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THE FIRST RECORD OF CYCLIDA (PANCRUSTACEA, MULTICRUSTACEA) IN THE CARBONIFEROUS OF THE DONETS BASIN, UKRAINE

ПЕРША ЗНАХІДКА ЦИКЛІДИ (PANCRUSTACEA, MULTICRUSTACEA) В КАРБОНІ ДОНЕЦЬКОГО БАСЕЙНУ, УКРАЇНА

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Cyclidans are an enigmatic poorly studied group of Late Paleozoic and Mesozoic crustaceans. This paper describes *Brittaniclus* cf. *scotti* (Woodward, 1893), the first record of Cyclida in Ukraine. The American species *Lophoops mckenzii* Easterday, 2004 (Kasimovian of Ohio, USA) is revised and transferred into the cyclidan genus *Brittaniclus* Schweitzer et al., 2020. Remains of *Brittaniclus* cf. *scotti* were collected from the lacustrine siltstone in the upper part of the Mospyne Formation (late Bashkirian, Early Pennsylvanian) of Luhansk Oblast' (Ukraine). The species *Brittaniclus mckenzii* (Easterday, 2004) comb. nov. differs from *B. scotti* (Woodward, 1893) and *B. testudo* (Peach, 1882) in the presence of sharp, small ellipsoidal and rounded tubercles on the outer and inner keels and on the median concentric keel. The species *Brittaniclus scotti* (Woodward, 1893) is distributed in the Langsettian and Duckmantian (late Bashkirian) strata of England: from the *communis* Zone to the lower *similis–pulchra* Subzone. Representatives of the genus *Brittaniclus* apparently inhabited brackish or even freshwater environments.
Keywords: Cyclida, *Brittaniclus*, Donets Basin, Ukraine, Bashkirian.

Цикліди — це проблематична недостатньо вивчена група пізньопалеозойських та мезозойських ракоподібних. Цю статтю присвячено опису виду циклід *Brittaniclus mckenzii* (Easterday, 2004) comb. nov. із відкладів касимовського ярусу штату Огайо (США) та першій знахідці цикліди (*Brittaniclus* cf. *scotti* (Woodward, 1893)) в Україні. Рештки *Brittaniclus* cf. *scotti* знайдено в алевролітах, що утворилися у солонуватоводному чи прісноводному басейні; вони залягають у верхній частині моспинської світи (верхня частина башкирського ярусу) Луганської області. Вид *Brittaniclus mckenzii* (Easterday, 2004) comb. nov. відрізняється від *B. scotti* (Woodward, 1893) та *B. testudo* (Peach, 1882) присутністю маленьких, гострих, еліпсоїдальних та округлих горбочків на зовнішньому та внутрішньому кілях та на медіальному концентричному кілі. Аналіз наявних даних показав, що вид *Brittaniclus scotti* (Woodward, 1893) поширений у вестфалі A та B (верхня частина башкирського ярусу) Англії: починаючи від зони неморських пелеципод *communis* і закінчуючи підзоною *similis–pulchra.* Представники роду *Brittaniclus*, ймовірно, існували в солонуватих чи навіть прісноводних умовах.
Ключові слова: Cyclida, *Brittaniclus*, Донбас, Україна, башкирський ярус.

INTRODUCTION

Cyclidans are an enigmatic group of fossil crustaceans, with the oldest representatives known from the Mississippian (late Tournaisian) and the latest from the Late Cretaceous (Maastrichtian) (Schweitzer et al., 2020). Due to their rarity, these crustaceans are poorly understood; their geographical distribution has not been precisely determined and their lifestyle is also not fully understood.

Here, I describe the first find of a representative of Cyclida in Ukraine, *Brittaniclus* cf. *scotti* (Woodward, 1893) from the Mospyne Formation (late Bashkirian — see Figs 1a, b) of the central Donets Basin. The American species *Lophoops mckenzii* Easterday, 2004 (Kasimovian of Ohio, USA) is revised and transferred into the genus *Brittaniclus* Schweitzer et al., 2020. This study significantly expands the palaeontological characteristic of Early Pennsylvanian succession of

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the Donets Basin and clarifies the range, taxonomy, and ecology of Carboniferous cyclidans.

GEOLOGICAL SETTING

The studied material was collected from a small outcrop 2 km north of the village of Makedonivka (Luhansk Oblast', Ukraine; coordinates: 48°14'59.0"N 39°17'48.9"E) (Figs 1c–e). The fossil-bearing rock is grey and yellowish grey siltstone with small limonite nodules, which lies at the base of the g_2 coal layer (Mospyne Formation) (Fig. 1b).

