Translated by Robert Welch

Predatory Dinosaurs of Mongolia

E. A. Maleyev, Candidate in the Biological Sciences, Paleontological Institute of the Academy of Sciences of the USSR

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The Mongolian Paleontological Expedition undertaken by the Academy of Sciences of the USSR provided a unique collection of many groups of Mesozoic reptiles that included several well preserved skeletons of predatory dinosaurs.

Predatory dinosaurs are an interesting group of extinct reptiles that existed from the Triassic to the end of the Cretaceous period. They were very numerous and existed throughout practically the entire world. Remains have been found in Europe, Asia, Africa, North and South America, Iceland and the Arctic archipelago.

Within the USSR incomplete, fragmentary remains of large and small predatory dinosaurs have been found in the Cretaceous deposits of Kazakhstan and Uzbekistan.

Predatory dinosaurs were first discovered in Mongolia and are uniquely interesting. Among these are the skeletons of the smallest predatory dinosaur, which was no more than 50-60 cm long, whereas the largest was 12-14 m long and stood 5-6 m tall (Fig. 1).

The giant predatory dinosaurs were represented by a group of Deinodonts, the largest of which was the huge Mongolian tyrannosaur (*Tyrannosaurus bataar*), a huge tyrannosaur whose skull was almost 1.5 m long (Fig. 2). This lizard was slightly smaller than *Tyrannosaurus rex* from the Upper Cretaceous of North America. Another large predator, assigned to the new genus *Tarbosaurus* is somewhat smaller than *Tyrannosaurus rex* and *Tyrannosaurus bataar*, but is larger than all of the other gorgosaurs.[1]

In addition to these giants, the remains of mid-size predators – very similar in structure to the gorgosaurs (*Gorgosaurus sternbergi* and *Gorgosaurus libratus*) from the Upper Cretaceous of the USA have been found.

The small predatory dinosaurs are represented by various ornithomimids (bird imitators) among which are new, previously unknown species.

The predatory dinosaurs were the successors of flesh-eating reptiles from the Permian and Lower Triassic. In size and strength they exceeded all the predatory animals that had ever lived on Earth. Their structure was so remarkable and unusual that they can be thought of totally as the most interesting of the fossilized reptiles.

Tarbosaurus was 10-12 m long and 5-5.5 m tall (see Fig. 1). It was apparently strong enough to attack any of its herbivorous contemporaries – Trachodonts, horned dinosaurs, and even the giant sauropods. Its body was heavily built. The skull was large – 1.2-1.5 m long, the jaw had strong, acinaciform teeth 12-15 cm long curved slightly to the rear and serrated along the edges. The joint with the lower jaw was shifted far to the rear, which allowed the mouth to open widely.

The teeth alternated during the animal's lifetime. The young tooth arose on the interior side of the tooth's base or within it. The tooth being cut was double-edged, i.e., both sides – front and back – were sharp and slightly serrated.

[1] Tarbosaurus – terrible lizard

These features in the structures of the jaws and teeth undoubtedly resulted from adapting to cutting and swallowing large pieces of meat.

