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The First Finding of Basilosauridae (Mammalia: Cetacea) in the Upper Eocene of the Baltic States (Russia, Kaliningrad Region)

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Abstract—Remains of a fossil cetacean, belonging to the family Basilosauridae, are for the first time found in the territory of the Baltic States. This finding is represented by a large vertebra and comes from the Late Eocene amber-bearing "Blue Ground" bed of the Sambia Peninsula in the Kaliningrad Region. The described fossil expands our knowledge on paleogeography and stratigraphic occurrence of Basilosauridae.

Keywords: Cetacea, Archaeoceti, Basilosauridae, Paleogene, Eocene, Priabonian, Baltic States, Kaliningrad Region

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INTRODUCTION

In the storehouse of the Kaliningrad Regional Museum of History and Art (KRMHA) there is a fossil vertebra originating from amber-bearing deposits of the quarries of the Kaliningrad Amber Combine. Fragments of the host rock, represented by clay particles with a high content of glauconite and light green siltstone, typical of the "Blue Ground" in amber deposits in the Kaliningrad Region, remained on the untreated sections of the vertebra. Morphological study of the vertebra made it possible to determine that it belonged to a large fossil Basilosaurus, a cetacean representing a group common in the warm-water marine basins of the Eocene.

LOCALITY

Paleogene deposits, which are well developed in the Kaliningrad Region, and represented by the Paleocene, Eocene, and possibly the Oligocene (Zagorodnykh et al., 2001; Mychko, 2019), have a complex facies structure and are characterized by the alternation of marine and continental formations (Grigyalis et al., 1971). The Upper Eocene deposits crop out on the coast of the Sambia Peninsula (Fig. 1b) and uncovered in the quarries of Kaliningrad Amber Combine (Figs. 1c, 1d).

The described fossil whale vertebra was found in one of the quarries of the Amber Combine in the second half of the 20th century in the sediments of the main amber-bearing layer, "Blue Ground", which refers to the Prussian Formation (Fig. 1a). In addition to the "Blue Ground", a number of other beds of different facies composition are recognized in the Prussian Formation: "Wild Ground", "Quicksand" and "White Wall" (Grigyalis et al., 1971; Krasnov, 1977; Zagorodnykh et al., 2001; Aleksandrova and Zaporozhets, 2007; Mychko, 2018a, 2018b, 2019).

The highest concentration of macrofauna is confined in the Prussian Formation to clay aggregates of the "Blue Ground" in the zone of contact with "Quicksand" and a bed of ferruginous sand and sandstones of "Krant Ground", overlying the "Blue Ground". This fauna was studied by a number of European researchers of the 19th century (Mayer, 1861; Schlüter, 1879; Noetling, 1885, 1888; Koenen, 1894 et al.), who considered its age to be Early Oligocene.

The remains of the vertebrates of this assemblage are very diverse and are represented by the teeth of chimeras and sharks, the remains of actinopterygians, the teeth of crocodiles (Noetling, 1885, 1888; Jentzsch, 1892), as well as the remains of bony fish and isolated vertebrae of pythons (Bericht ..., 1892).

At present, the Prussian Formation is dated as Priabonian and confirmed based on biostratigraphic data on dinocysts (Kosmowska-Ceranowicz et al., 1997; Aleksandrova and Zaporozhets, 2007), spores and pollen (Pokrovskaya and Sauer, 1960, 1964), and the