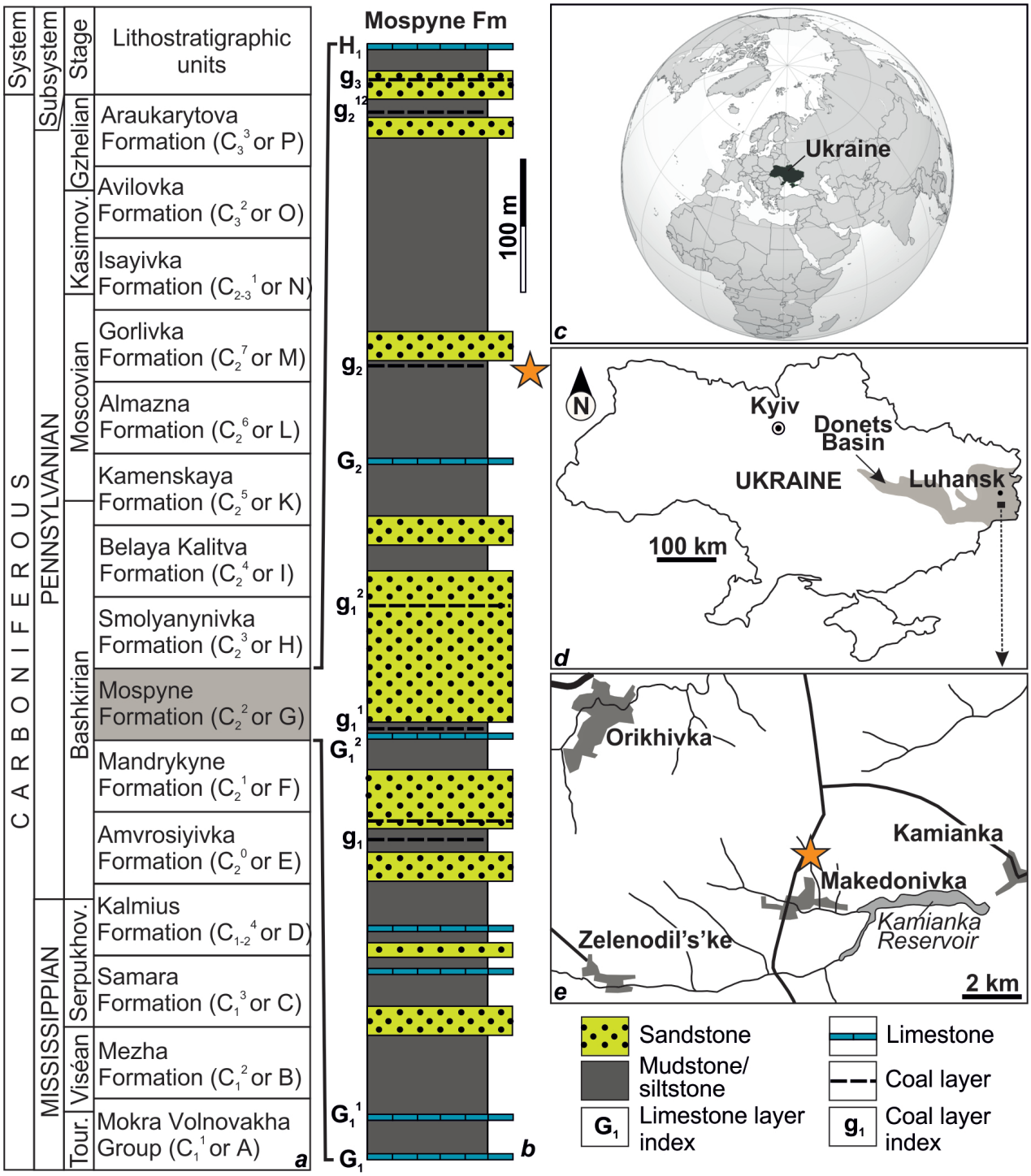

Fig. 1. Geological setting of the studied site: (a) Stratigraphic position of the Mospyne Formation in the Carboniferous succession of the Donets Basin; (b) Stratigraphic position of the locality of *Brittaniclus* cf. *scotti* (Woodward, 1893) (marked by asterisk); (c–e) Geographical location of the studied locality. Abbreviations: Tour. — Tournaisian, Serpukhov. — Serpukhovian, Kasimov. — Kasimovian.

Remains of millipedes, insects, (?)conchostracans and terrestrial plants *Stigmaria* sp. (appendices *in situ*), *Cyperites bicarinatus* Lindley et Hutton, 1832, *Annularia radiata* (Brongniart) Sternberg, 1825, *Calamariophyllum kidstonii* (Zalessky) Hirmer, 1927, *Calamites carinatus* Sternberg, 1823, *C. cistii* Brongniart, 1828, *C. suckowii* Brongniart, 1828, *Pinnularia capillacea* Lindley et Hutton, 1834 (roots *in situ*), *Aulacopteris* sp., *Paripteris gigantea* (Sternberg) Gothan, 1941 and *Cordaites principalis* (Germar) Geinitz, 1855 were found in this siltstone. Plant remains sometimes bear traces of damage produced by terrestrial arthropods such as millipedes and insects (Dernov, 2021a; 2021b).

The siltstone with remains of *Brittaniclus* cf. *scotti* (Woodward, 1893) lies in the upper half of the Mospyne Formation, which consists of a sequence (315 to 730 m) of mudstones, siltstones, sandstones, limestones, and coals (Nemyrovska, Yefimenko, 2013). The age of the Mospyne Formation is the early late Bashkirian (=Langsettian; Early Pennsylvanian) (Fig. 1a) (Nemyrovska, Yefimenko, 2013). The siltstone with *Brittaniclus* cf. *scotti* formed in a shallow brackish or freshwater lake with a dysaerobic environment in the bottom part of the water column. The upper part of the siltstone contains *Stigmaria* and *Pinnularia* roots and bears evidence of soil-forming processes.

MATERIAL AND METHODS

I examined two poorly preserved specimens of the cyclidan *Brittaniclus* cf. *scotti* (Woodward, 1893), one fragmental impression of the dorsal carapace (IGSU-15/01) and its counterpart (IGSU-15/02). These specimens are stored in the Department of Palaeontology and Stratigraphy of the Paleozoic Sediments, Institute of Geological Sciences, National Academy of Sciences of Ukraine (Kyiv).

