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ON A NEW TROODONTID (DINOSAURIA, THEROPODA) FROM THE EARLY CRETACEOUS OF MONGOLIA

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Described is a fragmentary juvenile theropod skeleton from the Lower Cretaceous deposits (Barunbayanskaya Svita) of the south-eastern Gobi Desert, Mongolian People's Republic. It displays manus and pes structure typical of the family Troodontidae. The preserved fragments do not allow generic determination.

Key words: Dinosauria, Theropoda, Troodontidae, Cretaceous, Mongolia.

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INTRODUCTION

During the 1979 Soviet-Mongolian Paleontological Expedition some associated bones of a small and supposedly juvenile theropod dinosaur were found by S. M. Kurzanov in deposits of the Barunbayaskaya Svita (?Aptian-?Albian) at the Khamareen Us locality, Dornogov (south-eastern Gobi Desert), Mongolian People's Republic. The specimen displays the manus and pes structure typical of representatives of the family Troodontidae Gilmore, 1924. The manus is the most complete one so far known. This family was until now represented by rare and mostly fragmentary specimens assigned to four species: *Saurornithoides mongoliensis* Osborn, 1924, *S. junior* Barsbold, 1974, *Borogovia gracilicrus* Osmólska, 1987 and *Troodon formosus* Leidy, 1856 (= *Stenonychosaurus inequalis* Sternberg, 1932). The three first mentioned species occur in the Upper Cretaceous (?Santonian-?Late Campanian, ?Early Maastrichtian) deposits of the Gobi Desert, Mongolia; the last occurs in the Campanian deposits of Alberta, Canada. Troodontid indet., described in the present paper, is the first representative of the family found in Lower Cretaceous deposits. The preserved fragments do not provide, however, sufficient diagnostic cha-

racters to allow generic determination. It is also impossible to state whether or not the skeleton displays primitive features in comparison to the Late Cretaceous species.

The specimen is housed at the Paleontology and Stratigraphy Section of the Geological Institute, Mongolian Academy of Sciences, Ulan Bator, abbreviated as SPS.

DESCRIPTION

Family **Troodontidae** Gilmore, 1924
Troodontid indet.
(pls. 49—52; figs. 1—2)

Material. — SPS 100/44 — basal fragment of braincase including: basioccipital with occipital condyle, fragmentary exoccipitals, posterior part of basisphenoid (?), prootics; left quadrate; fragment of right dentary and posterior part of left mandible including: fragments of angular, surangular, splenial, prearticular and articular; damaged neural arches of five cervical vertebrae; fragmentary right manus including: complete metacarpus with fragment of a distal carpal, phalanges I-1, II-1, II-2; left manus phalanx I-1; two almost complete manus unguals and a fragmentary one; fragmentary left and right pedes including: distal end of left femur, distal portions of metatarsi (the right one lacking Mtt I), left phalanx I-1, left and right digits II (the left one lacking ungual), right digit III lacking ungual, abnormally developed left phalanges III-1, III-2, right phalanges IV-1, IV-2 (?), left fragmentary phalanx IV-1, incomplete ungual of the digit IV (?).

Skull (pl. 49: 3, 4; fig. 1A). — Sutures are invisible on the preserved portion of the braincase, thus the identification of included bones was based upon such anatomical features as the nerve openings, remnant of the metotic fissure, etc. The basal tubera are very weakly developed. Medially on the anterior end of the fragment there is a broad, and concave, vertical surface which may represent either a contact surface for the basisphenoid or else the posterior wall of a sinus within the basisphenoid. In the internal aspect, the posterior region of the *medulla oblongata* is very wide and somewhat concave ventrally; the region of the right otic capsule is well preserved and there is a large, round and deep recess visible corresponding to the floccular fossa (= subarcuate fossa of Colbert and Russell 1969; = *recessus interacusticus* of Kurzanov 1976), but much larger than that in most dinosaurs in which this region is known. The recess is bounded posteriorly and ventrally by distinct prominences, which internally contain probably the vestibulum and the semicircular canal respectively (comp. Kurzanov 1976). Anteroventral to the floccular recess are two clusters of foramina, each one located in a depression; the anterior depression contains two foramina — for the VIIth nerve and presumably for a blood vessel, the posterior depression contains three foramina — presumably one or two of them for the branches of the VIIIth nerve. Posteroventral to the floccular fossa there is a semilunate fissure present — the remnant of the metotic fissure — which contained the roots of the IXth to XIth nerves and the jugular vein. Posterior to the fissure and just at the bottom of the endocranial cavity are two openings most likely for two branches of the XIIth nerve. The ventral portion of the foramen magnum seems to be exceptionally wide: almost twice the transverse diameter of the occipital condyle. However, as the dorsoposterior portions of the exoccipitals are not preserved it is imposible to state whether this condition concerns the entire

Table 1

Dimensions (in mm)

