Carnivorous Dinosaurs (Saurischia, Theropoda) from the Maastrichtian of the Volga–Don Interfluve, Russia

A. O. Averianov* and A. A. Yarkov**

*Zoological Institute, Russian Academy of Sciences, Universitetskaya nab. 1, St. Petersburg, 199034 Russia
e-mail: dzharakuduk@yahoo.com
**Volga Humanitarian Institute, Volzhsk, Russia
Received June 10, 2002

Abstract—Isolated bones (braincase fragment, tooth, and (?) the first metacarpal) of carnivorous dinosaurs from the Maastrichtian in the vicinity of the Bereslavka water reservoir (Volgograd Region) are described. The tooth may belong to a member of Dromaeosauridae, the other bones originate from a more primitive theropod of Ceratosauria–Megalosauridae evolutionary grade. The emergence of primitive tetrapods in the Maastrichtian of the Lower Volga Region and Romania could have occurred due to a general climatic cooling.

Key words: Dinosaurs, Saurischia, Maastrichtian, Volgograd Region, Russia.

INTRODUCTION

Dinosaur remains from the territory of European Russia and, in particular, from the Volga Region are extremely scarce. To date, in the Volga Region, only a few bones tentatively assigned to dinosaurs have been discovered in Campanian deposits in the vicinity of Polunino Farm in the Volgograd Region (Nessov, 1995, 1997; Yarkov, 2000). A series of caudal vertebrae of a sauropod from the family Brachiosauridae (or, according to more recent data, Titanosauridae, see Efimov, 2001) were described by Efimov (1997) from the Hauterivian in the Ulyanovsk Region. The limb bones of a juvenile sauropod were recently found in the same area (Efimov, 2001).

In other regions of European Russia, fragmentary dinosaur remains were recently found in the Middle Jurassic (Bajocian–Bathonian) of the Moscow Region (phalanges and teeth of carnivorous dinosaurs: Alifanov, 2000; Alifanov and Sennikov, 2001) and in the mid-Cretaceous (Albian–Cenomanian) of the Belgorod Region (a bone fragment of a carnivorous (?) dinosaur, an isolated tooth, and a cervical vertebra of the duck-billed dinosaur Hadrosauroidea indet.: Nessov, 1995; Arkhangelsky and Averianov, 2003). The present paper describes two bones and a tooth of carnivorous dinosaurs from the Early Maastrichtian of the Bereslavka locality in the Volgograd Region.

The Bereslavka locality (sometimes, it was referred to as Karpovka) is situated on the northern shore of the Bereslavka water reservoir (a segment of the Volga–Don Canal) approximately 32 km west of the city of Volgograd. A section of Late Cretaceous and Paleocene deposits is located on the shore of the reservoir (Yarkov, 2000). The base of the section is composed of Lower Maastrichtian sands containing teeth of the sharks *Palaeohypotodus, Cretolamna, Pseudocorax, Notidanodon*, and *Palaeogaleus* (hereinafter, identified by A.A. Yarkov); dental plates of the chimaeroid *Ischyodus*; bones of the mosasaurs *Plioplatecarpus* and *Mosasaurus*; numerous bivalve and gastropod shells; belemnite rostra; and cirriped crustacean tests. These strata are overlain by sands dated as the Upper Syzranian (Early Paleocene) and containing teeth of the sharks *Palaeocarcharodon, Sphenodus*, and *Odontaspis*; remains of the teleosts Albulidae and Ostraciontidae; and bones of sea turtles, tortoises, and crocodiles. These beds probably yielded a fragmentary crocodilian dentary, the holotype of *Asiatosuchus volgensis* Efimov et Yarkov, 1993 (Efimov and Yarkov, 1993). Upsection, there are coarse-grained sands of the Kamyshin Formation (Upper Paleocene) containing shark and ray teeth, crocodile bones, and mollusk molds. The gravelite overlying the sands of the Kamyshin Formation includes remains redeposited from various stratigraphic levels, mainly from the deposits of the Lower Maastrichtian and Early Paleocene: teeth of sharks and teleost fishes; bones of plesiosaurs, mosasaurs, the toothed birds Hesperornithidae indet. (Yarkov and Nessov, 2000), the sea turtle Osteopyginae indet., and the tortoises Trionychidae indet. (Averianov and Yarkov, 2000). A new very large primitive tortoise characterized by certain features common with *Kallokibotion* from the Maastrichtian of Romania and other still unidentified remains are yet undescribed. Dinosaur bones are described in the present paper.