The keys for the description of cyclidan species, taxonomy and morphological terminology proposed in the works of Feldman and Schweitzer (2019) and Schweitzer et al. (2020) are used here. The description of *Brittaniclus mckenzii* (Easterday, 2004) comb. nov. is based on the images of fossils and its description in the Master's Thesis of Cary R. Easterday (2004).

Institutional abbreviation: IGS NASU — Institute of Geological Sciences, National Academy of Sciences of Ukraine (Kyiv).

SYSTEMATIC PALAEONTOLOGY

Infraphylum Pancrustacea Zrzavý et Štys, 1997
Class Multicrustacea Regier et al., 2010
Order Cyclida Schram, Vonk et Hof, 1997
Family Americlidae Dzik, 2008
Genus *Brittaniclus* Schweitzer et al., 2020

Type species: *Cyclus rankini* Woodward, 1868; original designation.

Other included species: *B. scotti* Woodward, 1893; *B. testudo* (Peach, 1882); *B. mckenzii* (Easterday, 2004) comb. nov. (see below).

Diagnosis: See (Schweitzer et al., 2020: p. 267).

Discussion: This genus includes the cyclidan described by Easterday (2004) as the horseshoe crab *Lophoops mckenzii* Easterday, 2004 from the early Missourian rocks (Kasimovian, Late Pensylvanian) exposed by the 7–11 Mine in Columbiana County, Ohio, USA. The holotype of the species *Lophoops mckenzii* Easterday, 2004 (Fig. 2) is a fragment of the dorsal carapace,

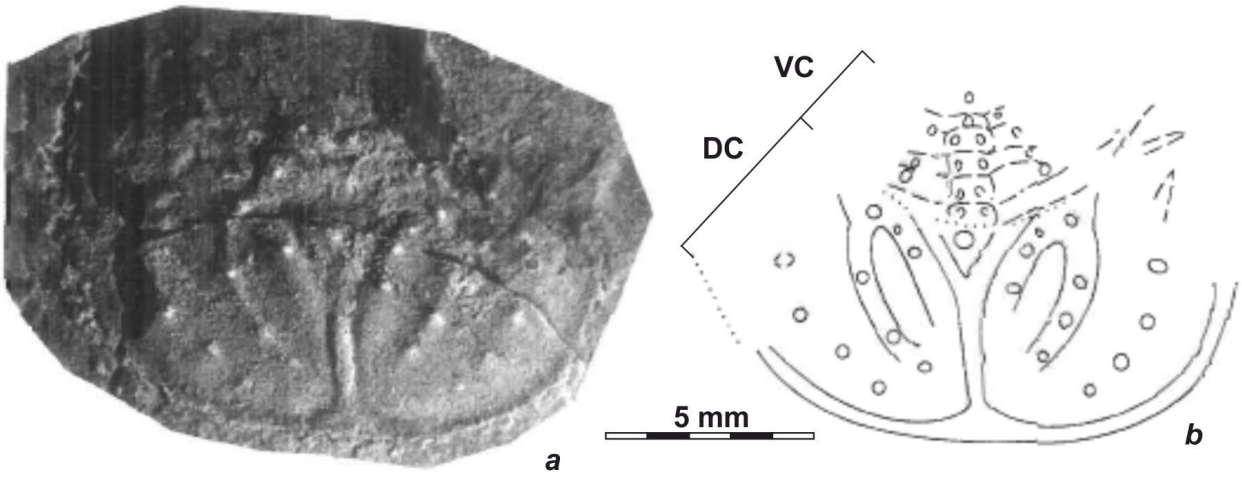

Fig. 2. *Brittaniclus mckenzii* (Easterday, 2004) comb. nov.: (a) Fragment of the dorsal carapace (specimen ET0328); (b) Graphic interpretation of the fossil figured in Fig. 2a (after Easterday (2004: Figs 6.6.1 and 6.6.2)). Abbreviations: DC — dorsal carapace, VC — ventral carapace.

which Easterday (2004) considered a prosoma, and a fragment of the ventral carapace, described by Easterday (2004) as the horseshoe crab opisthosoma. *Brittaniclus mckenzii* (Easterday, 2004) comb. nov. is described below.

Stratigraphic range: Serpukhovian to Kasimovian.

Brittaniclus mckenzii (Easterday, 2004) comb. nov. (Fig. 2).

Lophoops mckenzii: Easterday, 2004, p. 120, figs 6.6.1–4, 6.7.1.

Holotype: Specimen ET0328 (Easterday's Thesis0328) in the private collection of Gregory McComas (Marion, Ohio).

Type locality and stratigraphic horizon: 7–11 Mine near Madison Township, Columbiana County, Ohio, USA; early Missourian, Conemaugh Group, Glenshaw Formation (Easterday, 2004).

Diagnosis: Species of the genus *Brittaniclus* with a flattened and bilobed dorsal carapace bearing sharp, small ellipsoidal or rounded tubercles.

Description: Holotype ET0328 (Fig. 2a) is impression of the posterior part of a flattened and bilobed dorsal carapace with 14.6 mm maximum width and 9 mm long; the posterior notch is absent. The marginal rim is wide (~0.6–0.8 mm) and flattened. The posterior axial lobe is separated by a wide (~0.8 mm) arcuate inner lyrate keel; the outer lyrate keel is the same width as the inner lyrate keel. The outer and inner keels bear sharp, small, ellipsoidal and rounded tubercles, *c*. 0.4–0.5 mm in diameter. The axial keel is thin (~0.8–1.0 mm) and possibly merges with the posterior axial lobe. The posterior axial lobe is flattened with tubercles. Branchial region smooth, flattened with thin median concentric keel bearing sharp small ellipsoidal and rounded tubercles. Ventral surface with eight thoracomeres directed laterally (Fig. 2b).

