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FIRST RECORD OF THE LATE CRETACEOUS DUROPHAGOUS MOSASAUR *Carinodens belgicus* (SQUAMATA, MOSASAURIDAE) FROM VOLGOGRADSKAYA OBLAST' (RUSSIA) AND CRIMEA (UKRAINE)

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Two new late Maastrichtian (Cretaceous) occurrences of the highly specialized, durophagous mosasaur *Carinodens* are recorded, one from Russia (Volgograd Region), the other from Crimea (Ukraine). Its dietary specializations and geographic distribution are briefly discussed.

Keywords: *Carinodens*, Mosasauridae, Late Cretaceous, Maastrichtian, paleobiogeography, Volgogradskaya Oblast', Russia, Crimea, Ukraine.

INTRODUCTION

The enigmatic durophagous Late Cretaceous (Maastrichtian) mosasaurid genus, *Carinodens* (Squamata), is shown to have had a much wider distribution than previously thought. To date, only two dentaries of the type and sole species of the genus, *C. belgicus* (= *C. fraasi*) are available: the holotype and a recently collected fragment, both from the type area of the Maastrichtian Stage (Maastricht area, SE Netherlands). In addition, a few dozen isolated teeth and tooth crowns are known from the same area, but so far only a handful of isolated tooth crowns have been recorded from elsewhere (see section "distribution" below). We present two new records of the genus *Carinodens* from the Upper Cretaceous (Maastrichtian) of Russia and the Ukraine (Fig. 1), and the distribution of this unusual mosasaur is briefly discussed.

Institutional abbreviations: NHMM, Natuurhistorisch Museum Maastricht, Maastricht, the Netherlands; ZIN PH, Paleoherpetological collection of the Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia.

SYSTEMATIC PALEONTOLOGY

Squamata Oppel, 1811
Mosasauroidea Gervais, 1853
(nom. transl. Camp, 1923)
Mosasauridae Gervais, 1853
Mosasaurinae Gervais, 1853
(nom. transl. Williston, 1897)
Globidensini Russell, 1967 (see also Bell, 1997)
***Carinodens* Thurmond, 1969**
***Carinodens belgicus* (Woodward, 1891)**
(Fig. 2)

Material. Two isolated tooth crowns, ZIN PH 1/61 (Fig. 2*a–c*) and ZIN PH 2/61 (Fig. 2*d–f*).

Taxonomy. The taxonomic status of the genus *Carinodens* has changed considerably over the years; reference is made to Schulp et al. (2004) and references therein for more details. Kuypers et al. (1998) synony-

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Fig. 1. Map of western Russia and the Ukraine, showing localities in Crimea (*a*) and Volgogradskaya Oblast' (*b*) which yielded the present tooth crowns of *Carinodens belgicus*.

mized *Carinodens fraasi* (Dollo, 1913) with *C. belgicus* (Woodward, 1891), the latter having priority.

Locality and stratigraphy. ZIN PH 1/61, collected by F. A. Trikolidi, comes from Bakla Hill near the village of Trudolyubovka (45°22′ N, 34°37′ E) in the Bakhchisaray District of Crimea, Ukraine. The source is a glauconitic sandstone of Danian (early Paleocene) age, overlying Maastrichtian (Late Cretaceous) sandstone (Averianov and Trikolidi, 2000). Associated vertebrate taxa include shark and ray (*Squatina* sp. or *Cretorectolobus* sp., *Carcharias* sp., *Cretolamna appendiculata*, *Squalicorax* cf. *kaupi*, *Pseudocorax affinis*, and *Rhombodus* cf. *binkhorsti*) and mosasaur teeth, including those of cf. *Leiodon* sp. with serrated carinae, misinterpreted in a previous paper (Averianov and Trikolidi, 2000) as teeth of a ziphodont crocodile (cf. *Doratodon* sp.; misidentification first noted by A. A. Yarkov). We consider these vertebrate remains to have possibly been reworked from underlying Maastrichtian strata, because the selachian species are characteristic for the late Maastrichtian. The village of Trudolyubovka has been the base station for geological field practice of students from St. Petersburg University for more than fifty years, and the geology of the region is well known (Prozorovskii, 2002). In spite of this, remains of vertebrates have proved to be quite rare in the Cretaceous and Paleogene deposits in the area (e.g., Gorbach, 1967; Novikov et al., 1987). The most significant record from Crimea is the hind limb of the ornithopod dinosaur, "*Orthomerus*" *weberae* Riabinin, 1945, collected in 1934 by G. F. Weber from upper Maastrichtian deposits at Besh-Kosh Hill, near Bakhchisaray (Riabinin, 1945).