Skull	
Occipital condyle, transverse diameter	6
Foramen magnum ,, ,,	11
Length: Occipital condyle — ant. end of the fragment	12
Quadrate, depth	23.5
Forelimb	
Metacarpus, proximal width	12 e
Metacarpal I, length	15
,, I, distal width	5
,, II, length	40
,, II, distal width	5
,, III, length	37 e
,, III, distal width	3 e
Phalanx I—1, length	36
,, I—1, distal width	5
,, I—2, length	18 e
,, I—2, proximal depth (with tuber)	12
,, II—1, length	26
,, II—1, distal width	5
,, II—2, preserved length	24
Hindlimb	
Metatarsal I, length	13
,, II, distal width	8
,, III, distal width	9
,, IV, distal width	9
Phalanx I—1, length	13 e
,, II—1, length	25
,, II—1, proximal width	8
,, II—1, distal width	7
,, II—2, length (ventral)	17
,, II—2, length (dorsal)	12
,, II—2, distal width	5
,, II—3, length	20 e
,, II—3, proximal depth (without tuber)	11 e
,, III—1, length	29
,, III—1, distal width	8
,, III—2, length	17
,, III—2, distal width	6
,, III—3, length	12 e
,, III—3, distal width	5 e
,, IV—1, length	19
,, IV—1, distal width	7 e
,, IV—2 (?) length	13 e

foramen. The occipital condyle is very low and not very prominent. Here again, the rough dorsal surface of the condyle may be evidence that the exoccipitals, which probably participated in its formation, are lacking.

The small size of the basicranium, weakly developed basal tubera, as well as the widely open floccular recess seem to speak for immaturity of the investigated individual. On the other hand, the lack of any visible suture in this part of the

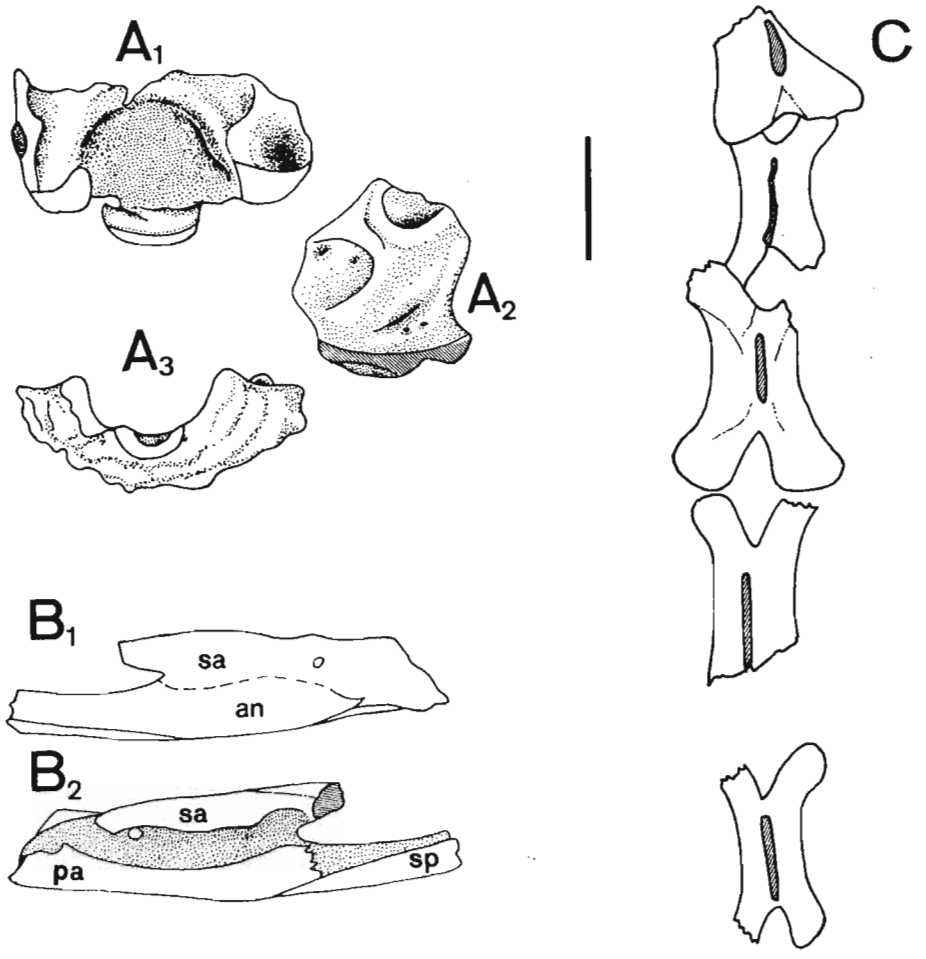

Fig. 1. Troodontid indet. SPS 100/44: *A* basal fragment of braincase, dorsal view (1), right medial view (2), posterior view (3); *B* posterior portion of mandible, external view; *C* dorsal view of cervicals ?2—?6. Abbr.: *an* angular, *pa* prearticular, *su* surangular, *sp* splenial. Scale-bar equals about 1 cm.

skull may be evidence that the animal was not as young as its skull size seems to indicate. The corresponding portion of the skull of *Saurornithoides junior* Barsbold (comp. Barsbold 1974: figs. 1, 2), which is about twice this size, also displays comparatively small basal tubera, although they are more strongly developed than those in the present specimen. The keyhole-shaped foramen magnum of *S. junior* does not resemble the ventrally broad foramen of the specimen described here. However, the difference may be partly due to the above-mentioned fact that large portions of the exoccipitals may be lacking in the latter. The basioccipital — basisphenoid portion of the skull of *Troodon formosus* Leidy (NMC 12340; comp. Russell 1969: 599) is more than twice as large as that of the troodontid indet. and it displays very strongly developed basal tubera and a much more prominent occipital condyle. Both *S. junior* and *T. formosus* are characterized by the presence of a peculiar, deep and spacious middle ear cavity which is partly located on the lateral surface of the basisphenoid, reaching posteriorly to the position of the basal tuber below (in *T. formosus*) or even further backward, almost to the position of the occipital condyle below (in

S. junior). No such structure is visible on the preserved basicranial portion in troodontid indet. If a similarly developed middle ear cavity was also present in the latter, its absence might be related to the presumed immaturity of this individual. Otherwise, the lack of this depression might be considered a primitive condition in the early Troodontidae.