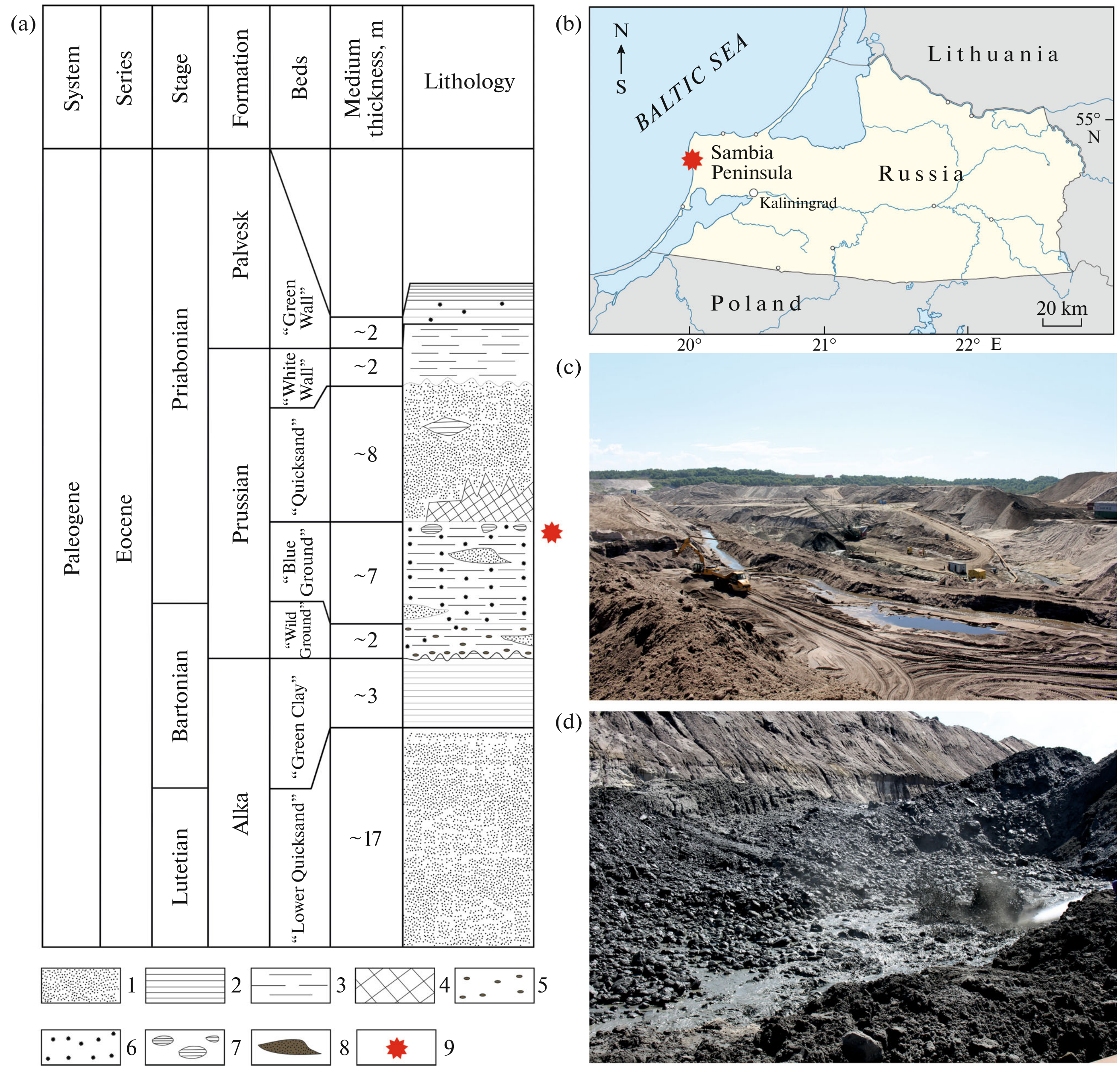

Fig. 1. Primorsky amber deposit (Russia, Kaliningrad Region; Eocene): (a) combined lithological-stratigraphic section of Paleogene deposits discovered in the quarry (Kaplan et al., 1977; as well as data from the official website of Kaliningrad Amber Plant JSC (ambercombine.ru) with changes and additions): (1) sands of quartz-glauconite greenish-gray; (2) light green thin-layered clays; (3) clay quartz-glauconite silts greenish-gray; (4) red ferruginous sandstones "Krant Ground"; (5) phosphorite nodules; (6) amber nodules; (7) clay nodules; (8) interbeds and lenses of quartz-glauconite sand; (9) finding a whale vertebra; (b) schematic map of Kaliningrad Region indicating the locality of the whale vertebra (asterisk); (c, d) Primorsky Quarry for amber extraction: general view (c), "Blue Ground" Bed (d); photo E.V. Mychko, 2018.

Hystrichosphaerida assemblage (Eisenack, 1938, 1954; Zatula, 1973) and other groups.