ZIN PH 2/61, collected by A. A. Yarkov, is from the Balykleyka River site in Volgogradskaya Oblast', Russia (approximately 49°22′ N and 44°58′ E). The specimen comes from a phosphoritic bone bed within the Maastrichtian Bereza Beds; this has yielded remains of phosphatized wood, bivalves, coleoid cephalopods, sharks, chimaerids, teleosts, mosasaurs and turtles (Yarkov, 2000; Popov and Yarkov, 2001). From a nearby locality, Rasstrigin 1, exposing the same beds, remains of a sturgeon ("*Acipenser*" *gigantissimus*), a chimaerid (*Edaphodon eolucifer*) and a large turtle (*Cryptodira*

Fig. 2. New material of the durophagous mosasaur, *Carinodens belgicus*. *a–c*: ZIN PH 1/61, from Trudolyubovka, Crimea (Ukraine), in occlusal (*a*) and lateral/lingual view (*b*, *c*); *d–f*: ZIN PH 2/61, from the Balykleyka River site, Volgogradskaya Oblast' (Russia), in occlusal (*d*) and lateral/lingual view (*e*, *f*).

incertae sedis) have been described (Nessov, 1997; Popov and Yarkov, 2001; Averianov and Yarkov, 2004).

Description. ZIN PH 1/61 (Fig. 2*a–c*) is incomplete; crown length, as preserved, is 10.9 mm, width 4.6 mm, and height 8.3 mm. The enamel cover is only partially preserved. The carina, still clearly visible, can be traced all over the tooth in occlusal view; the central occlusal surface is worn, exposing the underlying dentine. The thick enamel is wrinkled, both in lateral and in lingual view, part of the enamel cover is missing, showing the increase in thickness of the enamel layer along the crown towards the apex. In lateral view, the

