C. R. Palevol 16 (2017) 27–38

Contents lists available at ScienceDirect

Comptes Rendus Palevol

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General Palaeontology, Systematics and Evolution (Vertebrate Palaeontology)

First mammal species identified from the Upper Cretaceous of the Rusca Montană Basin (Transylvania, Romania)

Première identification d'une espèce de mammifère du Crétacé supérieur du bassin de Rusca Montană (Transylvanie, Roumanie)

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ARTICLE INFO

Article history:
Received 20 February 2016
Accepted after revision 3 April 2016
Available online 2 June 2016

Handled by Lars vanden Hoek Ostende

Keywords:
Mammals
Multituberculates
Kogaionids
Maastrichtian
Occidental Carpathians
Romania

Mots clés :
Mammifères
Multituberculés
Kogaionidés
Maastrichtien
Carpates occidentales
Roumanie

ABSTRACT

Multituberculate mammals are scarce in the Late Cretaceous of Europe, being recorded exclusively from the Maastrichtian terrestrial deposits of the Haţeg and Transylvanian basins, in Romania. Moreover, they all belong to the endemic and primitive cimolodontan family Kogaionidae. Here, we report multituberculate teeth originating from the Maastrichtian fluviatile sediments of the Rusca Montană Basin (Occidental Carpathians, Poiana Ruscă Mountains). This is the westernmost occurrence of these Cretaceous mammals in Romania. These teeth are assigned to *Barbatodon oardaensis*, the smallest Cretaceous kogaionid species. This study presents the first occurrence of this species outside the Metaliferi sedimentary area (southwestern Transylvania, Romania). The distribution of Romanian Maastrichtian kogaionids is also discussed.

RÉSUMÉ

Les mammifères multituberculés sont rares dans le Crétacé supérieur d'Europe et sont connus exclusivement dans les dépôts continentaux du Maastrichtien, dans les bassins de Haţeg et de Transylvanie, en Roumanie. De plus, ils appartiennent tous aux Kogaionidae, une famille endémique de Cimolodonta primitifs. Nous signalons ici des dents de multituberculés provenant des sédiments fluviatiles du bassin de Rusca Montană (Carpates Occidentales, monts Poiana Ruscă). C'est l'occurrence la plus occidentale de ces mammifères crétacés en Roumanie. Ces dents sont attribuées à *Barbatodon oardaensis*, la plus petite espèce de kogaionidé du Crétacé. Cette étude présente la première occurrence de cette espèce à l'extérieur de la zone sédimentaire Metaliferi (Sud-Ouest de la Transylvanie, Roumanie). La répartition des kogaionidés du Maastrichtien de Roumanie est également discutée.

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http://dx.doi.org/10.1016/j.crpv.2016.04.002

1. Introduction

Multituberculate mammals occurred early in the European fossil record and they evolved for a long period of time on the old continent. For many years, the Late Jurassic (Kimmeridgian) Guimarota Coal Mine of Portugal was the earliest known European locality with multituberculates (see Kielan-Jaworowska, 2013). However, Kermack et al. (1998) described some multituberculate-like teeth from the Middle Jurrasic (Bathonian) of England. Butler and Hooker (2005) revised the material of Kermack et al. (1998) and assigned some of these allotherian teeth to the geologically oldest known multituberculates, which belong to the families Kermackodontidae and Hahnotheriidae. Moreover, if *Mojo usuratus* from the Latest Triassic (Rhaetian) of Belgium (Hahn, 1987; Hahn et al., 1989) were to be confirmed as a multituberculate mammal, then the history of Mesozoic multituberculates in Europe would begin even far earlier.

Since the Late Jurassic, multituberculate mammals were abundant in Europe (Kielan-Jaworowska et al., 2004, and references therein). Guimarota Coal Mine is the richest locality yielding the most diverse multituberculate mammals of Europe. Albionbaataridae and mainly Paulchoffatidae representatives were described from this locality (Hahn's references, in Kielan-Jaworowska et al., 2004). In the Early Cretaceous, the European multituberculates were distributed in Britain and on the Iberian Peninsula, the diversity of the families being even higher than in the Late Jurassic. From Britain, the families Eobaataridae (Simpson, 1928; Sweetman, 2009), Plagiaulacidae (Cope, 1884; Falconer, 1857; Kielan-Jaworowska and Hurum, 2001; Owen, 1871; Simpson, 1928), Albionbaataridae, Paulchoffatiidae and Pinheirodontidae (Kielan-Jaworowska and Ensom, 1992, 1994) have been reported. From the Iberian Peninsula, the families Eobaataridae (Crusafont Pairó and Adrover, 1966; Hahn and Hahn, 1992, 2001), Paulchofatiidae (Hahn and Hahn, 1992; Kielan-Jaworowska et al., 2004), Pinheirodontidae (Canudo and Cuenca-Bescós, 1996; Hahn and Hahn, 1999), a family *incertae sedis* (Kielan-Jaworowska et al., 2004), and *Iberica hahni* (Badiola et al., 2011), of unclear family position, have been described. After this period of high diversity of the Early Cretaceous, the only multituberculates reported to date from the Late Cretaceous are those from the Haţeg and Transylvanian basins, Romania (Fig. 1), all belonging to the endemic and primitive cimolodontan family Kogaionidae (Codrea and Solomon, 2014; Codrea et al., 2002, 2009, 2012a, 2012b, 2014; Csiki and Grigorescu, 2000; Csiki et al., 2005; Rădulescu and Samson, 1996, 1997; Smith and Codrea, 2015; Smith et al., 2002; Solomon et al., 2016; see Table 1 for details). The kogaionids survived the Cretaceous/Cenozoic boundary events, being found in the Paleocene at Jibou (Romania; Gheerbrant et al., 1999; Table 1), but also in France, Spain, and Belgium (De Bast and Smith, 2016; Peláez-Campomanes et al., 2000; Vianey-Liaud, 1979, 1986). However, they were replaced around the Late Paleocene by the world-widely distributed North American Neoplagiaulidae (Vianey-Liaud, 1986), the latter being the last family occurring in Europe before the extinction of the multituberculates from the old continent during the Eocene.

In this long and nearly complete European history of one of the most successful groups in mammal evolution, the dark and poorly known period is the Late Cretaceous. This paper focuses on the description and identification of some previously reported specimens (P1 and p4; Codrea et al., 2012a) and of new dental specimens (P4, I2 and i1). The P1 (UBB Ng1-02) and p4 (UBB Ng2-01) were briefly described by Codrea et al. (2012a) and assigned to Kogaionidae indet. All this material is assigned to *Barbatodon oardaensis* (Codrea et al., 2014), reported here for the first time in the Upper Cretaceous fluvial deposits of the Rusca Montană Basin (RMB), Romania (Fig. 1).

