

A Pterosaurian Vertebra from the Upper Cretaceous of the Saratov Region

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Abstract—A dorsal vertebra referred to as Azhdarchidae indet. from the Rybushka Formation (Upper Cretaceous, Lower Campanian) of the Beloe Ozero locality in the Saratov Region is described. Its vertebral centrum has a hypapophysis and, at the base of the neural arch, there is a large pneumatic foramen. The vertebra possibly belongs to *Volgadraco bogolubovi* Averianov, Arkhangel'skii et Pervushov, 2008, described from the Rybushka Formation of the Shirokii Karamysh 2 locality in the Saratov Region.

Keywords: Pterosaur, Azhdarchidae, Upper Cretaceous, Lower Campanian, Saratov Region, Russia

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INTRODUCTION

In Russia, a pterosaur bone was first found in the Volga Region (Bogolyubov, 1914). Subsequent finds of pterosaurian bones in this region occurred in the middle and at the end of the 20th century and at the beginning of the 21st century (Glikman, 1953; Khozatsky and Yur'ev, 1964; Khozatsky, 1995; Averianov, 2004, 2007a, 2008; Averianov and Yarkov, 2004; Averianov et al., 2005, 2008; Averianov and Panteleyev, 2009). In the Volga Region, a rather promising locality in regard to searching for pterosaurs is situated near the village of Beloe Ozero in the southern right bank part of the Saratov Region, on the left bank of the Medveditsa River (Fig. 1a). In this area, a series of ravines discloses the Rybushka Formation of the Campanian Stage (Pervushov et al., 1999). The following pterosaur bones have been found there: a toothless rostrum fragment (ZIN PH, no. 14/43), coracoid fragments (ZIN PH, nos. 52 and 53/43), proximal end of phalanx 1 of the fourth (wing) digit (ZIN PH, no. 47/43), and distal fragment of phalanx 1 of the ?forth (wing) digit, which were identified as Azhdarchidae indet. (ZIN PH, no. 51/43) (Averianov, 2007a, 2008; Averianov and Panteleyev, 2009). The Beloe Ozero locality has also yielded a mandibular symphysis fragment of the pliosaur Polycotylidae indet. (Ochev, 1976; Arkhangel'sky et al., 2007) and undescribed specimens of cartilaginous and bony fishes, marine turtles, plesiosaurs and mosasaurs.

The present study describes a new pterosaur specimen, a dorsal vertebra, from Beloe Ozero. The material is housed at the Paleoherpertological Collections of

the Zoological Institute of the Russian Academy of Sciences in St. Petersburg (ZIN PH). Measurements are in mm.

GEOLOGICAL CONDITIONS

The Campanian Rybushka Formation is widespread on the right bank the Volga River within the Penza, Saratov, and Volgograd regions (Olfer'ev and Alekseev, 2005). The formation is up to 30 m thick, composed of yellowish and greenish gray inequigranular intensively bioturbated quartz–glaucopit sand and sandstones. Invertebrates are represented here by infrequent belemnites *Belemnellocamax mammillatus* (Nilsson, 1826), *Belemnitella mucronata* (Schlotheim, 1813) are even less frequent ammonite *Hoplitoplacenticerias* sp., bivalves *Oxytoma psilomonica* A. Ivanov, 1993, *O. tenuicostata* (Roemer, 1841), *Cataceramus balticus* (Böhm, 1907), and *C. regularis* (d'Orbigny, 1845), and benthic foraminifers of the *Cibicidoides aktulagayensis* Subzone of the *Brotzenella monterelensis* Regional Zone (Olfer'ev and Alekseev, 2005; Sel'tser and Ivanov, 2010). The formation largely corresponds in stratigraphic volume to the Lower Campanian (*Belemnitella mucronata alpha* and *Belemnellocamax mammillatus* regional mollusk zones) and basal Upper Campanian (*Hoplitoplacenticerias coesfeldtense/Belemnitella mucronata mucronata* Regional Zone) (Olfer'ev and Alekseev, 2005). The upper part of the formation contains phosphoritic nodules, which are both scattered in the layer forming small accumulations and concentrated in more or less pronounced phosphoritic interlayers. The level rich in phosphoritic

nodules is distinct in the region and contains a diverse assemblage of cartilaginous and bony fishes, turtles, plesiosaurs, mosasaurs, and less frequent members of subaquatic (hesperornises) and continental (?island) fauna (pterosaurs) (Panteleyev et al., 2004; Pervushov et al., 2012).

