Brachypotherium cf. *brachypus* and *Lartetotherium* sp. (Rhinocerotidae, Perissodactyla, Mammalia) from the Middle Miocene Dúbravka-Pole site (western Slovakia)

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Brachypotherium cf. brachypus a Lartetotherium sp. (Rhinocerotidae, Perissodactyla, Mammalia) zo strednomiocénnej lokality Dúbravka-Pole (západné Slovensko)

Abstract: The vertebrate fossil record from the Dúbravka-Pole site in the territory of Devínska Kobyla consists of *Brachypotherium* cf. *brachypus* and *Lartetotherium* sp. dental and osteological remains. The both taxa lived in swampy to forested land at the shore of shallow brackish sea (or lagoon?) during the Early Sarmatian (MN 7/8). Their occurrence is probably a result of intermittent faunal migrations during changing environmental conditions at the end of the Middle Miocene.

Key words: *Brachypotherium*, *Lartetotherium*, Miocene, palaeoenvironment, Dúbravka-Pole, Slovakia

1. INTRODUCTION

The fossil record of rhinoceroses from the territory of Slovakia is mainly documented from Pliocene (MN 16) and Pleistocene (MN 17, MQ 4) deposits. To the contrary, Miocene fossils of rhinoceroses are relatively rare, so far mentioned only from terrestrial deposits of Devínska Nová Ves – Fissures (also known as Neudorf – Spalte or Zapfe´s Fissures, early MN 6) (Zapfe, 1949) and from marine ones of the Devínska Nová Ves – Sandberg (late MN 6) (Thenius, 1952).

Another Miocene rhinoceros fossil material was found in 1980s during the surface prospection of Dúbravka-Pole, a locality situated near to above mentioned Devínska Nová Ves sites. This new rhinoceroses locality (Fig. 1) with geographic coordinates 48°11'08.20"N and 17°00'53.27"E is located approximately 300 m south of Dúbravska hlavica elevation point within Bratislava City district (Holec & Sabol, 1996; cf. Hyžný et al., 2012). The basic locality description together with a synopsis of its research was recently published by Hyžný et al. (2012).

The fossils of rhinoceroses were collected from clayed sediments situated directly in the overlaying of the marine calcareous sand and poorly lithified sandstone with *Glycimeris deshayesi*, *Linga* (*Linga*) *columbella*, *Cubitostrea digitalina*, *Pecten* (*Flabellipecten*) *besseri*, *Turritella* sp. (cf. *badensis* – cf. *partschi*), and *Conus* sp. (Holec & Sabol, 1996), attributed traditionally to the Late Badenian (Sandberg Mb., Studienka Fm.) (Baráth et al., 2004). The foraminiferal assemblage analysis from fine-grained sandy sediments of the site, however, indicates a possibility of the slightly younger age for fossiliferous deposits, probably Early Sarmatian (Holíč Fm.) (Hyžný & Hudáčková, 2012).

The new fossil record of rhinoceroses from the Dúbravka-Pole site (= locality 4.7 Dúbravská hlavica (DH) / Dúbravka point (7); Hyžný et al., 2012) enables the specification of the mammalian diversity and environmental conditions during the late Middle Miocene in the vicinity of Devínska Nová Ves sites.

2. MATERIAL AND METHODS

Fossil remains studied and reported herein are housed in the fossil vertebrate collection of the Department of Geology and Palaeontology, Faculty of Natural Sciences, Comenius University in Bratislava and labelled as KGP: MS 33/1-2 and KGP: MS 33/3-47. The large portion of this fossil record, representing probably remains of a juvenile (*Lartetotherium* sp.) and an adult specimen (*Brachypotherium* cf. *brachypus*), is preserved fragmentary. Only *Lartetotherium* dentition together with carpals, tarsals, metapodial bones, and phalanges of *Brachypotherium* has been preserved more or less completely. The preserved *Lartetotherium* lower molar is light blue-grey, whereas colour of found bones is (rose-)pale-brown (hemimandible fragment of *Lartetotherium*) up to the grey-brown with manganese detrites (post-cranial ones of *Brachypotherium*).