2. Geological setting

The RMB is an intramontane basin located in southwestern Romania, in the western Carpathians, south of Mureş River. It lays over the rocks of Valea lui Stan and Uria thrusting nappes, both belonging to the Supragetic Nappes erected in the Latest Cretaceous tectogenesis (Balintoni, 1997). Therefore, the sole of this basin concerns various metamorphic rocks, covered by Mesozoic sedimentary deposits (Lower Jurassic–Uppermost Cretaceous; Codrea et al., 2012a, and references therein).

The Latest Cretaceous evolution of this basin concerns a rather long lasting marine realm (Coniacian-Late Campanian; Dincă, 1977; Mamulea, 1955), ended by emersion. After that, only continental environments (?Late Campanian-Maastrichtian–?Paleogene; Pop et al., 1972) have developed, resulted from the evolution of a fluvial system. This marine/continental transition shares similitude with the Haţeg and Transylvanian basins (Codrea and Dica, 2005; Codrea et al., 2010; Grigorescu and Melinte, 2002; Melinte-Dobrinescu, 2010) and even the tectonic evolution of the RMB is very similar to that of the Haţeg Basin (Willingshofer et al., 2001).

The ?Late Campanian-Maastrichtian continental sedimentation concerns the following lithologic units (Maier and Lupu, 1979 in: geological map 1: 50,000, *folio* Băuţar): i. Coarse breccias and conglomerates reworking metamorphic rock fragments, exposed in dominance on large areas on the western side of the basin (Popa et al., 2014); ii. A lower andesitic volcano-sedimentary pile (breccias, tuffs and andesitic agglomerates, pyroxene and olivine andesite lava flows, called the Rusca Andesite, polygenetic breccias and conglomerates with clayish matrix); iii. Sandstone with ignimbrite; iv. Coal bearing sandstone (violet breccias, sandstone, blackish clays, coal); v. An upper volcano-sedimentary pile, with rather similar rocks like in the previous basal one.

The age of all these deposits is considered Uppermost Cretaceous (Maastrichtian), based on the pollen and spores (Antonescu et al., 1983), macroflora (Popa et al., 2014, 2016, and references therein) and vertebrates (Codrea et al., 2009, 2012a; Csiki-Sava et al., 2016; Vasile and Csiki, 2011).

The multituberculate teeth here described were discovered in the easternmost side of the RMB, near Lunca Cernii de Jos at Negoiu, along the Fărcădeana Creek (Fig. 2). Two levels bearing Maastrichtian vertebrates crop out along this creek. The lower one, located on the left side of the creek, consists of black clay and sand, not exceeding few

Table 1
Romanian Kogaionid multituberculates distribution in Late Cretaceous and Paleocene.
Tableau 1
Distribution des Kogaionidés roumains pendant le Crétacé supérieur et le Paléocène.

Taxon	Locality	Geographic location	Stratigraphic position	Age[b]	Size of taxon	Related references	Observations
Kogaionon ungureanui Rădulescu and Samson, 1996	Sânpetru	Central part of Haţeg Basin, Sibişel River valley, southwest of village of Sânpetru	Sânpetru Fm.	Early Maastrichtian	Large-sized kogaionid	Rădulescu and Samson, 1996	Type genus and species for Family Kogaionidae
Kogaionon sp.	Toteşti-baraj	Central part of Haţeg Basin, Râul Mare River valley, east of town of Toteşti	Sânpetru Fm.	Early/late Maastrichtian boundary	Small-sized kogaionid	Codrea et al., 2002	Comparable size to *B. oardaensis*. Likely is the same species
Barbatodon transylvanicus Rădulescu and Samson, 1986	Pui	Eastern part of Haţeg Basin, Bărbat River valley, south of village of Pui	Sânpetru Fm. or "Pui beds" in Therrien (2005)	Early/late Maastrichtian boundary[c]	Large-sized kogaionid	Codrea and Solomon, 2014; Csiki et al., 2005; Grigorescu and Hahn, 1987; Rădulescu and Samson, 1986; Smith and Codrea, 2015; Solomon et al., 2016	This species was named as *Paracimexomys ?dacicus* by Grigorescu and Hahn, 1987 (= junior synonym of *B. transylvanicus*)
Barbatodon oardaensis Codrea, Solomon, Venczel and Smith, 2014	Oarda de Jos	Southwestern part of Transylvanian Basin, Sebeş River valley, west of the village of Oarda de Jos	Şard Fm.	Maastrichtian	Small-sized kogaionid	Codrea et al., 2012b, 2014	
Barbatodon oardaensis Codrea, Solomon, Venczel and Smith, 2014	Negoiu-Fărcădeana	Eastern part of Rusca Montană Basin, along Fărcădeana Creeck, within the village of Negoiu	Unnamed rock unit	Maastrichtian	Small-sized kogaionid	Codrea et al., 2009, 2012a; This study	
Barbatodon sp.	Nălaţ-Vad	Central part of Haţeg Basin, Râul Mare River valley, southeast of village of Nălaţ-Vad	Sânpetru Fm.	Early/late Maastrichtian boundary	Small-sized kogaionid	Smith et al., 2002	Comparable size to *B. oardaensis*. Likely is the same species
"*Hainina* sp. A"[a]	Vălioara-Fântânele	Northwestern part of Haţeg Basin, northwest of the village of Vălioara	Densuş-Ciula Fm.	Early Maastrichtian	Small-sized kogaionid	Csiki and Grigorescu, 2000	Comparable size to *B. oardaensis*. Likely is the same species
"*Hainina* sp. B"[a]	Vălioara-Fântânele	Northwestern part of Haţeg Basin, northwest of the village of Vălioara	Densuş-Ciula Fm.	Early Maastrichtian	Small-sized kogaionid	Csiki and Grigorescu, 2000	Comparable size to *B. oardaensis*. Likely is the same species
cf. *Hainina* sp.	Jibou	Jibou town, Botanical Garden "Vasile Fati"	Jibou Fm.	Thanetian	Small-sized kogaionid	Gheerbrant et al., 1999	
?Kogaionidae indet.	Sânpetru	Central part of Haţeg Basin, Sibişel River valley, southwest of village of Sânpetru	Sânpetru Fm.	Early Maastrichtian	Small-sized kogaionid	Grigorescu, 1984	Comparable size to *B. oardaensis*. Likely is the same species
?Kogaionidae indet.	Vălioara-Fântânele	Northwestern part of Haţeg Basin, northwest of the village of Vălioara	Densuş-Ciula Fm.	Early Maastrichtian	Small-sized kogaionid	Csiki and Grigorescu, 2000	Comparable size to *B. oardaensis*. Likely is the same species
?Kogaionidae indet.	Tuştea	Northwestern part of Haţeg Basin, north of the village of Tuştea	Densuş-Ciula Fm.	Late early-early late Maastrichtian	Small-sized kogaionid	Csiki and Grigorescu, 2000	Comparable size to *B. oardaensis*. Likely is the same species
Kogaionidae indet.	Toteşti-baraj	Central part of Haţeg Basin, Râul Mare River valley, east of town of Toteşti	Sânpetru Fm	Early/late Maastrichtian boundary	Medium-sized kogaionid	Codrea et al., 2002	
Kogaionidae indet.	General Berthelot	Northwestern part of Haţeg Basin, north of the village of General Berthelot	Densuş-Ciula Fm.	Late Maastrichtian	Small-sized kogaionid	Csiki-Sava et al., 2016; Vasile et al., 2011	Comparable size to *B. oardaensis*. Likely is the same species
Kogaionidae indet.	Petreştii de Jos	Southwestern part of Transylvanian Basin, Sebeş River valley, south of Sebeş city	Şard Fm. (=lower Sebeş Fm. cf. Vremir et al., 2014)	Maastrichtian	Small-sized kogaionid	Csiki-Sava et al., 2012; Vremir et al., 2014	Comparable size to *B. oardaensis*. Likely is the same species
Kogaionidae indet.	Livezi	Northwestern part of Haţeg Basin, north of the village of Livezi	Densuş-Ciula Fm.	Late Maastrichtian	Small-sized kogaionid	Csiki-Sava et al., 2016	Comparable size to *B. oardaensis*. Likely is the same species

