Use of mathematical methods to determine the ichnofossils species composition

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SUMMARY

The studied specimen from the basal horizon of the Kanivska suite is an agglomeration of phosphatized debris of various types of ichnofauna, cemented with a phosphateous and sand substrate. To our opinion, there are fragments of a kernel decapoda dwelling structures of Thalassinoides Ehrenberg ichnogenus and cores of the burrows of Ophiomorpha Lundgren genus. Thalassinoides Ehrenberg can be inferred from the condition of the surface, absence of a constructed wall and its size. The phosphorite features of the Ophiomorpha Lundgren have a characteristic ophiomorphic sculpture in the form of knobbles on the outer surface. The structures of this type have certain differences in the distribution and nature of phosphate material. The described kernels are interpreted as domus of fossil fauna. They were not known earlier within of the Middle Dniper area.

Since the main sign of species diagnosis is kernel's diameter, we used Akaike criteria to assess the probability of the number of species in a sample. The models consisted of 1 and 2 groups. The result showed that the most probable is the model where the sample consists of 1 group. Computations were performed using the programs tpsDig2 ver. 2.31 and the Old Past ver. 2.17.

Keywords: Eocene, Kanivska suite, phosphatized remains, ichnophana.
Introduction
The object of our study was phosphatized remains of ichnofaunas from a basal horizon Kanivska suite (Eocene), which transgressively onlaps here the eroded top of the Upper Cretaceous deposits. This sequence outcrops in the gulleys of Kaniv area.

The basal horizon of the Kanivska suite is mostly composed of massive medium- and coarse grained gravellite quartz sandstone with occasional inclusions of phosphate nodules of irregular rounded shape. Apparent bed thickness is up to 15-25 cm. Numerous inclusion of carbonate organics are seen in the upper part of the layer. They are represented by almost intact 3-5 cm shells and detritus of Bivalvia, Brachiopoda and Ammonites. The phosphatized organic fossils contain shells of inarticulata brachiopods, small (up to 1 cm) fragments of fish bones and a shark tooth with a length of 1.5 cm. All remnants of Bivalvia and Brachiopoda are from benthic fauna. The layout of shells and their condition indicate at the redeposition of fossils. From this level remnants of marine reptiles are described too. Also a large amount of phosphate nodules with varying sizes, petrified wood are encountered there. A bedrock specimen was sampled from this level in the left wall of the first right ravine tributary of Glyadovy gulley (near Khmilna village) at a height of ca. 1.5 m from the thalweg.

Method and/or Theory
The specimen is an agglomeration of phosphatized debris of various types of ichnofauna, cemented with a phosphateous and sand substrate. Such kind of phosphate structures are widely known in Cretaceous deposits of East European platform (Shvanov, 1987). The phosphatized constituents of the specimen with different shapes, colors and sizes can be classified into two types (Fig.1a, b) according to their morphology. They were studied by polarizing microscope Micros MC 300(S) and paleontologic analysis. Computations were performed using the programs tpsDig2 ver. 2.31 and the Old Past ver. 2.17.

Conclusions
The first type is the largest straight rod-like fragment of ovate and cylindrical shape with length 10-12 cm and major diameter 5-6 cm. The surface is slightly rough, and its fresh fracture shows the granulated well cemented rock. The cross section markedly reveals the zonation with a clear peripheral part (3-5 mm) and dark center.

To our opinion, this is a fragment of a kernel decapoda dwelling structures of Thalassinoides Ehrenberg ichnogenus, which can be inferred from the condition of the surface, absence of a constructed wall and its size. The cylindrical shape can be an indication that the fossil is a part of a vertical "mine" (the terminology is borrowed from (Yanin and Baraboshkin, 2013); and the size would infer Th. suevicus type II (Reith) species, described in (Monaco and Giannetti, 2002) and some other works.

The structures of the second type are dark reddish and black. These are fragments of pipe-like (or cone-like) debris with diameters from 1 to 2.5 cm and length up to 6 cm with a specific hummocky surface, some fragments are branched. They also feature a zonal structure with darker peripheral parts compared to central areas. We believe that the phosphorite features of the second type are cores of the
decapoda burrows – Ophiomorpha Lundgren genus with a characteristic ophiomorphic sculpture in the form of knobbles on the outer surface. The wall is composed of rounded or ovale rock grains; the structure is like a tube constructed with a flat inner surface. One of the fragments has a Y-shaped branching at the edge. Since the principal feature for distinguishing between species is the diameter of the kernel, which indicates at the size of the animals (Vyalov, 1966), the described forms can be attributed as O. nodosa Lundgren genus (outer diameter range 1.5-3.3 cm). After the analysis of W. Häntzschel (Häntzschel, 1952), the ophiomorphs are considered as dwelling pipes of burrowing Decapoda. A specific sculpture of the walls was probably formed as a result of their lining with balls of sedimentation material.

The kernels of both types are passively (gravitationally) filled. According to the appearance, the representatives of both genera differ essentially, although, according to some researches, the shape of the burrows mostly depends on the nutrition, rather than on the substrate type, and is related to the specific features of species (Griffis and Suchanek, 1991). Others (Yanin and Baraboshkin, 2013) note that according to the substrate nature the change of Ophiomorpha patterns into Thalassinoides may occur.

Since the main sign of species diagnosis is kernel's diameter, we used Akaike criteria to assess the probability of the number of species in a sample. The models consisted of 1 and 2 groups.

Model from 1 group (Fig. 2a):
logarithmic likelihood function of this model (log l. hood): 4.125;
Akaike information criterion: -1.125.

![Fig. 2a. A model consisting of one group.](image)

Model from 2 groups (Fig. 2b):
the logarithmic likelihood function of this model (log l. hood): 6.275;
Akaike information criterion: -15.45.
Fig. 2b. A model consisting of two groups.

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<tr>
<th>Number of groups</th>
<th>likelihood assessment</th>
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<tbody>
<tr>
<td>1</td>
<td>0.82</td>
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<tr>
<td>2</td>
<td>0.21</td>
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The result showed that the more probable is the model where the sample consists of 1 group – the comparative probability of a model consisting of one group is 0.82.

The described kernels are interpreted as Domichnia: domus of fossil fauna. They were not known earlier within the Middle Dniper area. The animals constructed a system of void ducts in the well ventilated middle ichnolayer with depth up to 60 cm (as can be inferred from the diameter of *Thalassinoides*). Although crawfish burrows can be present in any formation, it is generally thought, that they are more specific for the littoral and fleet water environments (Singh et al., 2008).

The modern burrow builders as analogs of the described fauna, could be prawns – the representatives of Callianassa genus, which permanently reside in the dug holes. They feed on small organisms and detritus with the use of a filtration system. Modern Callianassidae reside in warm ocean waters, massively occupying areas from littoral to bathyal zones (Yanin and Baraboshkin, 2013).

References


