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THE FORGOTTEN DINOSAURS OF ZHETYSU (EASTERN KAZAKHSTAN; LATE CRETACEOUS)

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ABSTRACT

The Late Cretaceous dinosaur-bearing localities discovered in the Ili River Basin in the foothills of Dzhungar Alatau, in the center of the historical region Zhetysu (Semirechie), in 1925–1927 are among the first occurrences for dinosaurs discovered in Asia. Preliminary identifications of dinosaurian remains from the Zhetysu localities, reviewed by Nesov (1995a), included Sauropoda, Tyrannosauridae, Hadrosauridae, Ankylosauridae, and possible Ceratopsidae. The only previously described specimen from this assemblage is a tibia attributed to cf. Ceratopsia by Riabinin (1939) from the Kara-Cheku locality. This bone is considered currently as Dinosauria indet. We describe here the most important find from this fauna to date, a partial tyrannosaurid dentary collected by a team from the Institute of Zoology of the Kazakh Academy of Sciences at the Kara-Cheku locality in 1950. This specimen can be confidently identified as a derived tyrannosaurine based on the incrassate teeth and the small first alveolus. This is the first record of a tyrannosaurine from the Late Cretaceous of Kazakhstan and Middle Asia. The age of Zhetysu dinosaur fauna is possibly Campanian or Maastrichtian.

Key words: Dinosauria, Kazakhstan, Late Cretaceous, Tyrannosauridae, Zhetysu

ЗАБЫТЫЕ ДИНОЗАВРЫ СЕМИРЕЧЬЯ (ВОСТОЧНЫЙ КАЗАХСТАН; ПОЗДНИЙ МЕЛ)

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РЕЗЮМЕ

Местонахождения позднемеловых динозавров, открытые в 1925–1927 гг. в бассейне р. Или в предгорьях Джунгарского Алатау, в центре исторической области Семиречье (Жетысу), являются одними из первых известных динозавровых местонахождений в Азии. Предварительные определения динозавров из местона-

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хождений Семиречья, ревизованные Несовым (1995), включают Sauropoda, Tyrannosauridae, Hadrosauridae, Ankylosauridae и, возможно, Ceratopsidae. Единственный экземпляр динозавра, описанный ранее из этой фауны, это большая берцовая кость, отнесенная к cf. Ceratopsia Рябининым (1939). Данная находка не может быть определена точнее чем Dinosauria indet. В данной работе мы описываем наиболее важную находку известную в настоящее время из этой фауны – зубную кость тираннозаврида, найденную в 1950 г. сотрудниками Института Зоологии Казахстана в местонахождении Кара-Чеку. Этот экземпляр может быть надежно определен как Tyrannosaurinae indet. по наличию утолщенных зубов и мелким размерам первой зубной альвеолы. Это первая находка продвинутого тираннозаврина в позднем мелу Казахстана и Средней Азии. Возраст динозавровой фауны Семиречья, скорее всего, кампан или маастрихт.

Ключевые слова: динозавры, Казахстан, поздний мел, Tyrannosauridae, Семиречье

INTRODUCTION

In Kazakhstan four principal areas have yielded fossil remains of the Late Cretaceous dinosaurs (Fig. 1A): 1) the northeastern Aral Sea region; 2) southern Kazakhstan; 3) the valley of the Ili River; and 4) the Lake Zayssan depression in eastern Kazakhstan. In the last area only fragments of dinosaurian egg-shell have been known from the Manrak Formation on the Taizhuzgen River since 1959 (Nesov 1995a and references therein). Three other areas have occurrences of dinosaurian remains. The most productive is the Bostobe Formation in the northeastern Aral Sea region, which has yielded the stem lambeosaurine *Aralosaurus tuberiferus* Rozhdestvensky, 1968 and various theropods (Rozhdestvensky 1968; Nesov 1995a; Dyke and Malakhov 2004; Averianov 2007 and references therein). The first dinosaurian bones were discovered there in 1956 (Rozhdestvensky 1964). The Syuk Syuk Formation in southern Kazakhstan has yielded remains of the lambeosaurine *Jaxartosaurus aralensis* Riabinin, 1939 as well as indeterminate sauropods, ankylosaurs, and theropods (Riabinin 1939; Rozhdestvensky 1968; Nesov 1995a). Dinosaurian bones were first discovered in this unit in 1923 (Riabinin 1939).