[a] These "*Hainina*" species are uncertain.
[b] Age according to Venczel et al. (2016), except for Oarda de Jos, Jibou, and Petreştii de Jos.
[c] In the related references, these discoveries are assigned to indeterminate multituberculates.

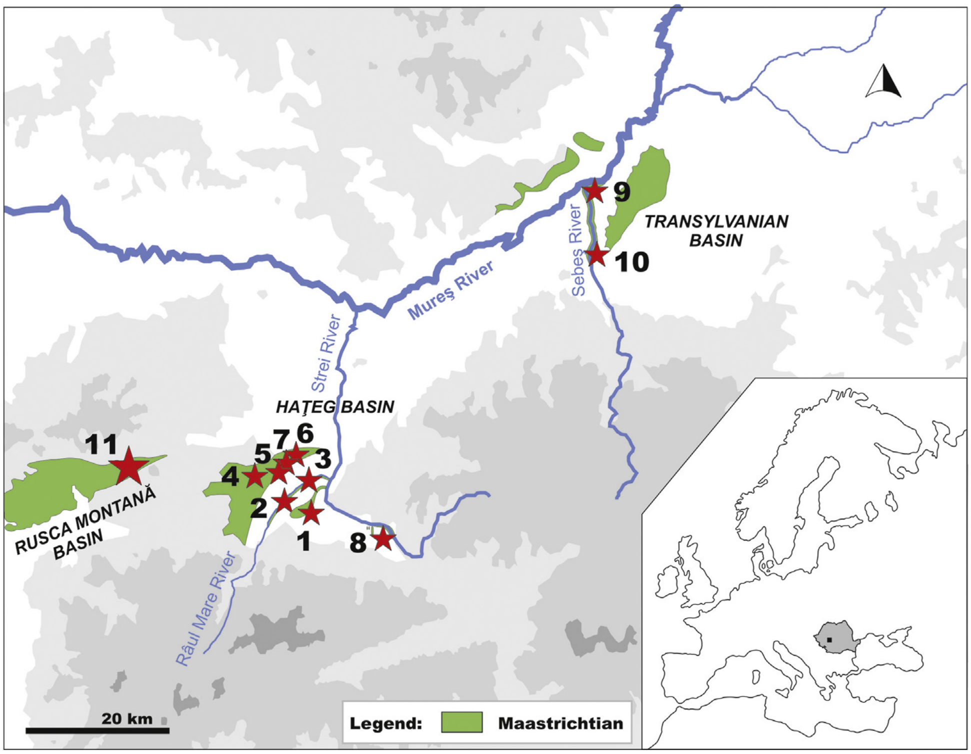


Fig. 1. Map of Romanian Upper Cretaceous (Maastrichtian) localities (indicated by star) that yielded kogaionid multituberculates. 1. Sânpetru; 2. Toteşti-baraj; 3. Nălaţ-Vad; 4. Vălioara-Fântânele; 5. Tuştea; 6. Livezi; 7. General Berthelot; 8. Pui; 9. Oarda de Jos; 10. Petreştii de Jos; 11. Negoiu-Fărcădeana (details in Table 1).

Fig. 1. Carte des localités roumaines du Crétacé supérieur (Maastrichtien) (indiquées par des étoiles) qui ont livré des multituberculés kogaionidés. 1. Sânpetru ; 2. Totesti-baraj ; 3. Nălaţ-Vad ; 4. Vălioara-Fântânele ; 5. Tuştea ; 6. Livezi ; 7. Général Berthelot ; 8. Pui ; 9. Oarda de Jos ; 10. Petreştii de Jos ; 11. Negoiu-Fărcădeana (voir Tableau 1 pour les détails).

centimeters in thickness, while the second one crops out on the right side of the creek, consisting of red and yellowish-greyish siltstones. We name them here Negoiu-Fărcădeana 1 and 2, respectively (abbreviated Ng as in Codrea et al., 2012a). Obviously, the first one belongs to the same level that yielded some of the macro- and microvertebrates reported by Codrea et al. (2009, 2012a) and Vasile and Csiki (2011), and was later named Fărcădeana by Vasile (2012).

3. Material and methods

The available material consists of six isolated teeth of multituberculate mammals, recovered by screen-washing and processing of about 750 kg of sediment. Micrographs of three of the studied specimens (UBB Ng1-01, UBB Ng1-02, UBB Ng2-01) were taken with an environmental scanning electronic microscope (ESEM Quanta 200) at the Royal Belgian Institute of Natural Sciences, Brussels. The other three specimens (UBB Ng2-02, UBB Ng2-03, UBB Ng2-04) were coated, under vacuum, with a thin film of gold, and subsequently investigated at a JSM-6610 LV scanning electronic microscope, at the Faculty of Mining and Geology (University of Belgrade, Serbia). The images were processed using Adobe Photoshop CS2. The cusp formula is counted from the labial towards the lingual side. Upper premolars position numbering follows Kielan-Jaworowska and Hurum (2001, see addendum p. 426 for more details).

Institutional abbreviations. – FGGUB: Faculty of Geology and Geophysics, University of Bucharest, Romania; FNT: Fontllonga, Lleida province, Spain; IRSNB: Royal Belgian Institute of Natural Sciences, Brussels, Belgium; UBB: Babeş-Bolyai University of Cluj-Napoca, Paleotheriology Laboratory collection, Romania; UBB Ng1 and UBB Ng2: Ng1 - Negoiu-Fărcădeana layer 1, Ng2 - Negoiu-Fărcădeana layer 2; UBB ODAN-Mt: ODAN-Mt the name given for the multituberculates from Oarda de Jos curate at UBB (see Codrea et al., 2014 for details); UCM: Complutense University of Madrid, Department of Paleontology collection, Spain.