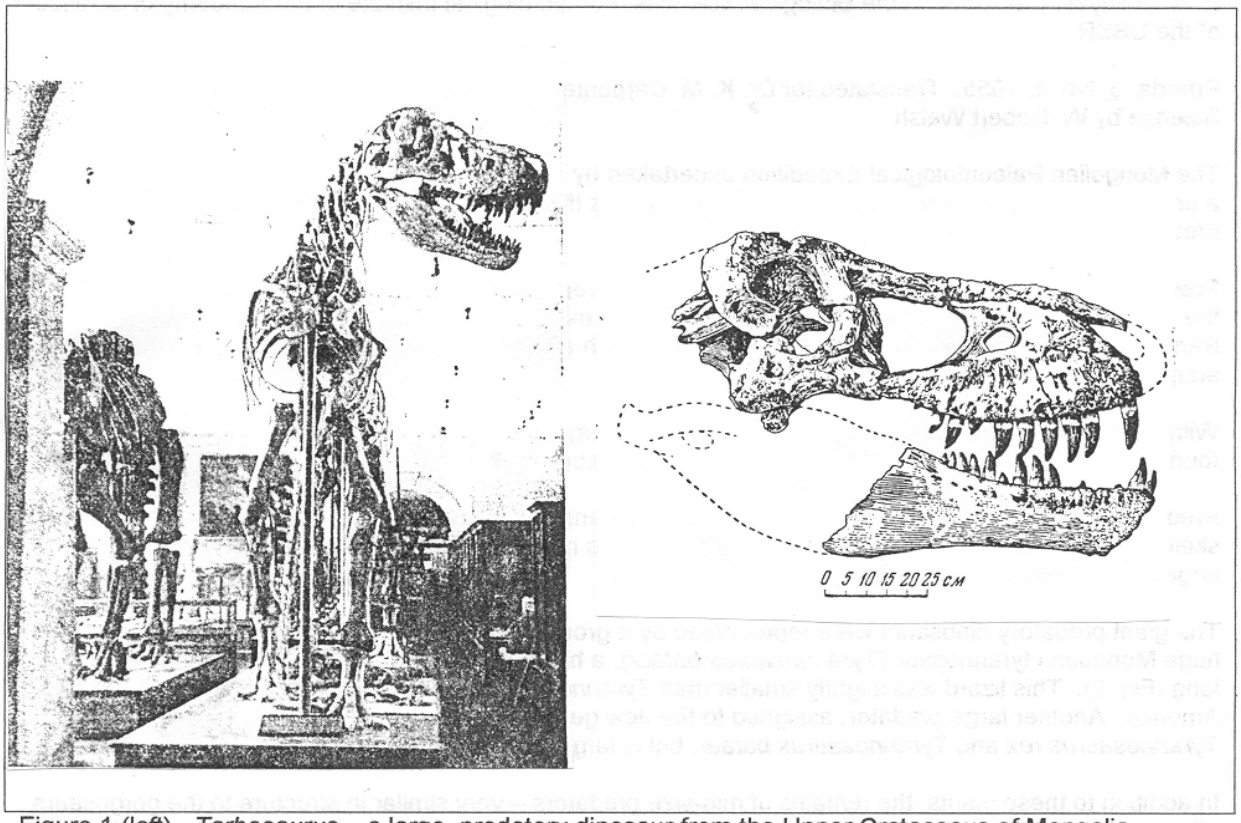

Figure 1 (left). *Tarbosaurus* – a large, predatory dinosaur from the Upper Cretaceous of Mongolia.
Figure 2 (right). Skull of the giant predatory dinosaur *Tyrannosaurus bataar* from the Upper Cretaceous of Mongolia.

The cervical vertebrae bore the weight of the massive head. They were short and wide with strong spinous and transverse processes. The articulation surfaces of the centers were skewed, which indicates a constantly raised head. This structure simultaneously speaks of low mobility in the neck.

The spinal vertebrae were high and double concave. A string of such vertebrae formed a strong, compact body that was less mobile than the crocodiles and large lizards. The torso ribs are long and sharply curved in their upper area and gently sloping convex in the center. This indicates that the torso was compressed from the sides and fairly high.

One feature in the skeletal structure of the predatory dinosaurs is the presence of strong sternal ribs that comprised a double-sided acuminate central rib and one-sided acuminate lateral ribs.

The lateral ribs were connected pairwise with one another, approximately like the compact and interwoven digits of both hands, forming strong breast armor that was similar to the breast armor seen in the modern tuataras. The formation of this strong armor was undoubtedly associated with the large predatory dinosaurs frequently laying on the ground. This armor alsosupported the internal organs and provided reliable protection from injury while hunting.

The structure of the forelimbs, one of the remarkable features of predatory dinosaurs, is interesting. These extremities were very small and weak and, visibly, almost useless: they were too short to reach the mouth and, apparently, too weak to aid in capturing and dismembering prey.

The length of the forelimbs overall is only one-tenth that of the hind limbs. In comparing dimensions the femur is 1 m long and 150-200 mm in diameter at its center; the humerus is 26.5 cm long and 35-50 mm in diameter (Fig. 3). The ulna and radius are short and thin, 10-12 cm long. The hand consists of three digits. The third digit is reduced. The digits ended in sharp, prehensile claws.

The giant predatory dinosaurs moved exclusively on their hind limbs, the pelvic girdle was very strong and was larger than the skull (Fig. 4). Its shape is somewhat reminiscent of the pelvic structure of the extinct giant birds such as the New Zealand moa, the flightless predator *Phororhacos*, and the diatryma. The hind limbs are long and massive, reminiscent of the extremities of ostrich-like birds.