MATERIALS

Dinosaur remains from the Bereslavka locality are rather fragmentary and strongly weathered, the occipi-
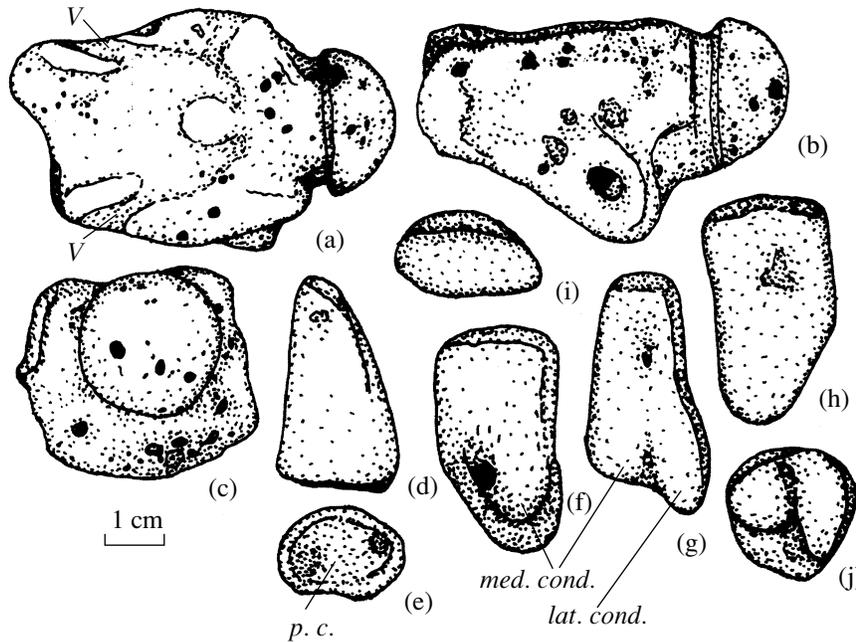
Fig. 1. Carnivorous dinosaur remains from the Maastrichtian of the Bereslavka locality, Gorodishchenskii District, Volgograd Region: (a–c) specimen VGI, no. 231/1, fused basioccipital and basisphenoid, (a) dorsal, (b) lateral, and (c) rear views; (d, e) specimen VGI, no. 231/2, tooth: (d) lateral and (e) basal views; (f–j) specimen VGI, no. 231/3, left metacarpal (?) of the first digit (metacarpal I): (f) medial, (g) frontal, (h) lateral, (i) proximal, and (j) distal views. Designations: (*lat. cond.*) lateral condyle, (*med. cond.*) medial condyle, (*p. c.*) pulp cavity, and (*V*) groove for the trigeminal nerve.

tal and metacarpal bones bear bore traces of lithophagous mollusks (Pholadidae). These bones might have been exposed to long transportation or wave erosion in the water-breaking part of the paleobasin, and were probably repeatedly redeposited. Nevertheless, it is worthwhile to describe these specimens, taking into account the extreme scarcity of dinosaur finds in European Russia and the fact that, notwithstanding their fragmentation, these fossils allow one to ascertain the existence of probably new taxa of carnivorous dinosaurs in the Late Cretaceous in this area.

Dinosaur remains described in the present paper are stored at the Volga Humanitarian Institute (VGI, Volzhsk, Volgograd Region), collection no. 231.