4. Systematic palaeontology

Class Mammalia Linnaeus, 1758
Subclass Allotheria Marsh, 1880
Order Multituberculata Cope, 1884
Suborder Cimolodonta McKenna, 1975
Family Kogaionidae Rădulescu and Samson, 1996
Genus ***Barbatodon*** Rădulescu and Samson, 1986

Type species: Barbatodon transylvanicus Rădulescu and Samson, 1986.

Other species: *Barbatodon oardaensis* Codrea, Solomon, Venczel, and Smith, 2014.

Barbatodon oardaensis

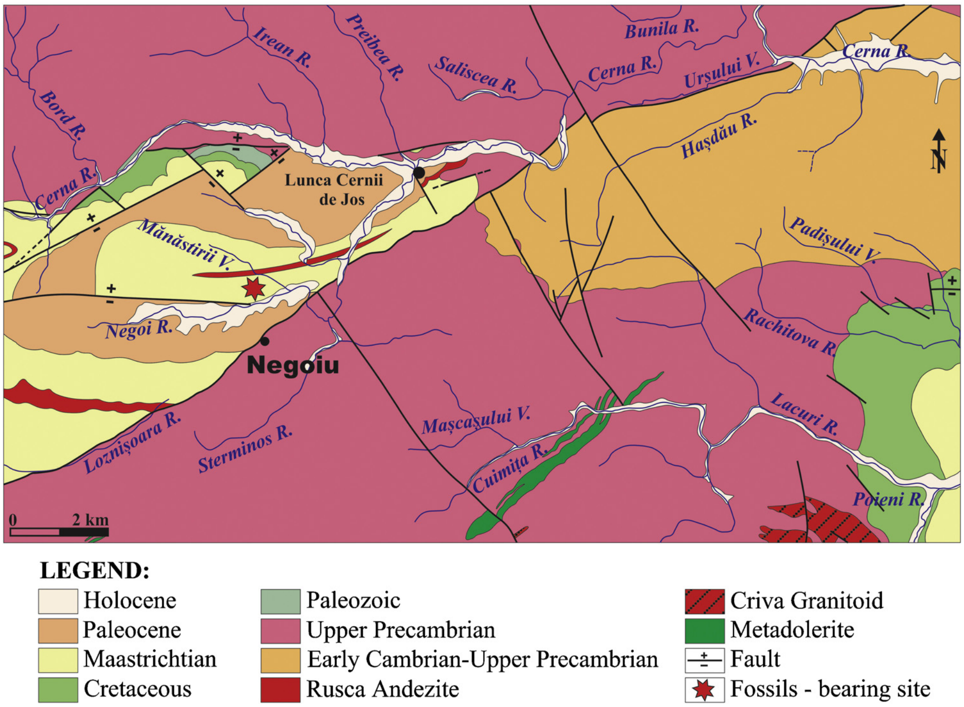


Fig. 2. Geological map of the Rusca Montană Basin; the star indicates Fărcădeana Creek.

Fig. 2. Carte géologique du bassin de Rusca Montană ; l'étoile indique Fărcădeana Creek.

Fig. 3

Holotype. UBB ODAN-Mt-13, isolated M1 (Codrea et al., 2014, fig. 2J1 and J2).

Referred specimens. The material described by Codrea et al., 2014; new available referred specimens: UBB Ng1-01: right I2; UBB Ng1-02: left P1; UBB Ng2-04: right P4; UBB Ng2-02: left i1; UBB Ng2-03: right i1; UBB Ng2-01: right p4.

Emended diagnosis - based on Codrea et al. (2014). Small species of *Barbatodon* with the following cusp formula: I2 bicusped; P1 1:1–2; P2 2:2; P3 3:3; P4 (1):4:2–3; M1 3:4:2; M2 2:3; p4 with ten to eleven serrations and six to seven ridges; m1 3:3; m2 2–3:2. It differs from *B. transylvanicus* in being approximately 35% smaller. Differs from *Kogaionon ungureanui* in being approximately 45% smaller, with an additional cusp in P3, and with only two cusps on the lingual row of M1 instead of three. Differs from all *Hainina* species in having a short lingual row in M1, while in *Hainina* the lingual row is as long as the labial row.

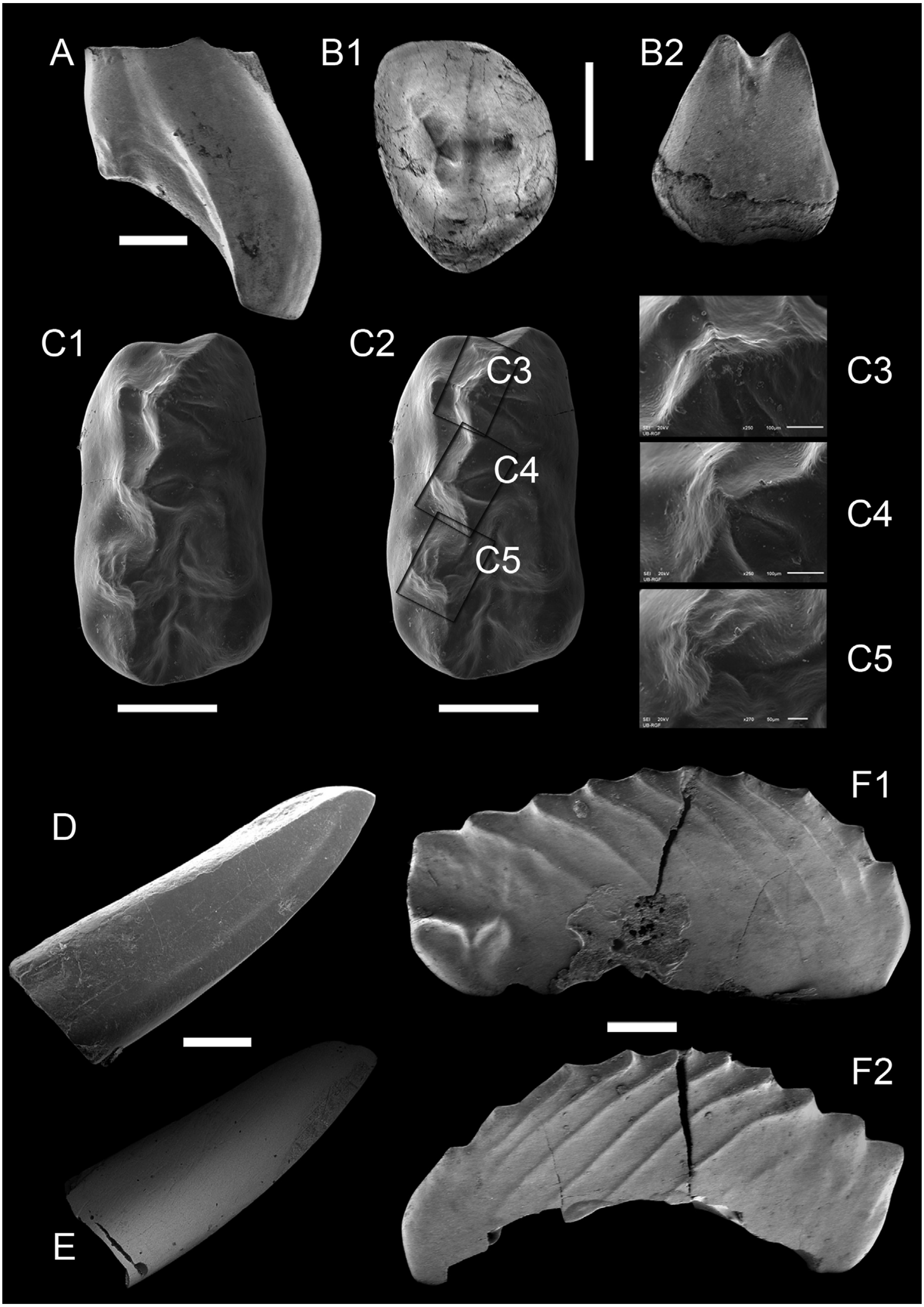
Occurrences. Oarda de Jos (ODA section), Alba District, Transylvanian Basin, Romania; Uppermost Cretaceous (Maastrichtian), Şard Formation (Type locality); Lunca Cernii de Jos, Negoiu, Fărcădeana Creek (Negoiu-Fărcădeana layers 1 and 2), Hunedoara District, Rusca Montană Basin, Romania; Uppermost Cretaceous (Maastrichtian), unnamed formation.