The valley of the Ili River is a part of the historical region Zhetysu (Kazakh) or Semirechie (Семиречье, in Russian), which translates into English as "seven rivers." This territory was the eastern part of the Russian Turkestan and now corresponds to the southeastern part of Kazakhstan and most of Kyrgyzstan. Zhetysu encompasses the basins of seven rivers, of which the Naryn, Chu, and Ili rivers are the largest, and two large lakes (Balkhash and Issyk Kul).

The three dinosaur-bearing localities in the valley of the Ili River were discovered in 1925, 1926, and 1927, shortly after the first discovery of dinosaurs in southern Kazakhstan (Kirikov 1927a, b; Yakovlev 1929). In 1928 a Swedish expedition led by the legendary explorer Sven Hedin found several complete sauropod skeletons in Jurassic strata of the neighboring Chinese part of Dzungaria (now the northern region of the Xinjiang Uyghur Autonomous Region of China). Young (1937) later assigned these finds to a new taxon, *Tienshanosaurus chitaiensis* Young, 1937. Between 1922 and 1925 the famous Central Asiatic Expeditions of the American Museum of Natural History explored the Gobi Desert of Mongolia and discovered complete dinosaurian skeletons and the first undisputed dinosaurian eggs and nests (Andrews 1932). Inspired by these discoveries, the Academy of Sciences of the USSR sent two expeditions to Zhetysu (in 1927 and 1929) to search for additional dinosaurian fossils (Gartman-Veinberg 1927; Efremov 1931). The results of these expeditions were for the most part disappointing as no complete or even partially articulated dinosaurian skeletons were recovered. Since that time the Cretaceous vertebrate sites in eastern Kazakhstan have not been considered promising for further exploration and have rarely been visited by paleontologists (Efremov 1931, 1933, 1944; Yur'ev 1954; Rozhdestvensky 1964; Rozhdestvensky and Khozatsky 1967). This report summarizes the known data about the Late Cretaceous dinosaur-bearing localities in the Ili River valley and their potential for future investigation.

Institutional abbreviations. CCMGE, Chernyshev's Central Museum of Geological Exploration, Saint Petersburg, Russia; IZK, Institute of Zoology, Almaty, Kazakhstan; ZIN PH, Zoological Institute of the Russian Academy of Sciences, Paleoherpetological Collection, Saint Petersburg, Russia.

LATE CRETACEOUS VERTEBRATE LOCALITIES IN THE ILI RIVER VALLEY

1. Karaoi (= Karoi), Almaty Province, Kazakhstan (Fig. 1B). The local area Karaoi (meaning "black lowland"; "local area" is used here as the translation of the Russian geographic term "урочище") is situated on the left bank of the Ili River between the Kurtu River (to the north and west), the Ili River (to the east), and the sands of the Moin-Kum (to the south) (Fig. 1B). In 1927 D.I. Yakovlev discovered fragments of large dinosaurian bones in a dry creek near the well Sary-Kuduk in a layer of brown conglomerate (Yakovlev 1929). According to Efremov (1944), the bones are light grey in color, fragmentary, and water-worn. Efremov (1944) listed remains of Hadrosauridae, Ornithomimidae and Trionychidae for this locality. Additional dinosaurian bones were recovered in this area, specifically in Tassai Creek, during the 1950s (Bazhanov and Kostenko 1958).

2. Shokpakty-Ozek, a dry creek on the left tributary of the Kerbulak River, which is a right tributary of the Ili River in Almaty Province, Kazakhstan (Fig. 1B). Dinosaurian bones and silicified tree trunks were discovered in sandy deposits (Bazhanov and Kostenko 1958).