A simplified lithological column of the Beloe Ozero locality (with the point of observation at SBO-2, 1 km northeast of the village) is shown in Fig. 1b. Vertebrates occur in a phosphoritic interbed (Bed 4), and just above (Bed 3) and below (Bed 5) it. The fossil fauna from the phosphoritic interbed includes infrequent invertebrates bivalve and gastropod molds, phosphatic shells of linguliform brachiopods (Ivanov, 1995). Vertebrates are mostly represented by teeth and bone fragments of bony fishes (including Enchodontidae), teeth of elasmobranchs [*Cretolamna appendiculata* (Agassiz, 1843), *Squalicorax kaupi* (Agassiz, 1843), *Pseudocorax laevis* Leriche, 1906, *Archaeolamna kopingsensis* (Davis, 1890), *Eostriatolamia* sp., *Heterodontus* sp. (accompanied by spines of the dorsal fins), *Squatirhina* sp.], dental plates of the chimaeroid fishes *Ischyodus bifurcatus* Case, 1978 (with spines of the dorsal fins), *Amylodon karamysh* Averianov et Popov, 1995, *Edaphodon* sp., and *Elasmodus* sp. Abundant fish coproliths (including large, up to 5 cm long, spiral coproliths of elasmobranchs). In addition, isolated, frequently fragmentary bones of marine reptiles (plesiosaurs, mosasaurs, turtles) have been recorded.

Enclosing sand of Bed 5 contains infrequent vertebrate specimens of finer preservation and weaker phosphatization. Autochthonously buried shells of linguliform brachiopods and thin bones and scales of small teleostean fishes, probably buried in decapod burrows, are also common here. Specimen ZIN PH, no. 55/43, which was found in the thalweg of a gully (non in situ), could have come from Bed 5, judging from its phosphatization character and color. Beds 1–3 are dated Late Campanian and Bed 4 is regarded as Late Campanian, with admixture of a redeposited Early Campanian fauna (E.M. Pervushov, personal communication); Bed 5 and, hence, specimen ZIN PH, no. 55/43 are dated here as Early Campanian.

DESCRIPTION OF THE VERTEBRA

The dorsal vertebra in question (specimen ZIN PH, no. 55/43; Fig. 2) is rather large; its centrum is 19.5 mm long; the anterior articular facet is 24.4 wide and 17.8 mm high and the posterior articular facet is 23.6 mm wide and 16.8 mm high. The vertebral centrum is procoelous, spool-shaped, with a deeply concave anterior articular facet (cotyle) and convex posterior articular facet (condyle). The anterior articular facet is cordate, with a deep notch at the middle of the dorsal edge and ventrally projecting hypapophysis at the middle of the ventral edge. The articular facet has short, but deep grooves, which are

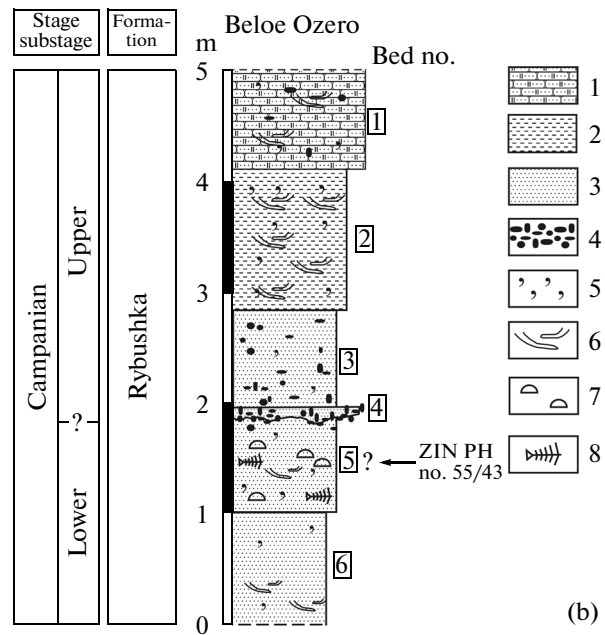
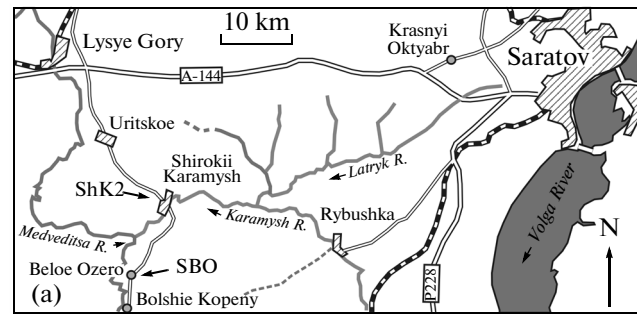


