowski*, 1859 and *Cyamocephalus* Currie, 1927; it is thus placed in the infraorder Pseudoniscina Eldredge, 1974, but certain characters are shared with the synziphosurines. It comes from the lagoonal deposits of the upper part of the Ustye Suite (Bagovytsa Horizon) where it occurred together with *Baltoerypterus tetragonophthalmus* (Fischer, 1839).

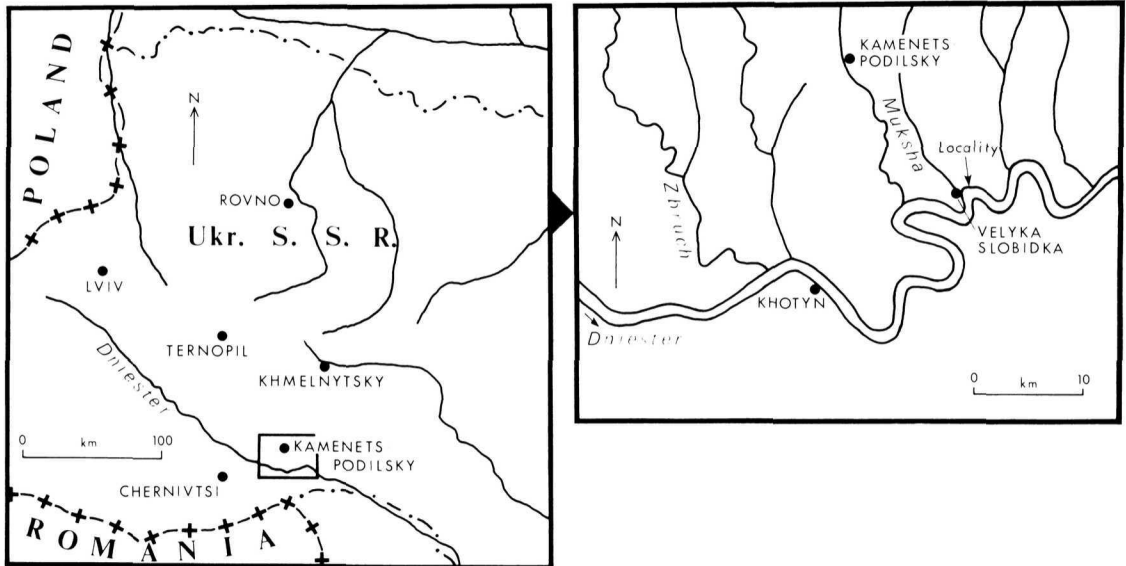
**АНОТАЦІЯ.** Описується єдиний неповний екземпляр мечохвоста *Pasternakevia podolica* gen. et sp. nov. із лудловського ярусу Поділля (УРСР). Представлений він гладким лопатовидним карапаксом із закругленими щічними шипами і опістосоєю. Опістосома складається з дев'яти видимих тергітів; перший тергіт редукований, схований під карапаксом. Тергіти мають широкі осьові частини та малі плеври; другий тергіт гіпертрофований. Тельсон і придатки не збереглися. Мечохвіст подібний до *Pseudoniscus Nieszkowski*, 1859 та *Cyamocephalus* Currie, 1927, у зв'язку з чим віднесений до інфраордону Pseudoniscina Eldredge, 1974, хоч має також і деякі ознаки синцифозур. Походить він із лагунних відкладів верхньої частини устівської світи баговицького горизонту, де знайдений разом із *Baltoerypterus tetragonophthalmus* (Fischer, 1839).

The late Silurian saw the climax of the first phase of evolution of the Xiphosura. In the *Treatise* (Størmer 1955) these middle Palaeozoic xiphosurans were united in the suborder Synziphosurina Packard, 1886, but some are now considered to belong to the sister group, the suborder Limulina Richter, 1929 (Eldredge 1974; Bergström 1975), and the infraorder Pseudoniscina Eldredge, 1974 was erected for them and some primitive bellinuroids. Xiphosuran phylogeny is founded to a large extent on scattered records of genera based on few, or commonly single, specimens; new finds often seem to confound rather than confirm established conceptions. The new genus described below follows this pattern since, while it undoubtedly lies within the Pseudoniscina, it also shares at least one character with some synziphosurines. For this and other reasons outlined below—and particularly if some bellinuroids are included in the Pseudoniscina (Eldredge 1974; cf. Fisher 1982, fig 1; 1984, fig. 2)—the monophyletic status of the infraorder must be considered suspect.