3. Zholaman, village and railway station on the Turkestan-Siberia Railway between Saryozek and Almaty, in the Arkarly Mountains in Almaty Province, Kazakhstan (Fig. 1B). Dinosaurian bones and silicified tree trunks were found in the vicinity of the railway station (Bazhanov and Kostenko 1958; Nurumov 1964).

4. Kara-Cheku (= Karachoku, Karacheko, Karashoky, Dzhurtan, Dzhurtas, Dzhurmas), 2 km southwest of the Kara-Chok village, on the right bank of the Ili River, Almaty Province, Kazakhstan (Fig. 1B; Efremov 1944 erroneously indicated a position on the left bank of the Ili River). The first dinosaurian bones were discovered at this locality by A.P. Kirikov during prospecting for manganese in 1926 (Kirikov 1927a, b). Kirikov found abundant dinosaurian bones in the Dzhurtan dry creek 2 km southwest of the Kara-Chok village. Based on identifications by A.N. Riabinin (cited by Kirikov 1927b) these materials included remains of Hadrosauridae and Ceratopsidae, the last family likely represented by *Triceratops* Marsh, 1889. In 1927 the locality was further explored by the Ili Expedition of the Academy of Sciences (Efremov 1931), and limited excavation was undertaken by E.I. Belyaeva and M.G. Prokhorov from the Paleontological Institute in Moscow. Large dinosaurian bones and pieces of tree trunks were found in cross-bedded black conglomerates. According to Riabinin (1939) the dinosaurian material from Kara-Cheku consists of poorly preserved bone fragments of Hadrosauridae and Stegosauria. Riabinin (1939, pl. 14, fig. 2) figured a left tibia (cataloged as CCMGE 74/5009) from Kara-Cheku and referred it to cf. Ceratopsia. This specimen can no longer be located in the CCMGE collection and thus its affinities cannot be assessed. However, the proportions of this bone and lack of partial co-ossification with the astragalus differ from those in Ceratopsidae (e.g., Hatcher et al. 1907: pl. 16). Efremov (1944) cited for the Kara-Cheku locality the occurrence of Hadrosauridae, Tyrannosauridae, Ornithomimidae, numerous bones of Sauropoda (Titanosauridae), possible Stegosauria and "Acanthopholidae" [=Nodosauridae], as well as numerous shell fragments referable to Trionychidae. The reports of stegosaurs and nodosaurs are probably based on remains of Ankylosauridae (Nesov 1995). A.K. Rozhdestvensky (1964) mentioned the occurrence of dinosaurian skull and jaw fragments at this locality but did not consider the site promising for further work.

In 1950s the locality was revisited by paleontologists from the Laboratory of Paleobiology of the Institute of Zoology of the Kazakh Academy of Sciences (Bazhanov and Kostenko 1958). One dinosaurian bone fragment from this locality was subsequently analyzed to determine its chemical composition (Bazhanov 1947). Later Bazhanov and Kostenko (1958: p. 13) reported the discovery at Kara-Cheku of a partial mandible of "*Tiranosaurus* [sic] sp., similar to *T. baator* [sic] from the Late Cretaceous of Mongolia." It was stated that V.S. Bazhanov collected this specimen in 1951, but this date was corrected to 1950 by a hand-written note (possibly made by the author) in the personal copy of the book belonging to one of us (AA). The specimen was also mentioned in the editorial footnote to the paper by Khozatsky (1957: p. 20) devoted to the history of trionychid turtles in Kazakhstan as a lower jaw of "*Tiranosaurus* [sic] aff. *bater* [sic] from Karacheko."