The quadrate has not been thus far described in any troodontid, being totally absent in specimens of *S. junior* and *T. formosus* while represented only by a pterygoid wing in *S. monogliensis* (*fide* Russell 1969: 607). The quadrate of troodontid indet. has not preserved the pterygoid wing. The shaft is gently concave posteriorly and bears a small foramen on its posterolateral surface which leads into a blind canal; there is a single articular head on the proximal end; the distal end is transversely widened and has two condyles for articulation with the mandible, the medial one being somewhat larger and more convex ventrally.

Mandible (pl. 49: 1, 2; fig. 1B). — The preserved fragment of dentary comes from the middle portion of the bone and contains four teeth; anteriorly to the preserved teeth there is one alveolus and posterior to the teeth are two alveoli. Along the external surface, close to the dorsal margin runs a deep groove within which foramina for blood vessels are aligned (comp. Carpenter 1982). The groove seems to be characteristic of the Troodontidae as it is present in all adequately known species. Although the aligned foramina on dentary are also known in other theropod families, to our knowledge they are not located within a distinct groove. Internally, the dentary does not differ from those known in other troodontids; it displays a narrow Meckelian groove. The articular cotylus on the posterior portion of the mandible is too fragmentary to allow a description. It seems that the mandibular fenestra was comparatively large. The sutures are weakly visible due to the poor state of preservation of the fragment. The retroarticular process is not preserved. This posterior portion of mandible is reminiscent of that described in the deinonychosaurs (Colbert and Russell 1969, Ostrom 1969) but it is much shallower.

Dentition. — Preserved mandibular teeth are small (2.5—3 mm long), and posteriorly recurved. Posterior edge of the crown is serrated, the number of denticles being 6—7 per 2.5 mm; serrations are perpendicular to the vertical axis of the tooth; the crown tip is directed posteriorly and almost parallel to the crown base.

Vertebral column (fig. 1C). — The only preserved portion of the vertebral column contains a series of five cervicals of which only the arches are preserved sufficiently to permit their shape to be determined. The vertebrae are elongated measuring about 22 mm to no more than 25 mm, the posterior ones being longer. The neural spines are damaged, but one can see that they were anteroposteriorly long and presumably low. The first vertebra of the preserved series lacks the very anterior portion; it seems to represent the axis, judging by the broad, plate-like postzygapophyses, the lateral edges of which diverge somewhat posteriorly. Similarly-shaped postzygapophyses are present on the second cervical of *Gallimimus bullatus* (comp. Osmólska, Roniewicz and Barsbold 1972, pl. 38: 1b; pl. 52: 2a). The last preserved cervical in the series (the sixth?) displays almost parallel postzygapophyses.

Forelimb (pl. 50: 1—4; fig. 2A, B). — Of the carpus there is preserved only a distal element closely adhering to the proximal surfaces of metacarpals I and II. It has a roughly semilunar shape. Whether there occurs a groove across its proximal surface, as in *T. formosus* (comp. Russell 1969: fig. 10a, b), is impossible to state. The manus is tridactyl. The naturally articulated metacarpus is slightly arched transversely. Metacarpal I is thicker than metacarpal II and its length is 37% of the length of the latter. Metacarpal III is somewhat shorter than metacarpal II and only slightly thinner than the latter. Phalanx II-2 is incomplete; it was as long as, or even longer than the preceding one, but thinner. The three separate almost complete manus unguals preserved are strongly compressed, well curved, with strong

