

The first report of *Necrocarcinus* (Crustacea: Brachyura: Raninoida) from the Cenomanian of Central Russia

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With 8 figures and 2 tables

Abstract: *Necrocarcinus gorbenkoi* sp. nov. from the Lyamino Formation (Cenomanian, Upper Cretaceous) from Moscow Region represents the third discovery of crabs in Central Russia and the first member of the genus *Necrocarcinus* in this geographical area. Morphologically, the new species is close to the species *N. bodrakensis* LEVITSKYI, 1974, *N. tauricus* ILYIN & ALEKSEEV, 1998, and *N. labeschii* EUDES-DESLONGCHAMPS, 1835, but has some differences that allow us to establish a new taxon.

Key words: Crustacea, Brachyura, Necrocarcinus, Raninoida, Cenomanian, Russia, Moscow Oblast.

1. Introduction

Despite the large areal extent of the Russia Federation, only a few Mesozoic crabs have been recorded to date (VAN BAKEL et al. 2021: table 1). So far, there are only a few published records of decapod crustaceans from Cretaceous strata in the Moscow area (= Moscow Oblast). However, in recent years, crabs have been collected at several localities in this region.

Until now only two crab carapaces in the Cretaceous of the Moscow region have been reported. One of the species, *Homolopsis glabra* WRIGHT & COL-LINS, 1972, comes from deposits near the village of Gavrilkovo (Moscow Oblast, Dmitrovsky District, River Volgusha) (ILYIN 2005). These deposits belong to the Albian Gavrilkovo Formation of the Kolchugino Group (OLFEREV 1986).

Another crab described recently (VAN BAKEL et al. 2021) is *Personadorippe kalashnikovi* VAN BAKEL et al., 2021. This find is geologically younger than the previous one and comes from the Cenomanian Lyamino Formation (Table 1).

Therefore, any new discovery of crab carapaces is of great interest. However, in the Cretaceous deposits of the region, the remains of fragments of crab claws are quite common, which, unfortunately, are not identifiable.

2. Locality

Sands, which OLFEREV (1986) identified as the Varavino Group, are deposited in deep (up to 20 m) incisions in the Moscow Oblast (Fig. 1). Its lower part (Yakhroma Formation) is represented by pure, quartz, fine-medium-grained, light-gray and yellow sands of either the disthenic or epidote-garnet-disthenic association. The grain size composition, light color, lack of glauconite, and dominance of disthene of these sands clearly differ from those of the underlying Albian Paramonovo Formation. The Lyamino Formation unconformably overlies the Yakhroma Formation which is the upper part of the Varavino Group. The Lyamino

| Series | Stage | Group | Formation | Crabs |
|------------------|------------|------------------|----------------|--|
| Upper Cretaceous | Cenomanian | _ | _ | _ |
| | | Varavino Group | Lyamino Fm. | Personadorippe kalashnikovi, Necrocarcinus gorbenkoi sp. nov. |
| Lower Cretaceous | Albian | | Yakhroma Fm. | _ |
| | | Kolchugino Group | Paramonovo Fm. | _ |
| | | | Gavrilkovo Fm. | Homolopsis glabra |
| | | | Kolokshino Fm. | _ |
| | | | | |

 Table 1. Stratigraphic subdivision of the Albian-Cenomanian deposits of the Moscow Oblast and findings of crabs. Adapted from OLFEREV (1986), with additions.

Formation is represented by coarser sands of similar mineralogical composition, but contains glauconites (12-43%) and sandy phosphorite concretions.

The Lyamino Formation is exposed in the Varavinsky ravine, known by geologists and paleontologists, located near the village of Varavino of Sergiev Posad District of Moscow Oblast. This locality has been well known since the middle of the 19th century (SHCHU-ROVSKY 1867). At present, a geological and botanical reserve of the SPNA "Varavinsky ravine" has been created and is functioning.

The currently uncovered section of Cretaceous deposits in the Varavinsky ravine is a 3-meter thickness of sands of the Lyamino Formation. These sands are heterogeneous, of various colors and granulations. Visually, they can be divided into at least 10 layers. Nodules and fossils can be found in these layers during sifting.