Eldredge (1974) convincingly argued that the most anterior opisthosomal tergite in synziphosurines and pseudoniscines belongs to the second opisthosomal somite. The tergite corresponding to the first opisthosomal somite is reduced to the form of an articulating half-ring and can only be seen in dorsally flexed specimens. Our identification of the opisthosomal tergites follows that of Eldredge (1974), so that the nine visible tergites are numbered second to tenth (II–X).

**Stratigraphy and geological setting.** The described specimen comes from dolomite marl (domerite) of the upper part (c. 22–23 m above the base) of the Ustye Suite of the Bagovytsa Horizon, which crops out on the left bank of the Dniester River c.1.5 km downstream of the village of Velyka Slobidka (Podolia, Ukraine, USSR; text-fig. 1). Subsequent extensive searches failed to reveal any more specimens of the genus.

The section consists of light-grey, vesicular, granular and platy, pelitomorphic, and rarely stromatolitic dolomites alternating with fine, platy domerites (text-fig. 2). Bed thicknesses are 0.15–



TEXT-FIG. 1. Location map.

1·50 m, and suite thickness as a whole is 30 m. These rocks are lagoonal in origin and contain only rare remains of chelicerates, of which the best known is *Baltoeurypterus tetragonophthalmus* (Fischer, 1839); shrinkage cracks commonly occur on the surfaces of domerite beds (Nikiforova *et al.* 1972).

In the lower part of the suite, rare, thick beds of limestones occur with abundant faunal remains which allow their correlation with Eltonian to lowermost Leintwardinian (Ludlow) strata of Britain (Tsegelnjuk *et al.* 1983; Drygant 1984); the layer with *Pasternakevia* correlates with the lowermost Leintwardinian.

*Preservation.* The fossil consists of a single piece: the cast and internal mould of the whole carapace and slightly damaged opisthosoma of nine tergites. Since the animal is not flexed dorsally, the half-ring belonging to the first opisthosomal somite cannot be seen and is presumed to be hidden beneath the carapace. The cuticle is rather thin, consisting of dark-grey matter which is clearly distinguished on the pale rock background. Though originally chitinous, the cuticle has almost certainly been replaced by material whose nature has not been determined.

#### SYSTEMATIC PALAEOLOGY

Phylum CHELICERATA Heymons, 1901

Class XIPHOSURA Latreille, 1802

Order XIPHOSURIDA Latreille, 1802

Suborder LIMULINA Richter and Richter, 1929

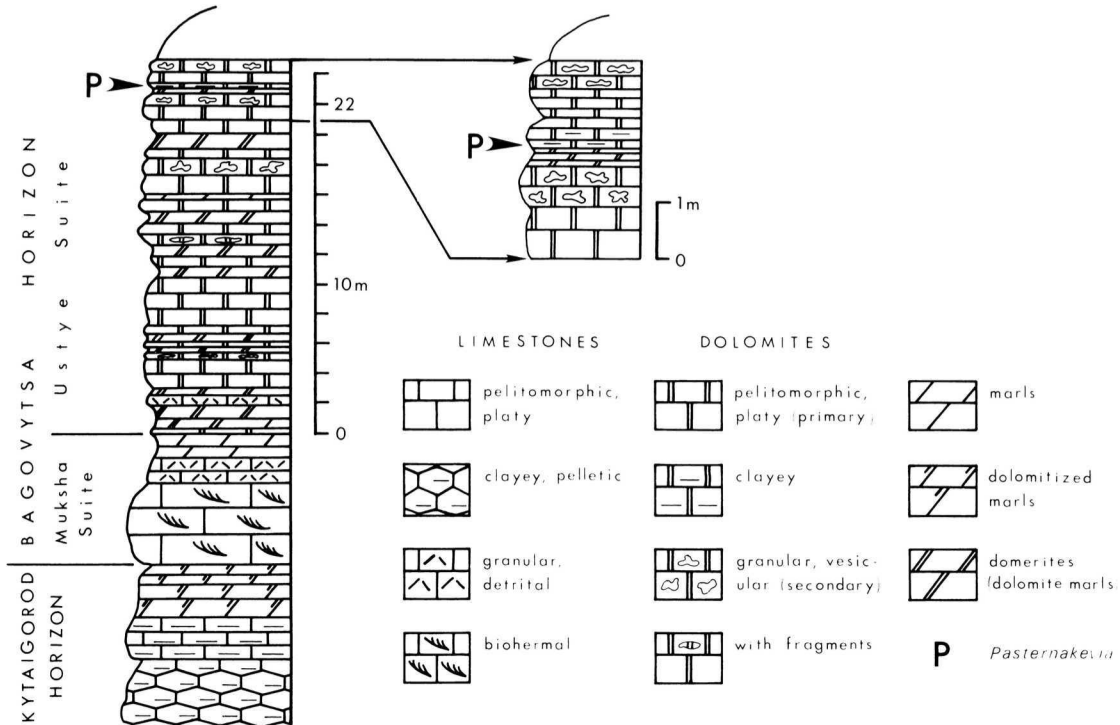
Infraorder PSEUDONISCINA Eldredge, 1974 (emended)

Genus PASTERNAKEVIA gen. nov.