Manuscript received 25 March 2013
Revised version accepted 2 May 2013

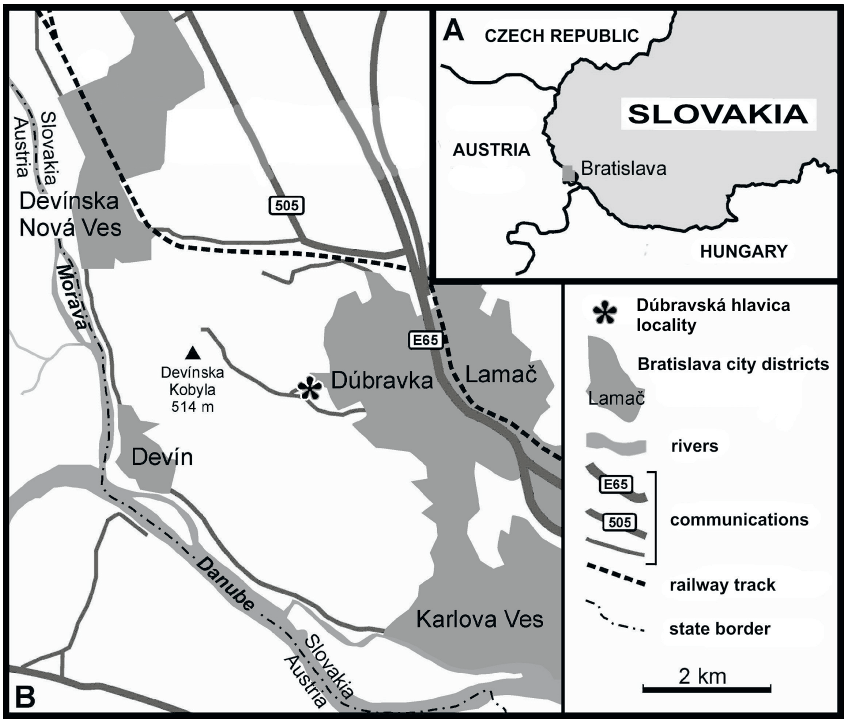

Fig. 1. Location of the Dúbravka-Pole site (Dúbravská hlavica) in the territory of Devínska Kobyla within Bratislava City district (borrowed from Hyžný & Hudáčková, 2012).

The PCA analysis have been used for the statistics, based on the logarithmically transmuted dimensions of morphological features of *Brachypotherium* remains as follows: maximum transverse dimension, maximum height, antero-posterior dimension, distal transverse dimension of articulation surface, and distal transverse dimension. Data for compared specimens from sites in France, Pakistan, Egypt, and Libya as well as from the site under study are in table within the appendix (Appendix 1).

Found fossils were documented by digital cameras Canon Power Shot S90 and Konica Minolta – Dimage Z3, and the photos have been converted for Figs. 2, 3, and 6 using Corel-Photo Paint 8 software. For exact determination of studied fossils, the morphometric analysis of dentition and osteological remains has been used. The measurements of studied rhinoceros remains were taken to the nearest 0.01 mm using a digital engineering vernier calliper with 0.29 mm standard deviation, 0.08 mm dispersion, and 2.05% random error. All measured data are in millimetres. Basic morphological terminology and measurement methods of rhinoceros remains have been borrowed from Guérin (1980^{b}).

The Miocene stratigraphic scale for the Central Paratethys area, used within the scope of this paper, has been borrowed from Harzhauser & Piller (2007).

3. SYSTEMATIC PART

Order Perissodactyla Owen, 1848
Family Rhinocerotidae Gray, 1821
Subfamily Rhinocerotinae Gray, 1821
Tribus Rhinocerotini Gray, 1821
Subtribus Rhinocerotina Gray, 1821
Infratribus Teleocerati Hay, 1902
Genus *Brachypotherium* Roger, 1904

1904 – Roger, O., Über *Rhinoceros goldfussi* Kaup und die anderen gleichzeitigen Rhinocerosarten. Bericht des Naturwissenschaftliches Vereins für Schwäben und Neuburg, 36, Regensburg, 1–52.