5. Description of the material from RMB assigned to *Barbatodon oardaensis*

I2 – a single right bicusped first upper incisor (UBB Ng1-01, Fig. 3A) is broken on the lingual side; the preserved crown length is 2.28 mm; the main mesial cusp is larger than the distal one. The tips of both cusps are worn. In labial view, the cusps are separated by a groove. The whole preserved part of the crown is covered by enamel.

P1–the first upper left premolar has an oval-shaped outline in occlusal view, with a simple morphology (UBB Ng1-02; L = 1.20 mm, l = 1.09 mm, Fig. 3B1 and B2). The crown bears two conical cusps of almost same size. Their heights are nearly the same, the cusps being separated by a longitudinal "V"-shaped valley. A wear facet is present on the lingual side. Fine enamel ridges are present on the lingual cusp. The roots are broken.

P4 – a right P4 is perfectly preserved (UBB Ng2-04; L = 1.78 mm, l = 1.00 mm, Fig. 3C1 and C2). It has a subrectangular outline in occlusal view. The cusp formula is (1):4:3. The cusps are aligned on two mesially convergent crests. The main labial crest is higher than the lingual one, bearing four cusps. The height of the labial crest is mesially increasing, while the lingual one is increasing on opposite direction. In the mesio-labial part of the crown, a vestigial, extremely small cusp can be observed. A "V"-shaped deep longitudinal valley, which closes at the level of the second labial and lingual cusps, separates the crests. Weak wear facets are present on the third and fourth labial cusps, as well as on the lingual cusps, the most advanced wear being observed on the first lingual cusp. The enamel is ornamented by fine wrinkles. These wrinkles are best observed on the lingual side of the first two labial cusps, and on the labial side on the third labial cusp. The mesio-labial cusp presents well-individualized, divergent enamel ridges (Fig. 3C3), the second labial cusp is the most spectacular ornamented cusp exposing sea star-like radial ridges


A
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B2
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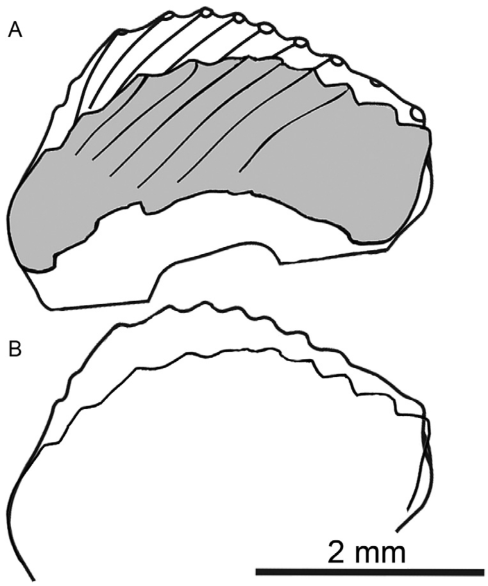

Fig. 4. The p4 of *Barbatodon oardaensis*. A. Comparison between p4 lateral profiles (grey - UBB Ng2-01; white - UBB ODAN-Mt-1); B. Variation of p4 lateral outline; Scale bar equals: 2 mm.

Fig. 4. La p4 de *Barbatodon oardaensis.* A. Comparaison entre les profils latéraux des p4 (gris - UBB Ng2-01 ; blanc - UBB ODAN-Mt-1). B. Variations du profil latéral de la p4 ; barre d'échelle : 2 mm.

(Fig. 3C4), and the third labial cusps is ornamented by a central wide ridge, with curved secondary ridges (Fig. 3C5).

i1 – two mesial extremities of lower first incisor are available for study (UBB Ng2-02: left i1, Fig. 3D; UBB Ng2-03: right i1, Fig. 3E). Both incisors have a slightly curved elongated crown. The total preserved length of the left i1 is 3.12 mm, while in the right i1 it is 3.00. On the lingual side of these teeth, a prominent curved line can be noticed in the basal third portion of the crowns. UBB Ng2-02 is slightly worn mesio-lingually, while UBB Ng2-03 is worn mesio-ventrally. The incisors have a worn tip, the enamel being present both on labial and lingual sides of the teeth, but more reduced on the lingual side. The enamel is almost lost on the dorsal side of the teeth, exposing the dentine, due to advanced wear.

p4 – a single blade-like p4 is available for study (UBB Ng2-01; L = 3.36 mm, l = 1.00 mm, Fig. 3F1 and F2; see also Fig. 4); only the crown edge is preserved, the roots being broken as well as a part of the crown base. The edge bears ten conical serrations, the last one being the largest. The maximum height of the edge is at the level of serrations four-five. The first two serrations are mesially trended, while the others distally. Seven ridges are present on the labial side under serrations three-nine, while on the lingual side only six ridges can be noticed, under serrations three-eight. "U"-shaped gentle slopes separate the serrations. Two well-distinct serrations (=labial cuspules; e.g., in Vianey-Liaud, 1986; Yuan et al., 2013), separated by a "V"-shaped valley, are present on the labio-distal platform of the edge. The second serration of the platform is larger and distally trended. Above this platform fine enamel wrinkles are present. A large fissure is crossing the crown, damaging the tooth.

