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A Large Marine Bird (Aves: Procellariiformes) from the Eocene of Western Siberia

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Abstract—The article describes the first find of a bird from the Paleogene of Siberia. A tibiotarsus fragment from the Eocene Tavda Formation of the Tyumen Region (Western Siberia) was assigned to Procellariiformes. The bird was morphologically closer to Procellariidae, but comparable in size to albatrosses (Diomedeidae) and was assumed to represent the stem members of the family. The find indicated for the first time that either stem albatrosses or similar large Procellariiformes could have had a worldwide distribution as early as the Eocene.

Keywords: fossil birds, Eocene, Western Siberia, Tavda Formation, Kyshtyrlinsky quarry

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Bird evolution and diversity in the Paleogene are known highly unevenly [1]. Paleogene bird fossils have not been described from Siberia as of yet [2], and the total Early Cainozoic step consequently remains poorly understood in the evolution of the North Asian avifauna. In 2014, a tibiotarsus of a large bird of the order Procellariiformes was found in an Eocene find-spot of marine fauna in the Kyshtyrlinsky quarry near Tyumen (Tyumen Oblast, southern part of Western Siberia; 56°55′07 N, 65°48′59 E). The find is described in this work. The tibiotarsus is the first find of Paleogene birds in Siberia and one of the few finds of pre-Oligocene Procellariiformes in the world [1]. The specimen is stored in the Borissiak Paleontological Institute (PIN). Tomography was carried out using a Neoscan N80 micro-CT scanner in PIN.

Paleogene depositions of the Kyshtyrlinsky quarry are represented by the Tavda Formation, which is widespread in the southern part of Western Siberia (Fig. 1). The Tavda Formation developed during the Lutetian–Priabonian, in conditions of an epicontinental marine basin that had lost its connection with the Arctic, but was still connected with the Turan Sea through the Turgai Strait [3, 4]. The exact boundaries of the Tavda Formation age are still a matter of discussion [3, 4]. Based on the composition of the mollusk fauna of the Kyshtyrlinsky quarry locality, the given taphocenosis formed in a shallow sea, possibly, with a desalinated surface water layer comparable with that of the modern Sea of Azov [5]. The shark fauna supports the formation of the locality in conditions of an open shallow sea [6]. The bird bone in question is from the uppermost step of the quarry. The step is a concretion-rich layer of blueish-gray and greenish-gray clays; is up to 8 m thick; and contains mollusk shells, bones of bony fish, shark teeth, and carbonized wood [7].

A distal fragment of the right tibiotarsus (specimen PIN 2612/6) of a large tube-nosed bird (Procellariiformes indet.) was preserved only partly. The condylus lateralis and condylus medialis have been destroyed, the extensor groove is indistinct, the trochlear crests are lost. A substantial part of the bone surface is eroded. The total length of the fragment is 36 mm; the distal width is 14 mm. The fragment corresponds in absolute dimensions to the modern black-browed albatross *Thalassarche melanophrys*.

Although preserved incompletely, the general structure of the distal part of the tibiotarsus allows diagnosis in specimen PIN 2612/6. A morphological feature of the specimen is that medial widening of the distal epiphysis relative to the shaft is almost undetectable, while the incisura intercondylaris is wide. This structure is characteristic of birds of the orders Procellariiformes, Gaviiformes, Ciconiiformes, and Ardeiformes, which are close relatives in the modern fauna and belong to the clade Aqueornithes. The geometry

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Fig. 1. Position of the Kyshtyrlinsky quarry on the map of Western Siberia.

of the distal part of the shaft is most similar to that in Procellariiformes and, in particular, Procellariidae. For example, a cranial view shows a characteristic lateral tilt of the distal edge of the incisura intercondylaris and a distinct bend of the distal bone profile at the transition to the condylus lateralis (Fig. 2). The latter feature is likely an apomorphy of Procellariiformes and is found in Diomedeidae and Procellariidae. At the same time, the distal ~~epiphysis~~ widens distally in modern Diomedeidae to a greater extent than in specimen PIN 2612/6, and the distal opening of the canalis extensorius is extended mediolaterally and is narrow. In specimen PIN 2612/6, the distal opening is narrower and is similar in shape to that in Procellariidae. The lateral view shows a characteristic lack of concavity at the transition from the shaft to the condylus lateralis. Again, the specimen is similar in this character to Procellariidae and differs from Diomedeidae. The condylus lateralis is slightly falling behind the shaft in Diomedeidae and is level with the lateral edge of the shaft in specimen PIN 2612/6 and Procellariidae. At the same time, the condylus medialis only slightly protrudes in the cranial direction in specimen PIN 2612/6 (its protrusion in the fossil bone might be somewhat lower than actual because of poor preservation of the bone). This feature distinguishes specimen PIN 2612/6 from both modern Procellariidae and Diomedeidae.