The highest concentration of fossils is confined to the so-called "condensation horizon", which is located in the lower part of the section. There are frequent findings of different invertebrate fossils (worms, bivalves, gastropods, scaphopods, belemnites, echinoderms, ammonites, etc.). A rich fauna of cartilaginous fish has been established, and bones of marine reptiles have been noted, including teeth and bones of plesiosaurs. Ammonites are rare and poorly preserved as internal molds belonging to *Schloenbachia varians* (SOWER-BY, 1817). This species was noted in this locality as early as the 19th century (TRAUTSCHOLD 1872; NIKI-TIN 1888). The occurrence of this species confirms the early Cenomanian age of these deposits (WILMSEN & MOSAVINIA 2010; KENNEDY 2013).

Among these fossils, remains of crustaceans represented by coprolites, casts of burrows, and fragments of claws are not uncommon. However, complete carapaces have not been noted previously. In 2020, a private collector and citizen scientist V.G. GORBENKO, in the Varavinsky ravine, discovered the internal mold of a crab carapace about 2 cm in diameter and transferred it to the PIN RAS (Moscow) for storage.

3. Systematic paleontology

We follow the classification of brachyurans proposed by KARASAWA et al. (2011); KARASAWA et al. (2014) and LUQUE et al. (2019) for the Raninoida as construed by AHYONG et al. (2007), as it is supported by phylogenetic analysis.

Order Decapoda LATREILLE, 1802 Infraorder Brachyura LATREILLE, 1802 Section Raninoida AHYONG et al., 2007 Superfamily Necrocarcinoidea FÖRSTER, 1968 Family Necrocarcinidae FÖRSTER, 1968 Subfamily Necrocarcininae FÖRSTER, 1968 Genus *Necrocarcinus* BELL, 1863

Type species: *Orithyia labeschii* EUDES-DESLONG-CHAMPS, 1835, by subsequent designation of WITHERS (1928).

Other species included (as SCHWEITZER et al. 2016): Necrocarcinus bodrakensis LEVITSKYI, 1974; N. christinae VAN BAKEL et al., 2022; N. gorbenkoi sp. nov.; N. inornatus BRETON & COLLINS, 2011; N. rathbunae ROBERTS, 1962; N. senonensis SCHLÜTER in VON DER MARCK & SCHLÜTER, 1868; N. tauricus IL-YIN & ALEKSEEV, 1998; N. undecimtuberculatus TAKE-DA & FUJIYAMA, 1983.



Fig. 1. Locality of *Necrocarcinus gorbenkoi* sp. nov.; \mathbf{a} – Map of Moscow Oblast (Central Russia); \mathbf{b} – map of vicinity of the Varavinsky ravine (Sergiev Posad District), star – locality; \mathbf{c} , \mathbf{d} – view of section Lyamino Formation in Varavinsky ravine, the crab pictogram shows the place where the carapace was found.



Fig. 2. *Necrocarcinus gorbenkoi* sp. nov., internal mold of the carapace; Borissiak Paleontological Institute, Russian Academy of Sciences (Moscow), no. PIN 5477/4955, holotype; Varavinsky ravine, Sergiev Posad District, Moscow Oblast; Lyamino Formation, Varavino Group, Cenomanian, Upper Cretaceous. \mathbf{a} – Dorsal view; \mathbf{b} – right lateral view; \mathbf{c} – frontal view.

| | N. gorbenkoi sp. nov. (Figs. 2, 6a) | N. bodrakensis LEVITSKYI, 1974 (Figs. 3, 6b) | N. tauricus ILYIN & ALEKSEEV, 1998 (Figs. 4, 6c) | N. labeschii (Eudes-Deslongchamps, 1835) (Figs. 5, 6d) |
|-------------------------------------|--|--|---|--|
| Locality | Moscow Oblast | Crimea | Crimea | southern England and northern France |
| Age | Cenomanian | Albian | Albian | Albian-Cenomanian |
| Sculpture of uro- gastric region | Only the large medi- an tubercle, smaller structures are not preserved | Only the middle me- dian tubercle, smaller structures are absent | In addition to the middle median tubercle, there are three rows of small tubercles on either side of it | Only the middle median tuber- cle, smaller structures are absent |
| Length of uro- gastric region | Long | Short | Short | Short |
| Tubercles on protogastric region | Two: one large tuber- cle located near the mesogastric region, and a small one clos- er to the anterolateral margin. Moreover, the small tubercle is located in front of the large tubercle. | Two: a large tubercle located near the mesogastric region, and a small one clos- er to the anterolateral margin. The small tubercle is located on the same line with the large tubercle. | One large tubercle located in the center of the protogastric region. Closer to the cervical groove, each protogas- tric region has chaotic small tubercles. | Two: a large tubercle is located near the mesogastric region, and small one closer to the antero- lateral margin. The small tuber- cle is located behind the large tubercle. There is also a small tubercle closer to each orbit |
| Tubercles on mesogastric region | Only the large medi- an tubercle | Only the middle median tubercle | Only the middle median tubercle | Two tubercles: one large one is located closer to the urogastric region, the second is slightly larger and is located closer to the rostrum |
| Tubercles on bran- chial region | One large tubercle posterior to branchio- cardiac groove | Tubercles are pres- ent, located closer to the posterolateral margin, arrayed in a line parallel to the posterolateral margin | One sharp tubercle pos- terior to branchiocardiac groove | Two large tubercles are present, located closer to the postero- lateral margin |