FINDINGS Of BASILOSAURIDS IN THE OLD WORLD

Recently, there have been many reports of findings of early basilosaurids (see Koëhler and Fordyce, 1997; Uhen et al., 2011; Zvonok, 2012; Kalmykov, 2012; Tesakov et al., 2012). Most of these occurrences are in the Upper Eocene deposits of the margins of the Tethys, and later of the Paratethys, which existed from the Oligocene to Miocene (Rögl, 1999) in the territory of a large part of Europe and Asia (Fig. 2). In the Priabonian, the northern part of Paratethys, or Northern Peri-Tethys, was one of the most spacious of the last semi-open Paleogene basins of Western Eurasia. It was connected through the Pripyat Strait to the North

Fig. 2. Geographical distribution of the Old World Eocene basilosaurid occurrences (paleogeographic map by Popov et al., 2004). The outlines of the modern and ancient land are shown as grey lines.

Sea Basin, which at that time had no connection with the Atlantic. Contacts with the Tethyan Region (Ancient Mediterranean) occurred through the Pre-Alpine and Slovenian straits, the basin of Central Iran and the Strait of the Lesser Caucasus. It is important to note that the connection of this sea with the Arctic Basin was lost even before the Late Eocene (Popov et al., 2004).

Several paleobiogeographic interpretations have been suggested for the Paratethys regions in the Priabonian. Two regions are recognized based on plankton, the northern subtropical and the southern subtropical. The boundary between these regions was following the system of uplifts of the mobile Alpine Belt, which separated the Tethyan region from Northern Peri-Tethys (Popov et al., 2009). Based on the paleozoogeographic zoning of this basin based on benthos and ichthyofauna, Popov et al. (2009) recognized two other large realms, northern European realm with a moderately thermophilic benthic fauna of the Latdorfian type and ancient Mediterranean realm with a tropical fauna, including various assemblages of colonial corals and other taxa inhabiting warm basins. It is worth mentioning that ancient-Mediterranean benthos was very different from the North European, however, the presence of transitional assemblages suggests wide connections between these basins, and also that the border between them was likely to have been climatic.

Very diverse and numerous basilosaurids are found in Egypt. Thus, *Dorudon atrox* (Andrews, 1906) comes from the late Eocene location of Wadi al-Khitan ("Valley of the Whales") in El Fayum, known for its numerous fragments of skeletons, including whole skulls (Uhen, 2004). *Saghacetus osiris* (Dames, 1894) described from well-preserved jaws (Gingerich, 1992) and *Stromerius nidensis* Gingerich, 2007 known from the thoracic, lumbar and caudal vertebrae (Gingerich, 2007) come from the Priabonian Qasr el-Sagha Formation near Qarun Lake. *Ancalecetus simonsi* Gingerich and Uhen 1996 was described from the Birket-Qarun Formation, dated as Bartonian-Early Priabonian (Seiffert et al., 2008), based on fragmentary material including a partially preserved skull (Gingerich and Uhen, 1996). *Basilosaurus isis* (Andrews, 1904) is known from the Wadi al-Khitan formation in Fayum, Egypt, as well as from the Wadi Esh-Shallala Formation of the same age in Jordan (Zalmout et al., 2000).

Chrysocetus fouadassii Gingerich and Zouhri, 2015 was described recently (Gingerich and Zouhri, 2015) based on the skeletal fragments from the Bartonian Aridal Formation in Morocco. *Basilosaurus puschi* (nom. nud.) from Poland was originally cited as *"Zeuglodon" puschii* (Brandt, 1873); its age is not entirely clear; the nature of the deposits is defined as "filling the cracks in compact white Jurassic limestone".

Table 1. The dimensions of the studied lumbar vertebra compared to the lumbar vertebrae of *Basilotritus* and other Basilosauridae

Vertebra	Body length	Anterior width	Anterior height	Posterior width	Posterior height
Basilotritus wardii USNM 310633	146e	–	–	123e	–
Basilotritus wardii USNM 310633	164.8	110	93	120.3	95.6
Eocetus sp. NSFM 4470	119e	80e	65e	71e	73e
Basilotritus sp. USNM 534001	210e	160e	–	–	–
Basilotritus uheni OF-1694*	133	138	115	155	127
Basilotritus uheni OF-1695*	160	147	120	158	134
Basilosauridae indet. coll. KRMHA specimen no. KGOM2-13184	120	135	150	–	–

To date, in Russia, basilosaurids were known only from the Late Bartonian Khoroshevka locality in the Rostov Region (Tesakov et al., 2012).

