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FIRST LAMBEOSAURINE DINOSAUR FROM THE NEMEGT FORMATION, UPPER CRETACEOUS, MONGOLIA

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The new genus and species *Barsboldia sicinskii* is here erected, based on an incomplete postcranial skeleton found in the Upper Cretaceous Nemegt Formation at the Nemegt locality, Gobi Desert, Mongolian People's Republic. It is the first lambeosaurine dinosaur so far described from this formation. The most striking character of *B. sicinskii* is the long club-like neural spines on the anterior caudals.

K e y w o r d s: Dinosauria, Ornithischia, Hadrosauridae, Lambeosaurinae, anatomy, Upper Cretaceous, Mongolia.

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INTRODUCTION

During the Polish-Mongolian Paleontological Expedition in 1970 (Kielan-Jaworowska and Barsbold 1972) an incomplete postcranial skeleton (fig. 1) of a hadrosaurid dinosaur was found in the Late Cretaceous sandy deposits of the Nemegt Formation, at the Nemegt locality (Northern Sayr). It was then considered to represent *Saurolophus angustirostris* Rozhdestvensky (Gradziński and Jerzykiewicz 1972, fig. 1: 23; fig. 2: 23). However, during our studies on *S. angustirostris* (Maryańska and Osmólska 1981, and in press) we ascertained that the specimen in question does not pertain to that species. It displays a ridged sacrum and comparatively long neural spines, both characters diagnostic of the Lambeosaurinae. *S. angustirostris* is usually considered a member of the Hadrosaurinae and has a grooved sacrum and relatively low neural spines, as is typical for this subfamily. The new specimen differs significantly from all known lambeosaurines, which prompted us to give it the new generic and specific designation, *Barsboldia sicinskii* gen. et sp.n.

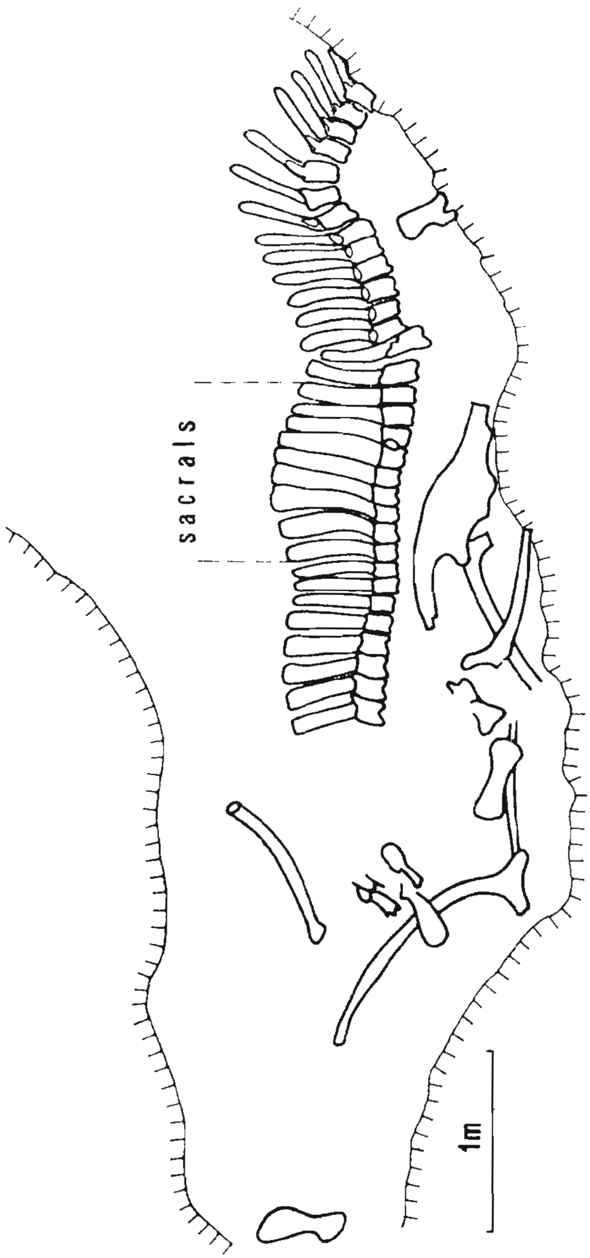

Fig. 1. *Barsboldia sicinskii* gen. et sp. n. Sketch drawing of the type specimen ZPAL MgD-I/110 as found at the North Nemegt locality, Nemegt Basin, Mongolia.

In deposits of the Nemegt Formation at three localities within the Nemegt Basin, Nemegt, Altan Ula and Tsagan Khushu, numerous specimens of *Saurolophus* were found (Rozhdestvensky 1952, 1957; Efremov 1955; Maryańska and Osmólska 1981) but no lambeosaurine was reported: *Barsboldia sicinskii* being the first. In Asia there are six valid lambeosaurine species, assigned to six genera (Maryańska and Osmólska 1981: table 1). These are *Bactrosaurus johnsoni* Gilmore, 1933, *Nipponosaurus sachalinensis* Nagao, 1936, *Jaxartosaurus aralensis* Riabinin, 1939, *Tsintaosaurus spinorhinus* Young, 1958, "*Procheneosaurus*" *convincens* Rozhdestvensky, 1968 (comp. Maryańska and Osmólska 1981: 11), and *Barsboldia sicinskii* gen. et sp.n. A seventh, new, still undescribed, probably lambeosaurine genus and species should be noted here: it was found in the Mongolian Upper Cretaceous by the Soviet-Mongolian Paleontological Expeditions (Kramarenko 1974: 15; Guide to the Paleontological Exhibition of the USSR Academy of Sciences in Japan, 1979: 26). Dodson (1975) recently reduced the number of North American lambeosaurine taxa, leaving only seven valid species: *Hypacrosaurus altispinus* Brown, 1913, *Corythosaurus casuarius* Brown, 1914, *Parasaurolophus walkeri* Parks, 1922, *Parasaurolophus tubicen* Wiman, 1931, *Parasaurolophus cyrtocristatus* Ostrom, 1961, *Lambeosaurus lambei* Parks, 1923, and *Lambeosaurus magnicristatus* Sternberg, 1935. It follows that in Asia and North America the number of lambeosaurine species is equal, although the total number of specimens found is significantly greater in North America.