Locus typicus: Eppelsheim (Late Miocene, MN 9), Germany
Occurrence: Early Miocene to Late Pliocene of Africa, Asia, Europe, and probably also North America.

Characteristic of genus: A large hornless representative of the Teleocerati with robust skull and short nasal bones. The mandibular symphysis is not enlarged. The upper and lower incisors are well-developed, big to huge. The cheek teeth are brachyodont, upper ones with the secondary folding and more robust cingulum. The anterocrochet is mostly secondary reduced. The lower cheek teeth have a very reduced buccal groove. The limbs are very shortened and forelimbs are three-toed. Robust metapodials are short and flattened (modified according to Heissig, 1972 and Guérin, 1989).

Brachypotherium cf. *brachypus* (Lartet, 1837)

1837 – Lartet, E., Sur les débris fossiles trouvés à Sansan, et sur les animaux antédiluviens en général. Comptes Rendus de l´Académie des Sciences de Paris, 5 (12), Paris, p. 418.

1986: *Brachypotherium* cf. *goldfussi* Kaup. – Holec: 225–226.

1996: Brachypotherium cf. goldfussi Kaup. – Holec & Sabol: 521–522.
2004: Brachypotherium sp. – Sabol, Joniak & Holec: 71, 79.

Locus typicus: Simorre (Middle Miocene, MN 7?), France
Occurrence: Middle Miocene of Europe.

Characteristic of species: A large hornless representative of the genus from the European Middle Miocene, differing from *B. goldfussi* by smaller dentition and more primitive astragalus morphology (modified according to Viret, 1961). See also Guérin (1980[b]: p. 400–401).

Material: fragment of ulna dext. (KGP: MS 33/3), fragment of radius dext. (KGP: MS 33/4), semilunare sin. (KGP: MS 33/5), hamatum sin. (KGP: MS 33/6), fragment of Mc II dext. (KGP: MS 33/7), fragments of Mc III sin. (KGP: MS 33/8a–b), Mc IV dext. (KGP: MS 33/9), fragments of femur dext. et sin. (KGP: MS 33/17a–c, 18a–c), patella sin. (KGP: MS 33/19), fragments of tibia dext. et sin. (KGP: MS 33/20a–b, 21a–b), astragalus dext. et sin. (KGP: MS 33/22–23), cuboideum sin. (KGP: MS 33/24), naviculare dext. et sin. (KGP: MS 33/25–26), cuneiforme II sin. (KGP: MS 33/27), cuneiforme III sin. (KGP: MS 33/28), Mt II sin. (KGP: MS 33/31), Mt III dext. et sin. (KGP: MS 33/29, 32), Mt IV dext. et sin. (KGP: MS 33/30, 33), 18 phalanges (KGP: MS 33/10–16, 34–44), and minimally 3 fragments of ribs (KGP: MS 33/45–47). The measurements of bones are in Tab. 1.

Description: The fragment of right ulna consists of the anconeus process only and the trochlear notch, longitudinally indistinctly divided into the narrower medial part and the wider lateral one.

Only fragment of the diaphysis and the distal epiphysis of the right radius are preserved. The radial diaphysis was robust with flattened sides and rounded margins. The relatively large styloid process is rather pointed than rounded. The carpal articular surface is deeply concave, probably wider mediolaterally, and divided by a longitudinal blunt crest to the larger medial and smaller lateral part. Two distinct tuberosities are developed on the medial side of the distal radial part. The anterior one is smaller, more rounded, the posterior one is more crest-shaped. The transverse dimension of the radius under study is larger than transverse dimensions of these from La Romieu and Malartic, whereas its distal epiphysis is smaller (cf. Cerdeño, 1993).