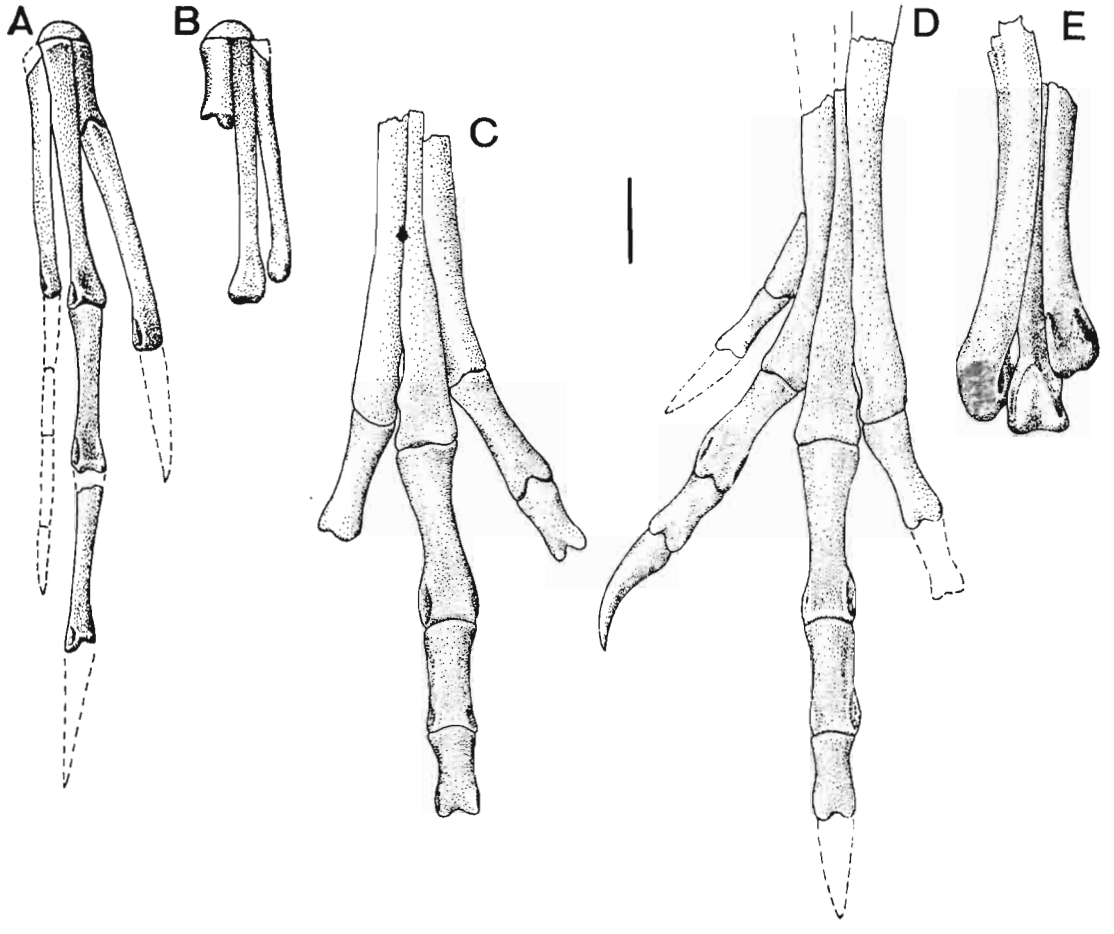

Fig. 2. Troodontid indet. SPS 100/44: *A* reconstruction of right manus with a carpal element, dorsal view; *B* right metacarpus, ventral view; *C* fragmentary right pes, position of metatarsal I as preserved, dorsal view; *D* fragmentary left pes, position of metatarsal II as preserved, dorsal view; *E* fragment of left metatarsus, ventral view. Scale-bar equals 1 cm.

flexor tubers; they lack the dorsoproximal "lip", such as is present in *Chirostenotes* and *Elmisaurus* (comp. Gilmore 1924, Osmólska 1981).

Hind limb (pl. 51, 52; fig. 2C—E). — There are only fragmentary pedes representing the hind limbs. The pes is tetradactyl. The metatarsus (known only distally) is slender and compact and presents the structure characteristic of all troodontids. The preserved length of the left metatarsus is 65 mm, which might correspond approximately to less than half of its total length. Metatarsal I is reduced, wedge-like, with an undivided distal articular surface. It is very similar to metatarsal I in *T. formosus*. It was found separated from the rest of the metatarsus and its exact position against metatarsal II cannot be determined. Metatarsal II deviates slightly medially; its distal articular surface is asymmetrically divided, the lateral condyle being the larger; the medial *fovea ligamentosa* is absent while the lateral one is well developed. There is a difference in position of the metatarsal II in each of the pedes: in the left, the distal surface is lower than in the right (fig. 2C, D). The preserved fragment of left metatarsus seems to be naturally articulated, thus this position is here considered as the proper one. However, comparing the position of metatarsal II within the metatarsus of *T. formosus*, the only troodontid species in which the complete metatarsus is known and adequately illustrated (comp. Russell 1969: fig. 12), one notices that the distal articular surface is higher up than that of the left pes in the troodontid indet. Metatarsal III is the longest, wedged between the adjoining ones and visible anteriorly up to its preserved end. Its distal articular surface is symmetrically divided by a shallow, broad groove; this surface extends posteroproximally in the form of a symmetrical tongue. Both foveae ligamentosae of metatarsal III are deep. Metatarsal IV is the strongest; it is longer than metatarsal II and only a little shorter than metatarsal III; posteriorly it develops a wing along its medial edge which results in both metatarsals II and IV almost covering metatarsal III posteriorly, a short distance above the distal end of the former. The distal articular surface of the metatarsal IV is undivided and faces somewhat laterally.

Phalanx I-1 is reduced. Phalanx II-1 is comparatively slender with a concave proximal articular surface divided only at the ventral edge; the distal surface is strongly ginglymoid, extends far onto the extensor surface and is flat ventrally; the *foveae* are deep, especially the medial one. Phalanx II-2 is shorter, comparatively slender, with enlarged proximal articular surface due to the backward prolongation of its ventral portion; the distal articular surface of this phalanx is ginglymoid and extends far ventroproximally; the *foveae* are deep. The ungual of the digit II is moderately curved, compressed and not very large, but with a large flexor tuber. The proximal articular surface of the ungual is very deep and distinctly divided by a median ridge.

Phalanx III-1 is comparatively slender and long; its proximal articular surface is symmetrically, but weakly, divided; the distal articular surface is very faintly ginglymoidal, the median groove being broad and shallow; the *foveae ligamentosae* are deep and large. Phalanx III-2 is much shorter than the preceding one and also has weakly-divided proximal and distal articular surfaces. Phalanx III-3 is the shortest of the three and also has a weak gingylmus.

Two phalanges are preserved of digit IV. One of them represents phalanx IV-1; it is comparatively long, about the length of phalanx III-2. Another phalanx is somewhat shorter than phalanx IV-1; it has a badly-preserved articular surface and it is difficult to state for sure whether it represents the phalanx IV-2 or IV-3, although the former determination is the more probable. There is also a fragment of a small ungual preserved, which is considered here to represent most probably that of the fourth digit; the ungual is weakly curved and weakly compressed lateromedially.