Discussion: *Brittaniclus mckenzii* (Easterday, 2004) comb. nov. differs from *B. scotti* (Woodward, 1893) and *B. testudo* (Peach, 1882) in the presence of the sharp, small, ellipsoidal and rounded tubercles on the outer and inner keels and on the median concentric keel.

Locality: United States, Ohio; Conemaugh Group, Glenshaw Formation (for details, see «Type locality and stratigraphic horizon»).

Stratigraphic and geographic range: Early Missourian of Ohio, United States.

Brittaniclus cf. *scotti* (Woodward, 1893) (Fig. 3)

Americlus sp.: Dernov, 2015, pl. 2, fig. 3 (an exhaustive list of synonymous names can be found in Schweitzer et al., 2020: p. 267).

Material: One fragmentary impression of the dorsal carapace (IGS NASU-15/01) and its counterpart (IGS NASU-15/02).

Description: Specimen IGS NASU-15/01 (Fig. 3a) is an impression of the posterior part of a flattened and bilobed dorsal carapace 7 mm wide. The marginal rim is wide (0.3–0.6 mm), flattened, with a thin concentric keel; it tapers towards a broad posterior notch. The posterior axial lobe is separated by a broad (0.4 mm) arcuate inner lyrate keel; the outer lyrate keel about twice as wide as inner keel. The posterior axial lobe flattened and narrowed posteriorly. The axial keel is thin (0.35–0.40 mm), fused with the posterior axial lobe. The branchial region is smooth, flattened, with a thin median concentric keel.

Discussion: The cyclidan described above is very similar to *Brittaniclus scotti* (Woodward, 1893), but differs from the holotype of this species (see Schweitzer et al., 2020: Figs 11.1 and 11.2) in

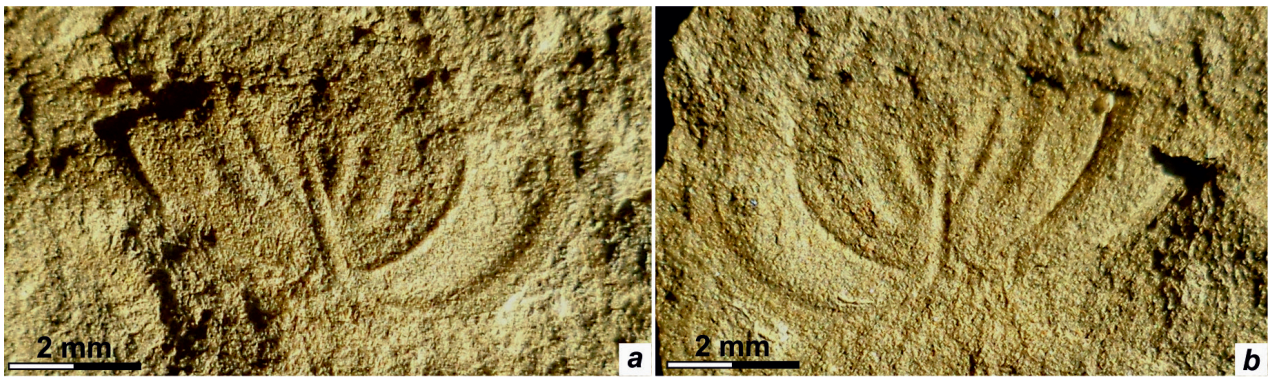

Fig. 3. *Brittaniclus* cf. *scotti* (Woodward, 1893): (a) Fragmental impression of the dorsal carapace (specimen IGS NASU-15/01); (b) Counterpart of the dorsal carapace figured in Fig. 3a (specimen IGS NASU-15/02).

several characteristic morphological features, e.g. a wider outer lyrate keel and marginal rim. In other morphological characters studied, the described cyclidan does not differ from *Brittaniclus scotti*.

Locality: See «Geological setting».

Stratigraphic and geographic range: Species *Brittaniclus scotti* (Woodward, 1893) is known exclusively from the Pennsylvanian strata of England, UK (Schweitzer et al., 2020).

RESULTS

The ecology of the genus *Brittaniclus* is not entirely clear, since species of the genus have been described mainly in very old works that do not report on the depositional environment of rocks with cyclidan remains. Below is a brief review of the taphonomy of *Brittaniclus* fossil sites, which is important for studying the ecology of cyclidans.

Brittaniclus scotti (Woodward, 1893) is known from the «Ganister seam» of the Lower Coal Measures (=Langsettian) at Bacup (Old Clough Colliery), Lancashire, England and «Pennystone Ironestone» at Coseley near Dudley, Staffordshire, England. The holotype of *Cyclus johnsoni* Woodward, 1894 (=*Brittaniclus scotti* (Woodward, 1893) according to Schweitzer et al. (2020)) is also found in the «Pennystone Ironestone» at Coseley (Woodward, 1894).

It is unclear what the «Ganister seam» is. It may be the Ganister coal seam that lies slightly above the Gastrioceras listeri marine zone (Cleal, Thomas, 1996) or the sandstone commonly employed as a roadstone (Percival, 1983); one of these ganisters lies at the base of the Ganister coal layer (De Rance, 1878; Cleal, Thomas, 1996).