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Abbreviations used:
AMNH — American Museum of Natural History, New York.
ZPAL — Institute of Paleobiology, Polish Academy of Sciences, Warsaw.

DESCRIPTION

Order **Ornithischia** Seeley, 1888
Suborder **Ornithopoda**, 1871
Family **Hadrosauridae** Cope, 1869
Subfamily **Lambeosaurinae** Parks, 1923

Genus *Barsboldia nov.*

Type species: *Barsboldia sicinski* sp.n.

Derivation of name: The genus is named in honour of Dr. Rinchen Barsbold, the eminent Mongolian paleontologist.

The genus is monotypic, therefore the diagnosis and distribution are as for the type species.

Barsboldia sicinskii gen. et sp.n.
(pls. 13—18; figs. 1—3)

Type specimen: ZPAL MgD-I/110, incomplete postcranial skeleton; pls. 13—18.

Type horizon: Nemegt Formation, ? Upper Campanian and/or Maastrichtian, Upper Cretaceous.

Type locality: Northern Sayr, Nemegt, Nemegt Basin, Gobi Desert, Mongolian People's Republic. Locality coordinates are given in: Gradziński and Jerzykiewicz 1972; 19, fig. 1.

Derivation of name: The species is named in honour of Mr. Wojciech Siciński, technical assistant in the Institute of Paleobiology, Polish Academy of Sciences, Warsaw.

Diagnosis. — A lambeosaurine dinosaur with comparatively high neural spines, that are highest at the middle of the synsacrum decreasing in height more abruptly forwards than backwards; neural spines of anterior caudals club-like; ilium very deep above the acetabulum.

Material. — One specimen, the holotype, ZPAL MgD-I/110: a series of nine posterior dorsals, nine coalesced sacrals, fifteen caudals, the left ilium, six or seven thoracic ribs, fragments of tibia and fibula, left metatarsals III and IV, phalanx 3 and the ungual of the third pedal digit, several fragments of dorsal and caudal neural spines, and fragments of the left and right pubis, fragments of ossified tendons. The vertebral column was found in articulation laying on its right side (fig. 1) with the left ilium slightly depressed from its normal position; ribs and other fragments were disarticulated, but generally not greatly displaced. The specimen was exposed on a mound, of which parts, probably containing the anterior- and posteriormost portions of the skeleton, were eroded and lost.

Vertebral column. *Dorsal vertebrae*. Nine presacral vertebrae are preserved. All dorsal centra are distinctly opisthocoelous and have much larger posterior faces than anterior ones. These faces are circular in shape. The more anterior dorsal centra within this series are somewhat longer and shallower than those of the remaining dorsals (table 1) and their lateral sides are less concave than those of the more posterior centra which are deeply excavated. A sharp, median keel runs ventrally along each of the dorsal centra. The dorsal neural spines are thick, anteroposteriorly wide, laterally flattened and with rectangular cross-sections at the top. This of the fourth dorsal (counting from the sacrum) is more than three times as high as the corresponding centrum is long and more than two times as high as this centrum is high. This neural spine is about four times as long as it is wide anteroposteriorly. The neural canal is about one sixth the height of the corresponding centrum. *Sacral vertebrae*. Nine vertebrae form the synsacrum, which measures 960 mm in length. Within the sacrum the vertebral column reaches its maximum depth, which at the middle of the sacrum is 950 mm. In the ventral view, three primary sacrals can be easily distinguished within the synsacrum, as they have a more slender form. These are the sacrals fourth to sixth. Three anterior dorsosacrals and three posterior caudosacrals are transversely much wider than are these three primary sacrals. The first centrum in the synsacrum bears a medial ridge ventrally, as is typical for the dorsal centra; the ventral surface of the second centrum is damaged. The third centrum is ventrally flattened, very broad transversely and it bears a ridge anteriorly which fades away to the rear of the centrum. The ventral surfaces of the fourth to fifth centra are transversely convex and the sixth centrum bears a distinct, although not sharp medial, longitudinal ridge, which is much less pronounced on the preceding centra of the sacrals fifth and fourth. The seventh sacral is convex ventrally but seems to be devoid of any ridge, while the eight and nineth ones have marked wide and shallow groove, which continues across the boundary between these centra. The sacral ribs are fragmentary but do not seem to differ from those of other hadrosaurs. The neural spines are, on the average, three times as high as the corresponding centra and about six times as high as the corresponding centra are long. The height to length ratio of the sacral neural spines ranges from 7 to 9. The spines of sacrals two to seven are attached to each other along more than half of their length, ventrally forming a continuous plate, and separated by narrow slits distally, where they are distinctly thickened. Along the middle of the synsacrum, the spines are almost perpendicular (to its longitudinal axis); the anterior sacral spines incline slightly forwards, while the posterior incline backwards. *Caudal vertebrae.* The anterior caudal centra are opisthocoelous, with the posterior faces larger than the anterior. The centra are subcircular in shape, and are short, deep and wide with concave lateral sides. The haemal arches are not preserved, but, judging from the articular facets, they started at the fourth caudal. The zygapophyses, along the entire preserved caudal series, have articular surfaces inclined at only small angle to the horizontal, implying that lateral movements were potentially quite extensive. The ribs of caudals one and two were in contact with the ilium, as suggests the shape of their ends. Those of caudals two to sixteen are comparatively broad and flattened dorsoventrally; begining with the eleventh caudal they become oval in cross-section and deflected strongly backwards. The anterior neural spines are approximately three times higher than the corresponding centra, and seven times as high as the anterior centra are long. This latter ratio diminishes backward, for caudal fourteen it is only slightly greater than four. This results from the centra becoming relatively longer towards the end of the tail. The height to length ratio of the neural spines varies within the same limits as it does for the sacrals, i.e. between 7 and 9. The neural spines of the anteriormost caudals are well separated, slightly curved (concave anteriorly) and inclined backwards; begining with caudal ten they become straight and more strongly inclined backwards, with the gap between neighbouring spines increasing. The spines are strong, massive, club-like, oval in cross-section at the middle of their height, and subcircular at the top. This is in contrast to the spines of the dorsals and sacrals, which are rectangular in section. The sides of the spines distally bear densely arranged ridges and grooves (also found on the dorsals and sacrals) for muscle attachment, probably for the *MM. spinoarticulares* and *articulospinales*. The tops of the spines are strongly corrugated and the strong, functionally supraspinous ligament (comp. Slijper 1946) certainly extended along the series of caudal neural spines, probably attaching to their cartilaginous summits.