Fig. 1. Geographical position of the Campanian (Upper Cretaceous) vertebrate localities of Beloe Ozero (SBO) and Shirokii Karamysh 2 (ShK-2) in the central part of the Saratov Region (a); and lithological column of the geological section of the Beloe Ozero locality (observed at point SBO-2, 2011). The bed where the vertebra ZIN PH, no. 55/43 was presumably found is marked by a horizontal arrow. Designations in the lithological column: (1) siliceous sandstone, (2) silty sand, (3) inequigranular sand, (4) phosphoritic nodules, (5) glauconite, (6) bioturbation, (7) thin-walled shells of linguliform brachiopods, (8) scales and bones of small teleostean fishes, including those buried in (?) decapod burrows.

probably traces of blood vessels extending radially from the dorsal incisure. The posterior articular facet is similar in shape and somewhat smaller than the anterior facet. It also has a deep dorsal incisure. In the middle of the posterior articular facet, there is a horizontal groove, which probably provided attachment area for the intervertebral disk. The ventral surface of the vertebral centrum is convex in frontal plane and concave in sagittal plane. The dorsal surface of the vertebral centrum forms a deep fossa between the dorsal incisures of articular facets, with a narrow longitudinal slit at the bottom. Most of the neural arch is missing.

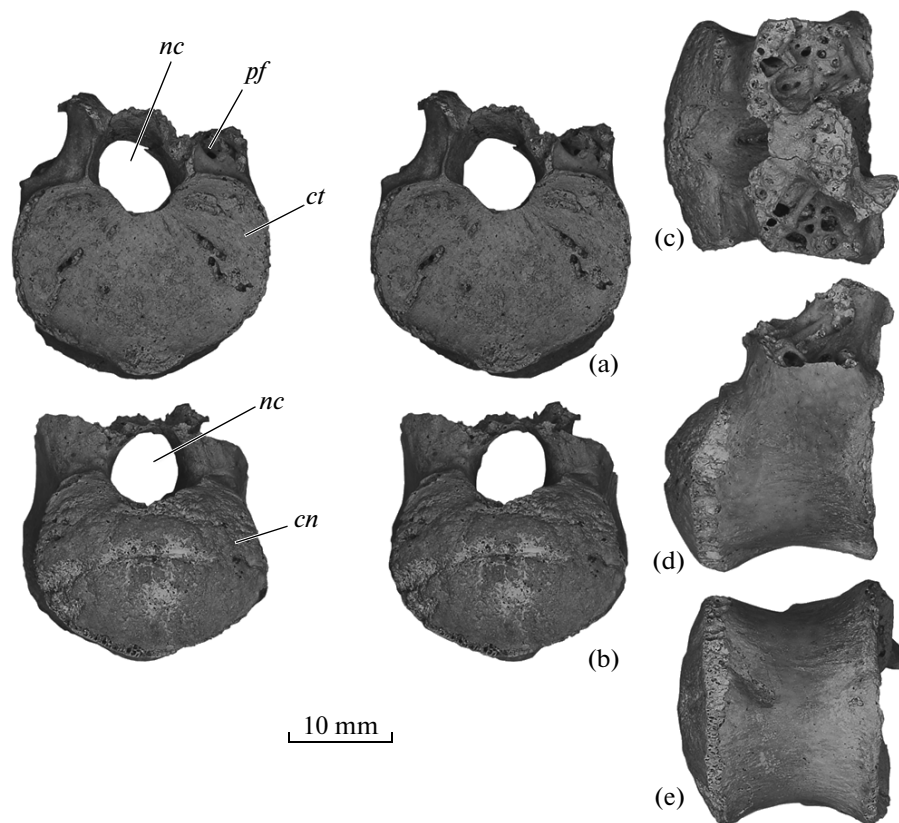


Fig. 2. Dorsal vertebra of Azhdarchidae indet., specimen ZIN PH, no. 55/43: (a) anterior, (b) posterior, (c) dorsal, (d) lateral, and (e) ventral views; Saratov Region, Beloe Ozero; Rybushka Formation, Upper Cretaceous, Lower Campanian. Designations: (cn) posterior articular condyles of a vertebral centrum, (ct) the anterior articular body surface of a vertebra, (nc) the neural canal, (pf) a pneumatic foramen.

The spinal canal foramen is ovate (with a longer dorsal axis). The neural arch is inclined anteriorly, overhanging the anterior articular facet. Approximately one-third of the centrum length is located behind the posterior edge of the neural arch. On the anterior side of the left wall of the spinal canal, the medial edge of a very large pneumatic foramen is preserved (Fig. 2a). The dorsal surface of the spinal canal is very short, only 36% of the vertebral centrum extent. Consequently, the zygapophyses were probably separated by deep vertical grooves. The neural arch is composed of strongly pneumatized bone tissue of bars and plates perforated by large foramina.

