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ENDOCRANIAL CAST OF THE CRETACEOUS EUTHERIAN MAMMAL *BARUNLESTES*

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An endocranial cast of the Late Cretaceous (?Middle Campanian) zalambdalestid *Barunlestes butleri* from the Gobi Desert in Mongolia is described and figured. The brain that produced this endocast had large, roughly pear-shaped olfactory bulbs; relatively wide lissencephalic cerebral hemispheres, strongly diverging posteriorly; the midbrain consisting of one pair of large colliculi extensively exposed on the dorsal side; relatively short and wide cerebellum. The rhinal fissure cannot be discerned with any certainty but the expansion of cerebral hemispheres suggests that the neocortex was possibly developed in this and other Cretaceous eutherian mammals.

Key words: Paleoneurology, endocranial casts, *Barunlestes*, Eutheria, Mammalia, Cretaceous, Mongolia.

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INTRODUCTION

In the Upper Cretaceous beds of Mongolia the oldest known endocranial casts of eutherian mammals have been preserved. These belong to the genera *Kennalestes*, *Asioryctes*, *Zalambdalestes* and *Barunlestes* (Kielan-Jaworowska 1984*a*, Kielan-Jaworowska and Trofimov 1980). *Barunlestes* Kielan-Jaworowska, 1975 is a monotypic genus of the derived proteutherian family Zalambdalestidae. It is known from entire skulls associated with lower jaws, a large part of the postcranial skeleton and a distorted endocranial cast seen in dorsal aspect (Kielan-Jaworowska 1975, 1978, 1984*a*, 1984*b*, 1984*c*, Kielan-Jaworowska and Trofimov 1980). After this material had been described, one more skull of *Barunlestes butleri* from the red beds of Khermeen Tsav (? Middle Campanian — see Gradziński *et al.* 1977) was recovered in the collection of the Paleontological Institute of the

USSR Academy of Sciences in Moscow. As endocranial casts of early Eutheria are very rare (Jerison 1973) we thought it desirable to describe the new endocranial cast in this paper.

Abbreviations used:
PIN — Paleontological Institute of the USSR Academy of Sciences, Moscow.
ZPAL — Institute of Paleobiology, Polish Academy of Sciences, Warsaw.

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MATERIAL

PIN 3142-701, red beds of Khermeen Tsav, Khermeen Tsav II, Gobi Desert, Mongolia, nearly complete, well preserved skull, associated with lower jaws; a cast of the nasal cavity and incomplete dorsal aspect of the endocast are exposed. The endocast shows the olfactory bulbs, distorted cerebral hemispheres and distorted cerebellum; the exposed midbrain is badly damaged.

PIN 3142-702, red beds of Khermeen Tsav, Khermeen Tsav II, Gobi Desert, Mongolia, skull associated with lower jaws; anterior part of the snout and most posterior part of the braincase are missing; the basicranial region is badly damaged. Much of the endocast was originally exposed in dorsal view. By removing part of the braincase we have exposed the lateral and ventral aspects of the endocast, the latter very incomplete.

DESCRIPTION
(pls. 51, 52; fig. 1)

Since an incomplete endocast of PIN 3142-701 has previously been described and figured by Kielan-Jaworowska and Trofimov (1980) and no details can be added to this description, we confine the description that follows to PIN 3142-702, which is more complete.

Dorsal aspect. — The estimated length of the whole endocast is about 17 mm, with the estimated length of the skull about 35 mm. The index $\frac{\text{brain length} \times 100}{\text{skull length}}$ is 48.6.

The olfactory bulbs are roughly pear-shaped in outline, each 4.5 mm long and 3 mm wide. The bulbs diverge posteriorly, while their middle and anterior parts are in close contact. They are separated from the cerebral hemispheres by a relatively wide transverse furrow.