A large amount of postcranial material is known from the territory of Ukraine (Goldin et al., 2012), represented by individual vertebrae and ribs. Many of these occurrences, as well as some other European "*Eocetus*", are described as representatives of the genus *Basilotritus* based on the morphology of the transverse processes and neural arch of the elongated last thoracic and lumbar vertebrae, as well as a particular pock-marked structure of the vertebral surface with small numerous irregularly located openings of vascular canals (Goldin and Zvonok, 2013).

Basilotritus, apart from the type species *B. uheni* Goldin and Zvonok, 2013 (Beloskelevatoye locality, Ukraine), also includes *"Eocetus" wardii* (Uhen, 2001) from North Carolina (USA) and several isolated postcranial remains "*Eocetus*" sp. from localities of Central Ukraine (Fig. 2). Also occurrences of "*Eocetus*" have been reported from the Lower Bartonian of North America and Egypt and Bartonian of Germany (Uhen and Berndt, 2008; Weems et al., 2011) and Gebel Mokattam in Egypt (Goldin and Zvonok, 2013). Here, it is also worth mentioning the finds from Kurenevka (near Kiev, Ukraine), assigned to the Kiev Regional Stage, which corresponds to the Upper Lutetian-Bartonian (Goldin et al., 2012). It should be noted that no whole skulls are known for *Basilotritus*, and some finds are represented by isolated vertebrae, although the tympanic bulla is known for *B. uheni*, while for *Basilotritus* sp. a fragment of the jaw and teeth, a number of thoracic, lumbar, and caudal vertebrae, scapula, and sternum are described (Goldin and Zvonok, 2013).

The remaining representatives of basilosaurids (*Cynthiacetus* Uhen, 2005, *Ocucajea* Uhen a al., 2011, *Supayacetus* Uhen et al., 2011, *Zygorhiza* True, 1908) are unknown from Old World locations, with the exception of *Basilosaurus drazindai* Gingerich et al., 1997 and *Basiloterus husseini* Gingerich et al., 1997, described from the Bartonian Drazinda formation in Pakistan (Gingerich et al., 1997).

SYSTEMATIC PALEONTOLOGY

The lumbar vertebra of *Basilosauridae* indet. (Pl. 14, fig. 1) (specimen KRMHA, no. KGOM2-13184) is represented by a shortened centrum with an incomplete neural arc. Laterally, the vertebral centrum is trapezoid in shape; the surface is smoothed, rugose in the region of the limbs of the vertebral centrum. The keel on the dorsal side of the vertebral centrum is poorly developed. The lateral apophyses are directed ventrally. No sclerotic changes in the lateral vertebral apophyses are present. The described vertebra is much shorter than the *Basilotritus* vertebrae and does not have a surface structure characteristic of this genus. The centrum length of the described vertebra is comparable to "*Eocetus*" [specimen National San Francisco Museum (NSFM), no. 4470], but the latter has a relatively lower height and width of the centrum (Table 1).

The described whale vertebra cannot be attributed to the known species of the genera *Eocetus* or *Basilotritus*, due to differences in proportions and sizes (Fig. 3). Unlike representatives of *Basilotritus*, the described

