

## THE BONY CREST AND HELMET ON THE SKULL OF PREDATORY DINOSAURS—OVIRAPTORS\*

Oviraptors are a group of edentate predatory dinosaurs from the Late Cretaceous of Mongolia. These animals were first studied by the American Central Asiatic Expedition which discovered skeletal remains of this dinosaur at the Bayn Dzak (Shabarak Usu in the American literature) deposits (Osborn, 1924). The skull of this dinosaur is distinguished by a unique formation. Perhaps it was only the edentate nature that was the basis for originally assigning oviraptors to the ornithomimids, until new discoveries compelled reassignment. In 1976 the uniquely preserved skull (Fig. 1a) and postcranial skeleton of an oviraptor from the Dzamyn Khond deposit (60 km southwest of Bayn Dzak) were discovered. This discovery seemingly gave a fairly thorough representation of the morphology of the group (Barsbold, 1981, 1983). This representation, nevertheless, according to data from recent collections, was more widely distributed.

The original description (Osborn, 1924) noted a horn in the facial region of the oviraptor skull that was not seen subsequently. It has been established in recent material, however, that an unmatched, lengthwise, plate-like bony crest had developed. This crest was compressed from the sides; its anterior edge was formed by the premaxillary bones above the external nasal fenestrae, and in the larger posterior region by the nasal and frontal bones. The lateral surface of the crest bore traces of a friable structure that reflected the brittleness of the bony tissue that existed during the animal's lifetime. To the front and above, the more solid bone edge had long, narrow paired openings (or pockets), the purpose of which is not clear. Apparently the bone crest was covered by a bony membrane, which resulted in a structure very similar to the small helmet seen in cassowaries. As it turned out, the horn that was mentioned in Osborn's original description was a fragment of the bony base of the helmet.

In the summer of 1984, a division of the Soviet-Mongolian Paleontological Expedition collected a partially destroyed skull (Fig. 1b) and the remains of the postcranial skeleton of a rather large specimen that was assigned to a new species of oviraptor (under investigation). These remains were discovered in the bone-bearing deposits at Altan Ula II (what I. A. Efremov called "The Dragon's Graveyard").

The skull's unusually large, tall dome-shaped crest is much taller than that of the Dzamyn Khond oviraptor, and has attracted a great deal of attention. That the dome-shaped crest of the newly discovered specimen extends through the entire skull roof, including the temporal bones, is striking. In typical fashion the premaxillary bones are part of the crest's anterior edge; however, the paired openings (or pockets) are not seen here, probably due to the poor preservation of this region of the skull.

The lateral surface of the crest also had an explicitly friable nature. Honeycombed regions produced by splicing of thin bony coverings are quite visible on the surface. These most likely

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testify to the brittleness of the bone tissue in life. Judging by the shattered region in the center of the lateral surface, where the wall thickness from the base of the crest to its fornix decreases from roughly 1.5 cm to 0.5 cm, the distribution of the covering was fairly dense and the crest wall was very thick. This testifies that during the animal's lifetime the brittle bone base of the crest was, as in cassowaries, distinguished by its massiveness.

It must be noted that the features of the crest were well preserved, in spite of the fact that the bone-bearing layers flattened the skull laterally after interment.

A boundary is seen between the halves of the bone crest on the dorsal edge. This boundary extends practically the entire length of the crest. The edge of the crest is a cupola compressed from the sides, at the midpoint of its height its width reaches 5-6 cm, increasing toward the base. In overall size the cupola is hardly equal to the skull. Consequently, during the animal's life the horny helmet that capped the head virtually doubled its size.

This dome-shaped crest differs in many ways from the plate-like crest of the Dzamyn Khond oviraptor. A greater number of bones from the roof of the skull participate in forming the dome-shaped crest (including the temporal bones, just as in cassowaries), which greatly increased the extent of the crest itself. The crest of the Dzamyn Khond oviraptor occupies a relatively small space between the premaxillary bones and the anterior region of the frontal bone, inclusive. The dome-shaped crest is distinguished by its great width (in cross-section) and at the base reaches the exterior edge of the orbit, whereas the plate-like crest was very compressed from the sides and situated almost between the nasal fenestrae.

The relationships between the bones of the skull roof (nasal, frontal, temporal) with the dome-shaped crest are not everywhere distinctly visible. These bones were probably forced backward and possibly are part of the crest's base, becoming friable as is seen in the Dzamyn Khond oviraptor. The apex of the dome-shaped crest corresponded in position to the level of the orbit's anterior edge. In shape and size, the dome-shaped crest is almost completely similar topographically with the bone base of the horny helmet of cassowaries, the function of which is not fully understood (Fig. 1c).