Ilium. The anteromedial portion of the upper margin of the ilium is strongly curved, the preacetabular process being markedly deflected. The postacetabular process of the ilium is massive and directed upwards, as far as preserved. This results in the outline of dorsal border forming, in lateral view, a sigmoid curve with the concavity situated just behind the antitrochanter. The antitrochanter is not complete but was evidently large and thick. The central body of the ilium is deep (325 mm), the ischiac and pubic peduncles are massive and the anterior edge of the latter is almost perpendicular. The ilium is strongly sigmoid in dorsal view, Medially, the ilium shows several depressions along its upper margin for the reception of the sacral ribs. These for the third and fourth ribs are placed at the base of the anterior process of the ilium, that for the fifth rib is above the pubic peduncle, while that for the sixth rib is above the anterior half of the acetabulum. Judging from the depressions on the dorsal iliac margin, the more dorsal portions of the third to fifth sacral ribs extended to the uppermost extremity of the ilium. These portions of the sacral ribs formed a series of bossess along the dorsal margin of the ilium, visible in lateral view. This feature is not peculiar to *B. sicińskii* as it also seems to be present in

Table 1

Measurements (in mm) of the vertebral column of *Barsboldia sicinskii* gen.et sp.n.

No. of vertebra	Height of centrum	Width of centrum	Length of centrum	Height of neural spine above postzygapophysis	Total height of neutral arch	Length of spine at middle (longitudinal)	Width of spine at top (transverse)
Dorsals:							
n+1	140	145	130	—	—	113	—
n+2	150	145	125	—	—	113	—
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
n+6	168	144	117	—	—	—	—
n+7	180	168	105	400	520	105	36
n+8	203	174	106	—	—	103	37
n+9	205	256	85	465	520e	70	—
Sacrals:							
1	185	—	100	520e	600	94e	—
2	—	—	100	550	700e	80	—
3	—	—	115	580	715e	80	—
4	—	—	107	595	—	80	—
5	—	—	110	610	—	110	—
6	—	—	110	620	—	100	—
7	—	—	115e	620	—	100	—
8	—	—	117e	635	—	95	—
9	—	—	85	620	655	85	—

c.d. tabl. 1

No. of vertebra	Height of centrum	Width of centrum	Length of centrum	Height of neural spine above postzygapophysis	Total height of neural arch	Length of spine at middle (longitudinal)	Width of spine at top (transverse)
Caudals:							
1	—	—	90	600	635	87	—
2	195	180	85	570	—	86	93
3	—	—	—	540	—	92	90
4	205	210	90	542	632	80	84
5	200	—	97	527	586	74	80e
6	193	—	89	498	567	72	73e
7	175	—	87	485	548	70	70e
8	172	—	85	469	536	67	70e
9	165	170e	92	461	540	60	—
10	157	—	91	431	474	60	—
11	—	—	86e	398	460	50	50e
12	166	—	90	383	446	62	—
13	160	150e	90	360	420	63	—
14	140e	—	92	350	400	70	—
15	130e	—	94	—	—	—	—

some other hadrosaurs e.g. *Saurolophus angustirostris* (Maryańska and Osmólska in press).

The preserved anterior portion of the left (?) prepubic blade is about 400 mm deep.

Pes. Crushed metatarsals III and IV of the left pes found are 420 and 345 mm long respectively and typical of hadrosaurs. The only preserved ungual of the pes pertains to the third digit and does not differ in shape from those of other hadrosaurs. It is 130 mm long, 130 mm wide and symmetrical.

DISCUSSION

In respect to the length of the sacral neural spines, *Barsboldia sicinskii* is among the lambeosaurines which have them most developed (fig. 2) and probably only *Hypacrosaurus altispinus* Brown might have longer neural spines in the sacral region.

The posterior dorsal neural spines of *Barsboldia sicinskii* are only four times

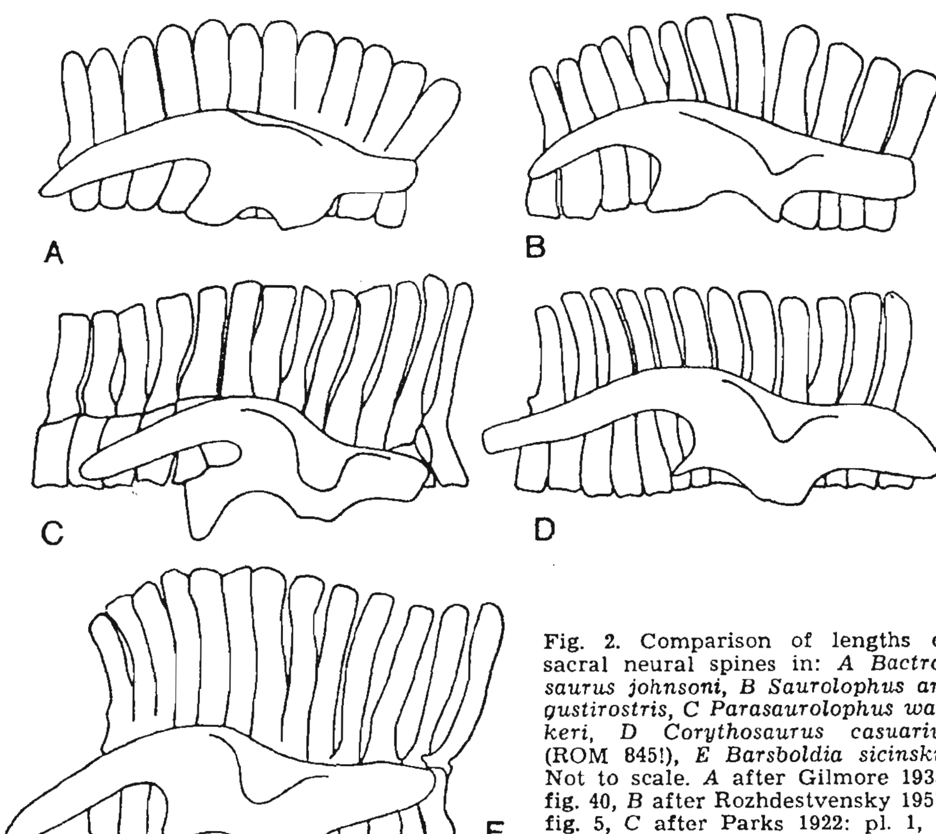

Fig. 2. Comparison of lengths of sacral neural spines in: *A Bactrosaurus johnsoni*, *B Saurolophus angustirostris*, *C Parasaurolophus walkeri*, *D Corythosaurus casuarius* (ROM 845!), *E Barsboldia sicinskii*. Not to scale. *A* after Gilmore 1933: fig. 40, *B* after Rozhdestvensky 1957: fig. 5, *C* after Parks 1922: pl. 1, *D* after Parks 1935: pl. 6:2, *E* original.