*Type and only known species.* *Pasternakevia podolica* sp. nov.

*Derivation of name.* In honour of Professor S. I. Pasternak, a prominent researcher of the Cretaceous fauna of the Ukraine.

*Diagnosis.* Carapace spatulate, nearly as long as opisthosoma (excluding telson); cardiac and ophthalmic morphology obscure; genal cornua broad and rounded, lacking anterior median projection.



TEXT-FIG. 2. Columnar section of the outcrop located on text-fig. 1 showing occurrence of *Pasternakevia* gen. nov.

Nine opisthosomal tergites with broad axial region and small pleurae; tergite of first opisthosomal somite greatly reduced, that of second hypertrophied. No fused tergites.

*Pasternakevia podolica* sp. nov.

Text-fig. 3a, b, d

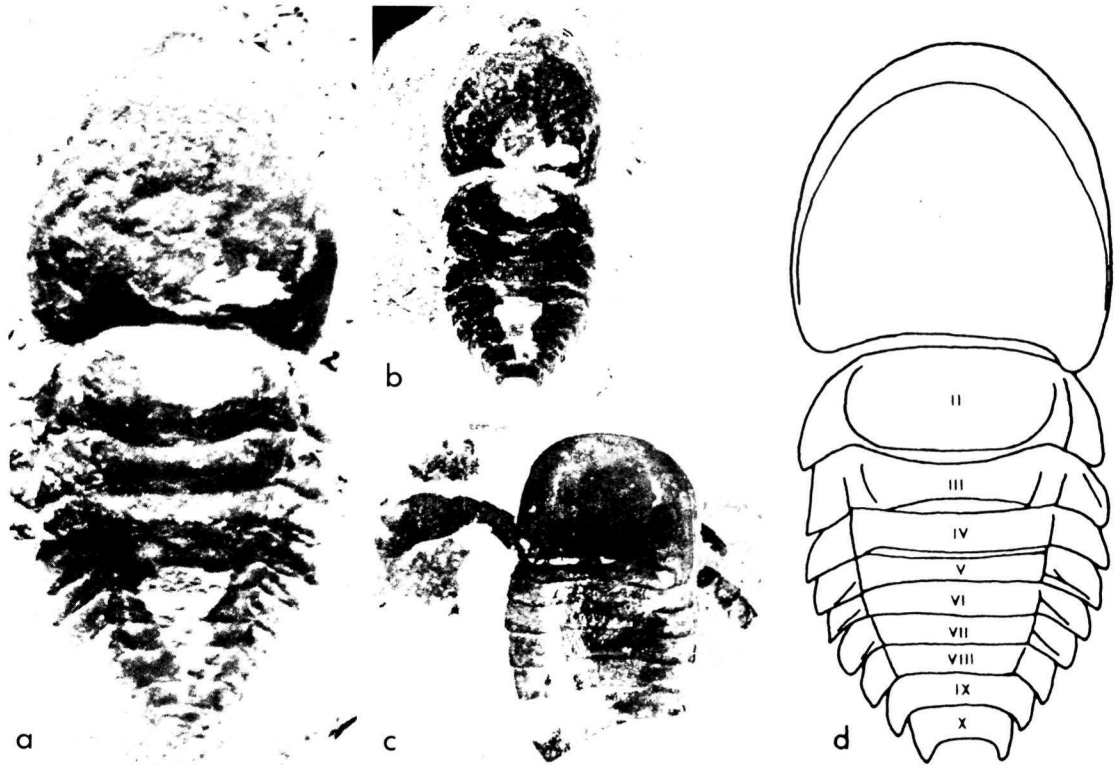
**Holotype.** Lviv State Natural Museum of the Ukrainian Academy of Sciences (Monographical Funds), No. 35611; single dorsal piece (only known specimen) consisting of the carapace and opisthosomal tergites; from the upper part (c. 22-23 m above the base) of the Ustye Suite (Bagovyitsa Horizon, middle Ludlow) on the left bank of the Dniester River c. 1.5 km downstream of the village of Velyka Slobidka (Podolia, Ukraine, USSR).