The Ganister coal layer sometimes laterally merges with the Upper Foot coal seam (=Bullion Coal seam) (Stopes, Watson, 1909) or is laterally replaced by the Hard Bed coal seam (=Upper Foot and Union coal seams) (Wilson, Chisholm, 2004); the lateral equivalent of the Ganister coal seam is also the Alton coal seam.

The roof shales of the Bullion and Alton coal seams contain a rich marine fauna, e.g. lingulids, bivalves *Dunbarella* and *Posidoniella*, orthocerids, coiled nautiloids *Ephippioceras*, ammonoids *Gastrioceras*, and fishes *Listracanthus*, *Megalichthys, Elonichthys*, and *Acanthodes* (Hind, 1905; 1910; Stopes, Watson, 1909; Vernon, 1909). Apparently, the remains of *Brittaniclus scotti* were found in the roof shale of the Ganister coal layer (early Langsettian or early late Bashkirian), because the ganister sandstones contain no marine fauna, but there are remains of plant roots and other characteristic features of a paleosoil horizon.

The Gastrioceras listeri marine band deposited slightly below the Ganister coal bed contains ammonoids *Gastrioceras listeri* (Sowerby, 1812), which indicate the early Langsettian age for these deposits. The early Westphalian non-marine bivalves *Curvirimula belgica* (Hind, 1912)*, C. trapeziforma* (Dewar, 1939) and *Naiadites* sp. were found slightly below the Hard Bed coal seam, which lies slightly below the Gastrioceras listeri marine band (Wilson, Chisholm, 2004).

The so-called «Pennystone Ironstones» are siderite nodules from non-marine mudstones. The Coseley fossil site is a well-studied Konservate-Lagerstätte (lower *similis–pulchra* Subzone, Duckmantian) where the remains of terrestrial plants, horseshoe crabs, trigonotarbids, haptopods, phalangiotarbids, euthycarcinoids, crustaceans, enigmatic arthropods, insects and fishes have been found (Woodward, 1871; Schram, 1979; Wilson, Almond, 2001; Wilson, 2005; Russell et al., 2009; Garwood, Sutton, 2010; 2012; Garwood, Dunlop, 2011; Legg et al., 2012; Pacyna, Zdebska, 2012; Jones et al., 2014, Russell, Dunlop, 2014, etc.).

Most of the ironstone concretions originated from the Ten Foot Ironstone layer above the Thick coal seam (Garwood, Sutton, 2010). The deposits of this lagerstätte were formed in a brackish to freshwater environment, possibly as a part of a prograding deltaic complex (Wilson, 2005) or a lacustrine environment typical of a Coal Measure swamp forest (Braznell, 2006; cited after Legg et al., 2012). The remains of *Brittaniclus rankini* (Woodward, 1868) comes from a relatively low-oxygen brackish-water environment (Clark et al., 2020).

Another specimen of *Brittaniclus scotti* (Woodward, 1893) was found in a siderite nodule from the shale above the Wigan 4 Foot coal layer (Langsettian, early late Bashkirian) at Bickershaw Lagerstätte, Lancashire, England (Smith, 2007). Terrestrial plants, non-marine bivalves, horseshoe crabs, trigonotarbids, euthycarcinoids, arthropleurids, insects, fishes and fish egg capsules were found here (Anderson et al., 1997; 1999; Smith, 2007).

The cyclidan identified as *Cyclus* cf. *johnsoni* Woodward was found in ironstones near the Crow coal layer (Middle Coal Measures, Duckmantian–Bolsovian) of the Tyne Coalfield (Tyne and Wear,

England) along with millipedes, horseshoe crabs, trigonotarbids, insects and fishes (Gill, 1924).

In summary, the species *Brittaniclus scotti* (Woodward, 1893) is distributed in the Langsettian and Duckmantian (late Bashkirian) of England: from the *communis* Zone to the lower *similis–pulchra* Subzone.

The holotype of *Brittaniclus mckenzii* (Easterday, 2004) comb. nov. comes from the brackish or freshwater rocks of the Glenshaw Formation in Ohio. The remains of terrestrial plants, microconchids, conchostracans, millipedes, trigonotarbids, insects, and fishes are co-occuring with *Brittaniclus mckenzii* (Easterday, 2004) comb. nov. (McComas, 1988; McComas, Mapes, 1988; Easterday, 2004).

Thus, representatives of the genus *Brittaniclus* apparently inhabited brackish or even freshwater environments, unlike other Carboniferous cyclidans, e.g. *Cyclus* de Koninck, 1841, *Uralocyclus* Mychko et Alekseev, 2018, *Tazawacyclus* Schweitzer et al., 2020, etc., which were marine animals (Schweitzer et al., 2020). The find of *Brittaniclus scotti* (Woodward, 1893) in the late Bashkirian of the Donets Basin significantly expands the range of the family Americlidae Dzik, 2008 and additionally indicates that representatives of this family were inhabitants of marine, brackish or even freshwater environments.

CONCLUSION

The representative of the cyclidans, *Brittaniclus* cf. *scotti* (Woodward, 1893), is described for the first time from Ukraine. The American species *Lophoops mckenzii* Easterday, 2004 is revised and transferred into the cyclidan genus *Brittaniclus* Schweitzer et al., 2020. The species *Brittaniclus mckenzii* (Easterday, 2004) comb. nov. differs from *B. scotti* (Woodward, 1893) and *B. testudo* (Peach, 1882) in the presence of sharp, small, ellipsoidal and rounded tubercles on the outer and inner keels and on the median concentric keel. Representatives of the genus *Brittaniclus* apparently inhabited both marine and brackish or even freshwater environments.