The jaw fragment (Fig. 2A-C) is now on display at the Museum of Nature in Almaty where it is accompanied by the label "*Tirannosaurus* [sic] sp., a carnivorous tyrannosaur; jaw fragment; Sary-Ozek,

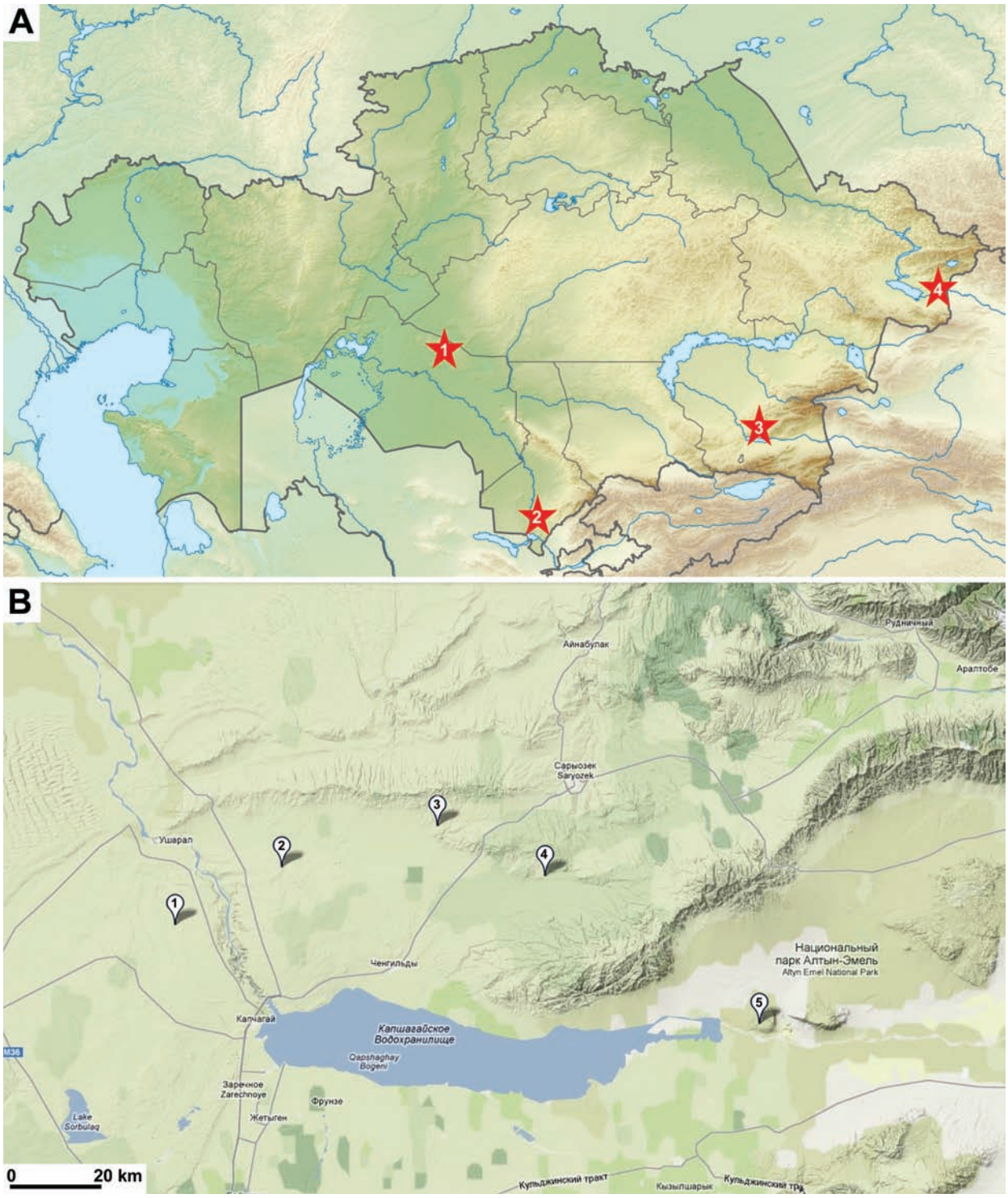

Fig. 1. Map of Kazakhstan (A) showing position of the principal areas with dinosaur localities (1, northeastern Aral Sea region; 2, southern Kazakhstan; 3, valley of the Ili River; 4, Lake Zayssan depression) and map of the valley of the Ili River (B) in the southwestern foothills of Dzhungar Alatau in eastern Kazakhstan with position of dinosaur-bearing localities (1, Karaoi; 2, Shokpakty-Ozek; 3, Zholaman; 4, Kara-Cheku; 5, Kshi-Kalkan). Map B is modified from http://maps.google.ru/maps.

local area Karaoi; collected by V.V. Kuznetsov; identified by T.N. Nurumov" (Fig. 2D).

L.I. Khozatsky (1957: p. 19) noted shell fragments of unusually large trionychid turtles in the collection made during the excavation in "Dzhurmas" [=Dzhurtan] Creek in 1927. He erroneously thought that Dzhurtan Creek is part of the Kshi-Kalkan locality (see below). The editorial footnote to this paragraph indicated that "this locality is practically exhausted." However, it is not clear if this comment referred to the Kshi-Kalkan or the Dzhurtan site.

L.A. Nesov (1995b) described a carapace fragment of *Adocus* sp. collected by E.I. Belyaeva and M.G. Prokhorov from the Dzhurtas ravine in 1927. He followed Khozatsky in the erroneous referral of Dzhurtas to the Kshi-Kalkan locality (see also Nesov 1995a, 1997). Syromyatnikova and Danilov (2009) assigned this specimen and a few other shell fragments from the 1927 excavation (collection ZIN PH 92) to a new species, *Adocus dzhurtasensis* Syromyatnikova et Danilov, 2009.