Table 2. Comparison of some (the most obvious) features between N. gorbenkoi sp. nov. and close species.

Remarks: According to VAN BAKEL et al. (2022), some species originally referred to (except type species) *Elektrocarcinus (E. davisi* BISHOP, 1985; *E. olsono-rum* BISHOP & WILLIAMS, 1991; *E. texensis* RATHBUN, 1935; *E. woodwardii* BELL, 1863) should be assigned to the genus *Necrocarcinus*. However, we are of the opinion that *Elektrocarcinus* is an independent genus (SCHWEITZER et al. 2016), and the originally referred species are retained in it.

Necrocarcinus gorbenkoi sp. nov. Figs. 2, 6a

Etymology: In honor of the private collector and citizen scientist who discovered and donated the specimen for study, VALENTIN GORBENKO. **Type:** An almost complete carapace (internal mold), no. PIN 5477/4955, holotype, Borissiak Paleontological Institute, Russian Academy of Sciences (Moscow).

Type locality: Varavinsky ravine, Sergiev Posad District, Moscow Oblast, Russia.

Type horizon: Lyamino Formation, Varavino Group; Cenomanian, Upper Cretaceous.

Diagnosis: Carapace ovate; axial regions including mesogastric, urogastric, and cardiac with large tubercles; mesogastric region long; protogastric regions with one large and one small tubercle; epibranchial regions with one large tubercle laterally; branchial regions with one large tubercle centrally without keels.



Fig. 3. *Necrocarcinus bodrakensis* LEVITSKYI, 1974, carapace; Vernadsky State Geological Museum (Moscow), no. GGM-1787-19/ $B\Pi$ -12202, holotype; Mangushsky ravine, Prokhladnoe village, Crimea; Mangush Formation, Upper Albian, Lower Cretaceous. **a** – Dorsal view; **b** – left lateral view.

Description: The carapace is subhexagonal in shape, moderately convex in the longitudinal direction and more convex in the transverse direction. The ratio of width and length = 1.13 and the maximum width is at about mid-length. The carapace regions are strongly vaulted. Dorsal regions are well defined. The protogastric region is wide and has two tubercles, the larger tubercle located closer to the mesogastric region. The mesogastric region is slightly inflated and has a large median tubercle. There is a long convex urogastric region with a large median tubercle. The cardiac region is subtriangular in shape and slightly convex with a large median tubercle. Postcervical grooves are distinctly arcuate, deeper than the cervical groove, and nearly reach the cervical groove. Branchiocardiac grooves are deep, wide, marked by muscle scars, and do not reach lateral carapace margins. The secondary groove is present and weaker than the cervical groove. A tubercle on the epibranchial region is present behind the protogastric region. The remainder of the branchial regions are undifferentiated with a large tubercle at the level of the anteriormost cardiac region. The orbito-frontal margin is ~45 % (?) of the maximum carapace width. The rostrum has not been preserved. The orientation of the orbital margin is horizontal. The anterolateral margin is bluntly rounded and as long as the posterolateral margin. Spines on anterolateral or epibranchial margins are unknown.



Fig. 4. Necrocarcinus tauricus ILYIN & ALEKSEEV, 1998; Borissiak Paleontological Institute, Russian Academy of Sciences (Moscow), no. PIN 4680/1, holotype; Mangushsky ravine, Prokhladnoe village, Crimea; Mangush Formation, Upper Albian, Lower Cretaceous. \mathbf{a} – Dorsal view; \mathbf{b} – right lateral view; \mathbf{c} – frontal view.

Comparison: The species described here shows the greatest similarity with three closely related species (found in the same paleogeographic region associated with a basin connected to the northern part of the Tethys) including the type species (Table 2).