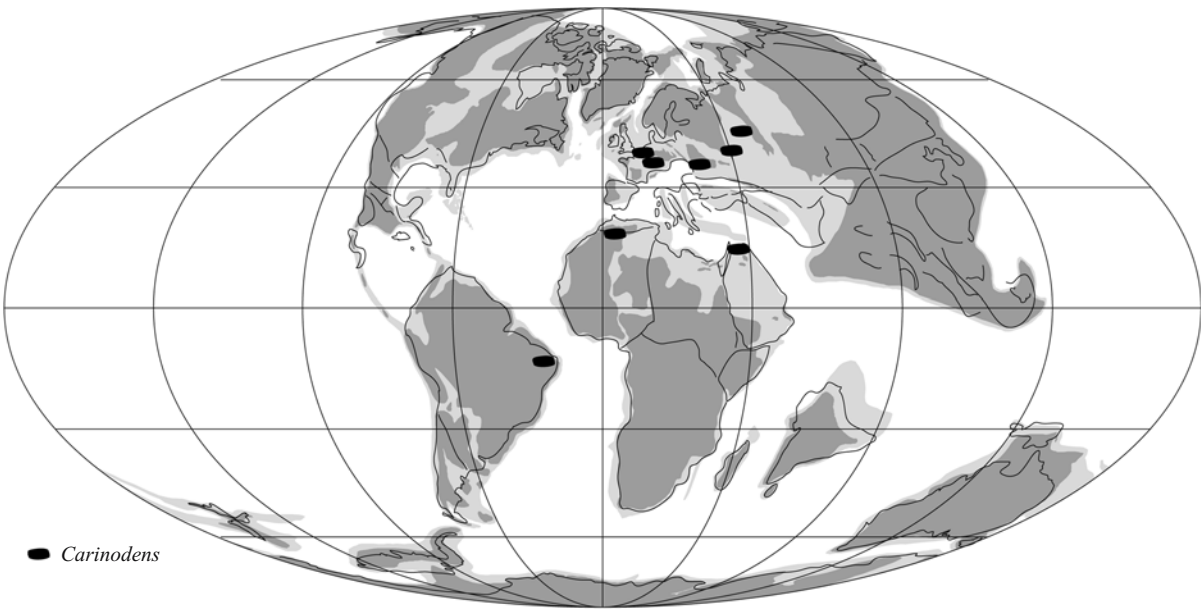

Fig. 3. Distribution of *Carinodens*; Maastrichtian paleogeography after *The Paleogeographic Atlas* Project, University of Chicago..

tooth crown is slightly asymmetrical, with the carinae on both shoulders concave in profile.

ZIN PH 2/61 (Fig. 2*d–f*) is larger and more massive; crown length is 16.7 mm, width 8.2 mm, and height 10.4 mm. The enamel cover, although abraded, is preserved. Only the posterior portion of the carina can be traced, the anterior one having worn down for the greater part; in addition to the highly abraded central occlusal surface (exposing the underlying dentine), along the anterior part of the carina a second wear facet developed. The shoulders of the crown (in lateral view) are convex, to become slightly concave just near the apex. Although this specimen is less well preserved than ZIN PH 1/61, the wrinkles on the enamel surface are still visible.

Systematic attribution. Both specimens can confidently be assigned to *Carinodens belgicus*, representing posteriormost teeth. Teeth of *Carinodens* in this position are characteristically bulbous in lateral view, blunt, labiolingually flattened and anterodistally elongate (Dollo, 1913; Schulp et al., 2004). Newly erupted teeth have one apical cusp, which is immediately subjected to wear, soon exposing the underlying dentine, and two relatively minor accessory cusps, which only become abraded once the tooth actually occludes with the opposite element or is subjected to a longer or more extensive period of wear. The enamel is wrinkled, like in most other globidensine mosasaurs (Bell, 1997). The enamel cover is thick, about 0.5 mm in ZIN PH 1/61. The variation in size and aspect ratio falls well within the range observed in material in the NHMM collections (compare Kuypers et al., 1998; Schulp et al., 2004; Schulp, 2005).

Tooth position. Despite the fact that there is a relatively high degree of heterodonty in *Carinodens*, it remains difficult to assign these two specimens to precise tooth positions within the dentary or maxilla — also because only two dentary fragments are known to date (Schulp et al., 2004). Although we may assume that the maxillary dentition to some degree represents a mirror image of that of the dentary, and although the asymmetrical placement of the central occlusal surface and the carinae would theoretically allow to assign isolated teeth to left or right dentaries or maxillae, the variation in the two available dentary specimens is already too wide to hazard a guess on the original position of these. Regardless of that, when comparing the specimens described here with the holotype, and taking particular attention to the outline in lateral view, we can assume that both ZIN PH 1/61 and ZIN PH 2/61 occupied one of the posteriormost positions in the tooth row.

Distribution. The present specimens represent the first record of *Carinodens* from Russia and Crimea (Ukraine). So far, *Carinodens* has been known from isolated teeth and tooth crowns and two dentaries from the Netherlands and Belgium (Dollo, 1913; Kuypers et al., 1998; Schulp et al., 2004), isolated tooth crowns from Brazil (Price, 1957), Morocco (Arambourg, 1952; Bardet et al., 2005), and Bulgaria (Tzankov, 1939). An addi-

tional occurrence of a *Carinodens*-like mosasaur from Jordan was mentioned by Mustafa and Zalmout (2001), again based on only an isolated tooth.

Although known only by isolated teeth, the distribution map (Fig. 3) shows that towards the end of the Cretaceous, *Carinodens* occupied a wide geographic range, both paleolongitudinally (Brazil to Russia), as well as in terms of paleolatitude: from sub-equatorial Brazil all the way up to the Forties of the Maastricht area, the northernmost occurrence. So far, finds from the Maastricht area have proved the richest.

