

Mongolian Hadrosaurids: Paleobiogeography, Dispersal and Environmental Relationships

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1. Introduction

Hadrosaurids were the most diverse large vertebrate herbivores during the Late Cretaceous, and are most thoroughly studied dinosaurs in terms of phylogenetics (e.g., Taquet, 1976; Sereno, 1986; Horner, 1990; Weishampel et al., 1993) functional morphology (e.g., Ostrom, 1961; Norman, 1984; Weishampel, 1984), biogeography (e.g., Brett-Surman, 1979; Milner and Norman, 1984), and paleoecology (e.g., Norman and Weisampel, 1985; Weisampel and Norman, 1989) in United States and Europe. With few exceptions, they are considered to be the natural crown group of a gradation of iguanodontian taxa, and are commonly thought to have originated in eastern Asia with subsequent migrations during the Late Cretaceous into North America and Europe (Weishampel and Horner, 1990).

Hadrosauridae is composed of two derived, multiple-taxon sister lineages and several primitive taxa. The derived lineages are the large, wide-beaked Hadrosaurinae, and the smaller, often crested Lambeosaurinae.

Hadrosaurids were less abundant and diverse vertebrates in Asia compared to North America during the Late Cretaceous but have been studied by Riabinin (1925, 1930, 1939), Wiman (1929), Gilmore (1933), Young (1958), Rodzhestvensky (1968) and Maryanska and Osmolska (1981, 1984).

Although more than 20 hadrosaurid taxa have been described from Asia (five of which should be considered as *nomina dubia*) only two species have thus far been described from the territory of Mongolia: *Saurolophus*

angustirostris Rozhdestvensky, 1952 (Hadrosaurinae) and *Barsboldia sicinskii* Maryanska et Osmolska, 1981 (Lambeosaurinae)

However only two species have been described from Mongolia, several indeterminate hadrosaurids were reported from different sites in Mongolia as follows: Bayn Bologay (Gilmore, 1933), Bayn Shireh (Maleev 1956), Bugeen Tav (Trofimov et al. 1970), Shereegeen Gashoon (Rozhdestvensky 1974), Bayn Dzak and Khermeen Tsav (Gradzinski et al. 1977), Baishin Tsav (Tsybin and Kurzanov 1979).

During the field work Japan - Mongolian Joint Paleontological Expedition since 1993 several articulated and associated specimens of Hadrosaurid dinosaur have been found from the Bayn Shire Formation at the localities Baishin Tsav, Khuurai Tsav, Khongil Tsav, Bayn Shire in Eastern Gobi region, Djadokhta Formation at the localities Alag Teg, Tugrikin Shire in the Central Gobi region and the Nemegt Formation at the localities Bugin Tsav, Gurilin Tsav and Nemegt in Western Gobi region.

According to the newly discovered those materials from Gobi regions expand to contribute knowledge of the spatio-temporal distribution of Mongolian hadrosaurs.

2. Data and Model Description

Bayn Shirenian Hadrosauroids (Santon-Senomanian - 99-86 mya)

One of the most important finding among collected

specimens is almost complete skeletons of hadrosauroid with best preservation were found at first from Baishin Tsav in 1995 then from Khuurai Tsav in 2004 (Bayn Shire Formation, Late Cretaceous).

The fossils in Baishin Tsav is preserved in a meandering fluvial system. The key to this interpretation are large scale inclined heterolithic strata, between which are sandwiched medium and small-scale trough cross stratification. The fluvial system apparently had a low energy floodplain, which is exposed as a laminated mudstone at the base of the fossil-bearing unit (Fastovsky, 1996).

Hadrosaurid specimens have been found before from Baishin Tsav by Soviet Mongolian Joint Paleontological Expedition and it was identified as *Arstanosaurus* sp. (Hadrosaurinae) by Kurzanov S.M. *Arstanosaurus* was erected by Shilin and Suslov in 1982 based on a fragmentary maxilla and distal fragment of femur collected from Aral region in ex-USSR.

Detailed morphological study on the newly discovered specimens from Baishin Tsav revealed that they did not belong to “*Arstanosaurus*”, but were assigned to the Lambeosaurinae, *Bactrosaurus* that was found in Iren Dabasu, Inner Mongolia, China. Cranial and pelvic characters of the examined specimen suggest their close relationship to the Lambeosaurine hadrosaurids. As taxon “*Arstanosaurus*” is based on poorly preserved specimen without definite taxonomic character, it should be considered as invalid taxon.

Specimens of Hadrosauroid were found from the Baynshire Formation of Upper Cretaceous localities as follows: Baishin Tsav, Khongil Tsav, Bayn Shire, Amtgai and Khuurai Tsav.

Hadrosaurid specimen from Bayn Shire Formation was determined as *Bactrosaurus*, the most primitive genus of lambeosaurine, holotype of this genus was found from the Iren Dabasu Formation in PRC. A Cenomanian age was suggested for this formation by Rozhdestvensky (1966, 1974, 1977). Currie & Eberth (1993) have been able to propose, at an extreme end of their range, a Campanian age for the Iren Dabasu deposits. Indeed,

the present cladistic analysis shows that *Bactrosaurus* is by far more primitive than any known typical Campanian – Maastrichtian Hadrosauridae. The correlation between the Iren Dabasu Formation and the Bayn Shire Formation is based on similarities in lithofacies and fossil vertebrate assemblages worked out by Currie & Eberth (1993). The stratotype of the Bayn Shire Formation with typical vertebrate fauna of the Baynshire age that comprises of the lower part of the Upper Cretaceous stratigraphic sequence. The sediments at Bayn Shire were probably deposited near the end of C34n, based on the preliminary paleomagnetic results that Baynshurenian time extended into a Cenomanian-Santonian age (Hicks et al., 1999)