The cerebral hemispheres are about 8 mm long, with a combined width of 11 mm. They diverge slightly anteriorly and strongly posteriorly, with a point of divergence

lying a little to the rear of the midlength of the hemispheres. The middle part of the dorsal surface, which was originally exposed, is badly damaged. Posteriorly, due to the distortion of the braincase, in particular on the left side, the posterolateral end of the hemisphere is not gently rounded. The dorsal and postero-lateral surfaces of the endocast meet at a right angle, with an artificial ridge being formed along the

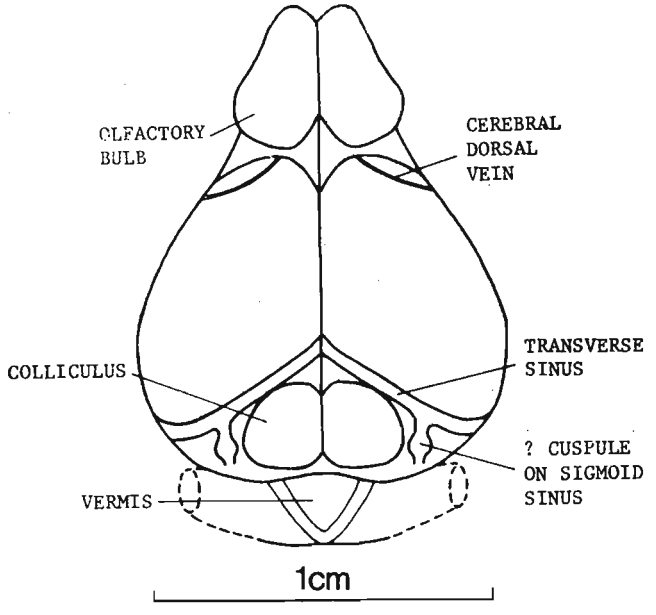

Fig. 1. *Barunlestes butleri* Kielan-Jaworowska — reconstruction of the endocast (dorsal aspect), based on PIN 3142-702.

postero-lateral margin. Near the anterior margin on each hemisphere there extends a very faint thread-like ridge, which is convex posteriorly; it continues onto the lateral side. This might be a cast of the cerebral dorsal vein (Dom *et al.* 1970). The surface of the hemisphere endocast is smooth which indicates that the hemispheres were lissencephalic.

Between the diverging caudal ends of the hemispheres an extensive midbrain is exposed on the dorsal side. This consists of one pair of large moderately convex colliculi, each 2.6 mm wide and 2.8 mm long. There is no trace of a division into anterior and posterior colliculi. Between the hemispheres and the colliculi there is a distinct, convex cast of a transverse sinus. Lateral to the posterior part of the colliculus the sinus bifurcates. One branch, possibly a cast of the prootic vein, extends laterally. The other, possibly a cast of the sigmoid sinus, extends posteriorly. At the beginning of the course of the latter a distinct cuspule has been preserved on both sides of the specimen.

Only the middle part of the cerebellum has been preserved. This is separated by a wide transverse furrow from the colliculi. Extending postero-medially from the middle of the posterior margin of each colliculus is a distinct ridge. The two ridges converge posteriorly and delimite the elevated, roughly triangular part of the cerebellum which might be the vermis. A fragment of the cerebellar hemisphere has been preserved on the left side. The parafloculli are not preserved.

Lateral aspect. — The olfactory bulb is short anteriorly and becomes gradually deeper up to midlength, where it measures about 2.1 mm; it becomes shorter again posteriorly. Below the bulbs on both sides, casts of the air compartments of the ethmoturbinals are preserved.

The lateral surface of the hemispheres is partly damaged on both sides, due to the distortion of the specimen. On the left side the surface of the endocast is broken along a vertical flexure, and the posterior part of the endocast overlaps somewhat the anterior one. Along the anterior part there extends a longitudinal groove which is absent from the posterior part. On the right side there are short grooves both on the anterior and posterior parts of the hemispheres. The two grooves are not continuous with each other and the middle part of the hemispheres is smooth between them. The described grooves delimite the pyriform lobes, which on both sides are incomplete and damaged. As the grooves are damaged as well, it is possible that they are artefacts.