Mulder (1999) extensively discussed transatlantic similarities between the type Maastrichtian and mosasaur faunas from New Jersey (USA), noting in particular the presence of *Mosasaurus* and *Plioplatecarpus* on both sides of the Atlantic. Interestingly, *Carinodens* has not yet been reported from North America. Was the northern Atlantic too wide or too cold to cross for this small mosasaur? Or could a lack of suitable environments along North American shores be an explanation?

Diet. The possible diet of *Carinodens* has been the subject of speculation and research ever since its initial description almost a century ago (Dollo, 1913; Russell, 1975; Lingham-Soliar, 1999; Schulp et al., 2004, Schulp, 2005). A better knowledge of the dietary specializations of *Carinodens* might help improve our understanding of the distribution of this taxon in the fossil record. Biomechanical experiments (Schulp, 2005) suggest that the dentition of *Carinodens* was suitable for processing a wide range of food items, with handling relatively small, hard-shelled food items such as mollusks and arthropods probably being the stronghold of *Carinodens*, so perhaps the lack of suitable food sources prevented this specialized mosasaur from expanding its range to North America.

CONCLUSION

Two new occurrences of the mosasaur *Carinodens* are recorded, one from Russia (Volgogradskaya Oblast'), the other from Crimea (Ukraine). *Carinodens* was a highly specialized, durophagous mosasaur which showed a wide distribution towards the end of the Cretaceous. Although this particular mosasaur is relatively rare, and known almost exclusively from isolated teeth and tooth crowns, the new occurrences show that *Carinodens* was even more widespread than previously thought.

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REFERENCES

Arambourg C. (1952), "Les vertébrés fossiles des gisements de phosphates (Maroc-Algérie-Tunisie)," *Notes Mém. Serv. Géol. Maroc*, **92**, 1–372.

Averianov A. O. and Trikolidi F. A. (2000), "The first find of a ziphodont crocodile from the Maastrichtian-Paleocene (?) of Crimea," *Vestn. LGU*, **7**(3), 73 – 75 [in Russian].

Averianov A. O. and Yarkov A. A. (2004), "New turtle remains from the Late Cretaceous and Paleogene of Volgograd Region, Russia," *Russ. J. Herpetol.*, **11**(1), 41–50.

Bardet N., Pereda Suberbiola X., Iarochène M., Amalik M., and Bouya B. (2005), "Durophagous Mosasauridae (Squamata) from the Upper Cretaceous phosphates of Morocco, with description of a new species of *Globidens*," in: A. S. Schulp and J. W. M. Jagt (eds.), *Proc. the First Mosasaur Meeting*, *Maastricht*, *May 2005*, *Neth. J. Geosci.*, **84**, 167 – 175.

Bell G. L., Jr. (1997), "A phylogenetic revision of North American and Adriatic Mosasauroidea," in: Callaway J. M. and Nicholls E. L. (eds.), *Ancient Marine Reptiles*, Acad. Press, New York – London, pp. 293–332.

Camp C. L. (1923), "Classification of the lizards," *Bull. Am. Mus. Nat. Hist.*, **48**, 289–481.

Dollo L. (1913), "*Globidens Fraasi*, Mosasaurien mylodonte nouveau du Maestrichtien (Crétacé supérieur) du Limbourg, et l'Ethologie de la Nutrition chez les Mosasauriens," *Arch. Biol.*, **28**, 609 – 626.

Gervais P. (1853), "Observations relatives aux reptiles fossiles de France," *C. R. Acad. Sci. Paris*, **36**, 374–377, 470–474.

Gorbach L. P. (1967), "First find of mosasaur remains in Crimea," *Geol. Zh.*, **27**, 93–96 [in Ukrainian].

Kuypers M. M. M., Jagt J. W. M., Peeters H. H. G., and de Graaf D. Th. (1998), "Laat-kretaceische mosasauriërs uit Luik-Limburg: nieuwe vondsten leiden tot nieuwe inzichten," *Publ. Natuurhist. Genootsch. Limburg*, **41**, 5–48.