5. Kshi-Kalkan (=Kalkan, Malyi Kalkan), southwest margin of the Kshi-Kalkan Mountains, on the right bank of the Ili River, Almaty Province, Kazakhstan (Fig. 1B). Dinosaurian bones were first discovered here in 1925 by a geological expedition led by V.G. Mukhin (Kirikov 1927a). Kirikov (1927b) cited for the Kshi-Kalkan locality the occurrence of Hadrosauridae and Ceratopsidae (tibia and fibula fragment of *Triceratops*) based on identifications by A.N. Riabinin. The Ili Expedition of the Academy of Sciences of the USSR further explored this locality in 1927 (Efremov 1931). Dinosaurian bones and tree trunks occur in a coarse conglomerate cemented by white sandstone. According to Efremov (1944) the most common bones were those of Hadrosauridae. There were also numerous remains of theropods (Tyrannosauridae and Ornithomimidae). Additional faunal elements included Ceratopsidae, Stegosauridae and Acanthopholidae [=Nodosauridae]. Efremov (1944: p. 45) noted that "at this locality for the first time among other localities were found undoubted ceratopsids like *Triceratops*. There are large dorsal plates, different from those known for ankylosaurs and extremely similar to plates typical for stegosaurs." A discovery of stegosaurian remains is rather unlikely for the Late Cretaceous. Possibly this description made reference to ankylosaurian osteoderms. Efremov also noted bones of sauropods possibly referable to Titanosauridae. Among turtles, the most common remains are plates of Trionychidae. There are also some shell elements of "Testudinidae" [=Adocidae?]. In 1932 a party from the Geological Exploration Bureau of Gas Fields collected additional dinosaurian remains from the Kshi-Kalkan Mountains, in a gully called Enbekish. These remains include two large fragments of indeterminate bones and a dinosaurian rib fragment (CCMGE 1/4242). Rozhdestvensky (1964) considered Kshi-Kalkan not particularly promising for further exploration.

SYSTEMATICS

Dinosauria Owen, 1842
Saurischia Seeley, 1887
Theropoda Marsh, 1881
Tyrannosauroidea Osborn, 1905
Tyrannosauridae Osborn, 1905
Tyrannosaurinae Osborn, 1905
Tyrannosaurinae gen. et sp. indet.
(Fig. 2)

Material. IZK 33/MP-61, a right dentary missing the posterior portion and all functional teeth.