Remarks: We describe the new species based upon a single poorly preserved specimen (internal mold). The species is closest to *Necrocarcinus labeschii* and *N. bodrakensis* (Fig. 3), but it differs from them in the absence of tubercles on the post-branchial region. The



Fig. 5. *Necrocarcinus labeschii* (EUDES-DESLONGCHAMPS, 1835); Sedgwick Museum, Cambridge University, Cambridge, U.K., SM B 23152; dorsal carapace.

absence of these tubercles makes it related to another species, *N. tauricus* (Fig. 4). However, the latter has only one tubercle in the protogastric region, and not two as in *N. labeschii* (Fig. 5) and the new species. In addition, a distinctive feature of the new species is a longer urogastric region than in *N. labeschii* or *N. tauricus*. It is quite possible that additional discoveries from the type locality will allow a more detailed description of the morphological features of the new species.

The trivial name of the type species of *Necrocarcinus*, *N. labeschii*, has been variously spelled as *labeschei* and *labeschii* over the nearly 200 years since it was named. The trivial name was erroneously spelled when it was first created by EUDES-DESLONGCHAMPS (1835); however, according to the ICZN Article 32, the original spelling must be retained. Thus, *Necrocarcinus labeschii* is the correct spelling (WRIGHT & COLLINS 1972).

It should be noted that ILYIN considered the species *N. bodrakensis* described by LEVITSKY to be a synonym for *N. labeschii*. In his work, ILYIN (2005: 199) indicated that he did not find differences between the structure of the carapace of these species; however, he apparently did not have the opportunity to study the typical material of *N. labeschii*. In our opinion, based on the study of *N. bodrakensis* and *N. labeschii*, we see that *N. bodrakensis* is different and can be considered to be a separate species (Fig. 6).

It is worth noting that a recent study by Ossó et al. (2022: fig. 2.1) figured a carapace of the crab *Necrocarcinus* from the Aptian of Catalonia. Based on the morphological features, this finding is most similar to *N. bodrakensis* and is of great interest for understanding the paleogeography and stratigraphy of this species, apparently not limited to the Albian of the Crimea.



Fig. 6. Schematic drawings of the carapaces of some species of *Necrocarcinus*: $\mathbf{a} - N$. *gorbenkoi* sp. nov.; $\mathbf{b} - N$. *bodrakensis* LEVITSKYI, 1974; $\mathbf{c} - N$. *tauricus* ILYIN & ALEKSEEV, 1998; $\mathbf{d} - N$. *labeschii* (EUDES-DESLONGCHAMPS, 1835).

4. Discussion

The new species expands our understanding of the distribution of Necrocarcinidae in the Cretaceous period in the marine basins of the territory of Eurasia.

The crab carapace described herein is not the only remains of crustaceans in the Cretaceous of the Varavinsky ravine. Fragments of crab claws were recently discovered. They consist of two small dactyli (Fig. 7), one of which is incomplete. On the proximal part of the dactylus, there are two large teeth, and on the distal part, closer to the end of the dactyl, there is a small tooth. On the upper surface of the dactylus are five pairs of small rounded spines. It should be noted that the claws of Necrocarcinidae are almost unknown. The dactyli we describe are similar to those of the family Paranecrocarcinidae (JAGT et al. 2010), although they differ by having a less curved shape and a greater number of spines on the proximal side.

Coprolites are also known from the Varavinsky ravine (Fig. 8). They are small (up to 2 cm) formations of an irregularly conical or irregularly cylindrical shape, tapering towards the ends. Transverse to the axis of the section, the coprolites are irregularly rounded, with uneven contours and chaotic points of gaps (canals). The coprolites are heterogeneous and consist of cemented elongated carbonate granules, which is why



Fig. 7. Claw remains, presumably Necrocarcinidae; Varavinsky ravine, Sergiev Posad District, Moscow Oblast; Lyamino Formation, Varavino Group, Cenomanian, Upper Cretaceous. \mathbf{a} – Outer view of fragment of dactylus; \mathbf{b} – upper view of fragment of dactylus; \mathbf{c} – occlusal surface of fragment of dactylus); \mathbf{d} – outer view of complete dactylus; \mathbf{e} – occlusal surface of complete dactylus.



Fig. 8. Coprolites of crustaceans (*Palaxius*? isp.); Varavinsky ravine, Sergiev Posad District, Moscow Oblast; Lyamino Formation, Varavino Group, Cenomanian, Upper Cretaceous.

their surface is obviously granular. We conditionally assign these coprolites to the genus *Palaxius* BRÖN-NIMANN & NORTON, 1960, and interpret them as fossil fecal pellets of crustaceans.

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