6. Comparisons of the *Barbatodon oardaensis* specimens from RMB with other known kogaionid multituberculates

Barbatodon was described as a new genus of multituberculate from the Uppermost Cretaceous (Maastrichtian) of Pui (Hunedoara District, Transylvania, Romania) by Rădulescu and Samson (1986). The type species, *B. transylvanicus* (Rădulescu and Samson, 1986) was coined based on a "M1". Grigorescu and Hahn (1987) correctly reassessed the tooth as an m1 and proposed the new species *Paracimexomys dacicus*–which is a junior synonym of *B. transylvanicus*. Rădulescu and Samson (1996), based on a skull found at Sânpetru described the new species *Kogaionon ungureanui* and erected the new multituberculate family Kogaionidae. Csiki et al. (2005) included *Barbatodon* in the family Kogaionidae based on additional fossils of *B. transylvanicus* including associated partial dentaries found at Pui. The complete dentition of *B. transylvanicus* was described based on a skull with associated dentaries found in the same locality of Pui and the relationships of this family were assessed (Smith and Codrea, 2015). The intraspecific variability of *B. transylvanicus* was recently highlighted by Solomon et al. (2016). The only other species of the genus *Barbatodon* is *B. oardaensis*–the smallest Maastrichtian kogaionid known to date–, described from Oarda de Jos locality (Codrea et al., 2014).

Earlier, Vianey-Liaud (1979) described from the Early Paleocene of Hainin, Belgium, the genus *Hainina*, with the type species *H. belgica*. Based on dental similarities with *Kogaionon*, the genus *Hainina* was assigned to the family Kogaionidae by Peláez-Campomanes et al. (2000). Other Paleocene species of the genus *Hainina* were present in Europe, as follows: *H. pyrenaica* from the Earliest Paleocene of Fontllonga (Spain; Peláez-Campomanes et al., 2000), *H. godfriauxi* from the Early Paleocene of Hainin (Belgium; Vianey-Liaud, 1979, 1986), *H. vianeyae* from the Late Paleocene of Cernay (France; Peláez-Campomanes et al., 2000)

Fig. 3. *Barbatodon oardaensis*, isolated teeth from RMB; A. UBB Ng1-01, right I2 in labial view; B1. UBB Ng1-02, left P1 in occlusal view; B2. UBB Ng1-02, left P1 in anterior view; C1. UBB Ng2-04, right P4 in occlusal view; C2. UBB Ng2-04, right P4, labial cusps detail; C3. UBB Ng2-04, first labial cusp detail; C4. UBB Ng2-04, second labial cusp detail; C5. UBB Ng2-04, third labial cusp detail; D. UBB Ng2-02, left i1 in lingual view; E. UBB Ng2-03, right i1 in labial view. F1. UBB Ng2-01, right p4 in labial view; F2. UBB Ng2-01, right p4 in lingual view; Scale bar equals: 0.5 mm.

Fig. 3. *Barbatodon oardaensis*, dents isolées de RMB ; A. UBB Ng1-01, I2 droite en vue labiale ; B1. UBB Ng1-02, P1 gauche en vue occlusale ; B2. UBB Ng1-02, P1 gauche en vue antérieure ; C1. UBB Ng2-04, P4 droite en vue occlusale ; C2. UBB Ng2-04, détail des cuspides labiales ; C3. UBB Ng2-04, détail de la première cuspide labiale ; C4. UBB Ng2-04, détail de la deuxième cuspide labiale ; C5. UBB Ng2-04, détail de la troisième cuspide labiale ; D. UBB Ng2-02, i1 gauche en vue linguale ; E. UBB Ng2-03, i1 droite en vue labiale ; F1. UBB Ng2-01, p4 droite en vue labiale ; F2. UBB Ng2-01, p4 droite en vue linguale ; barre d'échelle : 0,5 mm.

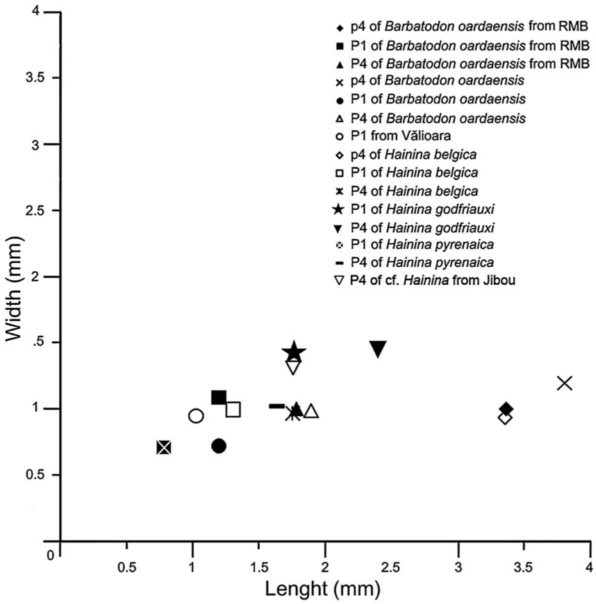

Fig. 5. Plot diagram with teeth sizes of *Barbatodon oardaensis* vs. *Hainina*.
Fig. 5. Diagramme des dimensions des dents de *Barbatodon oardaensis* vs. *Hainina*.

and an undefined species from the Late Paleocene of Jibou (Romania; Gheerbrant et al., 1999).

Comparisons of the new *B. oardaensis* remains with other kogaionids can be extended as detailed below.

The I2 is bicuspid as in *B. transylvanicus* (see Smith and Codrea, 2015, fig. 5), having a main mesial cusp and one accessory much smaller distal cusp, resembling in this aspect the small incisor FGGUB M.1609 described from Tuştea (Csiki and Grigorescu, 2000). Other similarity with the incisor from Tuştea is the same stage of the wear on the tips of the cusps. However, the incisor of Tuştea is a little smaller.