**Derivation of name.** After Podolia, the region in which the locality lies.

**Diagnosis.** As for the genus.

**Description.** *Pasternakevia* is nearly half as wide as it is long (excluding the telson which is not preserved), with the carapace occupying 0.44 of its length. The three largest opisthosomal tergites are nearly as wide as the carapace and thus the body appears parallel-sided for much of its length.

The carapace is spatulate, nearly as long sagittally (sag.) as it is wide; the sides are parallel in the posterior half, and the anterior rim of the carapace forms a semicircle. The posterior border of the carapace is gently procurved, meeting the lateral borders in blunt genal cornua. A long, crescentic feature on the carapace, widest anteriorly and tapering gradually to merge with the lateral borders near the genal angles, may represent the impression of the prosomal doublure or ventral marginal plate(s) adpressed against the carapace. The carapace is convex dorsally, the highest part being a broad circular area forming the posterior two-thirds; the surface slopes steeply away from this area to the crescentic feature and the genal areas. The posterior border is



TEXT-FIG. 3. *a, b, d*, *Pasternakevia podolica* gen. et sp. nov., No. 35611, holotype and only known specimen; upper part of Ustye Suite, Bagovytsa Horizon (middle Ludlow), near Velyka Slobidka, Ukraine, USSR; *a*, dorsal view in low-angle light,  $\times 3.0$ ; *b*, dorsal view in high-angle light,  $\times 1.5$ ; *d*, outline drawing of specimen showing main features and tergite numbers,  $\times 3.0$ . *c*, *Baltoeurypterus tetragonophthalmus* (Fischer, 1839), No. 35612, from same horizon and locality as *Pasternakevia*,  $\times 1$ .

gently arched. Typical xiphosuran carapace features cannot be discerned, except for a faint parabolic ridge situated centrally at the anterior side of the circular area; this could represent the anterior part of the cardiac lobe. Though obscured by a general wrinkling of the carapace surface, any original features must have been faintly expressed in life.

Nine dorsal tergites are readily apparent on the opisthosoma (belonging to the second to tenth opisthosomal somites); the first tergite is presumed to be concealed beneath the carapace (see above). Since the telson is not preserved attached, we cannot be certain that the most posterior tergite is the last, but its small size suggests that it is. The second tergite is the largest and is obviously hypertrophied. The third is only half the length (sag.) of the second, but is as wide. The fourth is three-quarters the length (sag.) of the third, and is also as wide as the second and third. Thereafter the tergites are roughly the same length but become increasingly narrower (exsag.). Each tergite consists of a wide, raised axial part, occupying about two-thirds of the total width, and narrower (exsag.) pleurae. The axial part of the second tergite is greatly swollen. On the third to tenth tergites the axial part has straight anterior and posterior borders. The anterior and posterior borders of the axial region of the third and more posterior tergites are depressed to accommodate adjacent tergites during flexure of the opisthosoma; that anteriorly on the third tergite is recurved on its posterior side to accommodate the hypertrophied second tergite. The pleurae are separated from the axis by dark coloured depressions, possibly indicating the presence of muscle attachments beneath. Together, these depressions line up as a pair of axial furrows which run nearly straight and converge from the genal angles of the carapace to the presumed anterolateral corners of the telson. As the outline of the opisthosoma is broadly curved, the pleurae are widest on the middle tergites. The pleurae curve gently backwards as spatulate lobes, with the posterior more strongly

curved than the anterior. At least the third to the eighth pleurae bear furrows running from the anteromedial to posterolateral corners, becoming shallower posterolaterally. The opisthosoma lacks ornamentation.

*Dimensions (in mm).* Lengths (sag.): total (excluding telson), 30.7; carapace, 13.5; opisthosoma (excluding telson), 17.2; tergites II, 4.8; III, 2.4; IV, 1.8; V, 1.6; VI, 1.1; VII, 1.4; VIII, 1.0; IX, 1.6; X, 1.5. Widths: carapace, 14.0; tergites II, 13.2; III, 13.2; IV, 13.2; V, 12.5; VI, 11.5; VII, 10.6; VIII, 8.1; IX, 7.0; X, 4.7.