higher than the length of the corresponding centra, while those of the mid-dorsals of *Hypacrosaurus altispinus* are seven times higher than the length of the corresponding centra (Brown 1913*b*). Because the posterior dorsal spines are usually equal to or higher than those of the mid-dorsals, this indicates higher neural spines in the posterior dorsal region of *H. altispinus* than in *B. sicinskii*. However, the greatest difference between the two species concerns the shape of the spines, which are much thicker transversely at the top in our species than in *H. altispinus*.

Differences between these species are evident in the ilia as well. But any comparison here is very difficult without seeing the North American material. The ilium of the type specimen of *H. altispinus* (AMNH 5204) illustrated as the right by Brown (1913*b*: figs. 1, 4) and as the left by Morris (1978: pl. 1:8) is quite different from the opposite ilium of the same specimen (Morris 1978: pl. 1:9). Moreover, as illustrated by Morris (1978: pl. 1:6—10) the shape of the ilium seems to be variable in *Hypacrosaurus*. If true, it contradicts Brett-Surman's (1979) opinion concerning the diagnostic value of the pelvic elements in the hadrosaurids, at the generic level.

Among the Asiatic species which may be compared with *Barsboldia sicinskii* are *Bactrosaurus johnsoni* Gilmore and *Tsintaosaurus spinorhinus* Young the remaining species being either completely different or having not preserved the corresponding skeletal parts. In *B. johnsoni* the club-like neural spines occur in the posterior dorsal series (Gilmore 1933: fig. 30). The dorsal neural spines in *Barsboldia sicinskii* are, however, laterally flattened: the club-like form is present only in the anterior caudals. The ilium of *B. johnsoni* is quite different from that of *Barsboldia sicinskii*, being primitive e.g. in respect to the development of its antitrochanter. *Tsintaosaurus spinorhinus*, which we consider a lambeosaurine (Maryańska and Osmólska 1981), also displays slightly club-like neural spines in the caudals, although they seem to be somewhat more slender in the Chinese species (Young 1958:fig. 18) than in our form. The ilium of *T.spinorhinus* generally resembles that of *B. sicinskii* (comp. Young 1958: fig. 26: 1, 2) but differs in the less deflected preacetabular process, shallower central body and a postacetabular process not rising backwards.

The preserved portion of the ilium of *B. sicinskii* suggests that the length of this bone was between 1300 and 1400 mm. This is greater than the iliac lengths of such hadrosaurs as *Saurolophus osborni* (AMNH 5220: 1160 mm, *fide* Lull and Wright 1942) and *Corythosaurus casuarius* (AMNH 5338: 987 mm, *fide* Lull and Wright 1942). Each of these two animals has been estimated by Brown (1913*a*, 1916) as about 10 m long. Thus, if indeed the length of the ilium bears a constant proportion to the overall length in these animals, the length of *B. sicinskii* would have been about 12 m from tip of snout to tip of tail. The size of the preserved ribs, the longest of which measures 1500 mm in length, also implies that ours was a large animal with a deep thoracic cavity.

The characteristics of the neural spines of the tail, such as their significant height, thickness and club-like form, speak for especially strong development of the epaxial musculature and ligaments in *B. sicinskii*. The backward inclination of the caudal and posterior sacral neural spines imply an oblique anterodorsal direction of the muscular force (Slijper 1946).

The well developed, flattened dorsoventrally transverse processes present at least on fourteen anterior caudals imply that *M. caudifemoralis longus* was adequately well developed.

The anterior nine caudal centra form a gentle upward curve, as preserved, similar to that noted by Galton (1970) in other hadrosaurs (fig. 3). All this suggests that the tail was held horizontally and off the ground while the animal walked. Taking into account that the high and comparatively thick tail of *B. sicinskii* was rather heavy, heavier probably than in most other hadrosaurs, one expects that strong inter-

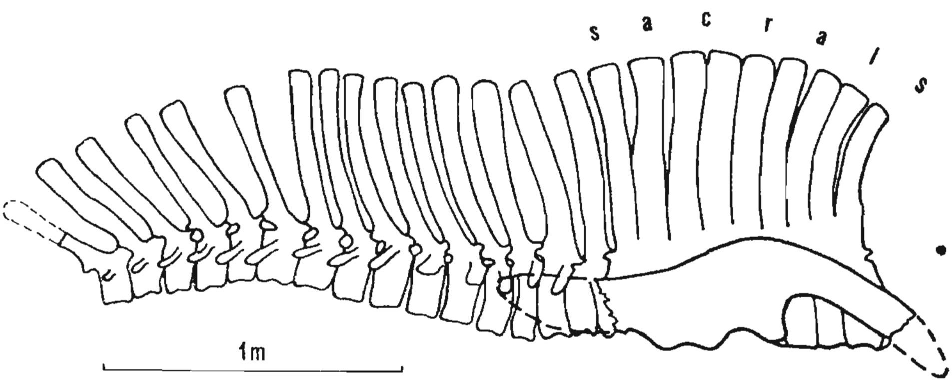

Fig. 3. *Barsboldia sicinskii* gen. et sp.n. Reconstruction of sacrocaudal region in type ZPAL MgD-I/110.

spinous ligaments had been developed. We are unable to state whether, or to what extent, interspinous musculature was present in the tail, although it was very probably present.