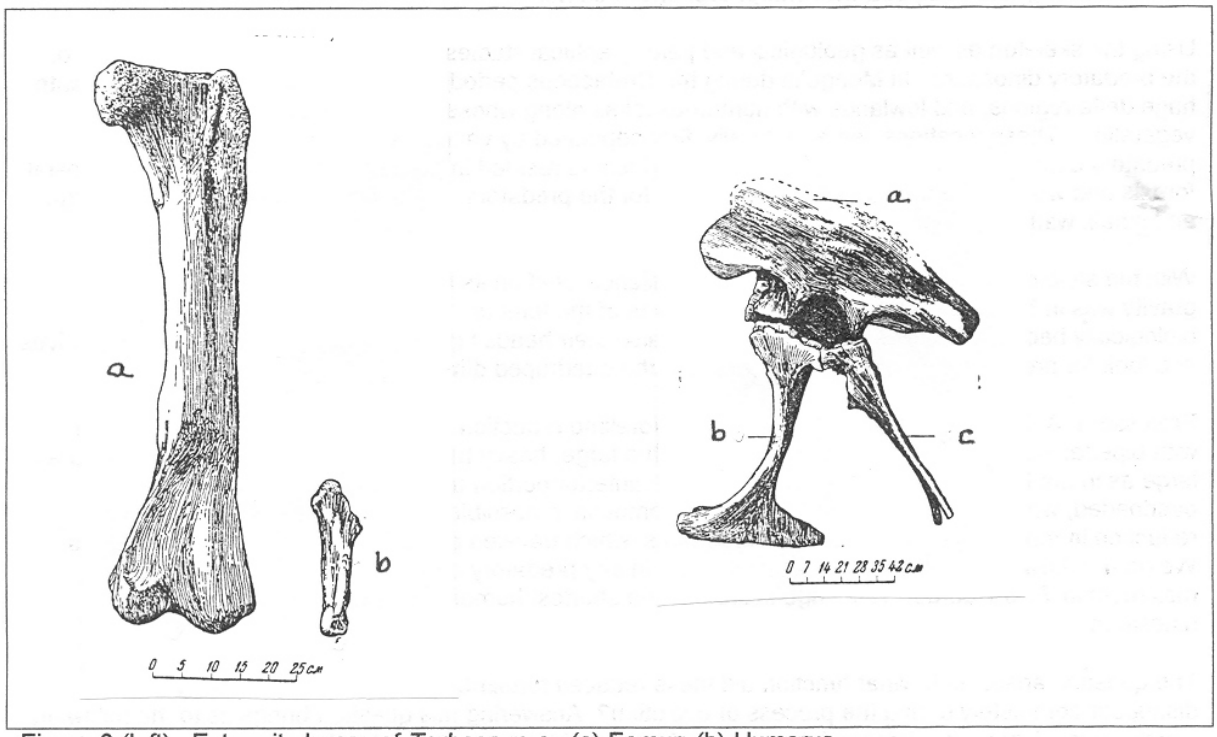

Figure 3 (left). Extremity bones of *Tarbosaurus*. (a) Femur; (b) Humerus.
Figure 4 (right). Pelvic girdle of *Tarbosaurus*. (a) Ilium; (b) Pubis; (c) Ischium.

The tibia is shorter than or almost equal in length to the femur. The ratio of femur to tibia length indicates that the giant predators were slow moving. In the heavy, slow-moving quadruped dinosaurs the femur is long and the tibia short. In all of the fast moving animals the femur is somewhat shorter than the tibia; this promotes significant speed of locomotion through short, rapid movements of the thigh muscles and, consequently, a long leg stroke. The metatarsals are long and massive and set almost vertically with respect to the digits.

The foot is small and massive, similar to the foot of the extinct giant birds. Only three digits (second, third and fourth) were well developed. The digits ended in sharp, powerful claws that could have been used to dismember prey or cut meat from the bones.

The tail was long and consisted of 35-40 vertebrae. It was almost half the total body length. It was tall and wide in the anterior region and gradually became small and round toward the rear. The first tail vertebrae were tall and double concave. At the rear they became smaller and longer. The articular processes were very long, the facets converge and rigidly connect the vertebrae together. This kind of tail vertebrae connection indicates the tail had low mobility, was rigid, served as a third base of support, and was also a counterweight for the compact torso and heavy head.