COMPARISON AND DISCUSSION

Judging from a few available detailed descriptions, the dorsal vertebrae of Pterodactyloidea are more or less uniform. The dorsal vertebra of *Pteranodon* sp. from the Coniacian–Campanian of Kansas, United States (Bennett, 2001, text-fig. 48) differs from specimen ZIN PH, no. 55/43 in the transversely narrower vertebral centrum, the absence of a hypapophysis, and in the smaller pneumatic foramen at the base of the prezygapophysis. The transversely wider centra of

the dorsal vertebrae are apparently characteristic of the pterosaur family Azhdarchidae (Bennett, 2001, p. 52; Averianov, 2010, p. 291).

Specimen ZIN PH, no. 55/43 is somewhat larger than the vertebrae of the azhdarchoid “*Bennettazhia oregonensis*” (Gilmore, 1928) from the Albian of Oregon, United States (Gilmore, 1928, text-fig. 2). These vertebrae lack a hypapophysis and, at the base of the prezygapophysis, there is neither lateral depression nor pneumatic foramen. Remaining features of the vertebral shape are very similar.

The vertebra in question (ZIN PH, no. 55/43) is more than twice as large as known free dorsal vertebrae of the azhdarchid *Azhdarcho lancicollis* Nesov, 1984 from the Turonian of Uzbekistan (Averianov, 2010, text-fig. 19). None of these vertebrae have a hypapophysis. The large lateral pneumatic foramen in the neural arch of ZIN PH, no. 55/43 apparently corresponds to the lateral depression recognized in one specimen of *A. lancicollis* (Averianov, 2010, text-fig. 19D). The neural arch in the form from Saratov is pneumatized to a much greater extent than in *Azhdarcho*.

The posterior articular facet of specimen ZIN PH, no. 55/43 is almost identical to that of the notarium of the azhdarchid *Volgadraco bogolubovi* Averianov,

Arkhangelskii et Pervushov, 2008 from the Rybushka Formation of the Shirokii Karamysh 2 locality (Averianov et al., 2008, pl. VI, fig. 1b) and differs from it in the smaller size, which is possibly accounted for by age variation. Based on the close geographical position and age of the Beloe Ozero and Shirokii Karamysh 2 localities, it is natural to propose that specimen ZIN PH, no. 55/43 belongs to *V. bogolubovi*.