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TERESA MARYAŃSKA i HALSZKA OSMÓLSKA

PIERWSZY PRZEDSTAWICIEL DINOZAURÓW PODRODZINY LAMBEOSAURINAE Z GÓRNOKREDOWEJ FORMACJI NEMEGT W MONGOLII

Streszczenie

Opisano nowy rodzaj i gatunek dinozaura kaczodziobego, *Barsboldia sicinskii*, reprezentującego podrodzinę Lambeosaurinae. Holotyp, będący jedynym znanym dotychczas okazem, stanowi niekompletny szkielet pozaczaszkowy i znaleziony został przez polsko-mongolskie ekspedycje paleontologiczne w osadach górnokredowej forfacji Nemegt, w stanowisku Nemegt (południowogobijski ajmak, Mongolska Republika Ludowa). Jest to pierwszy znany przedstawiciel tej podrodziny dinozaurów kaczodziobych opisany z osadów górnokredowych Mongolii. Najbardziej charakterystyczną cechą *B. sicinskii* są długie, maczugowate wyrostki kolcowe przednich kręgów ogonowych. Kształt i kierunek tych wyrostków wskazują na to iż długi i ciężki ogon *B. sicinskii* trzymany był nad ziemią w czasie lokomocji.

Praca wykonana została w ramach problemu MR II.6.

EXPLANATION OF THE PLATES 13—18

Plate 13

Barsboldia sicinskii gen. et sp.n., type specimen ZPAL MgD-I/110, Nemegt Formation, N Nemegt, Nemegt Basin, Gobi Desert, Mongolia

1. Dorsal vertebra n+1; *a* anterior, *b* left lateral, *c* posterior views.
2. Dorsal vertebra n+2; *a* anterior, *b* left lateral, *c* posterior views.
3. Ungual of pedal digit III; *a* dorsal, *b* ventral views.

All stereophotographs
1 and 2×0.10; 3×0.16

Plate 14

Barsboldia sicinskii gen. et sp.n., type specimen ZPAL MgD-I/110, Nemegt Formation, N Nemegt, Nemegt Basin, Gobi Desert, Mongolia

1. Dorsal vertebra n+7.
2. Dorsal vertebra n+8.
   a anterior, *b* left lateral, *c* posterior views.

All stereophotographs, ×0.10

Plate 15

Barsboldia sicinskii gen. et sp.n., type specimen ZPAL MgD-I/110, Nemegt Formation, N Nemegt, Nemegt Basin, Gobi Desert, Mongolia

1. Right lateral view of sacrum, neural spine of last dorsal and two anterior caudals included.
2. Caudals 5—16 in right lateral view.

All × about 0.10

Plate 16

Barsboldia sicinskii gen. et sp.n., type specimen ZPAL MgD-I/110, Nemegt Formation, N Nemegt, Nemegt Basin, Gobi Desert, Mongolia

1. Dorsals n+3 and n+4; *a* left lateral view, *b* anterior view of dorsal n+3, *c* posterior view of dorsal n+4.
2. Sacrum in ventral view.
3. Left dorsal rib; *a* lateral view, *b* medial view.

1 and 2 stereophotographs, × 0.10
3×0.11

Plate 17

Barsboldia sicinskii gen. et sp.n., type specimen ZPAL MgD-I/110, Nemegt Formation, N Nemegt, Nemegt Basin, Gobi Desert, Mongolia

1. Fragmentary left ilium; *a* medial, *b* dorsal, *c* lateral views, ×0.10.
2. Proximal portion of left dorsal rib; *a* lateral, *b* medial views, ×0.15.