DISCUSSION

Within the Troodontidae, the basicranium has been adequately described only in two Upper Cretaceous specimens assigned to *Troodon formosus* (Russell 1969) and to *Saurornithoides junior* (Barsbold 1974, 1983). The skull fragment belonging to the specifically and generically undeterminable young Lower Cretaceous specimen, described in the present paper as the troodontid indet., has comparably small basal tubera, as has *S. junior* and in this respect it differs considerably from *T. formosus* in which the tubera are strongly developed. Although the known sample of troodontid skulls is too small and too fragmentary to solve the problem of whether *Saurornithoides* is a synonym of *Troodon* (comp.: Russell 1969, Barsbold 1974, Carpenter 1982, Osmólska 1987), it seems that the small basal tubera may be characteristic of the Asian line of the family (they are also small in *S. mongoliensis*) while the larger ones may be characteristic of the North American lineage. The minute basioccipital UCM 43218, considered by Carpenter (1982) as belonging to a hatchling of '*Saurornithoides inequalis*' (Carpenter regards *Stenonychosaurus* (= *Troodon*) as the junior synonym of *Saurornithoides*) also has small basal tubera, but one can agree with that author that it may be due to the immaturity of the individual. Nevertheless, this hatchling basioccipital already displays "the occipital condyle well developed and separated from the main body of the basioccipital by a constricted neck" (Carpenter 1982: 129). This is not the case in the occipital fragment of the much larger troodontid indet. as the condyle is less distinctly separated than in any other troodontid described.

The total length of skull in the specimen described in the present paper cannot be estimated with confidence, as only a portion of its basicranium is preserved. However, comparing corresponding parts of basicrania in the types of *S. mongoliensis* (AMNH 6516) and *S. junior* (SPS 100/1), as well as in *T. formosus* (NMC 12340), one can estimate that the skull in the troodontid indet. was about the size of that in *S. mongoliensis* which is 216 mm long (*fide* Russell 1969) or even somewhat smaller. This estimation of the skull size is in accordance with data obtained from postcranial measurements. Comparing the lengths of some pedal phalanges (Table 2) in AMNH 6516 and in the here-described specimen SPS 100/44 (these are the only postcranial bones duplicated in both specimens) one notices that the length differences are generally within 2.5 mm to 4 mm, depending on the phalanx. Some greater discrepancies concern the ungual of the second toe which is much longer in *S. mongoliensis*, as well as the relatively much longer distal phalanges (2 and 3) of the third toe in the latter species.

The metacarpus described in the present paper is the only known complete metacarpus in the troodontids. As well, no complete manus

phalanges were so far reported. The data provided by the here described specimen support Russell's (1969) conclusion that the manus in *T. formosus* was less delicately proportioned than in *Chirostenotes pergracilis*. There is, however, no evidence that the third digit was opposable as suggested by Russell and Séguin (1982).

Table 2

Pedal phalanges lengths in three troodontid species
(in mm)

	Saurornithoides mongoliensis AMNH 6516*	troodontid indet. SPS 100/44	*Troodon formosus* NMC 8539*
Phalanx I—1	16	13 e	29 e
„ I—2	> 21	—	45 e
„ II—1	27.5	25	50.5
„ II—2	14	12	29
„ II—3	34	20 e	—
„ III—1	33 e	29	66 e
„ III—2	24 e	17	41.2
„ III—3	—	12 e	39.3
„ III—4	—	—	55.0
„ IV—1	—	19	34.2 e

* —*fide* Russell 1969: tables 5 and 7,
e —estimated
— element absent or not measured.

The differences in the second and third pedal toes might warrant a more definite taxonomic status for the troodontid indet., especially taking into account its older, Lower Cretaceous, stratigraphic age. However, incompleteness and rather bad preservation state of that specimen, the probability of its being immature, and the scarcity of data concerning its skull structure, all make it impossible to distinguish any reliable diagnostic characters, either on the generic or specific level.

Taxonomic status of the Saurornithoididae Barsbold, 1974 *versus* Troodontidae Gilmore, 1924, as well as synonymies of the genera included, have been recently discussed by Currie (1987) whose opinions are followed in the present paper.

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NOWY PRZEDSTAWICIEL RODZINY TROODONTIDAE (DINOSAURIA, THEROPODA) Z DOLNEJ KREDY MONGOLII

Streszczenie

Opisano niekompletny szkielet dinozaura z grupy teropodów, reprezentujący przypuszczalnie młodego osobnika. Okaz został znaleziony w 1979 roku przez radziecko-mongolską ekspedycję w osadach dolnej kredy południowo-wschodniej Gobi, Mon-

golia. Budowa ręki oraz stopy wskazuje, że jest to przedstawiciel niewielkiej i słabo poznanej rodziny Troodontidae. Dinozaury zaliczane do tej rodziny były dotychczas znane tylko z osadów górnej kredy w Azji (Mongolia) i Północnej Ameryce (Kanada, USA).

Większość przedstawicieli Troodontidae wykazuje szczególną specjalizację drugiego palca stopy, który ma zwiększony zakres ruchomości w płaszczyźnie pionowej i znacznie powiększony, zakrzywiony pazur. Te cechy były już wykształcone u dolnokredowych Troodontidae. Nie stwierdzono natomiast innej charakterystycznej cechy, występującej u górno-kredowych Troodontidae — powiększonej jamy ucha środkowego. Mimo pewnych różnic, znaczna niekompletność szkieletu nie pozwala na wyróżnienie istotnych cech diagnostycznych, rodzajowych i gatunkowych.