Gaviiformes have a partly similar tibotarsus structure. The Kyshtyrlinsky bird differs from Gaviiformes in having ~~proximal positions of~~ the distal opening of the canalis extensorius and the pons supratendineus (the two structures are displaced distally in Gaviiformes). Specimen PIN 2612/6 is distinguished from Pelagornithidae by a weaker medial bend of the shaft. The medial edge of the bone is concave at the level immediately proximal of the pons supratendineus in Pelagornithidae and, in particular, similarly sized *Lutetodontopteryx tethyensis* Mayr et Zvonok, 2012 from the Eocene of Eastern Europe [8]. Pelagornithidae additionally have a flattened surface on the cranial side of the bone at the transition from the shaft to the condylus lateralis (like in Diomedeidae), while a distinct bend is absent in the distal edge at the transition from the incisura intercondylaris to the condylus lateralis. The distal ~~epiphysis~~ in specimen PIN 2612/6 is narrower than in *Lutetodontopteryx tethyensis*, while the shaft width is comparable.

Families of the order Procellariiformes are not always possible to distinguish by fossil bone fragments. However, a large size makes the bird from the Kyshtyrlinsky quarry comparable with Diomedeidae (other members of the order Procellariiformes are considerably smaller in size). Large sizes of crown Diomedeidae are associated with their adaptation to dynamic soaring. However, stem albatrosses from the Eocene–Oligocene were mostly small in size and were probably not as specialized to dynamic soaring [1, 9]. The last is true for the large albatross *Tydea* from the Early Oligocene of Belgium as well [9]. The species is known only by forelimb bones, but matches the find under study in size and may represent the same or close form. It is noteworthy that the shark fauna of the Kyshtyrlinsky quarry also includes forms that are known from the Oligocene and even the Miocene [6].

The find of a large ~~tube-nosed~~ bird in the Eocene of Western Siberia is of importance for understanding the early evolution of albatrosses. The most ancient putative Diomedeidae, which were appreciably

Fig. 2. Tibiotarsi of a fossil bird from the Eocene of Western Siberia and selected modern Procellariiformes: (a, b, e, f) Procellariiformes indet., specimen PIN 2612/6, distal fragment of a right tibiotarsus; locality Kyshtyrlinsky quarry, Tyumen Region; Eocene; (c, g) *Thalassarche melanophrys* (Diomedeidae), PIN osteological collection, specimen 7-7-1, modern species; (d, h) *Ardenna gravis* (Procellariidae), PIN osteological collection, specimen 8-52-1, modern species. Views: (a, c, d, e) cranial ((a, c, d) photographs and (e) computer model), (b) lateral, and (f, g, h) distal. Designations: cm, condylus medialis; cl, condylus lateralis; da, distal opening of the canalis extensorius; iic, incisura intercondylaris; pst, pons supratendineus; pt, protrusion of the lateral condyle relative to the distal surface of the incisura intercondylaris (see text).

smaller in size than modern members of the family, are known from the Upper Ypresian of Antarctica [10]. In the North Hemisphere, small *Murunkus subitus* Panteleyev et Nesov, 1993 from the Upper Lutetian–Bartonian of Uzbekistan is the most ancient putative representative of the group [11]. Large Eocene ~~tube-nosed~~ birds (stem albatrosses) are represented only by the Kyshtyrlinsky find and a poorly preserved tibiotarsus from the Upper Bartonian–Priabonian of Antarctica (the Seymour Island), which has presumably been assigned to Diomedeidae [10]. In spite of its poor preservation, the Antarctic form is similar in general outlines and size to the Kyshtyrlinsky find. Thus, stem albatrosses or closely related large ~~tube-nosed~~ birds might have already had a cosmopolitan distribution no later than the Late Eocene. Their Eocene appearance in the fossil record generally agrees with putative Late Eocene divergence assumed for Diomedeidae from molecular data [12] or possibly shifts their divergence to an earlier period (in view of the probable Mid-Eocene age of deposits of the Kyshtyrlinsky quarry). At the same time, the morphological differences in limb bone structure from modern Diomedeidae and the existence of large Eocene ~~tube-nosed~~ birds, in particular, in a half-closed shallow epicontinental basin in Western Siberia suggest other adaptations and another lifestyle for these birds.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work does not contain any studies involving human and animal subjects. Museum specimens were used.

CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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