The P1 (= P2 of Peláez-Campomanes et al., 2000) of *B. oardaensis* from RMB is much smaller than those of *K. ungureanui* and *B. transylvanicus*. It bears two conical cusps as seen in *H. pyrenaica*, *H. godfriauxi* and the P1s FGGUB M.1610 and M.1611 from Vălioara (Csiki and Grigorescu, 2000), but differs from *H. belgica*, *K. ungureanui*, *B. transylvanicus* and the P1 of *B. oardaensis* form Oarda de Jos (Codrea et al., 2014), which have three cusps. The different cusp formula in UBB Ng1-02 and UBB ODAN-Mt-38 could result from intraspecific variations like "type a" and "type b" of kogaionid P1 (Peláez-Campomanes et al., 2000). The height of the cusps is quite similar, resembling in this aspect the P1s from Vălioara and of *H. pyrenaica*. The enamel is wrinkled, differing from the smooth enamel present in UBB ODAN-Mt-38, but less ornamented than those of *H. belgica* and *H. godfriauxi*. The size of the P1 (Fig. 5) is comparable to that of UBB ODAN-Mt-38 and *H. belgica*, being somewhat smaller than that of *H. godfriauxi*, and larger than that of *H. pyrenaica*. This P1 is somewhat larger (Fig. 5) than the P1s from Vălioara (Csiki and Grigorescu, 2000) and also less wrinkled. In the tooth from Rusca, the common base of the couple of cusps runs higher compared to the teeth from Vălioara. In Oarda, the P1 has a more complicate tooth pattern, with three cusps and a distal slope.

The new P4 (= P5 of Peláez-Campomanes et al., 2000) has a sub-rectangular outline and possesses conical cusps as in *K. ungureanui*, *H. belgica*, *H. godfriauxi*, *H. pyrenaica* and *B. oardaensis* from Oarda de Jos. It resembles "type e" of kogaionid premolars (Peláez-Campomanes et al., 2000). It differs from *H. belgica* in having one less cusp on the labial row and two more on the lingual row. The number of cusps on each row is similar to the specimens from Oarda de Jos, the small vestigial mesio-labial cusp of UBB Ng2-04 being interpreted as an intraspecific variability. The intraspecific variation seen on the P4s of *B. oardaensis* was indeed documented and discussed by Codrea et al. (2014) based on samples with statistically adequate number of specimens (n = 8). The wear affects the labial side of this tooth as in *H. pyrenaica* and the P4s from Oarda de Jos (Codrea et al., 2014; Peláez-Campomanes et al., 2000). The wearing is less pronounced than in *H. pyrenaica*. The enamel is wrinkled, differing in this aspect from some of the P4s from Oarda de Jos (Codrea et al., 2014) and from *K. ungureanui*, but resembling the more ornamented P4s of *H. belgica* and *H. godfriauxi*. The ornamentation of the enamel is similar to that of UBB ODAN-Mt-25 and UBB ODAN-Mt-26 (Codrea et al., 2014, fig. 2F1 and 2I) and the different states of wear seem to affect the wrinkled enamel of the P4 of this species. The P4 size is larger than that of *H. pyrenaica*, similar in length, but less wide than that of cf. *Hainina* sp. from Jibou (Gheerbrant et al., 1999). It is similar in size with the mean dimensions of the P4s from Oarda de Jos, having also nearly the same size as that of *H. belgica* and being smaller than that of *H. godfriauxi* (Fig. 5).

The i1 of *B. oardaensis* shares the same morphology of the crown with the incisor FGGUB M.1612 from Vălioara (Csiki and Grigorescu, 2000, fig. 3), described as an indeterminate multituberculate. Also, the reduced lingual enamel is the same in these specimens.

The p4 is blade-like and has an arcuate crown outline, with oblique ridges resembling other cimolodontan p4s (Kielan-Jaworowska and Hurum, 2001; Figs. 3F and 4). Few kogaionid p4s are known to date. The p4 (UBB Ng2-01) is smaller than the one of *B. transylvanicus* (Csiki et al., 2005; Smith and Codrea, 2015; Solomon et al., 2016), but has a similar general shape. UBB Ng2-01 differs from UBB ODAN-Mt-1 in having one less serration (Fig. 4) on the edge (ten *vs.* eleven), resembling *H. belgica* in this aspect. UBB Ng2-01 also bears two well-individualized labial cuspules on the labio-distal platform. The distal cuspule is separated from the distal serration of the edge by a "U"-shaped valley and may be interpreted as a distinct serration, or even as a distinct cusp due to its dimensions and conical shape (Fig. 3F1). The distal part of UBB Ng2-01 is less worn than the same part in UBB ODAN-Mt-1 (Fig. 4). *Hainina belgica* and UBB ODAN-Mt-1 bear seven oblique ridges both on the lingual and distal sides, while the UBB Ng2-01 has seven labial ridges, and only six lingual ones (Figs. 3F and 4A). From a morphometrical point of view (Figs. 4 and 5), compared to UBB ODAN-Mt-1 (3.85 × 1.20 mm), UBB Ng2-01 is somewhat smaller (3.36 × 1.00 mm), but the size differences, as well as the morphological ones, may be attributed to intraspecific variations. The p4 from RMB nearly equals the size of that of *H. belgica* (3.35 × 0.94 mm). We point out here that the p4 of *B. oardaensis* is longer than the one of *H. belgica*, and not shorter as we mentioned in a previous paper (Codrea et al., 2014). The first two serrations of UBB Ng2-01 project mesially as in UBB ODAN-Mt-1 (Fig. 4). A fissure is present in the RMB p4's crown, therefore the edge is incomplete, whereas UBB ODAN-Mt-1 is a complete p4 (including both roots). This is the reason why the edge of UBB Ng2-01 appears smaller in Fig. 4.

7. Discussion and conclusions

Although the multituberculate sample from RMB is not very rich, its importance is high. This material documents the first Mesozoic multituberculate species identified from the RMB and extends the distribution of *B. oardaensis* (Codrea et al., 2014) westward in Romania, outside the Transylvanian Basin.

We interpret the six dental specimens here described as belonging to the same species, *B. oardaensis*, because of their comparable size and morphology with the specimens from the type locality-Oarda de Jos (Alba District; Codrea et al., 2014) and because they were collected from two nearby layers (Negoiu-Fărcădeana 1 and 2, Fig. 2) in the same locality, an exposure that yielded other Maastrichtian vertebrates too (Codrea et al., 2012a).

Barbatodon oardaensis is by far smaller than *Kogaionon ungureanui* and *B. transylvanicus*, but comparable in size with *Hainina belgica* (Fig. 5). We describe herein the first upper and lower incisors belonging to *B. oardaensis*, which are morphologically similar to the I2 and i1 of ?kogaionid (identified as indeterminate multituberculates) specimens reported earlier from Tuştea and Vălioara (Haţeg Basin; Csiki and Grigorescu, 2000). The morphology of the P1 (UBB Ng1-02) suggests that this tooth position of *B. oardaensis* has a variable cusp formula (1:1–2) and from a morphometrical viewpoint the P1 of *B. oardaensis* (UBB OBAN-Mt-38 and UBB Ng1-02) is very similar to the P1 of *H. belgica* (Fig. 5).