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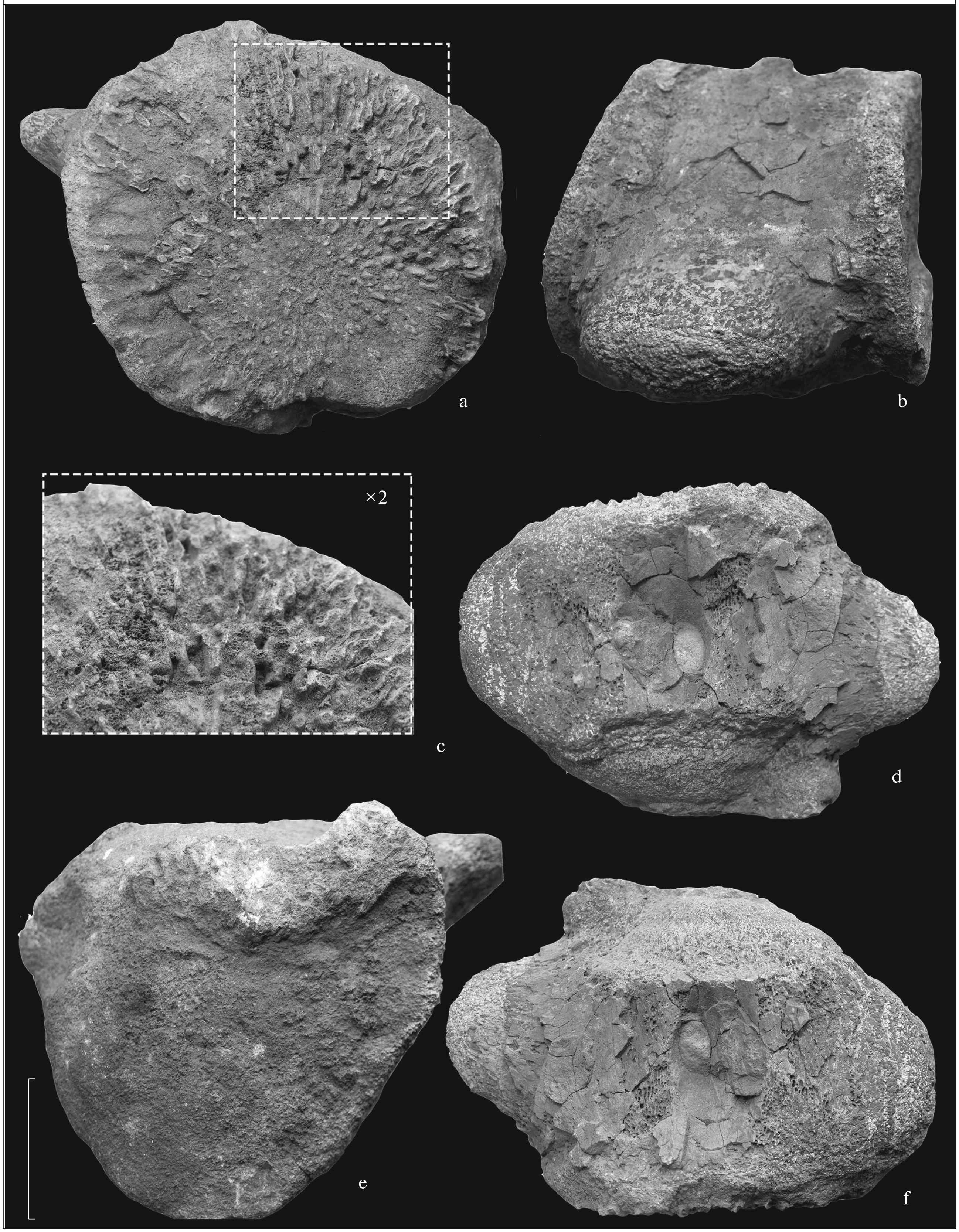
Explanation of Plate 14

Fig. 1. Lumbar vertebra of Basilosauridae indet.; specimen KRMHA, no. KGOM2-13184: (1a) anterior view; (1b) lateral view; (1c) anterior view (enlarged); (1d) bottom view; (1d) posterior view; (1e) upper view; Russia, Kaliningrad Region, quarry of the Amber Combine; Upper Eocene, Priabonian, Prussian Formation, upper "Blue Ground" bed.