Locality and horizon. Kara-Cheku, Almaty Province, Kazakhstan. Unnamed Late Cretaceous unit.

Description. The dentary lacks a few missing smaller pieces along the alveolar margin and much of the posterior part of the bone with the greater part of the Meckelian fossa and the posteroventral process of the dentary. On the lingual surface of the dentary, a piece is missing between the fourth and sixth alveoli and a smaller fragment at the ninth alveolus (Fig. 2A–C); both were restored in colored plaster. The preserved length of the dentary is about 49 cm. The bone attains its greatest height between the third and fourth alveoli (about 14 cm). The lowest point of the dentary is at the level of the eighth alveolus. Thus the dorsal margin of the element is slightly convex anteriorly and concave posteriorly. The ventral margin of the dentary is nearly straight. The anterior margin of the element extends obliquely so that the dorsal margin projects anteriorly beyond the ventral margin by three alveoli. The dentary is widest labiolingually at the level of the fourth alveolus and gradually becomes narrower both anteriorly and posteriorly.

The labial surface of the dentary bears two rows of poorly preserved neurovascular foramina. The ventral

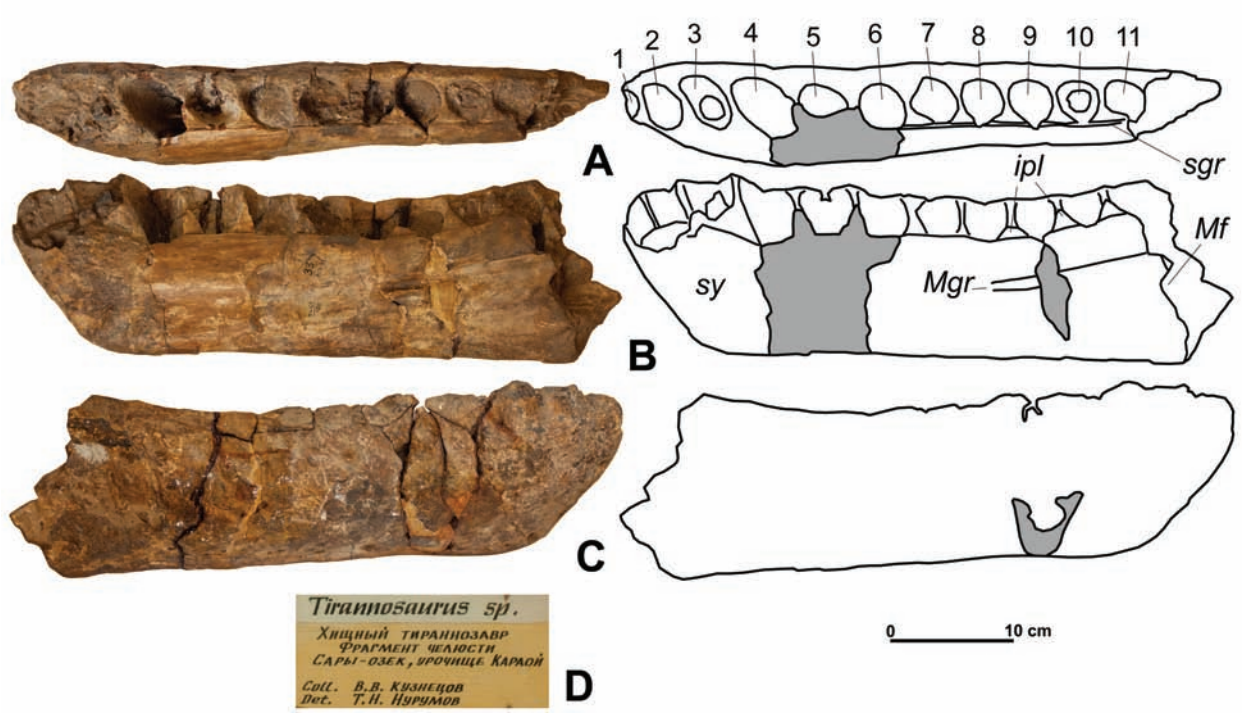

Fig. 2. Tyrannosaurinae indet., IZK 33/MP-61, partial right dentary in dorsal (A), lingual (B), and labial (D) views with accompanying outline drawings showing position of parts restored in plaster (grey) and the museum exhibit label (D). Abbreviations: *ipl*, interdental plates; *Mf*, Meckelian fossa; *Mgr*, Meckelian groove; *sgr*, supradental groove; *sy*, symphysis. Numbers 1-10 denote tooth positions. Scale bar = 10 cm.

row of openings extends close to the ventral margin of the bone, whereas the dorsal row is separated from the dorsal margin by a distance equal to one fourth or one third of the height of the dentary. Another row of large foramina extends along the anterior margin of the dentary.