Ventral aspect. — The olfactory bulbs are partly obscured in this view by the ethmoid bone, and casts of ethmoturbinal air compartments which have not been removed. Because most of the basicranium has been damaged, only a small part of the endocast is exposed in this view. On the right side there is a calcite endocast of the cochlea, arranged obliquely with regard to the horizontal surface, consisting of one and a half whorls. Anteromedially to the cochlea, very close to it, there is a large, strongly inflated body — a cast of a hypophysis. In front of it another, smaller, inflated body is preserved, which may correspond to the posterior part of the optic chiasma. Lateral to the hypophysis, on both side, damaged and incomplete casts of pyriform lobes are preserved, separated from the rest of the hemispheres by grooves described above. The olfactory tubercles are badly damaged.

DISCUSSION

The endocranial cast of *Barunlestes* resembles those of other Late Cretaceous eutherian genera *Kennalestes*, *Asioryctes* and *Zalambdalestes* (Kielan-Jaworowska 1984*a*). The brains that produced them displayed no flexure, were macrosomatic and lissencephalic, with cerebral hemispheres strongly diverging posteriorly, wide midbrain exposure on the dorsal side, relatively short and wide cerebellum and large paraflocculi (the latter unknown in *Barunlestes*).

The endocast of *B. butleri* is similar to that of *Zalambdalestes lechei*, but it is smaller, as is the skull of *Barunlestes*. The olfactory bulbs are pear-shaped in *Barunlestes* rather than more oval in *Zalambdalestes*, and relatively less deep, especially posteriorly, as viewed in lateral aspect; the cerebral hemispheres appear more expanded laterally and the exposed colliculi are larger. The ridges which delimite the middle part of the cerebellum in *Barunlestes* are apparently absent in *Zalambdalestes*. Another difference concerns the presence in *Barunlestes* of a cuspule on the sigmoid sinus. Such a cuspule has not been preserved in the *Zalambdalestes lechei* endocast ZPAL MgM-I/16 (Kielan-Jaworowska 1984*a*, pl. 30: 2).

As in all other Late Cretaceous eutherian endocasts, the midbrain in *Barunlestes* consists of one pair of very large colliculi, which are larger relative to brain size than in the other known Late Cretaceous eutherian endocasts. In brains of extant Macroscelididae the midbrain roof consists of large anterior (optic) colliculi and very small posterior (acoustic) ones (Le Gros Clark 1928, Stephan and Spatz 1962). The small cuspule on the sigmoid sinus in *Barunlestes* has the same proportion to the exposed colliculus as does the posterior colliculus to the anterior one in macroscelidid genera and may be confused with the posterior colliculus. On the other hand the acoustic colliculus is always placed posteriorly to the optic one (Ariëns Kappers *et al.* 1960, Starck 1962) and not lateral to it as is the cuspule in question in *Barunlestes*. Moreover, the cuspule in *Barunlestes* apparently lies at the begining of the sigmoid sinus and that is why we regard it as belonging to the vascular system, and not to the brain.

The lack of division of the midbrain into the anterior and posterior colliculi (corpora quadrigemina) in Cretaceous eutherian mammals is difficult to interpret. In most reptiles with the exception of snakes and some lizards (Ariëns Kappers *et al.* 1960) there occur only the corpora bigemina (optic colliculi). This is apparently characteristic also of the brains of cynodonts, although the midbrain casts in cynodonts are not very clear and have only been reconstructed (Simpson 1927, Hopson 1979, Kemp 1979, Quiroga 1980).

If but one pair of colliculi were present in the brains that produced the known eutherian Cretaceous endocasts, then this would be a very primitive feature. It is also possible, however, that the midbrain roof consisted of two pairs of colliculi, and one pair has been overlapped. As the cerebellum in these endocasts is separated from the colliculi by wide furrow, and apparently did not overlap the midbrain, it seems more probable that the anterior colliculi have been overlapped by the cerebral hemispheres, and if so, the exposed colliculi are the posterior ones (see Starck 1962, 1963). It is also possible that the midbrain consisted of four pairs of colliculi and that the furrow separating the anterior and posterior ones has not been preserved on the endocasts.