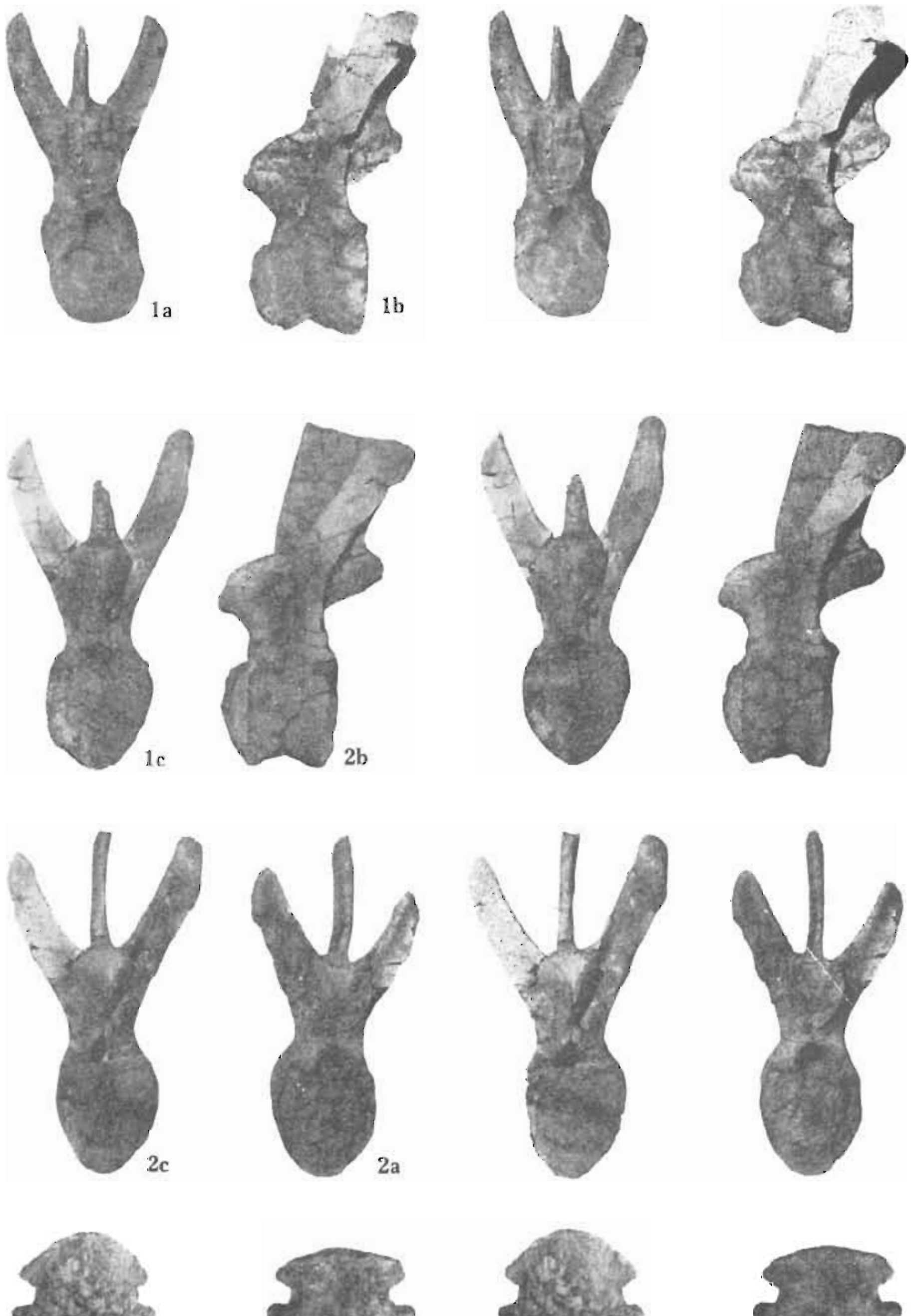
1*a* and 1*c* stereophotographs

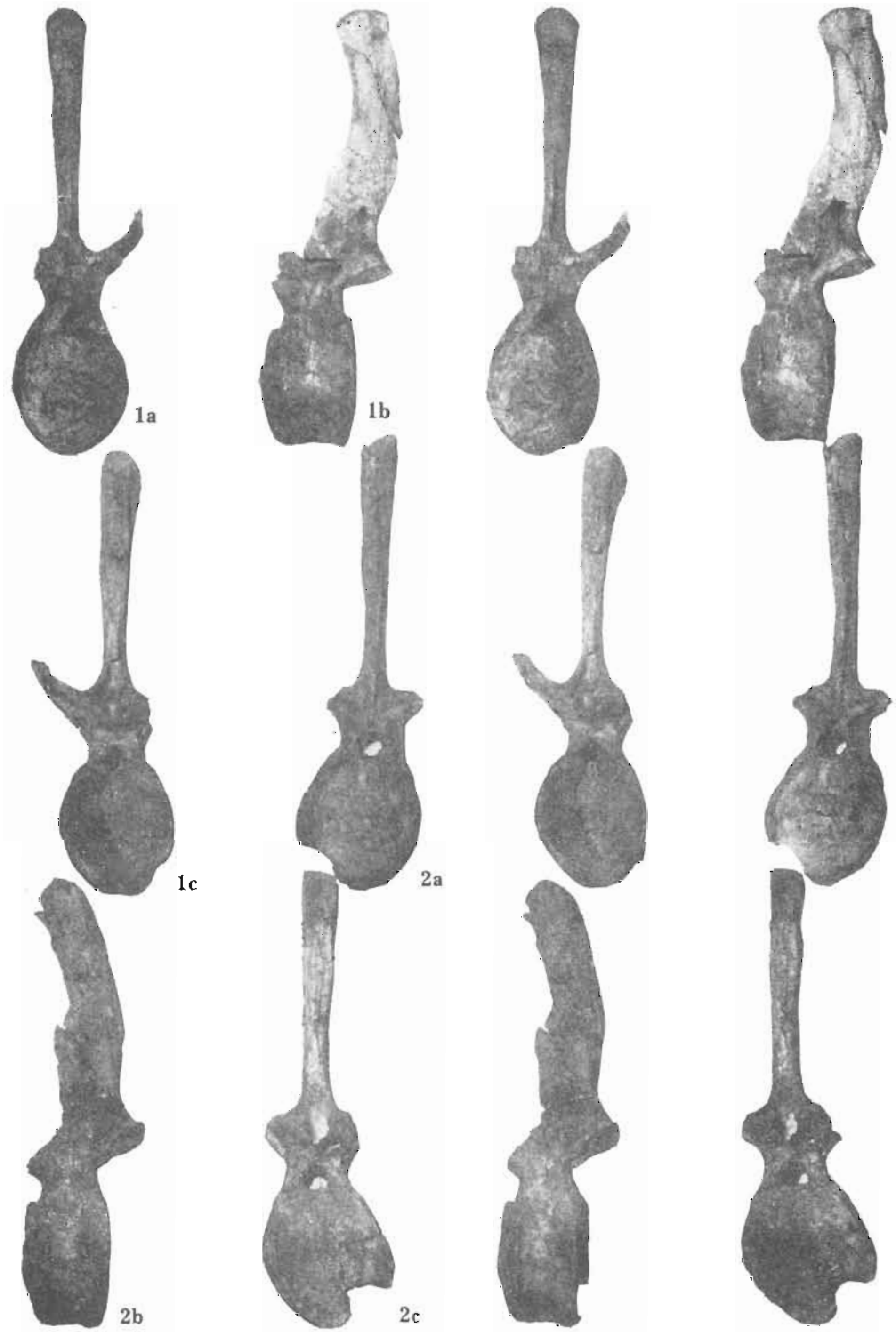
Plate 18

Barsboldia sicinskii gen. et sp.n., type specimen ZPAL MgD-I/110, Nemegt Formation, N Nemegt, Nemegt Basin, Gobi Desert, Mongolia

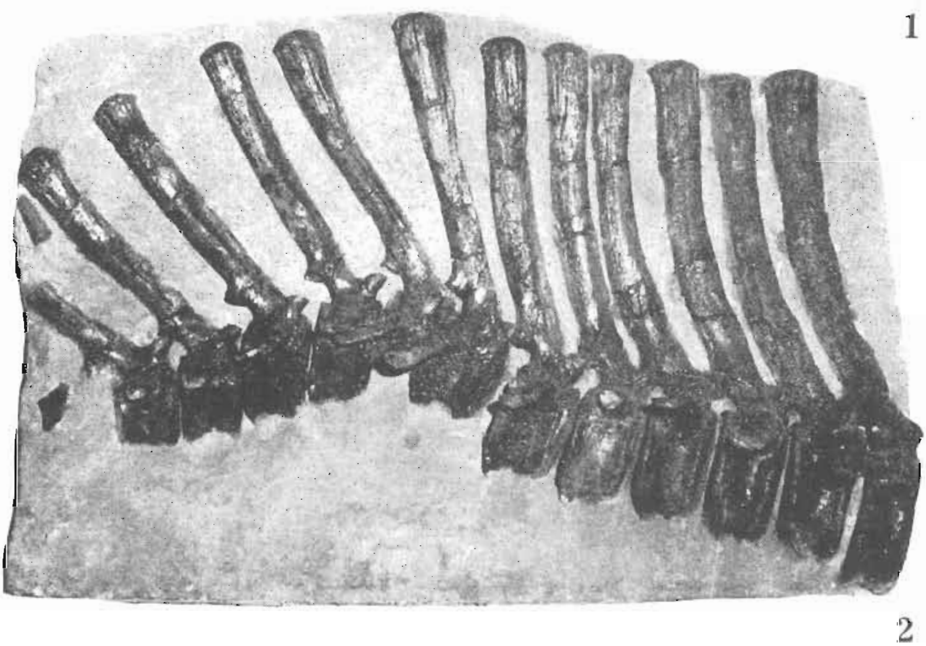
1. Fourth caudal vertebra.
2. ?Seventeenth caudal vertebra.
3. Neural arch of ?eighteenth caudal vertebra.
   a posterior, *b* lateral views.