Lingham-Soliar T. (1999), "The Durophagous Mosasaurs (Lepidosauromorpha, Squamata) *Globidens* and *Carinodens* from the Upper Cretaceous of Belgium and The Netherlands," *Paleontol. J.*, **33**, 638–647.

Mulder E. W. A. (1999), "Transatlantic latest Cretaceous mosasaurs (Reptilia: Squamata) from the Maastrichtian type area and New Jersey," *Geol. Mijnbouw*, **78**, 281–300.

Mustafa H. and Zalmout I. (2001), "On the dentitions of Mosasauridae (Marine Reptiles) from the Late Cretaceous (Early Maastrichtian) of the Jordanian phosphate," *Dirasat*, **28**, 56–62.

Nessov L. A. (1997), *Cretaceous Nonmarine Vertebrates of Northern Eurasia* (posthumously edited by L. B. Golovneva and A. O. Averianov), Izd. SPbU, St. Petersburg [in Russian].

Novikov I. V., Zlatinsky V. D., and Engelman F. (1987), "On finds of Cretaceous and Paleocene vertebrates in the

eastern part of the Bakhchisaray District (Crimea)," *Izv. Vuzov Geol. Razvedka*, **1**, 109–110 [in Russian].

Oppel M. (1811), *Die Ordnungen*, *Familien und Gattungen der Reptilien als Prodrom einer Naturgeschichte derselben*, Joseph Lindauer, München.

Popov E. V. and Yarkov A. A. (2001), "A new giant species of *Edaphodon* (Holocephali: *Edaphodon*tidae) from the Berezovaya Beds (Lower Paleocene) of the Volgograd Volga Region," *Paleontol. Zh.*, **2**, 76–80 [in Russian].

Price L. I. (1957), "A presença de *Globidens* no Cretácico superior do Brasil," *Bol. Div. Geol. Mineral.*, **169**, 1–24.

Prozorovskii V. A. (2002), "50 years in Crimea," *Uch. Zap. Kaf. Ist. Geol.*, **2**, 8–23 [in Russian].

Riabinin A. N. (1945), "Dinosaurian remains from the Upper Cretaceous of the Crimea," in: *Mat. Vsesoyuz. Nauchno-Issled. Geol. Inst.*, *Paleontol. Stratigr.*, **4**, 4–10 [in Russian].

Russell D. A. (1967), "Systematics and morphology of American mosasaurs," *Bull. Peabody Mus. Nat. Hist. Yale Univ.*, **23**, 1–241.

Russell D. A. (1975), "A new species of *Globidens* from South Dakota, and a review of Globidentine Mosasaurs," *Fieldiana*, **33**, 235–256.

Schulp A. S., Jagt J. W. M., and Fonken F. F. (2004), "New material of the mosasaur *Carinodens* from the Upper Cretaceous of The Netherlands," *J. Vertebr. Paleontol.*, **24**, 744–747.

Schulp A. S. (2005), "Feeding the mechanical mosasaur: what did *Carinodens* eat?," in: A. S. Schulp and J. W. M. Jagt (eds.), *Proc. the First Mosasaur Meeting*, *Maastricht*, *May 2005*, *Neth. J. Geosci.*, **84**, 345–357.

Thurmond J. T. (1969), "New name for the mosasaur *Compressidens* Dollo 1924," *J. Paleontol.*, **43**, 1298.

Tzankov V. (1939), "Note sur la présence des reptiles fossiles du Crétacé supérieur de la Bulgarie du Nord," *Geol. Balkanica*, **3**, 13–20.

Williston S. W. (1897), "Range and distribution of the mosasaurs," *Kansas Univ. Quart.*, **6**, 177–189.

Woodward A. S. (1891), "Note on a tooth of an extinct alligator (*Bottosaurus belgicus*, sp. nov.) from the lower Danian of Ciply," *Belg. Geol. Mag. Nov. Ser.*, **8**(3), 114–115.

Yarkov A. A. (2000), *Substantiation of the Establishment of the Geographical–Paleontological Nature Sanctuary in the Volgogradskaya Oblast' on the Basis of Paleogeographical Reconstruction*, Izd. VGPI, Volgograd [in Russian].