REFERENCES

Anderson L. I., Dunlop J. A., Eagar R. M. C., Horrocks C. A., Wilson H. M., 1999. Soft-bodied fossils from the roof shales of the Wigan Four Foot coal seam, Westhoughton, Lancashire, UK. *Geological Magazine*. Vol. 135. No. 3. Pp. 321–329.

Anderson L. I., Dunlop J. A., Horrocks C. A., Winkelmann H. M., Eagar R. M. C., 1997. Exceptionally preserved fossils from Bickershaw, Lancashire UK (Upper Carboniferous, Westphalian A (Langsettian)). *Geological Journal*. Vol. 32. Pp. 197–210.

Clark N. D. L., Feldmann R. M., Schram F. R., Schweitzer C. E., 2020. Redescription of *Americlus rankini* (Pancrustacea: Cyclida: Americlidae) and interpretation of its systematic placement, morphology, and paleoecology. *Journal of Crustacean Biology*. Vol. 40 (2). 13 p.

Cleal C. J., Thomas B. A., 1996. British Upper Carboniferous Stratigraphy. Dordrecht: Springer, 339 p.

De Rance C. E., 1878. On the Lancashire Coal-fields. *Proceedings of the Geologists' Association*. Vol. 5 (7). Pp. 389–406.

Dernov V., 2015. New finds of arthropod remains and their trace fossils in the Bashkirian of the Donets Basin. *Paleontological Review*. Vol. 47. P. 120–126. (In Ukrainian).

Dernov V., 2021a. The earliest insect endophytic oviposition (Early Pennsylvanian, Eastern Ukraine). *Visnyk of Taras Shevchenko National University of Kyiv. Geology*. Vol. 95 (4). Pp. 16–24.

Anderson L. I., Dunlop J. A., Eagar R. M. C., Horrocks C. A., Wilson H. M. Soft-bodied fossils from the roof shales of the Wigan Four Foot coal seam, Westhoughton, Lancashire, UK. *Geological Magazine*. 1999. Vol. 135. No. 3. Pp. 321–329.

Anderson L. I., Dunlop J. A., Horrocks C. A., Winkelmann H. M., Eagar R. M. C. Exceptionally preserved fossils from Bickershaw, Lancashire UK (Upper Carboniferous, Westphalian A (Langsettian)). *Geological Journal*. 1997. Vol. 32. Pp. 197–210.

Clark N. D. L., Feldmann R. M., Schram F. R., Schweitzer C. E. Redescription of *Americlus rankini* (Pancrustacea: Cyclida: Americlidae) and interpretation of its systematic placement, morphology, and paleoecology. *Journal of Crustacean Biology*. 2020. Vol. 40 (2). 13 p.

Cleal C. J., Thomas B. A. British Upper Carboniferous Stratigraphy. Dordrecht: Springer, 1996. 339 p.

De Rance C. E. On the Lancashire Coal-fields. *Proceedings of the Geologists' Association*. 1878. Vol. 5 (7). Pp. 389–406.

Дернов В. Нові знахідки залишків та слідів життєдіяльності членистоногих у башкирських відкладах Донбасу. *Палеонтологічний збірник*. 2015. Т. 47. С. 120–126.

Dernov V. The earliest insect endophytic oviposition (Early Pennsylvanian, Eastern Ukraine). *Visnyk of Taras Shevchenko National University of Kyiv. Geology*. 2021. Vol. 95 (4). Pp. 16–24.

Dernov V., 2021b. Plants biodamages from the Bashkirian of the Donets Coal Basin, Eastern Ukraine. *Lethaea Rossica*. Vol. 23. Pp. 32–44. (In Russian).

Easterday C. R., 2004. Stratigraphy and paleontology of Cemetery Hill (Desmoinesian-Missourian: Upper Carboniferous), Columbiana County, Eastern Ohio. A Thesis presented in Partial Fulfillment of the Requirement for the Degree Master of Science in the Graduate School of The Ohio State University, 505 p.

Feldmann R. M., Schweitzer C. E., 2019. The enigmatic Cyclida (Pancrustacea): morphological terminology and family-level classification. *Journal of Crustacean Biology*. Vol. 39. Pp. 617–633.

Garwood R. J., Dunlop J. A., 2011. Morphology and systematics of Anthracomartidae (Arachnida: Trigonotarbida). *Palaeontology*. Vol. 54 (1). Pp. 134–161.

Garwood, R. J., Sutton, M. D., 2010. X-ray micro-tomography of Carboniferous stem-Dictyoptera: new insights into early insects. *Biology Letters*. Vol. 6. No. 5. Pp. 699–702.

Garwood R. J., Sutton M. D., 2012. The enigmatic arthropod *Camptophyllia*. *Palaeontologia Electronica*. Vol. 15 (2). 12 p.

Gill E. L., 1924. Fossil arthropods from the Tyne Coalfield. *Geological Magazine*. Vol. 1. Pp. 455–471.

Hind W., 1905. Notes on the palaeontology on the marine bands in the North Staffordshire Coal Measures. *Quarterly Journal of Geological Society*. Vol. 61. Pp. 527–547.

Hind W., 1910. On four new Carboniferous nautiloids and a goniatite new to Great Britain. *Proceedings of the Yorkshire Geological Society*. Vol. XVII (II). Pp. 97–109.