The general shape and cusp formula of the new P4 (=P5 of Peláez-Campomanes et al., 2000) are similar to those of the P4s from Oarda de Jos and the mesial and distal margins are almost parallel, differing in this aspect from the P4s of *Hainina*. Similar wear as seen on UBB Ng2-04 was reported on the P4s from Oarda de Jos and the P4 UCM FNT3-2 of the Paleocene *Hainina pyrenaica* (Codrea et al., 2014; Peláez-Campomanes et al., 2000). The ornamentation of the enamel of UBB Ng2-04 resembles that of some P4s of *B. oardaensis* from Oarda de Jos (Codrea et al., 2014, fig. 2F) and is more similar to those of *H. belgica* and *H. godfriauxi*, differing in this aspect from *K. ungureanui* (Fosse et al., 2001; Rădulescu and Samson, 1996). From a morphometrical point of view (Fig. 5), UBB Ng2-04 fits in the mean sizes of *B. oardaensis* (Codrea et al., 2014, table 1) and is also similar to *H. belgica*, being smaller than *H. godfriauxi* and close to the P4s of *Hainina* from Jibou (Gheerbrant et al., 1999).

The p4 from RMB (UBB Ng2-01) bears a similar number of serrations on the edge as that of *H. belgica* (IRSNB M1956), but one less than in UBB ODAN-Mt-1of *B. oardaensis* from Oarda de Jos (Codrea et al., 2014, fig. 2Q). It differs from the two mentioned p4s in having two well-individualized labial cuspules on the labio-distal platform. Labial cuspules on the labio-distal platform of *H. belgica* and UBB ODAN-Mt-1 seem absent, but this may also be the result of the advanced stage of wear, but these cuspules were present in *B. transylvanicus* (Solomon et al., 2016). The general shape, the profile, and the size are very similar to the p4s of *H. belgica* and to UBB ODAN-Mt-1 (Figs. 4 and 5).

It is established that the variations in teeth morphology (i.e., variable cusps formula, and presence of accessory crests/cusps) can be very frequent, as well as the size variations of the same teeth in the same species of multituberculate. Such examples of intraspecific variations were pointed out also in North American multituberculates originating from different localities (e.g., Donohue et al., 2013; Eaton, 2006a, 2006b; Eaton and Cifelli, 2001; Hunter et al., 2010; Scott, 2003). The general shape, cusp formulae, and the size dimensions of the check teeth from RMB are similar to those of *B. oardaensis* from Oarda de Jos, for which the intraspecific variation was largely discussed (Codrea et al., 2014). Intraspecific variation is present also in other Maastrichtian kogaionids such as *B. transylvanicus* (Solomon et al., 2016). The sample from RMB originates from Maastrichtian fluvial deposits (Codrea et al., 2012a) as is the case of *B. oardaensis* from Oarda de Jos (Codrea et al., 2014), while all the *Hainina* species described originate from various Paleocene deposits in Europe (Gheerbrant et al., 1999; Peláez-Campomanes et al., 2000; Vianey-Liaud, 1979, 1986). Due to the closer morphological similarity and similar Maastrichtian age, the RMB material can be more confidently assigned to *B. oardaensis*, than to *Hainina*, and represents the first record of *B. oardaensis* in that area.

Based on the available material from RMB, a revised diagnosis of *B. oardaensis* has been proposed.

Recent discoveries of new Maastrichtian kogaionids indicate a higher diversity and distribution of these multituberculate mammals on the Transylvanian landmass than previously thought. Based on the known discoveries since the mid-1980s, the distribution of Maastrichtian kogaionids (Fig. 1) can now be summarized as follows (see more details in Table 1): i. Small-sized kogaionids were present in the Metaliferi area of the Transylvanian Basin (Codrea et al., 2012b, 2014; Csiki-Sava et al., 2012; Vremir et al., 2014), in the Densuş-Ciula Formation of the northern side of the Haţeg Basin (Csiki and Grigorescu, 2000; Csiki-Sava et al., 2016; Vasile et al., 2011), as well as in the RMB (Codrea et al., 2012a; this paper); ii. Small and medium-sized kogaionids were recorded from the Râul Mare sites in the Sânpetru Formation of the Haţeg Basin (Codrea et al., 2002; Smith et al., 2002); iii. The largest kogaionids, *K. ungureanui* and *B. transylvanicus*, were reported from the famous Sânpetru and Pui localities (Sânpetru Formation) also of the Haţeg Basin (Codrea and Solomon, 2014; Csiki et al., 2005; Grigorescu and Hahn, 1987; Grigorescu et al., 1985; Rădulescu and Samson, 1986, 1996; Smith and Codrea, 2015; Solomon et al., 2016).

A few small multituberculate specimens discovered from Tuştea and Vălioara were originally referred to the genus *Hainina* (Csiki and Grigorescu, 2000). However, as seen in the present paper, the discovery of the new small teeth from the RMB and the re-assignment of the previously reported P1 and P4 (Codrea et al., 2012a) extend the occurrence of *B. oardaensis* towards the western parts of Romania and demonstrate that small representatives of the genus *Barbatodon* were also present in this area (Fig. 1, Table 1). For this reason, it is more likely that the material from Tuştea and Vălioara (Densuş-Ciula Formation) belongs to one of the known Maastrichtian kogaionid genera (*Barbatodon* or *Kogaionon*), aside from small-sized kogaionids such as *B. oardaensis* (this paper). The Sânpetru Formation is dominated by larger kogaionids, such as *K. ungureanui* and *B. transylvanicus*; however, small and medium-sized kogaionids were also recorded from these sequences (Codrea et al., 2002; Smith et al., 2002). Based on these remarks, we may assume that the RMB terrestrial deposits are only a westward extension of the Densuş-Ciula Formation (Anastasiu and Csobuka, 1989; Bojar et al., 2005; Grigorescu et al., 1990a) than of the Sânpetru Formation (Grigorescu, 1990; Grigorescu et al., 1990b; Weishampel et al., 1993).

The presence of *Barbatodon oardaensis*, in association with other Maastrichtian vertebrates, underlines once again the similarities of the faunal assemblages from the RMB with those known from the Haţeg and Transylvanian basins, demonstrating that in these peculiar and complex Maastrichtian ecosystems, dominated by dinosaurs, the endemic multituberculate mammals were also important components of the terrestrial communities.

Acknowledgments

This research was supported by grant PN-II-PCE-2011-3-0381 of the National Council of Scientific Research - CNCS, Romania (to V.A.C., A.A.S., M.V.), Projects MO/36/001-004 of the Belgian Science Policy Office (to T.S.). The authors thank all people involved in field missions in the RMB, as well as Cristina Fărcaş for digital drawings and Corina Ionescu for assistance with SEM micrographs of some specimens. Also, we thank the anonymous reviewers, as well as the Associate Editor Lars van den Hoek Ostende, for their useful comments that greatly helped to improve the manuscript.

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