DESCRIPTION

Fragmentary braincase (specimen VGI, no. 231/1; Figs. 1a–1c) is represented by the basioccipital and the basisphenoid fused together without any trace of sutures. This specimen may also include fragmentary exoccipitals; however, there is no trace of exoccipital participation in the formation of the occipital condyle. The bottom of the brain cavity forms a notable recess located near the anterior edge of the specimen, where grooves of a large nerve, most likely the trigeminal nerve, extend lateroanteriorly on each side (Fig. 1a, *V*); a shallower recess is located anterior to the occipital condyle. A clear small expansion shaped into a longitudinally extended crest is located between these recesses

on the concave bottom of the brain cavity. The occipital condyle is almost spherical, its articular surface is delineated by a well-pronounced short neck. The dorsal edge of the occipital condyle does not form a notch for the medulla oblongata, although it protrudes dorsally above the bottom of the brain cavity. The posterior wall of the basioccipital is almost vertical and its preserved part is relatively low, i.e., its depth does not exceed the occipital condyle diameter. The lower edge of the wall is convex and slightly rounded. The basal tubers form thickenings along this edge; probably, their greater part was destroyed as a result of postmortem sample abrasion. The ventral wall of the basisphenoid gently slopes anterodorsally at an angle of approximately 25° to the braincase bottom. A small depression is formed in the central part immediately posterior to the basal tubers, it is followed by a clear crest running along the midline.

If the occipital condyle (specimen VGI, no. 231/1) is actually composed only of the basioccipital, this would be a unique character distinguishing this animal from the rest of theropods and other dinosaurs, whose exoccipitals also participate in the formation of the condyle (Currie, 1997). The other unique feature is the absence of a notch for the medulla oblongata in the dorsal edge of the occipital condyle. This feature has never been noted in other dinosaurs. It cannot be completely excluded that the basipterygoid processes were located right below the basal tubers but were destroyed during the burial. If this is the case, specimen VGI, no. 231/1 demonstrates similarity to the braincases of advanced
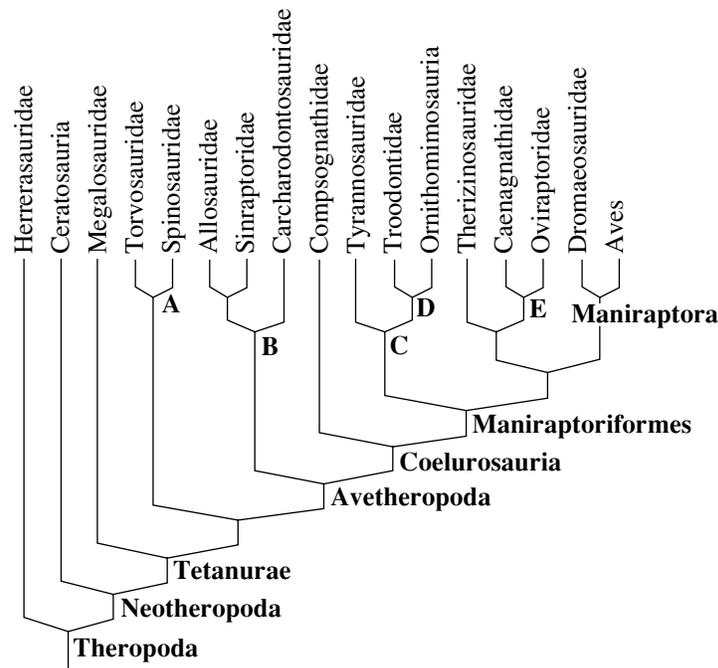
Fig. 2. Simplified cladogram of carnivorous dinosaurs (Theropoda) after Padian (1997b, modified). Designations: (A) Torvosauroidea, (B) Allosauroidea, (C) Arctometatarsalia, (D) Bullatosauria, and (E) Oviraptorosauria.