All stereophotographs, × about 0.15

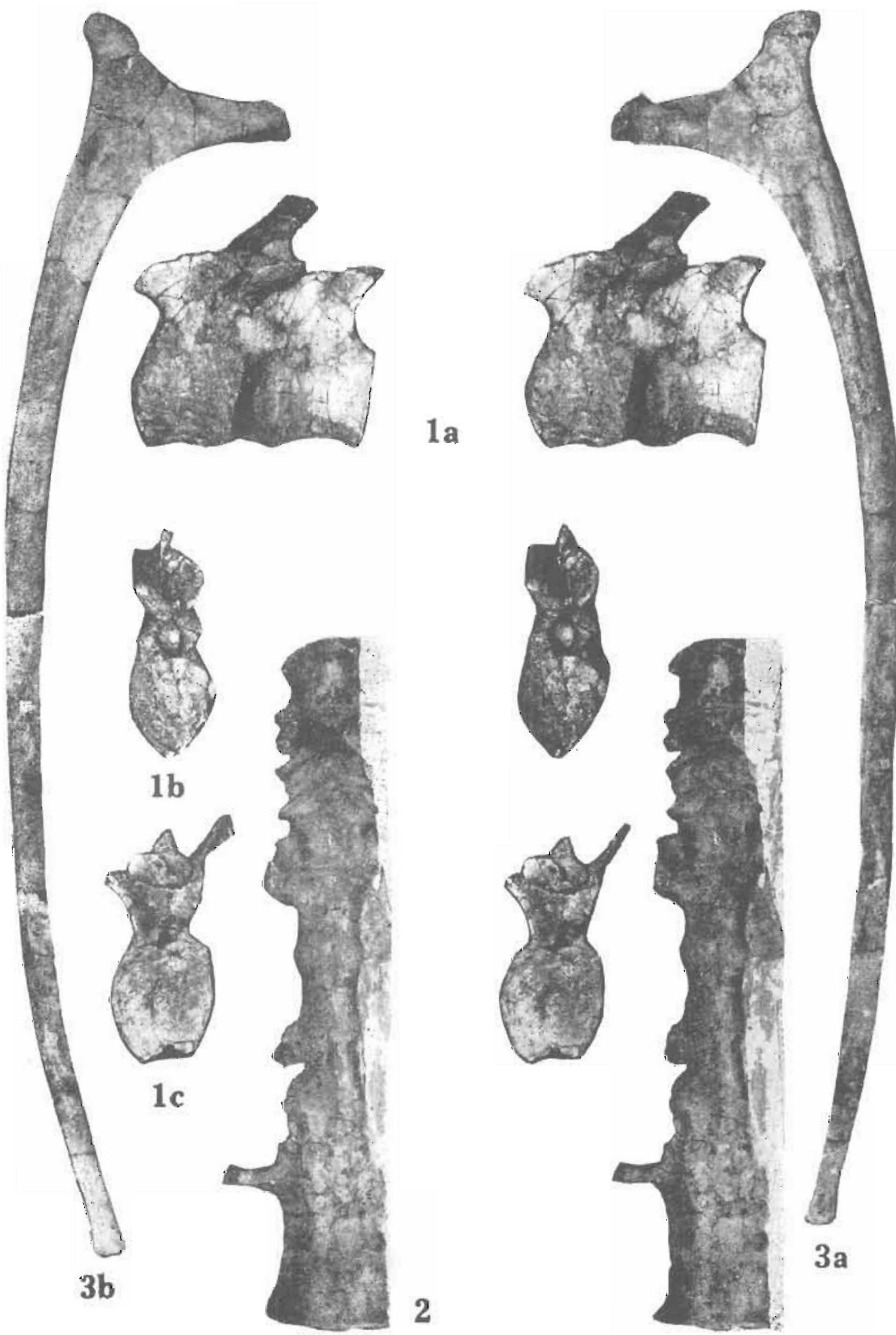

1a
1b
1c
2b
2c
2a
3a
3b


1a
1b
1c
2a
2b
2c

1



2