The left semilunar bone (*os intermedium*) is preserved nearly completely, although it was broken into two pieces originally. Its tuber (apophysis) is asymmetrical, expanded medially to a small blunt crest-shaped process. The damaged anterior articular surface is relatively narrow and high, similar to the specimen from Sansan. The hamatum articular surface is rather flat to slightly convex and narrow, differing from that one of *B. perimense* from Pakistan. The proximal lateral articular surface (for scaphoid) is smaller than the distal one, which is long and narrow. Generally, all articular surfaces are relatively flat as already mentioned by Roger (1904). Based on the measurements, the bone from Dúbravka-Pole is similar to the French record of *B. brachypus*, but it is more gracile in comparison with Pakistan fossils (Fig. 4).

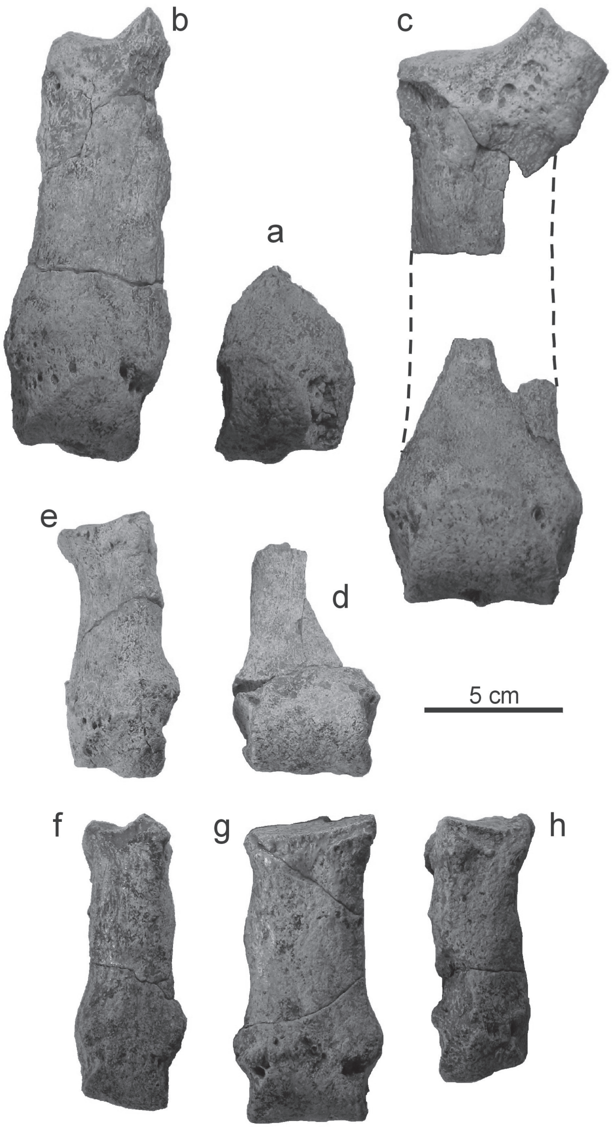

Fig. 2. ***Brachypotherium*** **cf.** ***brachypus*** **(Lartet, 1837), metapodial bones, Middle Miocene (Early Sarmatian, Late Astaracian, MN 7/8), Dúbravka-Pole; dorsal view.**
a – fragment of Mc II dext., b – Mc IV dext., c – proximal and distal part of Mc III sin., d – fragment of Mt III dext., e – Mt IV dext., f – Mt II sin., g – Mt III sin., h – Mt IV sin.

The left hamatum (*os carpale* IV) is robust large bone with originally broken off distinct apophysis that is less massive than tuber of the semilunar bone. The width and the height of the bone represent about 75% and 64% of its length. Articular surfaces for the pyramidal and Mc IV are relatively flat to slightly convex and wide, corresponding with the description of Roger (1904) and Klaits (1973). The articular surface for Mc V is not fully developed, rather absent (a condition similar to the hamatum from Baigneaux).

Metacarpals (Fig. 2a–c) are represented only Mc II dext., Mc III sin., and Mc IV dext. Whereas Mc II and Mc III are preserved in fragments, Mc IV was found more or less completely. Only distal head fragment of the right second metacarpal bone is preserved.