On the lingual side of the dentary the symphyseal surface is rather smooth and extends posteriorly toward the level of the fourth alveolus. However, the posterior extent of the surface cannot be determined due to damage to the bone in this region. The Meckelian groove can be clearly traced only between the eighth and eleventh alveoli. It is narrow in its preserved anterior portion; posteriorly, its ventral edge is not clearly visible. Most of the posterior end of the dentary is missing. The only intact part is situated just below the Meckelian groove and contains a small triangular depression, which represents the anterior end of the Meckelian fossa. This end is situated at the level of the (missing) twelfth alveolus, as in other tyrannosaurines (e.g., Maleev 1974: fig. 14; Brochu 2003: fig. 40B, D; Hone et al. 2011: fig. 3B, D).

The interdental plates are well developed and fused with the lingual ends of the interalveolar septa. The interdental plates separated from each other, as in other tyrannosaurids (Currie 2003). They are also set off from the lingual surface of the mandibular ramus by a distinct groove that probably housed the dental lamina. The better preserved posterior interdental plates are triangular and lack distinct sculpturing. The incomplete dentary preserves eleven alveoli. The original number of tooth positions in the dentary may have been as high as fifteen based on the relative position of the anterior end of the Meckelian fossa (see above). The first alveolus of the dentary is only about half as large as the second. It is incomplete anteriorly but there appears to be no space between the tooth row and mandibular symphysis. The fourth alveolus is the largest, although its size appears somewhat exaggerated by the loss of the lingual wall. The more posterior alveoli gradually decrease in size posteriorly. Most alveoli are empty. Remnants of roots are preserved in the third and eighth alveoli. The tenth alveolus contains the broken crown of a replacement

tooth with a distinct mesial carina. The distal part of this tooth has been destroyed. The mesiodistal length of the replacement tooth crown is about 25 mm and its labiolingual width is 17.5 mm (width-to-length ratio of 70%).