1a

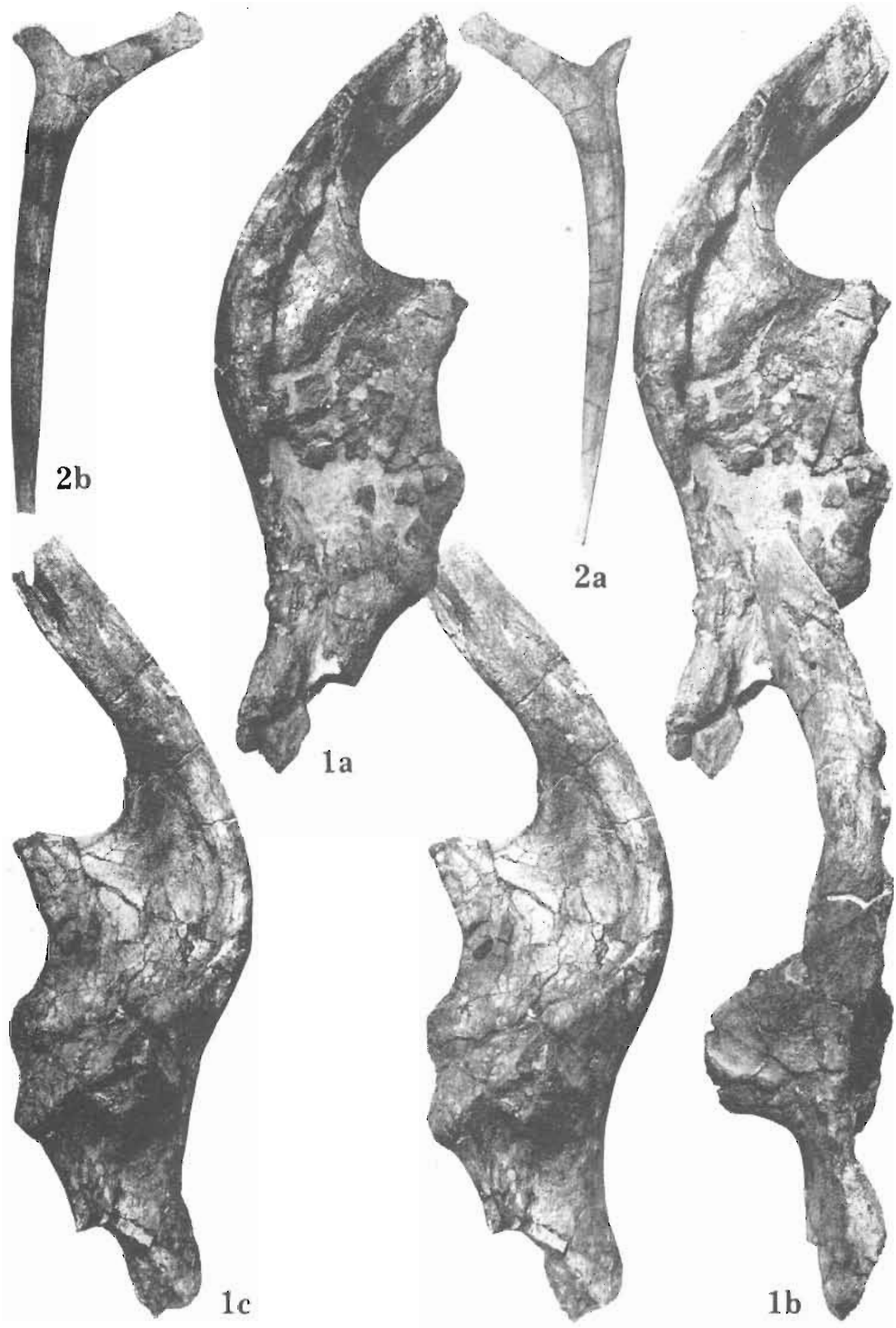
1b

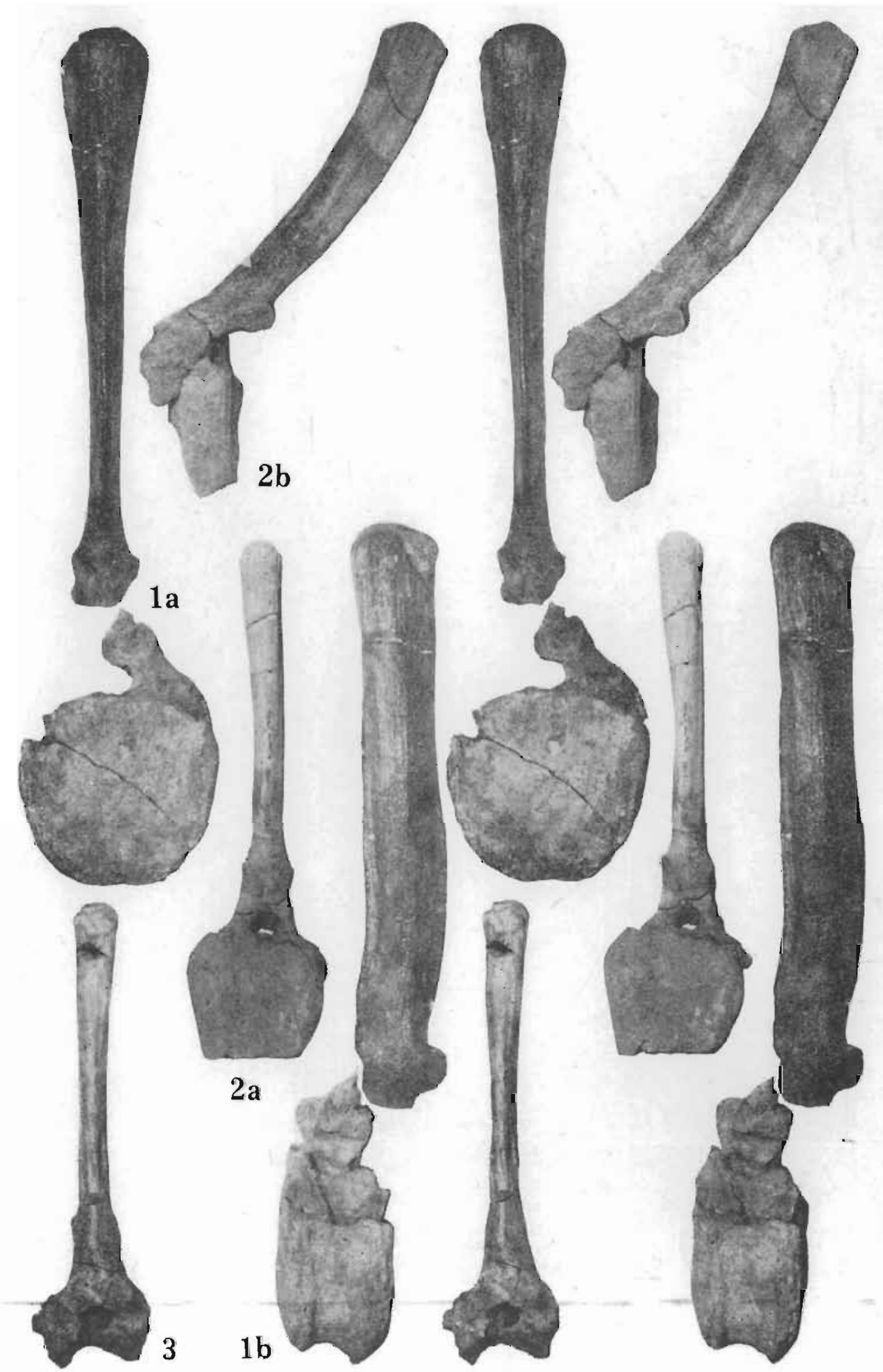
1c

2

3a

3b


2b
1a
2a
1c
1b


2b
1a
2a
3
1b