Tab. 1. Postcranial elements measurements of *Brachypotherium* cf. *brachypus* from Dúbravka-Pole. Data in parenthesis are only estimated.
AH – anterior height (Guérin´s "H ant."), APD – antero-posterior dimension ("DAP"), APDa – antero-posterior dimension of articulation surface ("DAP artic."), APDD – antero-posterior dimension of diaphysis ("DAP dia."), APDi – antero-posterior dimension of astragalus trochlea ("DAP int."), APPD – antero-posterior proximal dimension ("DAP prox."), DAPD – distal antero-posterior dimension ("DAP dist."), DAPDa – distal antero-posterior dimension of articulation surface ("DAP artic. dist."), DTD – distal transverse dimension ("DT dist."), DTDa – distal transverse dimension of articulation surface ("DT artic. dist."), H – maximum height ("H"), L – maximum length ("L"), TD – maximum transverse dimension ("DT"), TDa – transverse dimension of articulation surface ("DT artic."), TDD – transverse dimension of diaphysis ("DT dia."), TPD – transverse proximal dimension ("DT prox."), W – maximum width ("l").

Brachypotherium* cf. *brachypus	**L / TD**		**W / APD**		**H**		**AH**	**TPD / TDa**	
Dúbravka-Pole	**dext.**	**sin.**	**dext.**	**sin.**	**dext.**	**sin.**	**sin.**	**dext.**	**sin.**
radius	-	-	-	-	-	-	-	-	-
semilunar	-	80.08	-	(44.18)	-	50.93	53.87	-	-
hamatum	-	85.87	-	64.30	-	54.49	-	-	-
Mc III	-	-	-	-	-	-	-	-	74.03
Mc IV	151.82	-	-	-	-	-	-	-	-
patella	-	102.60	-	67.50	-	96.40	-	-	-
astragalus	102.60	-	-	-	68.90	69.00	-	-	-
cuboideum	-	68.66	-	44.08	-	32.61	29.58	-	44.50
naviculare	76.88	76.80	54.11	54.26	34.82	35.31	-	-	-
cuneiforme II	-	40.33	-	28.07	-	17.43	-	-	-
cuneiforme III	-	61.92	-	55.73	-	25.37	-	-	-
Mt II	-	123.44	-	-	-	-	-	-	46.19
Mt III	-	126.70	-	-	-	-	-	-	47.72
Mt IV	112.67	114.12	-	-	-	-	-	53.57	51.41
phalang prox. (Mc III)	59.24	58.20	39.97	40.29	32.24	33.00	-	-	-
phalang prox. (Mc IV)	52.73	50.92	38.55	36.98	35.56	30.42	-	-	-
phalang med. (Mc III)	55.00	54.99	30.20	29.54	20.89	20.84	-	-	-
phalang med. (Mc IV)	48.98	-	32.19	-	23.83	-	-	-	-
phalang prox. (Mt III)	58.39	-	29.39	29.08	35.01	36.15	-	-	-
phalang prox. (Mt IV)	47.30	42.75	30.17	28.34	37.79	-	-	-	-
phalang med. (Mt IV)	41.92	41.78	21.54	20.06	25.97	27.57	-	-	-
phalang dist. (Mt II)	40.60	-	26.07	-	22.55	-	-	34.85	-
phalang dist. (Mt III)	50.61	50.29	25.08	26.05	31.62	29.31	-	32.99	31.77
phalang dist. (Mt IV)	39.41	-	22.05	22.23	17.62	19.41	-	28.50	-

APPD / APDa		TDD		APDD / APDi		DTD		DAPD		DTDa		DAPDa	
dext.	sin.	dext.	sin.	dext.	sin.	dext.	sin.	dext.	sin.	dext.	sin.	dext.	sin.
-	-	(63.61)	-	-	-	80.23	-	-	-	57.84	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	62.24	-	-	-	-	-	67.48	-	49.38	-	51.29	-	-
43.11	-	45.00	-	24.04	-	55.67	-	42.92	-	41.29	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	55.70	56.00	-	79.80	-	-	-	84.80	52.00	51.80
-	48.34	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	48.11	-	37.03	-	27.56	-	44.47	-	44.77	-	37.58	-	-
-	-	-	49.62	-	24.25	63.82	63.56	46.26	46.15	55.36	51.94	-	-
44.06	44.37	35.34	36.49	24.21	22.16	51.60	-	46.63	44.08	37.87	35.87	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
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19.62	-	-	-	-	-	-	-	-	-	-	-	-	-
27.51	20.40	-	-	-	-	-	-	-	-	-	-	-	-
17.95	16.53	-	-	-	-	-	-	-	-	-	-	-	-