tyrannosaurids. However, this is highly unlikely, taking into account the small size of the animal (specimen VGI, no. 231/1 belongs to an adult) and the comparatively small basioccipital depth below the occipital condyle. If the basipterygoid processes were located anterior to the preserved fragment, the described specimen displays the most primitive variant of the braincase structure in theropods (Chure and Madsen, 1998). Specimen VGI, no. 231/1 is similar to the Megalosauridae braincase in that the basisphenoid ventral surface gently rises dorsally between the basal tubers and the basipterygoid processes (Chure and Madsen, 1998, text-fig. 6D). The absence of the basisphenoid sinus on this surface excludes the relation of this specimen to the Dromaeosauridae (Colbert and Russell, 1969; Currie, 1995) and other advanced Avetheropoda (Fig. 2).

Tooth crown (specimen VGI, no. 231/2; Figs. 1d, 1e) is short and thick, especially at the base; the apex is moderately curved posteriorly. The denticles of the posterior and anterior carinae are completely worn. The anterior carina is shifted onto the lingual side of the crown immediately below the crown apex and terminates short of reaching the base. The posterior carina reaches the crown base. The pulp cavity occupies approximately half of the basal part of the crown.

The lingual displacement of the anterior carina (observed in specimen VGI, no. 231/2) is characteristic of the teeth of some Dromaeosauridae (Currie *et al.*, 1990); though, this also occurs in the premaxillary teeth of many other theropods. However, the crown shape where the basal part is wide anteroposteriorly obviously excludes the assignment of this tooth to the pre-

maxillary or anterior dentary teeth; most likely, it was located in the posterior part of the mouth. Dromaeosaurid teeth possessing thick crowns similar to specimen VGI, no. 231/2 are known from the Santonian of Fergana (Nessov, 1995).

Metacarpal I (?) (specimen VGI, no. 231/3; Figs. 1f–1j) is relatively short and stout. Mediolaterally, its proximal end is almost half as thick as the distal end; its articular surface is rectangular, proximodistally extended, and pointed posteriorly. In the lateral view, the bone strongly tapers distally, approximately from its middle point. The lateral bone surface is slightly concave, while the medial surface is convex. The distal articulation is asymmetrical, the medial condyle is almost half as large as the lateral condyle. The posterior articular surface extending posteriorly beyond the level of the medial condyle is discernible on the lateral condyle. A weak depression probably corresponding to the lateral ligament pit is present on the medial surface of the medial condyle.

DISCUSSION

Specimen VGI, no. 231/3 was earlier (Yarkov, 2000, p. 17) identified as a "large digital phalanx of the carnivorous dinosaur *Tyrannosaurus*." The flat (rather than concave) proximal articular surface in this specimen suggests this is a metapodial rather than a phalanx. Specimen VGI, no. 231/3 may be interpreted as either metacarpal I or metatarsal I. The latter is highly improbable, since metatarsal I of all theropods that are more advanced than the Herrerasauridae (except for