Praca była wykonana częściowo w ramach problemu CPBP.04.03 oraz w ramach współpracy między Polską i Mongolską Akademią Nauk (temat 2).

EXPLANATIONS OF PLATES 49—52

Plate 49

Troodontid indet., SPS 100/44

1. Posterior part of left mandible, *a* external, *b* internal, *c* dorsal, views.
2. Fragment or right dentary, *a* external, *b* internal, views.
3. Fragment of basicranium, *a* dorsal, *b* lateral, *c* ventral, views.
4. Left quadrate, posterior view.
5. Distal part of left femur, *a* anterior, *b* posterior, views.
6. Fragment of ?left femoral shaft.

Khamareen US, south-eastern Gobi Desert, Mongolia, Barunbayanskaya Svita, Early Cretaceous (?Aptian — ?Albian)

1—4×2; 5, 6×1

Plate 50

Troodontid indet., SPS 100/44

1. Right metacarpus with phalanges: I-1, II-1, II-2 and a fragment of a distal carpal attached, *a* palmar, *b* dorsal, views.

2—4. Manus unguals.

Khamareen US, south-eastern Gobi Desert, Mongolia, Barunbayanskaya Svita, Early Cretaceous (?Aptian — ?Albian)

Plate 51

Troodontid indet., SPS 100/44

1. Fragmentary right pes with phalanges: II-1—II-3, III-1—III-3, IV-1, ?IV-5, *a* dorsal, *b* plantar, views, *c* lateral view of second digit.

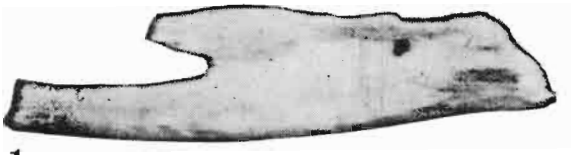
Khamareen US, south-eastern Gobi Desert, Mongolia, Barunbayanskaya Svita, Early Cretaceous (?Aptian — ?Albian)

Plate 52

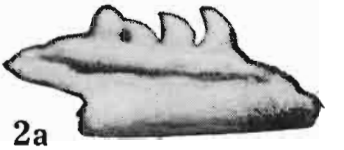
Troodontid indet., SPS 100/44

1. Fragmentary left pes with phalanges: I-1, II-1, II-2, III-1, III-2, *a* dorsal, *b* plantar, views, *c* medial view of second digit lacking ungual.

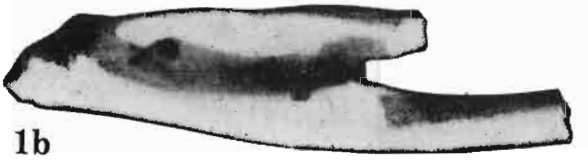
Khamareen US, south-eastern Gobi Desert, Mongolia, Barunbayanskaya Svita, Early Cretaceous (?Aptian — ?Albian)