PHYLOGENETIC POSITION OF THE KARA-CHEKU TYRANNOSAURINE

IZK 33/MP-61 can be confidently referred to Tyrannosauroidea based on the following combination of character states: large size; strongly concave dorsal margin of dentary in labial (lateral) view; dorsoventrally shallow Meckelian groove; and unfused interdental plates (Currie 2003; Currie et al. 2003; Brusatte et al. 2010; Carr and Williamson 2010; Hone et al. 2011). An almost straight anterior margin of dentary is also characteristic for Tyrannosauroidea (Carr and Williamson 2010; Brusatte et al. 2010), although the transition between the anterior and ventral margins of IZK 33/MP-61 is below the third rather than the fourth alveolus (as in other tyrannosauroids). The labiolingually thick (incrassate) teeth of IZK 33/MP-61, based on the partial replacement tooth in the tenth alveolus, supports assignment of this specimen to Tyrannosauridae. Non-tyrannosaurid tyrannosauroids as well as some tyrannosaurids (*Alioramus* Kurzanov, 1976, *Teratophoneus* Carr, Williamson, Britt et Stadtman, 2011) have labiolingually flattened tooth crowns with a labiolingual (transverse) width at the base of less than 60% of the mesiodistal length (Brusatte et al. 2010, 2012). In *Albertosaurus* Osborn, 1905, *Daspletosaurus* Russell, 1970, and *Gorgosaurus* Lambe, 1914, the transverse width of the crown base is greater than 60% of the mesiodistal length, whereas in *Tarbosaurus* Maleev, 1955 and *Tyrannosaurus* Osborn, 1905 the transverse width of the crown is nearly equal to its mesiodistal length. The ontogenetic and positional variability of this character state has not yet been examined in detail. In IZK 33/MP-61 the single preserved posterior tooth crown has width to length ratio 70%, which is almost identical to the ratio for a dentary tooth of *Tarbosaurus* figured by Maleev (1974: fig. 15). IZK 33/MP-61 is clearly different from *Alioramus* from the Late Cretaceous of Mongolia in having labiolingually thick (incrassate) teeth and a relatively deeper, more robust dentary (Brusatte et al. 2009, 2012). IZK 33/MP-61 differs from other tyrannosaurines in the smooth texture of the dentary symphysis, which is distinctly rugose in *Tyrannosaurus* and *Tarbosaurus* (Brusatte et al. 2010). However, it shares with these two taxa the presence of a distinctly smaller first dentary alveolus, a feature absent in other tyrannosauroids (Brusatte et al. 2010). This character state is also present in the tyrannosaurine *Zhuchengtyrannus* Hone et al., 2011 from the Campanian of Shandong Province, China (Hone et al. 2011). The incrassate teeth and reduced first dentary alveolus of IZK 33/MP-61 support its referral to derived Tyrannosaurinae including *Tarbosaurus*, *Tyrannosaurus*, and *Zhuchengtyrannus*. Thus the original identification of this specimen as *Tyrannosaurus* or *Tarbosaurus* was not far off the mark.

DISCUSSION

The Late Cretaceous dinosaurian fauna of Zhetysu (eastern Kazakhstan) has been known since the 1920s, almost as long as the famous dinosaurian assemblages from the Gobi Desert of Mongolia. Efremov (1944) noted that more than 1500 catalogued specimens had been collected from the Kazakh localities. To date, however, only a single fossil, an incomplete tibia (CCMGE 74/5009) from Kara-Cheku, has been reported in the literature (Riabinin 1939: pl. 14, fig. 2). The Zhetysu fauna, based on the review by Nesov (1995a), includes five dinosaurian groups: Sauropoda, Tyrannosauridae, Hadrosauridae, Ankylosauridae, and possible Ceratopsidae. The presence of the last group (which is rare in Asia) cannot be confirmed. The tibia figured by Riabinin is not referable to Ceratopsidae. The first four groups of dinosaurs are also known from the Maastrichtian-age Nemegt Formation of the Gobi Desert, including the tyrannosaurine *Tarbosaurus* (Weishampel et al. 2004). Hadrosauridae, Ankylosauridae, the tyrannosaurine *Zhuchengtyrannus*, Ceratopsidae and Leptoceratopsidae have been recorded from the Campanian Wangshi Series of Shandong Province, China (Xu et al. 2010a, b; Hone et al. 2011). Thus, the tyrannosaurine from Kara-Cheku and its associated fauna may well be Campanian or Maastrichtian in age. Nesov (1995b) and Syromyatnikova and Danilov (2009) previously considered the Zhetysu assemblage Santonian to early Campanian in age. Additional work is needed to constrain the age of this assemblage.

IZK 33/MP-61 represents the first record of a derived tyrannosaurine with incrassate teeth from the territory of Kazakhstan and from Middle Asia.

The Zhetysu region clearly has significant potential for future dinosaurian discoveries.

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