The structure of the small predatory dinosaurs was different. They were as big as a large ostrich and all of their body proportions were more slender. The skull was small and light. The jaws were short and weak. The teeth were small and more compressed from the sides. In some forms the teeth were quite reduced and apparently replaced in function by a horny rostrum.

Even though the small predatory dinosaurs also moved on two legs, their forelimbs were fairly long. The hind limbs were tridactylous and extremely avian. The femur was much shorter than the tibia, which indicates that these small predators traveled more rapidly. The metatarsals are very long and thin. The foot was strong and equipped with sharp, prehensile claws.

Using the skeleton as well as geological and paleographical studies we can approximate the lifestyle of the predatory dinosaurs. In Mongolia during the Cretaceous period were wide, rapidly flowing rivers with huge delta regions, and lowlands with numerous lakes along whose shores grew lush arboreal vegetation. These locations, were, naturally, first populated by various reptiles. Large and small predatory dinosaurs settled here. The huge ankylosaurs resided in the more open areas of these coastal forests and were apparently a major food source for the predators. All of the predatory dinosaurs, large and small, walked and ran on two legs.

With the style of locomotion, the animal had to balance itself on its hind limbs. The body's center of gravity was in the pelvic area on a line at the heads of the femurs. This was immensely significant biologically because it allowed the predators to raise their heads high so that they could orient themselves and look for prey and to travel more rapidly than the quadruped dinosaurs.

Professor I. A. Efremov has recently shown that forelimb reduction in the predatory dinosaurs is linked with bipedal locomotion and the development of the large, heavy head. If the forelimbs had remained as large as in the Iguanodonts and Trachodonts, the anterior portion of the body would have been overloaded, which would have made bipedal locomotion impossible. We can see a similar forelimb reduction in modern kangaroos and many jerboas, which traveled on their hind legs like the dinosaurs. We do not, however, find total forelimb reduction in any predatory dinosaur, although it reaches a maximum in *Tarbosaurus*. This huge lizard has the shortest humerus of all the known predatory dinosaurs.

The question arises as to what function did these reduced forelimbs perform? Why did they not disappear completely during the process of evolution? Answering this question brings us to the following conclusions. A huge predator weighing several tons could not stand constantly, even on its powerful hind limbs and had to frequently squat or lie on its belly, stretching the neck and head.

In this position the body weight was borne by the pubis, the hind legs, the base of the tail and in part by the sternal ribs. This resting position, especially when laying full length was probably typical for similarly shaped reptiles. When resting on the ground the predator may have used the forelimbs for support but their primary function was to lift the animal. Lifting the heavy head and anterior part of the body from the ground was very difficult even for such a powerful predator as *Tarbosaurus.* The animal undoubtedly supported itself on its front feet while lifting its head, after which it was easier to stand up. This can be very well seen in the way modern giant kangaroos use their reduced forelimbs.

How the giant predatory dinosaurs fed themselves is a question that has occupied many investigators. Some believe that the predatory dinosaurs were incapable of killing healthy animals and fed on decaying corpses.

However, all the features of the skeletal structure and especially the nature of the teeth and jaws indicate that *Tarbosaurus* and other predatory dinosaurs from the Upper Cretaceous were active and powerful predators capable of killing very large animals. This is also indicated by numerous traces of teeth that could only have come from the teeth of large predatory dinosaurs and remained in the bones of Trachodonts, horned dinosaurs and Ankylosaurs.

The method of attack for these giant lizards was not the same as that used by modern predatory mammals. The brain of these beasts was very slightly developed, perhaps even less than that of the crocodiles. They probably also lacked the mammalian keen sense of smell.

Their chief sense was sight. The eyes were located in lobes of the skull that projected outward, which enabled eyes to rotate slightly forward and, as a result, stereoscopic vision that was very important for orientation and attacking its victim.

The structure of the extremities shows that *Tarbosaurus* could hardly have overtaken its prey by chasing it down or by suddenly leaping onto it. Only one plausible suggestion remains: the giant predatory dinosaurs waited in concealment for their prey.

The small predatory dinosaurs differed from the large predators in activity and speed: they probably overtook their prey by leaping or rapid running. Some of them might have specialized in eating the eggs of dinosaurs and turtles, the abundance of which could have fed hundreds and thousands of small predators.