Another problem is whether or not the neocortex has been developed in brains of Late Cretaceous eutherian mammals. One of us (Kielan-Jaworowska 1984*a*) stated in abstract: "The rhinal fissure has not been found in *K. gobiensis*; it is tentatively recognized in *A. nemegetensis*, in which the neocortex is very small, while in *Z. lechei* the rhinal fissure is situated low down on the lateral side of the hemisphere suggesting the presence of an extensive neocortex". The abbreviations above refer to the genera *Kennalestes*, *Asioryctes* and *Zalambdalestes*.

As *Barunlestes* belongs to the same family as *Zalambdalestes*, one should expect to find the rhinal fissure in about the same place as in *Zalambdalestes*. This cannot be demonstrated with any certainty. In PIN

3142-702 there are furrows on both sides of the endocast in ventral aspect (pl. 51: 1b) at about the same place as the apparent ?rhinal fissure in the *Z. lechei* endocast — ZPAL MgM-I/16 (Kielan-Jaworowska 1984*a*, fig. 2c and pl. 31: 1b and 1c), however, an examination of *B. butleri* specimen in lateral view shows that the furrow is missing in the middle on the right side, and is present only in the anterior part of the endocast on the left side (pl. 52: 1b, 1c). Thus the furrows might be artefacts.

The conclusion on the existence of the neocortex based on the presence or absence of the rhinal fissure may be misleading. In some modern mammals (e.g. in marsupial mole *Nothoryctes typhlops*) there is no rhinal fissure visible on the cortical surface, but the microscopic sections show a neat rhinal fissure pattern (Schneider 1968). It follows that the absence of the rhinal fissure says nothing one way or the other about neocortical development, but its presence does signify the neocortex. Nevertheless, on the basis of the expansion of cerebral hemispheres we tentatively conclude that the neocortex was well developed in *Barunlestes*, and possibly in all other Cretaceous eutherian mammals.

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ODLEW JAMY CZASZKI KREDOWEGO SSAKA ŁOŻYSKOWEGO *BARUNLESTES*

Streszczenie

W pracy opisano odlew jamy czaszki ssaka łożyskowego *Barunlestes butleri*, z późnej kredy Mongolii. Jak można sądzić na podstawie odlewu, mózg tego ssaka miał gładką korę, duże, gruszkowatego kształtu opuszki węchowe, półkule mózgowe stosunkowo duże, w części tylnej silnie rozchodzące się na boki, śródmózgowie szeroko odsłonięte na stronie grzbietowej, stosunkowo krótki i szeroki móżdżek. Bruzda węchowa nie zachowała się na opisywanym odlewie, jednakże kształt półkul mózgowych wskazuje, że kora nowa była już u tego ssaka zapewne rozwinięta.

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EXPLANATION OF THE PLATES 51—52

Plate 51

Barunlestes butleri Kielan-Jaworowska

Upper Cretaceous, red beds of Khermeen Tsav, Khermeen Tsav II, Gobi Desert, Mongolia, PIN 3142-702 (see also pl. 52).

1a. Stereo-photograph of the skull with exposed endocranial cast, dorsal view, ×3.

1b. Stereo-photograph of the same skull, ventral view, ×3.