Plate 14



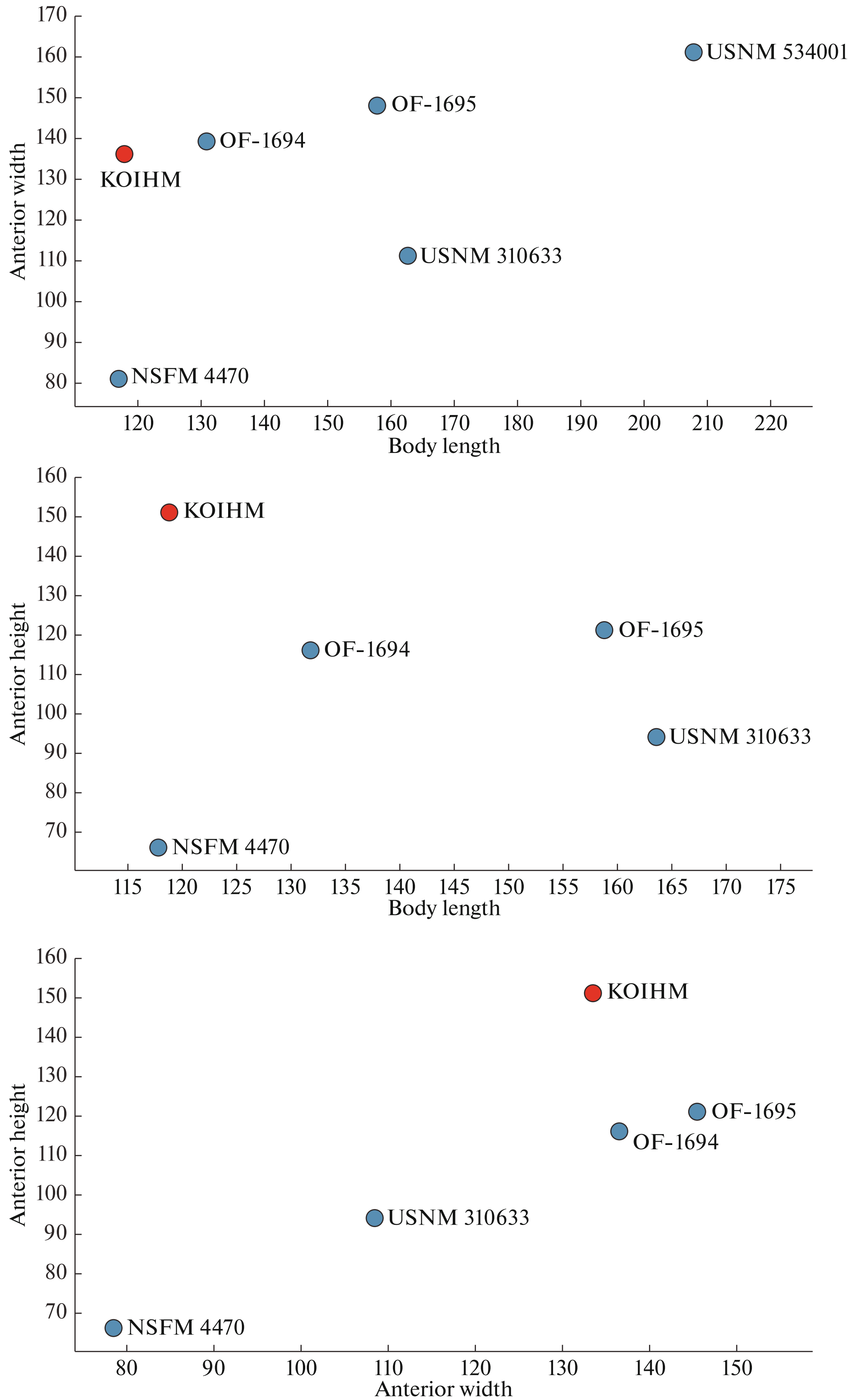


Fig. 3. Comparison of the proportions of the described vertebra with the lumbar vertebrae of Basilotritus and other Basilosauridae.

specimen does not have a clearly distinguishable and characteristic ornamentation formed by vascular openings. It is rather problematic to identify this specimen with other basilosaurids because there is no cranial material that could be associated with postcranial material. In addition, the neural arch is not present in the studied vertebra, which makes it difficult to compare it with a number of characters with *Eocetus*, *Basilotritus*, and other basilosaurids.

It should be noted that the main problem in the systematic identification of all finds of basilosaurids in the territory of the former USSR is associated with the scattering and incompleteness of the material. Nevertheless, the described vertebra expands the knowledge on the paleogeographic and stratigraphic distribution of basilosaurids.

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