*Discussion.* *Pasternakevia* resembles *Pseudoniscus*, known from Saaremaa, Estonia (*P. clarkei* Ruedemann, 1916), Lesmahagow, Scotland, and Ludlow, England (*Pseudoniscus* spp., Eldredge 1974), all of which are Ludlow in age. Similarities include: overall dimensions, spatulate carapace, number of opisthosomal tergites, no fused tergites, and lack of opisthosomal tagmosis (see Eldredge 1974, table 3). *Pasternakevia* differs from *Pseudoniscus* in lacking an anterior median carapace projection, its broad opisthosomal axial region, and hypertrophied second tergite. Another pseudoniscine, *Cyamocephalus* Currie, 1927, resembles *Pasternakevia*. *Cyamocephalus* is known from rocks of Ludlow age at Lesmahagow, Scotland (*C. loganensis* Currie, 1927), and Ludlow, England (*C. cf. loganensis* Eldredge and Plotnick, 1974).

Both *Pasternakevia* and *Cyamocephalus* lack the median anterior carapace projection found in *Pseudoniscus*. *Cyamocephalus* has a long opisthosoma with fused sixth and seventh opisthosomal tergites and the seventh hypertrophied, features absent from *Pseudoniscus* and *Pasternakevia*. These dissimilarities warrant the separation of all three animals at the generic level. To include *Pasternakevia* within the infraorder Pseudoniscina Eldredge, 1974, this taxon requires emendation to remove the character 'second segment not hypertrophic'. At present, it seems appropriate to include the genus within Pseudoniscina with this emendation.

The presence of a hypertrophic second opisthosomal tergite is a character which *Pasternakevia* shares with the synziphosurines *Bunodes* Eichwald, 1854 and *Limuloides* Salter in Woodward, 1865 (Eldredge 1974). The question arises: is this character homoplasous, i.e. derived independently in two separate clades? Eldredge (1974), Bergström (1975), and Stürmer and Bergström (1981) agree that the synziphosurines (*Bunodes*, *Weinbergina*, *Legrandella*, and *Limuloides*) are separate from other Xiphosura at high taxonomic rank. However, the distinguishing characters (carapace morphology and opisthosomal tagmosis) are not always strictly definable. In the Pseudoniscidae, for example, the carapace morphology is typically obscure, and in a reconstruction of *Weinbergina* by Stürmer and Bergström (1981, e.g. fig. 5) the separation of pre- and postabdomen is indistinct. The Ordovician genus *Lemoneites* Flower, 1968 also shares characters in common with both synziphosurines and limulines (Eldredge 1974). Consequently, the current phylogeny of these lower and middle Palaeozoic Xiphosura must be considered speculative; as more new taxa are described, character matrix analyses (e.g. Eldredge 1974) will help to answer the homoplasy question and produce new phylogenetic schemes.

As mentioned above, in the dolomite rocks of Ustye Suite of Podolia a normal marine fauna is absent. *Pasternakevia* is accompanied only by relatively few fossils of the eurypterid *B. tetragonophthalmus* (Fischer, 1839) (mainly as isolated parts but occasionally as almost whole animals; text-fig. 3c), fragments of *Pterygotus* sp., and some unidentifiable arthropods. No *Baltoeurypterus* specimen exceeds 10 cm in length; the fragments of *Pterygotus* indicate that the complete animals were much bigger. These chelicerates lived in a shallow lagoon, separated from an open basin to the west by a chain of bioherms (Drygant 1984). Sedimentary conditions in the lagoon were not stable, hence the deposition of thin, rhythmical, magnesian sediments which were periodically enriched with clayey material. Common desiccation cracks indicate frequent subaerial exposure in some places. The bed with *Pasternakevia* is a thin-bedded, clayey dolomite formed during a regressive phase, but before its maximum.

The mode of life of *Pasternakevia* cannot be determined with certainty. Sphaeroidal enrolment was almost certainly possible, since it is known in *Pseudoniscus* (Bergström 1975) which has a similar gross morphology. Flexure of the opisthosoma into a dorsally concave shape was also possible, as evidenced by the topography of the axial region of the tergites. Enrolment was

undoubtedly a defence strategy, while flexure in the opposite direction was used in righting the overturned animal and may also have been a help in burrowing. The spatulate carapace, effaced features, and broad axial region of the opisthosoma give *Pasternakevia* a streamlined shape similar to that of burrowing illaenid trilobites; it might also have been advantageous to a swimming form, but at small size and slow swimming speeds (low Reynolds numbers) effacement confers little advantage, so burrowing seems a more likely explanation. The hypertrophic second tergite suggests enlarged ventral organs: genitalia or, more likely, gills. It could be that enhanced gas- or ion-exchange abilities enabled *Pasternakevia* to inhabit a hypersaline environment. *Bunodes lunula* Eichwald, 1854 also has a hypertrophic second tergite and is found in similar dolomitic limestones in Estonia, but it is there accompanied by *Pseudoniscus aculeatus* Nieszkowski, 1859, which has a normal second tergite, so this hypothesis remains speculative.

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