Jones F. M., Dunlop J. A., Friedman M., Garwood R. J., 2014. *Trigonotarbus johnsoni* Pocock, 1911, revealed by X-ray computed tomography, with a cladistic analysis of the extinct trigonotarbid arachnids. *Zoological Journal of the Linnean Society.* Vol. 172. Pp. 49–70.

Legg D. A., Garwood R. J., Dunlop J. A., Sutton M. D., 2012. A taxonomic revision of orthosternous scorpions from the English Coal Measures aided by X-ray micro-tomography (XMT). *Palaeontologia Electronica.* Vol. 15 (2). 16 p.

McComas G., Mapes R. H., 1988. Fauna associated with the Pennsylvanian floral zones of the 7–11 Mine, Columbiana County, Northeastern Ohio. *Ohio Journal of Science*. Vol. 88 (1). Pp. 53–55.

McComas M. A., 1988. Upper Pennsylvanian compression floras of the 7–11 Mine, Columbiana County, Northeastern Ohio. *Ohio Journal of Science*. Vol. 88 (1). Pp. 48–52.

Nemyrovska T. I., Yefimenko V. I., 2013. Middle Carboniferous (Lower Pennsylvanian). In: Gozhyk P. F. (ed.), Stratigraphy of the Upper Proterozoic and Phanerozoic of Ukraine. Volume 1. Stratigraphy of the Upper Proterozoic, Paleozoic and Mesozoic. Kyiv, pp. 283–303. (In Ukrainian).

Pacyna G., Zdebska D., 2012. Carboniferous plants preserved within sideritic nodules — a remarkable state of preservation providing a wealth of information. *Acta Paleobotanica*. Vol. 52 (2). Pp. 247–269.

Peach B. N., 1882. Further researches among the Crustacea and Arachnida of the Carboniferous rocks of the Scottish

Дернов В. С. Биоповреждения растений из башкирских отложений Донецкого бассейна (Восточная Украина). *Lethaea rossica*. 2021. Т. 23. С. 32–44.

Easterday C. R. Stratigraphy and paleontology of Cemetery Hill (Desmoinesian-Missourian: Upper Carboniferous), Columbiana County, Eastern Ohio. A Thesis presented in Partial Fulfillment of the Requirement for the Degree Master of Science in the Graduate School of The Ohio State University, 2004. 505 p.

Feldmann R. M., Schweitzer C. E. The enigmatic Cyclida (Pancrustacea): morphological terminology and family-level classification. *Journal of Crustacean Biology*. 2019. Vol. 39. Pp. 617–633.

Garwood R. J., Dunlop J. A. Morphology and systematics of Anthracomartidae (Arachnida: Trigonotarbida). *Palaeontology*. 2011. Vol. 54 (1). Pp. 134–161.

Garwood, R. J., Sutton, M. D. X-ray micro-tomography of Carboniferous stem-Dictyoptera: new insights into early insects. *Biology Letters*. 2010. Vol. 6. No. 5. Pp. 699–702.

Garwood R. J., Sutton M. D. The enigmatic arthropod *Camptophyllia*. *Palaeontologia Electronica*. 2012. Vol. 15 (2). 12 p.

Gill E. L. Fossil arthropods from the Tyne Coalfield. *Geological Magazine*. 1924. Vol. 1. Pp. 455–471.

Hind W. Notes on the palaeontology on the marine bands in the North Staffordshire Coal Measures. *Quarterly Journal of Geological Society*. 1905. Vol. 61. Pp. 527–547.

Hind W. On four new Carboniferous nautiloids and a goniatite new to Great Britain. *Proceedings of the Yorkshire Geological Society*. 1910. Vol. XVII (II). Pp. 97–109.

Jones F. M., Dunlop J. A., Friedman M., Garwood R. J. *Trigonotarbus johnsoni* Pocock, 1911, revealed by X-ray computed tomography, with a cladistic analysis of the extinct trigonotarbid arachnids. *Zoological Journal of the Linnean Society.* 2014. Vol. 172. Pp. 49–70.

Legg D. A., Garwood R. J., Dunlop J. A., Sutton M. D. A taxonomic revision of orthosternous scorpions from the English Coal Measures aided by X-ray micro-tomography (XMT). *Palaeontologia Electronica.* 2012. Vol. 15 (2). 16 p.

McComas G., Mapes R. H. Fauna associated with the Pennsylvanian floral zones of the 7–11 Mine, Columbiana County, Northeastern Ohio. *Ohio Journal of Science*. 1988. Vol. 88 (1). Pp. 53–55.

McComas M. A. Upper Pennsylvanian compression floras of the 7–11 Mine, Columbiana County, Northeastern Ohio. *Ohio Journal of Science*. 1988. Vol. 88 (1). Pp. 48–52.

Немировська Т. І., Єфіменко В. І. Середній карбон (нижній пенсильваній). Гожик П. Ф. (Ред.) *Стратиграфія верхнього протерозою та фанерозою України. Т. 1. Стратиграфія верхнього протерозою, палеозою та мезозою України*. Київ: ІГН НАН України, 2013. С. 283–303.

Pacyna G., Zdebska D. Carboniferous plants preserved within sideritic nodules — a remarkable state of preservation providing a wealth of information. *Acta Paleobotanica*. 2012. Vol. 52 (2). Pp. 247–269.

Peach B. N. Further researches among the Crustacea and Arachnida of the Carboniferous rocks of the Scottish border.

border. *Transactions of the Royal Society, Edinburgh*. Vol. 30. Pp. 511–529.

Percival C. J.,1983. A definition of the term ganister. *Geological Magazine*. Vol. 120 (2). Pp. 187–190.