Djadokhtian Hadrosaurids (Campanian-Santonian-86-71 mya)

In 1995, the joint expedition team excavated more than 20 juvenile individuals of ankylosaur *Pinacosaurus* from Alag Teg locality with Djadokhtian age. Those specimens were discovered in mudstone (siltstone) in the position of up side down and normal. Besides the specimens of *Pinacosaurus*, two partial skeleton of hadrosaurus were discovered. One skeleton preserved a part of skull. Another one supplied well-preserved hind limb bones and vertebrae. The third specimens of the hadrosaurus showed interesting preservation condition, namely, nearly vertically situated articulated metatarsals and digits in the mudstone that was the same one yielded the second skeleton. The hadrosaurian skeletons in this locality showed interesting taphonomic preservation situation.

Sedimentary environment of Alag Teg is braided river system (fluvial) (D. E. Fastovsky). The fluvial sequence is overlain by eolian sandstone that is observed typically in Tugurikin Shire. This stratigraphic relationship indicates the braided river environments were replaced by the eolian environments. The difference of the environments affected the faunal compositions of dinosaur in both sediments (fluvial and eolian).

The partial skull of Hadrosaurid dinosaur which were found from mudstone layer at Alag-Teg has number of primitive characteristics, including elongated facial region, mandibular condyle of quadrate is transversely expanded, short and shallow braincase, denticulated oral margin of prementary all of which are more common to the basal hadrosaurids than advanced hadrosaur-saurolophus *angustirostris* from the Nemegt Formation in Western Gobi Desert. This is probably new genera and species of Hadrosaurid dinosaur from Djadokhta and/or Barun Goyot Formation. The correlation of fossil vertebrate assemblages from Djadokhta and Barun Goyot Formations has been reviewed by Lillegraven & McKenna(1986). These authors suggest that the assemblages are temporal equivalents of the younger and older parts of the Judithian of middle Campanian. The specimens are belonging to the new species were found from the localities Alag Teg and Tugrikin Shire and adjacent region.

Nemegtian Hadrosaurids (Maastrichtian-71-65 mya)

Hadrosaurid dinosaurs of Nemegt formation in Mongolia is characterized by *Saurolophus angustirostris* Rozhdestvensky, 1952 and *Barsboldia sicinskii* Maryanska and Osmolska, 1981. Mongolian *Saurolophus angustirostris* and North American *Saurolophus osborni* have a close relationship.

Saurolophus angustirostris, may be the stratigraphically youngest Asian duck-billed dinosaur, probably not older than the late Campanian. Representatives of the hadrosaurian genus *Saurolophus* occur both in Mongolia and western Canada. The North American species has been collected in strata of early Maastrichtian age.

Saurolophus angustirostris was preliminary described by Rozhdestvensky (1952) who later added (1965) some comments on its allometric changes. The original material of *S. angustirostris* collected by the Mongolian Paleontological Expedition of the USSR -Academy of Sciences in 1947-1949 includes several complete skel-

etons derived from the Altan Ula, Tsagaan Khushuu and Nemegt localities. During the Polish-Mongolian Paleontological Expeditions several other specimens of this species were collected from the Nemegt Formation. One complete skeleton of a young individual was found at the locality Altan Ula IV. The skull of this specimen provided some new data on the circumorbital and crestal regions (Maryanska and Osmolska 1979).

Almost complete very large skeleton without skull of *Saurolophus* was found from the Nemegt Formation in Gurilin Tsav locality by Mongolian paleontologists in 1987. Then complete skeleton with skull was found from Bugin Tsav locality by JMJE in 1995

Specimens of *Saurolophus angustirostris* were discovered from the Nemegtian Formation of those localities as Nemegt, Altan Ula II & IV, Tsagan Khushu, Bugin Tsav and Gurilin Tsav in Western Gobi Desert of Mongolia.

Another advanced hadrosaurid which was discovered from Mongolia is *Barsboldia sicinskii* Maryanska and Osmolska, 1981. Incomplete postcranial skeleton of *Barsboldia sicinskii* was found in the Late Cretaceous sandy deposits of the Nemegt formation, at the Nemegt locality (Northern Sayr) in 1970. It displays a ridged sacrum and comparatively long neural spines, both characters diagnostic of the Lambeosaurinae.

The similarity of dinosaur's assemblages including Hadrosaurids between the North America and East Asia is occurred the end of Late Cretaceous (Maastrichtian). Twelve of the dinosaur families were discovered at both continents; Tyrannosauridae, Dromaeosauridae, Troodontidae, Oviraptoridae, Ornithomimidae, Diplodokidae, Camarasauridae, Hadrosauridae, Pachycephalosauridae, Neoceratopsia and Ankylosauridae. Only Therizinosauridae was endemic to Asia. And two families (Ceratopsia and Nodosauridae) are not known to occur in Mongolia.

The distribution patterns of these families suggest that their pre-Kimmeridgian dichotomy was a vicariance event generated by geographical isolation. From the Bajocian to the Maastrichtian, East Asia is mostly isolated

from the other continents by the Obik (Turgai) shelf-sea to the west and the Bering Seaway to the east. An early Cretaceous regression could have permitted terrestrial faunal exchange across the Obik region, while late Cretaceous continental movements produced the Beringian corridor from the Campanian onwards.

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