Plate 52

Barunlestes butleri Kielan-Jaworowska

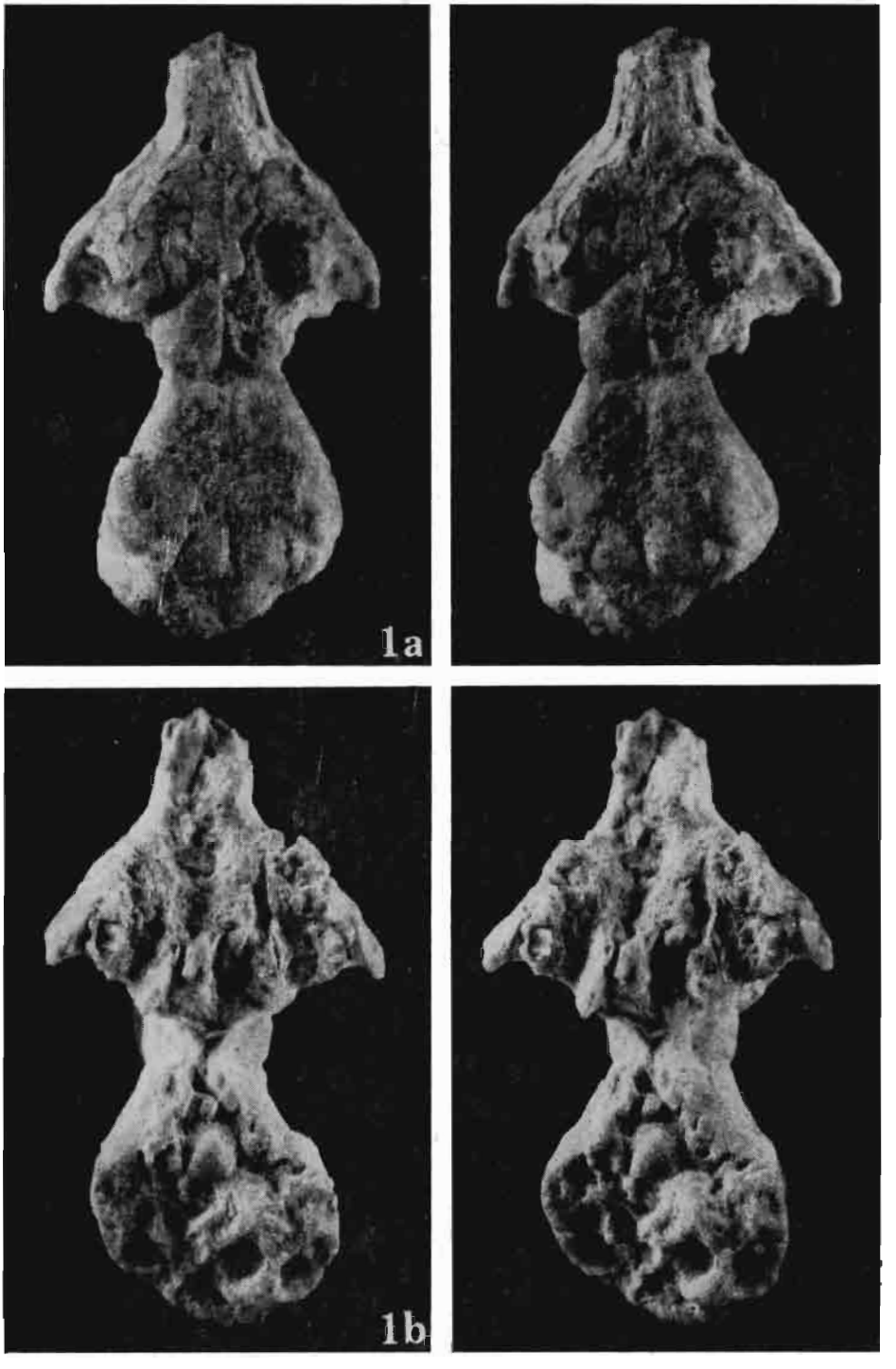
Upper Cretaceous, red beds of Khermeen Tsav, Khermeen Tsav II, Gobi Desert, Mongolia, PIN 3142-702 (see also pl. 51).

1a. Stereo-photograph of the posterior part of the endocast in dorsal view. The specimen coated with ammonium chloride, ×5.

1b. Stereo-photograph of the skull in right lateral view, ×3.

1c. Stereo-photograph of the skull in left lateral view, ×3.

Photo E. Wyrzykowska and M. Dziewiński


1a
1b


1a


1b


1c