Russell J. G., Dunlop J., 2014. Three-dimensional reconstruction and the phylogeny of extinct chelicerate orders. *PeerJ* 2: e641. 33 p.

Russell J. G., Dunlop J., Sutton M. D., 2009. High-fidelity X-ray micro-tomography reconstruction of siderite-hosted Carboniferous arachnids. *Biology Letters*. Vol. 5. Pp. 841–844.

Schweitzer C. E., Mychko E. V., Feldmann R. M., 2020. Revision of Cyclida (Pancrustacea, Multicrustacea), with five new genera. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*. Vol. 29 (3). Pp. 245–303.

Schram F. R., 1979. British Carboniferous Malacostraca. *Fieldiana: Geology*. Vol. 40. Pp. 1–129.

Smith R. D. A., 2007. Flora en fauna van een oud regenwoud in het Laat-Carboon van Noord-Engeland. *Gea*. Vol. 2. P. 46–53. (In Dutch).

Stopes M. C., Watson D. M. S., 1909. On the present distribution and origin of calcareous concretions in coal seams, known as «coal balls». *Philosophical Transactions of the Royal Society. Biological Sciences*. Vol. 200 (262–273). Pp. 167–218.

Vernon R. D., 1909. The geology of the Lower Coal Measures of the Derbyshire and Nottinghamshire portion of the Yorkshire Coalfield. *Geological Magazine*. Vol. VI (VII). Pp. 289–299.

Wilson A. A., Chisholm J. I., 2004. Reference sections of faunal bands in the Lower Coal Measures Formation at Elland, west Yorkshire, UK. *Proceedings of the Yorkshire Geological Society*. Vol. 55 (I). Pp. 21–32.

Wilson H. M., 2005. A new genus of archipolypodan millipede from the Coseley Lagerstätte, Upper Carboniferous, UK. *Palaeontology*. Vol. 48 (5). Pp. 1097–1100.

Wilson H. M., Almond J. E., 2001. New euthycarcinoids and an enigmatic arthropod from the British Coal Measures. *Palaeontology*. Vol. 44 (1). Pp. 143–156.

Woodward H., 1871. On the discovery of a new and very perfect arachnide from the ironstone of the Dudley Coalfield. *Geological Magazine*. Vol. 8 (87). Pp. 335–338.

Woodward H., 1893. Note on a new British species of *Cyclus* from the Coal Measures of Bacup, Lancashire. *Geological Magazine*. Vol. 10. Pp. 28–29.

Woodward H., 1894. Contributions to our knowledge of the genus *Cyclus* from the Carboniferous formation of various British localities. *Geological Magazine*. Vol. 1. Pp. 530–539.

Transactions of the Royal Society, Edinburgh. 1882. Vol. 30. Pp. 511–529.

Percival C. J. A definition of the term ganister. *Geological Magazine*. 1983. Vol. 120 (2). Pp. 187–190.

Russell J. G., Dunlop J. Three-dimensional reconstruction and the phylogeny of extinct chelicerate orders. 2014. *PeerJ* 2: e641. 33 p.

Russell J. G., Dunlop J., Sutton M. D. High-fidelity X-ray micro-tomography reconstruction of siderite-hosted Carboniferous arachnids. *Biology Letters*. 2009. Vol. 5. Pp. 841–844.

Schweitzer C. E., Mychko E. V., Feldmann R. M. Revision of Cyclida (Pancrustacea, Multicrustacea), with five new genera. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*. 2020. Vol. 29 (3). Pp. 245–303.

Schram F. R. British Carboniferous Malacostraca. *Fieldiana: Geology*. 1979. Vol. 40. Pp. 1–129.

Smith R. D. A. Flora en fauna van een oud regenwoud in het Laat-Carboon van Noord-Engeland. *Gea*. 2007. Vol. 2. P. 46–53. (In Dutch).

Stopes M. C., Watson D. M. S. On the present distribution and origin of calcareous concretions in coal seams, known as «coal balls». *Philosophical Transactions of the Royal Society. Biological Sciences*. 1909. Vol. 200 (262–273). Pp. 167–218.

Vernon R. D. The geology of the Lower Coal Measures of the Derbyshire and Nottinghamshire portion of the Yorkshire Coalfield. *Geological Magazine*. 1909. Vol. VI (VII). Pp. 289–299.

Wilson A. A., Chisholm J. I. Reference sections of faunal bands in the Lower Coal Measures Formation at Elland, west Yorkshire, UK. *Proceedings of the Yorkshire Geological Society*. 2004. Vol. 55 (I). Pp. 21–32.

Wilson H. M. A new genus of archipolypodan millipede from the Coseley Lagerstätte, Upper Carboniferous, UK. *Palaeontology*. 2005. Vol. 48 (5). Pp. 1097–1100.

Wilson H. M., Almond J. E. New euthycarcinoids and an enigmatic arthropod from the British Coal Measures. *Palaeontology*. 2001. Vol. 44 (1). Pp. 143–156.

Woodward H. On the discovery of a new and very perfect arachnide from the ironstone of the Dudley Coalfield. *Geological Magazine*. 1871. Vol. 8 (87). Pp. 335–338.

Woodward H. Note on a new British species of *Cyclus* from the Coal Measures of Bacup, Lancashire. *Geological Magazine*. 1893. Vol. 10. Pp. 28–29.

Woodward H. Contributions to our knowledge of the genus *Cyclus* from the Carboniferous formation of various British localities. *Geological Magazine*. 1894. Vol. 1. Pp. 530–539.

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