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REFERENCES

- Arkhangelsky, M.S., Averianov, A.O., and Pervushov, E.M., Short-necked plesiosaurs of the family Polycotylidae from the Campanian of the Saratov Region, *Paleontol. Zh.*, 2007, no. 6, pp. 62–66.
- Averianov, A.O., New data on Cretaceous flying reptiles (Pterosauria) of Russia, Kazakhstan, and Kyrgyzstan, *Paleontol. Zh.*, 2004, no. 4, pp. 73–83.
- Averianov, A.O., New records of azhdarchids (Pterosauria, Azhdarchidae) in the Late Cretaceous of Russia, Kazakhstan, and Central Asia, *Paleontol. Zh.*, 2007a, no. 2, pp. 73–79.
- Averianov, A.O., Mid-Cretaceous ornithocheirids (Pterosauria, Ornithocheiridae) from Russia and Uzbekistan, *Paleontol. Zh.*, 2007b, no. 1, pp. 75–82.
- Averianov, A.O., Superorder Pterosauria in *Iskopaemye pozvonochnyye Rossii i soprodel'nykh stran. Iskopaemye reptilii i ptitsy. Chast' 1* (Fossil Vertebrates of Russia and Adjacent Countries: Fossil Reptiles and Birds: Part 1), Ivakhnenko, M.F. and Kurochkin, E.N., Eds., Moscow: GEOS, 2008, pp. 319–342.
- Averianov, A.O., The osteology of *Azhdarcho lancicollis* Nessov, 1984 (Pterosauria, Azhdarchidae) from the Late Cretaceous of Uzbekistan, *Proc. Zool. Inst. RAS*, 2010, vol. 314, no. 3, pp. 264–317.
- Averianov, A.O., Arkhangelsky, M.S., Ivanov, A.V., and Pervushov, E.M., A New Record of an Azhdarchid (Pterosauria: Azhdarchidae) from the Upper Cretaceous of the Volga Region, *Paleontol. Zh.*, 2005, no. 4, pp. 91–97.
- Averianov, A.O., Arkhangelsky, M.S., and Pervushov, E.M., A New Late Cretaceous Azhdarchid (Pterosauria: Azhdarchidae) from the Volga Region, *Paleontol. Zh.*, 2008, no. 6, pp. 61–68.
- Averianov, A.O. and Panteleyev, A.V., Coracoid fragments of a large azhdarchid (Pterosauria, Azhdarchidae) from the Campanian of the Saratov Region, in *Issledovaniya po paleontologii i biostratigrafii drevnikh kontinental'nykh otlozhenii (pamyati prof. V. G. Ocheva): Sbornik nauchnykh statei* (Studies on Paleontology and Biostratigraphy of Ancient Continental Deposits: in Memory of Prof. V.G. Ochev: Collected Scientific Works, Saratov: Nauchn. Kniga, 2009, p. 74.
- Averianov, A.O. and Yarkov, A.A., On the Occurrence of a Giant Flying Reptile (Pterosauria) in the Terminal Late Cretaceous of the Lower Volga Region, *Paleontol. Zh.*, 2004, no. 6, pp. 78–80.
- Bennett, S.C., The osteology and functional morphology of the Late Cretaceous pterosaur *Pteranodon*: Part 1. General description and osteology, *Palaeontogr., Abt. A*, 2001, vol. 260, nos. 1–6, pp. 1–112.
- Bogolyubov, N.N., On a pterodactyl vertebra from the Upper Cretaceous of the Saratov Region, *Ezhegodn. Geol. Mineral. Ros.*, 1914, vol. 16, no. 1, pp. 1–7.
- Gilmore, C.W., A new pterosaurian reptile from the marine Cretaceous of Oregon, *Proc. US Nat. Mus.*, 1928, vol. 73, no. 24, pp. 1–5.
- Glikman, L.S., Upper Cretaceous vertebrates the vicinity of Saratov: Preliminary data, *Uch. Zap. Saratov. Gos. Univ.*, 1953, vol. 38, pp. 51–54.
- Ivanov, A.V., *Marinakulaty—problematicnyy novyy tip zhivotnykh iz mela i paleogena Rossii* (Marinaculates—a Problematic New Type of Animals from the Cretaceous and Paleogene of Russia), Saratov: Kolledzh, 1995.
- Khozatsky, L.I., A Pterosaur from the Cenomanian (Late Cretaceous) of Saratov, *Vestn. St. Peterb. Gos. Univ. Ser. 3*, 1995, no. 2 (10), pp. 115–117.
- Khozatsky, L.I. and Yur'ev, K.B., Superorder Pterosauria: Flying Reptiles, in *Osnovy paleontologii. Zemnovodnyye, presmykayushchiesya i ptitsy* (Fundamentals of Paleontology: Amphibians, Reptiles, and Birds), Rozhdestvensky, A.K and Tatarinov, L.P, Eds., Moscow: Nauka, 1964, pp. 589–603.
- Ochev, V.G., A new pliosaur from the Upper Cretaceous of the Penza Region, *Paleontol. Zh.*, 1976, no. 2, pp. 135–138.
- Olfer'ev, A.G. and Alekseev, A.S., *Stratigraficheskaya skhema verkhnelovoykh otlozhenii Vostochno-Evropeiskoi platformy. Ob'yasnit. zapiska* (Stratigraphic Chart for the Upper Cretaceous Deposits of the East Europe Platform), Moscow: Paleontol. Inst. Ross. Akad. Nauk, 2005.
- Panteleyev, A.V., Popov, E.V., and Averianov, A.O., New record of *Hesperornis rossicus* (Aves, Hesperornithiformes) in the Campanian of Saratov Province, Russia, *Paleontol. Res.*, 2004, vol. 8, no. 2, pp. 115–122.
- Pervushov, E.M., Arkhangelsky, M.S., and Ivanov, A.V., *Katalog mestonakhozhdenii ostatkov morskikh reptilii v yur'skikh i melovykh otlozheniyakh Nizhnego Povolzh'ya* (Catalogue of Localities of Jurassic and Cretaceous Marine Reptiles in the Lower Volga Region), Saratov: Kolledzh, 1999.
- Pervushov, E.M., Arkhangelsky, M.S., and Ivanov, A.V., On distinctive features of paleogeographical conditions in the Campanian–Maastrichtian marine basin of the right-bank Volga Region, *Izv. Vyssh. Uchebn. Zaved. Geol. Razved.*, 2012, no. 1, pp. 10–12.
- Sel'tser, V.B. and Ivanov, A.V., *Atlas pozdnemelovykh ammonitov Saratovskogo Povolzh'ya* (Atlas of Late Cretaceous Ammonites of the Volga Region near Saratov), Moscow: Knizhn. Dom Universitet, 2010.

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