segnosaurs) does not participate in the metatarsal articulation (Fig. 2), because its proximal extremity becomes reduced to a subulate process attached by a ligament to the lateral surface of metatarsal II, as is observed in birds (Christiansen, 1997). In segnosaurs, metatarsal I is much larger and its proximal extremity is much wider. The well-pronounced asymmetry of the distal joint and general shortness of the bone also suggest this is the first metacarpal rather than a metatarsal. Metacarpal I is short, approximately half as long as metacarpal II, in all theropods, except for the Deinocheiridae and Ornithomimidae, excluding *Harpymimus* (Barsbold, 1983). However, in the majority of theropods, metacarpal I is usually flattened mediodorsally, which makes its proximal articular surface characteristically triangular or triradiate (Barsbold, 1983). At the same time, the proximal end of the bone is mediolaterally wider than, or at most equal to, the distal end. Specimen VGI, no. 231/3 lacks such flattening, the proximal end is narrower than the distal one, and its articular surface is rectangular, extended proximodistally, and pointed posteriorly. The narrow distal end of metacarpal I is characteristic of some ceratosaurs, for example, Late Jurassic *Ceratosaurus* (Gilmore, 1920, text-fig. 60; Rowe and Gauthier, 1990, text-fig. 5.6). However, in *Ceratosaurus*, the proximal articular surface is oblique and adjoins metacarpal II, probably, being completely excluded from the metacarpal joint. In specimen VGI, no. 231/3, the proximal articulation surface is not oblique and probably contacted the distal carpal rather than metacarpal II. Specimen VGI, no. 231/3 cannot belong to a member of the Dromaeosauridae or other Maniraptora (Fig. 2), because in these taxa, the medial condyle of the distal articulation of metacarpal I is shifted dorsally with reference to the lateral condyle, and the proximal articular surface extends distally along the medial edge of the bone and forms an additional facet. This facet is a continuation of the proximal articular surface of the semilunar carpal, which increases the range of movements in the carpal joint up to 190°; this is a maniraptoran synapomorphy (Padian, 1997a; Sereno, 1999). The formation of the additional articulation between the proximal parts of the first and second carpals (character 76 in Currie and Carpenter, 2000) is apparently characteristic of all Avetheropoda (Fig. 2). Specimen VGI, no. 231/3 lacks such an additional facet and, consequently, should not be assigned to the Avetheropoda clade; possibly, it belongs to a member of the Ceratosauria. In this connection, it is interesting to note that a primitive medium-sized ceratosaur (possibly, a member of the family Abelisauridae) was discovered in the Maastrichtian of Romania (Csiki and Grigorescu, 1998).

Although the vertebrate fauna from the Maastrichtian of the Lower Volga Region is still poorly understood, it clearly demonstrates certain similarity to the Maastrichtian vertebrate fauna of Romania and, to a lesser degree, to that of other regions in Western Europe. In the Maastrichtian of Romania, an important part is played by primitive groups of the Early Cretaceous, or even earlier, evolutionary level: the primitive cryptodiran turtle *Kallokibotion*, the iguanodontid *Rhabdodon*, the most primitive known hadrosauroid *Telmatosaurus*, a presumable ceratosaur from the family Abelisauridae, and the primitive multituberculates *Kogaionon, Barbatodon*, and *Haininia* (Gaffney and Meylan, 1992; Weishampel *et al.*, 1993; Radulescu and Samson, 1996; Grigorescu *et al.*, 1999; Csiki and Grigorescu, 1998, 2000; etc.). To date, four taxa of terrestrial tetrapods have been discovered in the Maastrichtian of the Lower Volga Region; two are typical of the Late Cretaceous (Theropoda indet. cf. Dromaeosauridae and Hesperornithidae indet.) and two are relict taxa remaining at the Early Cretaceous or even earlier organization level (a new turtle similar to *Kallokibotion* and Theropoda indet. Of the same evolutionary level as the Ceratosauria and Megalosauridae). Sudden appearance of very primitive taxa is also characteristic of the Maastrichtian in a number of other regions, for example, the occurrence of the turtle *Mongolochelys* in the Maastrichtian of Mongolia (Sukhanov, 2000). Apparently, these relict taxa persisted during a large part of the Late Cretaceous in certain refugia (possibly, in the north of Eurasia) and, in the conditions of the Maastrichtian drop in temperature and the general biotic crisis, expanded to southerner areas, including southeastern Europe. It is not yet clear, whether or not Transylvania was initially such a refugium, because the earliest known Late Cretaceous vertebrates from this region are dated as Maastrichtian.

REFERENCES

1. V. R. Alifanov, Priroda (3), 76 (2000).

2. V. R. Alifanov and A. G. Sennikov, Dokl. Akad. Nauk **376** (1), 73 (2001).

3. M. S. Arkhangelsky and A. O. Averianov, Paleontol. Zh. **44** (1), 60 (2003).

4. A. O. Averianov and A. A. Yarkov, Russ. J. Herpetol. **7** (2), 161 (2000).

5. R. Barsbold, *Carnivorous Dinosaurs from the Cretaceous of Mongolia* (Nauka, Moscow, 1983) [in Russian].

6. P. Christiansen, in *Encyclopedia of Dinosaurs*, Ed. by P. J. Currie and K. Padian (Academic, San-Diego, 1997), pp. 320–328.