Fig. 3. ***Brachypotherium*** **cf.** ***brachypus*** **(Lartet, 1837), right and left astragalus, Middle Miocene (Early Sarmatian, Late Astaracian, MN 7/8), Dúbravka-Pole; anterior (a, c) and posterior (b, d) view.**
a, b – astragalus dext., c. d – astragalus sin.

The Mc III sin. consists of damaged proximal and distal bone parts. The articular surface for the magnum (*os carpale* III) is convex, palmarly narrowed, with distinctly bordered lower arched protuberance. The irregular trapezoid-shaped articular surface for the hamatum is flat, orientated laterally, forming a sharp margin with the magnum articular surface. The narrow articular surface for the Mc II extends more plantarly. The dorsal articular surface for the Mc IV is relatively narrow, but larger than oval plantar one (it is in contradiction to Heissig (1972), mentioning no Mc IV facets at Mc III of *B. brachypus*). The faintly damaged right fourth metacarpal bone is relatively short, robust, faintly horizontally rotated and bowed laterally, without an articular surface for the Mc V (a condition similar to material from French sites of Baigneaux and Malartic). The articular surface for the hamatum is relatively deep, triangular, with rounded corners, convex in upper part and concave in lower one. The articular surface for the Mc III is narrow, plantarly widened, more rectangular (similar to that of *B. brachypus* from Sansan and differing from the one found in Çandir in Turkey; cf. Geraads & Saraç, 2003), forming a sharp margin with the hamatum articular surface.

From phalanges of forelimbs, only proximal ones of the third and the fourth right and left digit together with medial ones of the third and the fourth right digit and the third left digit were found. All these phalanges are short and wide, with distinct tuberosities especially in their proximal parts.

Within the fossil record, both femora are represented only by immense fragments of the femoral head and lateral (external) and medial (internal) condyles. Also the preservation of both tibiae is similar – the right and left bone is fragmentarily preserved, consisting only of immense, relatively massive and shallow articular surface fragments of proximal and distal shinbone parts.

The left patella is robust wide bone, preserved more or less completely (apart from damaged lateral border). Its anterior (cranial) side consists of massive tuberosity whereas posterior (caudal) one is formed by an irregularly oval, relatively shallow to moderately concave articular surface divided by longitudinal blunt crest to smaller medial and larger lateral part. The crest is more protruding in its dorsal part. The patella measurements from Dúbravka-Pole site correspond relatively well with these ones of *B. brachypus* from French sites, although it is somewhat deeper (cf. Cerdeño, 1993).

The both astragali (Figs. 3,4) are preserved more or less entirely, although the left one is more damaged. These relatively robust bones are much lower in comparison to their length and relatively wide. Their asymmetrical, slightly medially shifted and relatively shallow large trochlea, typical for the Teleocerati, is inferiorly bordered by a distinct groove, extending and opening more laterally. The both calcaneal facets (slightly concave, larger and more oval calcaneal facet 1 with a small distal appendage and slightly convex, smaller and more rounded calcaneal facet 2) on the posterior surface are connected to one continuous articular facet. The large, slightly concave scaphoid facet with irregular rounded margin forms the substantial part of the plantar surface. The cuboid facet is smaller, through a blunt transversal crest fused with scaphoid one as well as through next one short crest with a very small facet on the postero-plantar margin (calcaneal facet 3). The bulge-shaped medial tuber is distinct. Based on the calculated index DT (maximum transverse dimension) x100/H (height), the right astragalus from Dúbravka-Pole (148.91) can be correlated with *B. brachypus* specimens especially from La Artesilla (144.5), Pontlevoy (144.7), Malartic (143.9), La Grive (150.8), and Steinheim (144) (cf. