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Reet MÄNNIL

NEW PHACOPID TRILOBITES FROM THE UPPER SILURIAN OF THE EAST BALTIC

The phacopid trilobites are generally rare in the East Baltic Silurian, except the Llandoverly, where many species of *Acernaspis* occur beginning from the Ordovician-Silurian boundary. Unknown in the Wenlock and Lower Ludlow, phacopids reappear in the Upper Ludlow, being represented by *Ananaspis decora* sp. nov. in mudstones of the Pagegiai Formation in Latvia. This species, described below, belongs to the abundant and highly diverse trilobite community, which is coeval with and taxonomically related to the trilobite association from the *Ananaspis fecunda* Biozone of the Kopanina Formation in Czechoslovakia.

Pridolian phacopids are represented by two species of *Eophacops* — *E. helmuti* sp. nov. and *E. serotinus* sp. nov., described in this paper. These species were found only recently from the outcrops of the Kaugatuma and Ohesaare stages in Saaremaa, where they occur rarely among the abundant calymenid and proetid trilobites in the open shelf biomicritic limestones. Both the species are significant also as the two stratigraphically youngest members of this genus.

The generic and suprageneric classification is that of I. Chlupáč (1977). The terminology of descriptions employed here essentially follows the "Treatise on Invertebrate Paleontology". "Postocular area" is used in the sense of I. Chlupáč (1977, p. 10). Specimens used in this work are housed at the Institute of Geology of the Academy of Sciences of the Estonian SSR, Tallinn (EGI) and at the Museum of Natural History of the Latvian SSR, Riga (LM).

I am grateful to I. Silina for the arrangement of the loan of specimens from the Museum of Natural History of the Latvian SSR, to Drs R. Ulst and L. Gailite who facilitated to collect the fossils from the Latvian cores, to Dr. A. W. A. Rushton for sending the photographs of Salter's type material. I am also indebted to Dr. D. Kaljo for the critical reading of the manuscript, A. Noor for linguistic help and K. Ronk for the drawings.

Family Phacopidae Hawle et Corda, 1847
Genus *Ananaspis* Campbell, 1967

Type species: *Phacops fecundus* Barrande, 1846 from the Kopanina Formation (Ludlow), Kolednik, Beroun, Czechoslovakia.

Ananaspis decora sp. nov.
Pl. I, figs. 1—15

Name: Latin, *decora*, decorative, referring to the well-defined surface sculpture.

Holotype: Cephalon with three thoracic segments, LM Tr 72/3/, Pavilosta boring, 728 m, West Latvia.

Material: 14 cephalata, 2 cheeks and 12 pygidia from Pavilosta core (690.2—737.9 m), two poorly preserved cephalata and one pygidium from Priekule core (998.4—1023.5 m).

Diagnosis: *Ananaspis* species with moderately convex, coarsely tuberculated glabella; axial furrows diverge at 65° . Eyes large, consisting of 16 to 17 files of up to 7 (rarely 8) lenses each. Vincular furrow shallow anteriorly, unsharply notched laterally; hypostomal suture transversal. **Description:** Cephalon of parabolical anterior outline bluntly angular medially, 1.7 times as wide as long. Glabella moderately convex, not overhanging the margin anteriorly, with the central part extending above the level of palpebral lobes. Maximum glabellar width approximately 1.2 times the median length and 1.8 times the minimum glabellar width at 1L. Glabellar furrows distinctly incised; 1S curved forward adaxially, 2S nearly straight with outer dip recurved posteriorly. Proximal part of 3S moderately bent forwards, lateral part almost straight with proximal dip slightly recurved posteriorly, and running into the axial furrow at 25 to 30° . Intercalating ring moderately convex, unsharply but definitely demarcated anteromedially, with distinct subcircular lobes laterally. Occipital furrow moderately deep and wide, occipital ring highly convex with a slightly flattened median part and low lateral lobes, defined by short anteriorly incised furrows.

Axial furrows rather deep and narrow, straight or gently convex abaxially and diverge at about 65° in front of 1S.

Eyes large, the length (exsag.) being 0.43 times the medial length of cranidium. Visual surface steeply inclined, containing in the adult specimens 17 (in some small cephalons 16) dorsoventral files usually with up to seven lenses each (rarely 8). Number of lenses 90 to 105 (exceptionally 49 in a juvenile specimen), in holotype 98 with the following arrangement (commencing at the front of eye): 455 767 777 776 655 43. Eye socle concave, dipping laterally; palpebral lobe narrow, demarcated by a distinct palpebral furrow; deeply incised both anteriorly and posteriorly. Palpebral area deeply sloping towards the axial furrow. Postocular area of fixed cheek in lateral profile inflated, with length (exsag.) equal to that of posterior border behind. Anterior cephalic border thin, rounded marginally and demarcated dorsally by narrow but distinct anterior border furrow. Lateral border rather flat anteriorly, slightly convex and broad posteriorly. Lateral border furrow very shallow and poorly defined anteriorly, strongly increasing in depth on the fixigena. Posterior border typical to *Ananaspis*, posterior border furrow deep, V-shaped adaxially, shallows abaxially and joins the lateral border furrow at a gently rounded angle. Genal angle bluntly rounded, usually with gentle genal node.

Vincular furrow unsharply notched laterally and shallow but well defined anteriorly. Doublure slightly convex ventrally, with median length (from posterior edge of vincular furrow) about 0.3 the total cranial length. Hypostomal suture almost straight medially.

Ornament of glabella and adaxial part of fixed cheek consists of moderately large tubercles (0.2—0.5 mm in diameter) with smaller tubercles between them. Tubercles on the occipital ring are more subdued than those on glabella, and very weak on the palpebral lobe. All tubercles and remaining surface of cephalon are covered with fine granules.

Hypostome unknown.

Only three anterior thoracic segments are known. Axis wide, the width exceeding a third the total width of thorax; rings are moderately arched, with slightly convex lateral lobes, defined by shallow notches anteriorly. Pleurae with deep pleural furrow. Ornament consists of low tubercles on the rings (with a tubercle on each lateral lobe) and granules over the entire surface (except the furrows).

Pygidium of broadly rounded posterior outline, approximately 1.6 times as wide as long. Axis 0.3 times as wide anteriorly as the pygidium, moderately tapering posteriorly, it has six or seven complete rings, two

or three indistinct rings and a short terminal piece. Pleural field with six or seven deep pleural furrows and five shallow interpleural furrows, fading out some distance before margin. Surface of axial rings granulate, in some specimens with barely visible tubercles.

Discussion: Cephala of juvenile specimens (with cranial length of 4 to 6 mm) differ from those of adult specimens in larger divergence angle of axial furrows (70°), broadly rounded anterior outline, prominent genal node and markedly less eye lenses arranged in 16 files of up to 4 lenses each (Pl. I, fig. 5). Larger specimens show minor variation in the arrangement of lenses in the eye (described above). Exceptional is the stratigraphically earliest specimen (Pavilosta boring, 737.7 m; Pl. I, fig. 9—10), which seems to have relatively small eyes, finer and denser tuberculation and short (sag.) anterior doublure, being similar to *Ananaspis fecunda aspera*. However, it is difficult to make a detailed comparison because of strong longitudinal compression of the cephalon, and therefore this specimen is treated herein as a temporal variety of *Ananaspis decora*.

The closest and coeval species to *A. decora* is the type species *A. fecunda* (Barrande, 1846). The two subspecies of the latter, described by I. Chlupáč (1977), show great similarity with one another in composition of pygidia. *A. decora* differs from both in relatively narrow pygidium with broader, shorter and more strongly tapering pygidial axis, also in longer (sag.) cephalic doublure with transverse hypostomal suture and less inflated composite glabellar lobe. Besides, as compared to *A. fecunda fecunda*, *A. decora* has sparser and more regular cephalic tuberculation, and smaller number of lens files in eye; from *A. fecunda aspera* (Hawle et Corda, 1847) it differs in markedly longer (exsag.) eye and less arcuate proximal part of 3S. *Ananaspis orientalis* (Максимова, 1968) from the Ludlow of Central Kazakhstan is distinguished from *A. decora* by its glabellar profile, shape of glabellar furrows and weak cephalic tuberculation. *Ananaspis amelangi* Ramsköld, 1985 from the Mulde Beds (Upper Wenlock) of Gotland differs in having more transverse anterior glabellar outline, smaller number of files and lenses per file in the visual surface, weaker tuberculation on the whole carapace and less segmented pleural field of pygidium. *Ananaspis stokesii* (Milne-Edwards, 1840) from British Wenlock, judging by the photographs of specimens, figured by J. W. Salter (1864) Pl. 2, figs. 1 and 6 (kindly sent to me by A. W. A. Rushton) and Ramsköld, 1985 (Pl. 4, fig. 7a, b), is distinguished from *A. decora* by weakly developed tuberculation on glabella, by lacking tubercles over remainder of cephalon, lacking lateral nodes on thoracic rings and also by weak segmentation of pygidium. As compared to *A. calvescens* Chlupáč, 1972, *A. latigenalis* (Etheridge and Mitchell, 1895; see Sherwin, 1972), *A. guttulus* Campbell, 1967 and *A. sp. n.* Holloway, 1980, the main differences are that *A. decora* has less inflated glabella, more coarser cephalic tuberculation and larger eyes.

Occurrence: West Latvia, Pavilosta borehole (690.2—737.9 m), Priekule borehole (998.4—1023.5 m), greenish-grey calcareous mudstones of the Pagegiai Formation, Kuressaare Regional Stage, Ludlow. Associated with trilobites *Proetus* cf. *signatus*, *Coniproetus* sp. and others as well with brachiopods of the *Dayia* Community.

Genus *Eophacops* Delo, 1935

Type species: *Phacops handwerki* Weller, 1907 from Niagaran dolomites (Wenlock) near Lemont, Illinois, U.S.A.

Eophacops helmuti sp. nov.

Plate II, figs. 1—17; text-fig. 1

Name: This species is named in memory of Helmut Alberti.

Holotype: Cephalon with damaged occipital ring and genal angles, EGI Tr 3329. Outcrop at the Kaugatuma Cliff, Saaremaa. Aigu Beds, Kaugatuma Regional Stage, Pridoli.

Material: One cranidium and two pygidia (all internal moulds) from Kaugatuma Cliff; five cephala, three cheeks and one pygidium from outcrops nearby cliff; one compressed cephalon from West Latvian borehole Piltene-1 (469.7 m).

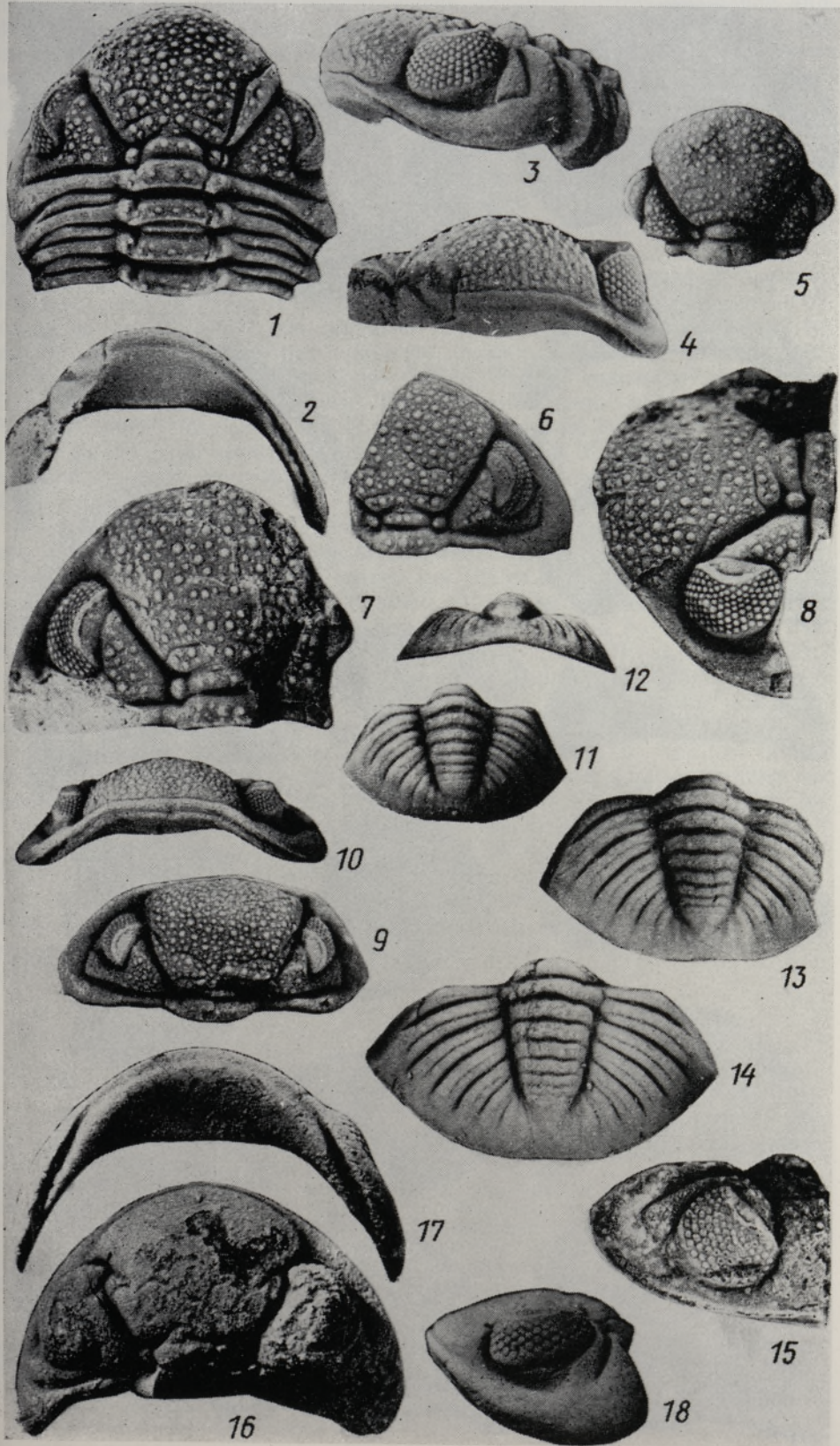
Diagnosis: *Eophacops* species with semicircular outline of cephalon. Glabella moderately convex, strongly expanding forward; outer part of the 3S subparallel to the axial furrow. Eye large, consists of 18 to 19 files of up to five lenses each. Postocular area very short. Genal region short posterolaterally; vincular furrow weakly continuous anteromedially.

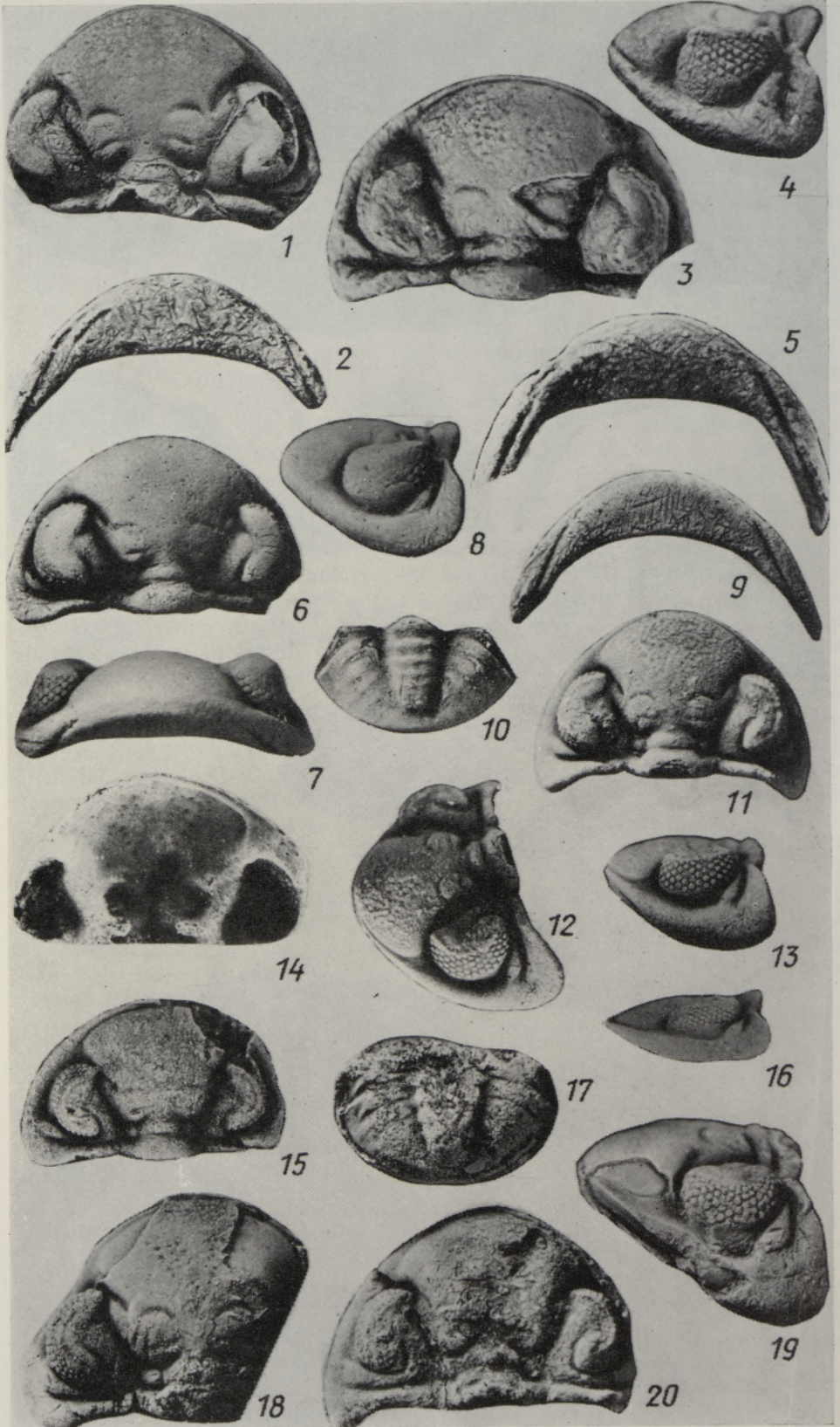
Description: Cephalon 1.6 to 1.7 times as wide as long. Glabella with rounded anterior outline, moderately convex, with marked indentation at the front of the eye. Maximum glabellar width nearly twice the minimum width and 1.1 times the glabellar length (sag., excluding the occipital ring). Glabellar furrows distinctly incised; 1S deep and wide (exsag.) laterally, 2S slightly oblique and straight or gently convex forwards. Proximal part of 3S moderately convex forwards, lateral part gently bent inwards, subparallel to the axial furrow and joins it adjacent to the front of the palpebral lobe. 1L subcircular, slightly nodular. 2L small, inflated, with length (exsag.) almost equal to that of 1L. Occipital furrow rather shallow medially. Axial furrows wide and shallow, bent abaxially at the anterior end of the palpebral lobe, diverging at 60 to 70° along 2L and 3L. Eyes large, about one half as long as the cranidium; palpebral lobes lie slightly below the level of glabella. Visual surface steeply inclined, consisting of 61 to 70 (average 67) lenses, arranged in 18 to 19 dorso-ventral files, each containing usually 1 to 4 lenses (rarely with a small fifth lens at the top of file). Typical arrangement (commencing at the front of the eye): 234 444 454 444 444 332 1. Postocular area about a half as long (exsag.) as posterior border behind eye. Beneath the visual surface concave area at the midpoint of eye. Anterior cephalic border thin, though distinct in front of glabella, rounded or bluntly sharp marginally. Anterior border furrow narrow, gently angular medially. Lateral border broadly rounded, lateral border furrow shallow and poorly defined. Posterior border narrow and convex adaxially, moderately broadening abaxially; posterior border furrow curves gently forward laterally. Posterolateral part of genal region short, genal angle rounded.

PLATE I

Figs 1—15. *Ananaspis decora* sp. nov. All specimens are from Ludlow, Pagegiai Formation, Pavilosta core. 1—4 — holotype cephalon, LM Tr 72/3/, at a depth of 728 m, dorsal, ventral, lateral and frontal views, $\times 3$; 5 — cranidium of juvenile specimen, LM Tr 72/1/, depth 731.5 m, dorsal view, $\times 6$; 6 — cephalon, EGI Tr 2897, depth 722.9 m, dorsal view, $\times 3$; 7, 8 — cephalon, EGI Tr 2996, depth 722.9 m, dorsal and dorsolateral views, $\times 3$; 9, 10 — compressed cephalon, EGI Tr 2997, depth 737.7 m, dorsal and frontal views, $\times 3$; 11, 12 — pygidium of juvenile specimen, EGI Tr 2898, depth 734.6 m, dorsal and posterior views, $\times 6$; 13 — pygidium, LM Tr 72/2b/, depth 737.5 m, dorsal view, $\times 3$; 14 — pygidium, LM Tr 72/10/, depth 690.2 m, dorsal view, $\times 6$; 15 — genal region with eye, EGI Tr 2998, depth 728.8 m, anterolateral view, $\times 3$.

Figs 16—18. *Eophacops serotinus* sp. nov. Pridoli, Ohesaare Regional Stage, Ohesaare Cliff. Holotype cephalon, EGI Tr 3336, dorsal, ventral and lateral views, $\times 4$.





Anterior doublure at the medial part of hypostomal suture gently convex ventrally, approximately 0.3 times as long as the cephalon (sag.); hypostomal suture slightly bent forwards. Vincular furrow unnotched and deep laterally, barely visible medially as a gently concave band. Auxiliary impressions on the external surface of the frontal glabellar lobe represented by indistinct pads and calluses (text-fig. 1, A), on the visceral surface expressed as pits, arranged in subtriangular pattern (Pl. II, fig. 14).

Pygidium known only from internal moulds, lenticular in outline; 1.7 times as wide as long. Axis anteriorly about one third as wide as the pygidium, consisting of 7 to 8 axial rings, first five well defined. Pleural field weakly segmented, consists of 4 to 5 pleural ribs, dying out before reaching posterior margin.

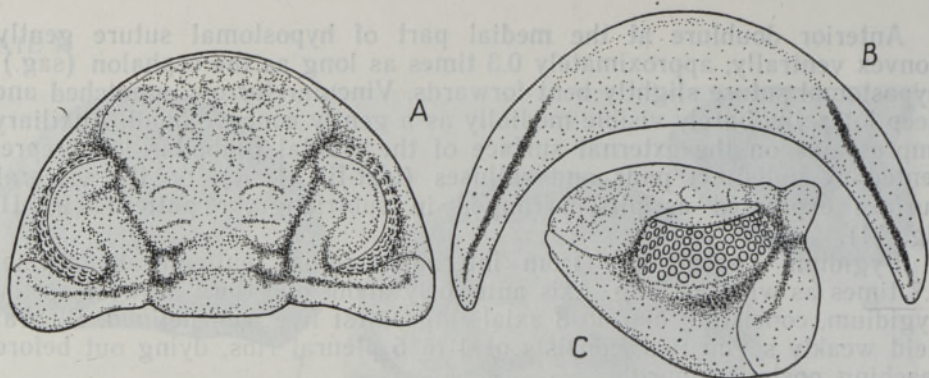
Discussion: *E. helmuti* shows slight variation in degree of divergence angle of axial furrows, in convexity of glabella, and in arrangement of lenses in the eye. Only one cephalon (Pl. II, figs. 11—13) compared to others from typical area has relatively longer and flatter glabella and longer posterolateral part of genal region, being somewhat similar to *E. serotinus* (described below). The cephalon from Latvian borehole Piltene-1 (469.7 m), occurring at or about the same horizon in the same basin, seems to be similar to the type material of *E. helmuti* except the flattened glabella, possibly due to the post-depositional deformation (Pl. II, figs. 15, 16.).

From the type species *E. handwerki* Weller, 1907 (see K. S. W. Campbell, 1967) *E. helmuti* differs in having more strongly forward expanding glabella, a smaller number of lenses per file of eye and anteriorly bent hypostomal suture. *E. helmuti* is most similar to *E. fontana* Holloway, 1980 from the Wenlock of North America, differing in having somewhat shorter and wider glabella and pygidium, arcuate lateral part of 3S, smaller number of lenses per file of eye and relatively narrow pygidial rachis. *E. lauensis* Ramsköld, 1985 from the Eke and Hamra beds of Gotland has moderately inflated and strongly forward expanding glabella as in the present species. The latter is distinguished by shallow axial furrows, long (exsag.) eye and short postocular area, smaller number of lenses per file of eye and short (exsag.), inflated 2L. Rather similar to *E. helmuti* is also *E. bulliceps* (Barrande, 1864) from the lower part of the Kopanina Formation of Czechoslovakia (see Příbyl, Vaněk, 1970; Chlupáč, 1977). As compared to *E. helmuti*, the eyes of both subspecies of *E. bulliceps* (described by I. Chlupáč, 1977) are remarkably smaller, the number of dorsoventral files greater, glabella relatively longer and more weakly expanding forward, and relatively longer, narrower and more strongly segmented pygidium.

PLATE II

Figs 1—17. *Eophacops helmuti* sp. nov. Pridoli, Kaugatuma Regional Stage. 1—14, 17 — specimens from outcrops near Kaugatuma Cliff, Äigu Beds, EGI. 1, 2 — holotype cephalon, Tr 3329, dorsal and ventral views, $\times 4$; 3—5 — cephalon, Tr 3334, dorsal, lateral and ventral views, $\times 4.3$; 6—9 — cephalon, Tr 3333, dorsal, frontal and ventral views; $\times 4$; 10 — internal mould of pygidium from Kaugatuma Cliff, Tr 3335, dorsal view, $\times 4$; 11—13 — cephalon, Tr 3330, dorsal, dorsolateral and lateral views, $\times 4$; 14 — visceral surface of cephalon with auxiliary impressions, Tr 3331, ventral view, $\times 4$; 15, 16 — depressed cephalon, LM Tr 72/58/, Piltene core, depth 469.7 m, the Minija Formation, dorsal and lateral views, $\times 4$; 17 — internal mould of pygidium, Tr 3332, dorsal view, $\times 4$.

18—20. *Eophacops serotinus* sp. nov. Pridoli, Ohesaare Regional Stage, Ohesaare Cliff, EGI. 18, 19 — cephalon, Tr 3311, dorsal and lateral views, $\times 4$; 20 — cephalon with damaged surface of glabella, Tr 3337, dorsal view, $\times 4$.



Text-fig. 1. *Eophacops helmuti* sp. nov. A, B, C. Reconstruction of cephalon in dorsal, ventral and lateral views, based on several specimens, $\times 4$ approx.

Occurrence: Estonia, southwestern coast of Saaremaa, Sõrve Peninsula. Biosparitic crinoidal limestone on the Kaugatuma Cliff and biomicritic limestone near the cliff. Lower part of the Kaugatuma Formation, Äigu Beds. Rare specimens of *E. helmuti* are accompanied by frequent *Proetus nieszkowski*, *Calymene kaugatumensis*, *C. schmidti* and brachiopods of the *Homoeospira* Community. West Latvia, Piltene-1 borehole, 469.7 m, organo-detritic calcareous mudstone of the Minija Formation. Kaugatuma Regional Stage, Pridoli.

Eophacops serotinus sp. nov.

Plate I, figs. 16—18; plate II, figs. 18—20; text-fig. 2

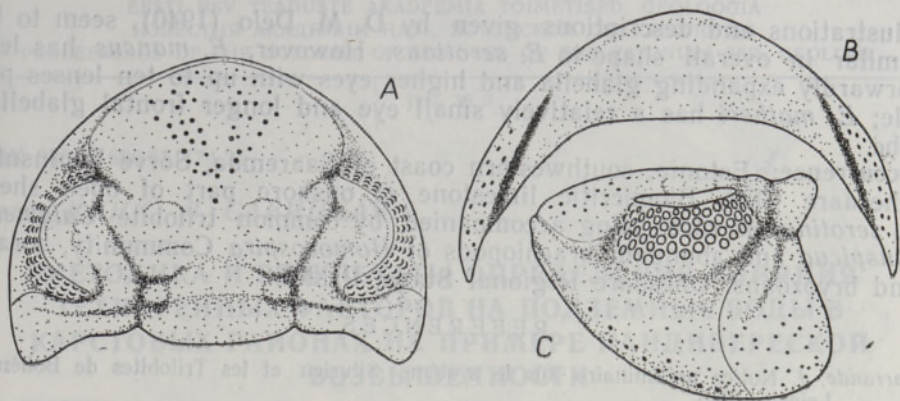
Name: Latin, serotinus, late; the species is the latest known member of this genus.

Holotype: Cephalon with partly eroded external surface, EGI Tr 3336 (Pl. I, figs. 16—18). Ohesaare Cliff, Ohesaare Regional Stage, Pridoli.

Material: Five rather poorly preserved cephalons and one cheek with anterior doublure from typical locality.

Diagnosis: *Eophacops* species with faintly subtriangular outline of cephalon. Glabella rather weakly convex; strongly expanding forward. Lateral part of the 3S joins the axial furrow at about 30° . Eye consists of 19 files of up to 5 lenses each. Vincular furrow very shallow medially. Posterolateral part of genal region long.

Description: Cephalon of parabolical anterior outline slightly angular medially, 1.7 times as wide as long. In lateral profile the glabella rather flattened, with central region extending above the level of palpebral lobes. Maximum glabellar width measures 1.1 to 1.2 times the median length and approximately 1.7 times the minimum width at 1L. The posterior parts of cephalons examined poorly preserved, however, the 1S, 2S and proximal part of 3S seem to have been similar to those of *E. helmuti*. Lateral part of 3S slightly bent inwards and joins the axial furrow at 30° . Axial furrows wide and shallow, bent laterally at the anterior end of palpebral lobe and diverge at about 60° along 2L and 3L. Eyes fairly large, the length (exsag.) being 0.45 times the median length of cephalon. Visual surface incompletely preserved, but contains presumably 19 dorso-ventral files with maximum of 5 lenses in a file. Postocular area short, with length (exsag.) about three quarters the length of posterior border behind eye. Beneath the visual surface concave area at the midpoint of eye. Anterior cephalic border thin in front of glabella and rather sharp marginally. Anterior border furrow narrow but distinct, slightly angular medially. Lateral border and border furrow are similar to those of *E. hel-*



Text-fig. 2. *Eophacons serotinus* sp. nov. A, B, C. Reconstruction of cephalon in dorsal, ventral and lateral views, based on specimens EGI Tr 3311 and 3336, $\times 4$ approx.

muti. Posterior border strongly broadens (exsag.) laterally, posterolateral part of genal region long. Genal angle rounded or gently pointed.