7. D. J. Chure and J. A. Madsen, J. Vertebr. Paleontol. **18** (1), 115 (1998).

8. E. H. Colbert and D. A. Russell, Am. Mus. Novit. **2380**, 1 (1969).

9. Z. Csiki and D. Grigorescu, Oryctos **1** (1), 87 (1998).

10. Z. Csiki and D. Grigorescu, Acta Palaeontol. Pol. **45** (1), 85 (2000).

11. P. J. Currie, J. Vertebr. Paleontol. **15** (3), 576 (1995).

12. P. J. Currie, in *Encyclopedia of Dinosaurs*, Ed. by P. J. Currie and K. Padian (Academic, San-Diego, 1997), pp. 81–85.

13. P. J. Currie and K. Carpenter, Geodiversitas **22** (2), 207 (2000).

14. P. J. Currie, J. K. Rigby, Jr., and R. E. Sloan, in *Dinosaur Systematics: Perspectives and Approaches*, Ed. by K. Carpenter and P. J. Currie (Cambridge Univ. Press, Cambridge, 1990), pp. 107–125.

15. D. V. Efimov, in *Geologists of the 21st Century: Theses of Regional Scientific Conference of Students, Postgraduates, and Young Researchers, Saratov, March 26–28, 2001)* (Saratov, 2001), p. 111.

16. M. B. Efimov and A. A. Yarkov, Paleontol. Zh. **34** (2), 87 (1993).

17. V. M. Efimov, Paleontol. Zh. **38** (6), 86 (1997).

18. E. S. Gaffney and P. A. Meylan, Am. Mus. Novit. **3040**, 1 (1992).

19. W. C. Gilmore, Bull. US Nat. Mus. **110**, 1 (1920).

20. D. Grigorescu, M. Venczel, Z. Csiki, and R. Limberea, Geol. Mijinb. **78**, 301 (1999).

21. L. A. Nessov, *Dinosaurs from Northern Eurasia: New Data on the Composition of Assemblages, Ecology, and Paleobiogeography* (St. Peterb. Gos. Univ., St. Petersburg, 1995) [in Russian].

22. L. A. Nessov, *Nonmarine Vertebrates from the Cretaceous of Northern Eurasia* (Biol. Inst. Ross. Akad. Nauk, St. Petersburg, 1997) [in Russian].

23. [a] K. Padian, in *Encyclopedia of Dinosaurs*, Ed. by P. J. Currie and K. Padian (Academic, San-Diego, 1997), pp. 411–414.

24. [b] K. Padian, in *Encyclopedia of Dinosaurs*, Ed. by P. J. Currie and K. Padian (Academic, San-Diego, 1997), pp. 647–653.

25. C. Radulescu and P. M. Samson, Ann. Inst. Geol. Rom. **69** (1), 177 (1996).

26. T. Rowe and J. Gauthier, in *The Dinosauria*, Ed. by D. B. Weishampel, P. Dodson, and H. Osmolska (Univ. California Press, Berkeley, 1990), pp. 151–168.

27. P. C. Sereno, Science **284**, 2137 (1999).

28. V. B. Sukhanov, in *The Age of Dinosaurs in Russia and Mongolia*, Ed. by M. J. Benton, M. A. Shishkin, D. M. Unwin, and E. N. Kurochkin (Cambridge Univ. Press, Cambridge, 2000), pp. 309–367.

29. D. B. Weishampel, D. B. Norman, and D. Grigorescu, Palaeontology **36** (2), 361 (1993).

30. A. A. Yarkov, Candidate's Dissertation in Geography (Volgogr. Gos. Ped. Inst., Volgograd, 2000).

31. A. A. Yarkov and L. A. Nessov, Russk. Ornitol. Zh. **94** (suppl.), 3 (2000).