It must be noted that a bone crest is not seen in other small oviraptors, among which are *Ingenia* (Barsbold, 1981) and the oviraptors from the Khermin Tsav deposits of southwest Mongolia, previously assigned to the standard species (Barsbold, 1976) and presently being examined for possible reassignment to a new genus of oviraptorid. *Ingenia* was characterized by an unusually massive skeleton for its small size (the skeleton is 1.0-1.2 m long, whereas it is twice as large in the "helmeted" oviraptor). The completeness of the articular regions is rather strong evidence for the discovery of an adult.

Another matter, the oviraptors from Khermin Tsav are comparable in size with *Ingenia* but have an extremely graceful skeleton with explicitly juvenile features. We may assume that the bone crest in *Ingenia* was either distinctive because of its slight development and was therefore not preserved as a fossil, or it was completely absent. In relationship with the juvenile forms (by analogy with cassowaries) we may add that the crest had not developed at this stage.

Indirect indicators of the possible presence of a crest in small oviraptors appear to be traces of a delicate structure in individual regions of the nasal and frontal bones that were more highly developed when a crest was present. The development of a bone crest (in shape and size) was common not only in the various oviraptor groups (species-specific for the cassowaries) but was presumably related to the individual's age, which is also typical of the comparable birds.

The brittleness (delicacy in the fossilized state) of the oviraptor bone crest and the development of the horny covering confirm a copious blood supply to the helmet, as is seen in

cassowaries. The development of paired fenestrae on the anterior edge of the crest was previously assumed to be connected with innervation of the rostral region of the skull—the passage of the opening for the facial (maxillary) nerve (Barsbold, 1981). Cassowaries have no comparable fenestrae. In oviraptors these fenestrae most likely opened on the outside surface of the horny helmet, which suggests a possible physiological connection (salt secretion, hormonal activity, etc.). The helmet may also have performed a thermal regulating function—the dissipation or storage of heat.

In contrast to a number of herbivorous dinosaurs, bony structures are sometimes set on the skulls of predatory dinosaurs. Among these are the development of horns in one case and of paired plate-like crests in other cases (Welles, 1970), respectively, in two species of North American carnosaurs. It may be that the paired crests were the foundation of a wall of the dome-shaped projection that was generally similar to that of oviraptors.

The shape of the skull in herbivorous dinosaurs varies, achieving a maximum mainly in ceratopsians and hadrosaurs. If the horn-like structures of ceratopsians might have been used possibly as a means of defense (Lull, 1933), then the purpose of other forms, especially hadrosaurs, are frequently interpreted differently: allaesthetic (*sic*) and perigramic (*sic*) forms (Davitashvili, 1961). Besides, the bony projection in “helmeted” hadrosaurs is perhaps most similar in shape and size to the dome-shaped crest of the Altan Ula II oviraptor, although the composition of the component bones are more restricted and constant (the premaxillary and nasal bones). In addition, the hadrosaur crest does not have the friable structure (non-brittle in life); it is frequently fairly dense and rigid, although instances of a fairly thin and fragile structure are known. Air pockets within the crest have also been noted (Lull, Wright, 1942) and are most likely absent in oviraptors.

Features in the oviraptor crest structure markedly distinguish it from the enlargement in the skull roof that is seen in pachycephalosaurs and is often viewed as a combat weapon. The oviraptor helmet can hardly have been used for similar situations. Apparently, the oviraptor helmet most likely had allaesthetic significance. Also, there is no particular reason to reject the possibility of a fairly brightly colored helmet as is seen in cassowaries. The similar structure probably corresponds to a similar purpose. That the helmet performed other functions is unclear.

The discovery of “cassowary-helmeted” oviraptors attests to the wide variety of skull structures in dinosaurs overall. The development of such a well-formed, horny membrane-covered projection is as yet unique to theropods. To be able to explain the functions this structure performed may promote a greater understanding of the ecology and lifestyle of these animals which, at present, is very much in the dark.

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#### Figure Caption

Fig. 1. View of oviraptor and cassowary skulls from the right.

a) *Oviraptor philoceratops* from Dzamyn Khond (No. 100/42); b) *Oviraptor* sp. nov. from Altan Ula II (No. 100/321);  
c) cassowary skull with horny helmet.