Anterior doublure fairly long (sag.) with median length a third of the total cephalic length. The central part of doublure slightly convex downwards, hypostomal suture straight medially. Vincular furrow deep laterally, considerably shallowing medially and definite as a concave band around the front of doublure. External surface very finely granulose, slightly coarser on the doublure. Auxiliary impressions are noticeable on the external surface of the frontal glabellar lobe of one specimen, being represented by small depressions arranged in a subtriangular pattern (Pl. II, fig. 18; text-fig. 2, A). On the lateral cephalic doublure visible elongated depressions (text-fig. 2, B, C).

Hypostome, thorax and pygidium unknown.

Discussion: The holotype cranium differs from two others examined in having relatively big eye, the length (exsag.) being about a half the length of cranium (sag.). The number and arrangement of lenses in the visual surfaces cannot be exactly determined, probably there are not substantial differences except the size of lenses. That may show some dimorphism, though accordingly to K. S. W. Campbell (1977) different eye morphs of one and the same species differ in having remarkably unequal number of lenses and files. The auxiliary impressions on the external surface of anterior glabellar lobe are fairly distinct on both species of *Eophacons* described above. The subtriangular pattern of impressions is apparently typical of the genus (see also Holloway, 1980, Pl. 17, fig. 6; Chlupáč, 1977, Pl. II, fig. 14), being more similar to the dalmanitid than sub-circular phacopid pattern (cf. Eldredge, 1971; Clarkson et al., 1977).

E. serotinus is similar to stratigraphically preceding species *E. helmuti* in strongly forward expanding glabella and morphology of eye, most likely being its closest described relative. It is, however, distinguished from *E. helmuti* by slightly subangular anterior outline of cephalon, flatter glabellar profile, greater angle between distal part of 3S and axial furrow, considerably bigger posterolateral prolongation of the border in genal angle and transverse hypostomal suture. *E. serotinus* is also similar in cephalic outline and large eye to the type species *E. handwerki* and *E. musheni* (Salter, 1864) from the Much Wenlock Limestone of England (see Clarkson, 1966; Campbell, 1967), but differs from both species in having greater divergence of axial furrows and smaller number of lenses per file of eye. Two rather poorly known species from North America, *E. mancus* (Foerste, 1919) and *E. matheri* Delo, 1940, judging by the

illustrations and descriptions given by D. M. Delo (1940), seem to be similar in overall shape to *E. serotinus*. However, *E. mancus* has less forwardly expanding glabella and higher eyes with up to ten lenses per file; *E. matheri* has a relatively small eye and longer frontal glabellar lobe.

Occurrence: Estonia, southwestern coast of Saaremaa, Sõrve Peninsula, Ohesaare Cliff. Biomicritic limestone of onshore part of open shelf. *E. serotinus* is rare, being accompanied by common trilobite *Calymene conspicua* and abundant brachiopods of *Homoeospira* Community, corals and bryozoans. Ohesaare Regional Stage, Pridoli.

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Academy of Sciences of the Estonian SSR,
Institute of Geology

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Reet MÄNNIL

UUSI FAKOPIIDE (TRILOBITA) BALTIKUMI ÜLEMSILURIST

On kirjeldatud kolme uut liiki Baltikumi ülemsilurist: *Ananaspis decora* Lääne-Lätist (Ludlow), *Eophacops helmuti* Kaugatuma ja *E. serotinus* Ohesaare lademe avamuselt Saaremaal.

Резе МЯННИЛЬ

НОВЫЕ ФАКОПИДЫ (TRILOBITA) ИЗ ВЕРХНЕГО СИЛУРА ПРИБАЛТИКИ

В статье описываются три новых вида факопид — *Ananaspis decora* из мергелей пагегайской свиты курессаарского горизонта (Западная Латвия) и два вида рода *Eophacops* из пржидольских отложений в районе выходов: *E. helmuti* из каугатумаского, *E. serotinus* из охесаарского горизонтов на о. Сааремаа.