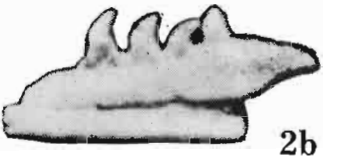
1a



2a



1b



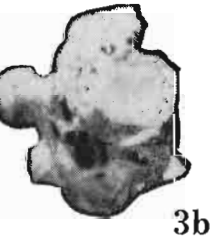
2b

6

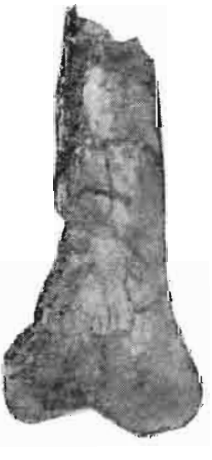
4

3a

1c

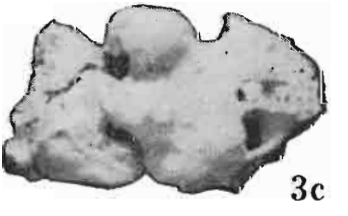


3b

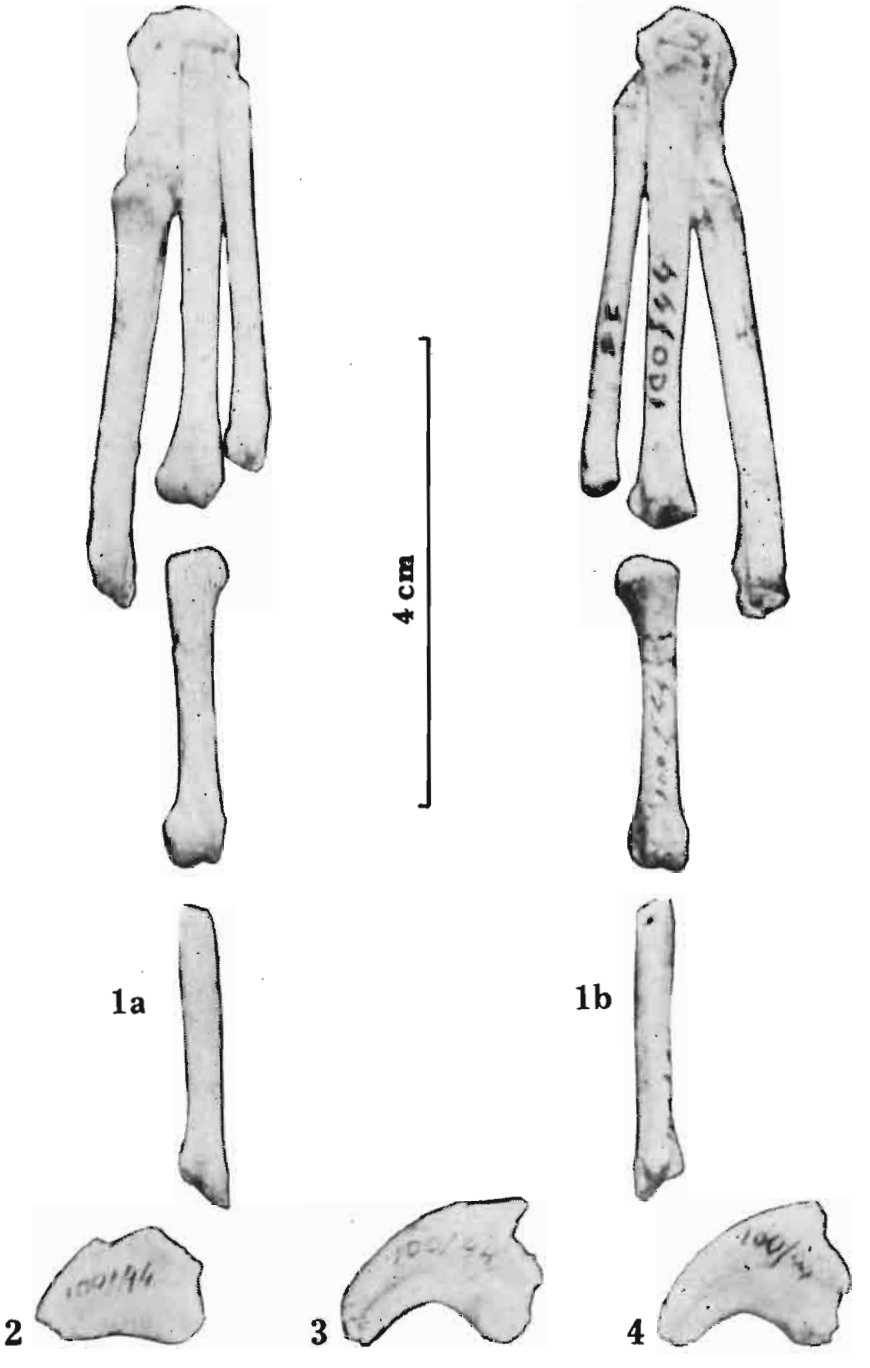


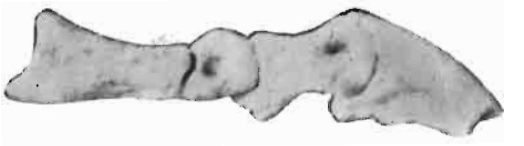
5a

5b

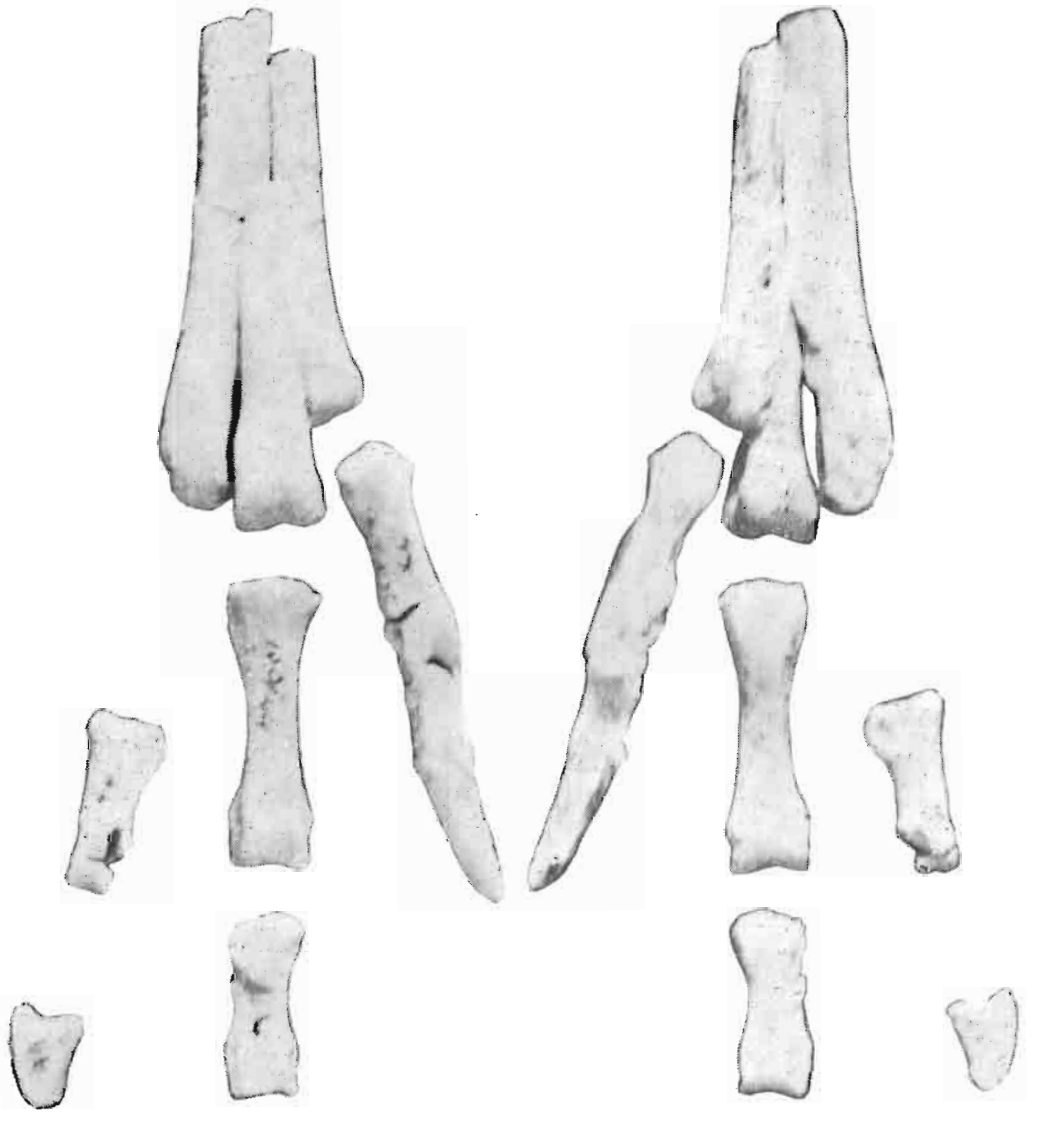


3c


4 cm
1a
1b
2
3
4



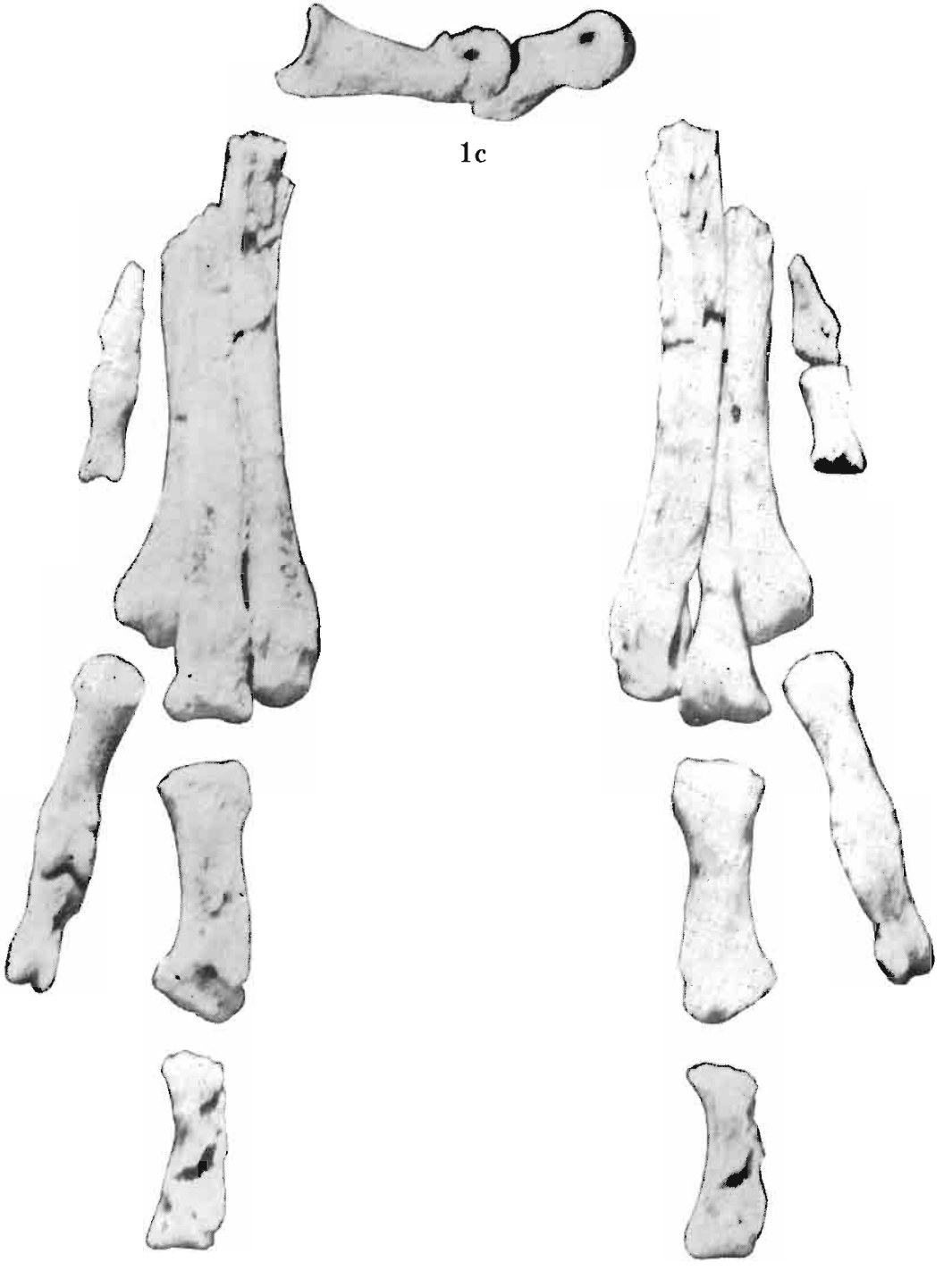
1c



3 cm

1a

1b


1c
1a
3 cm
1b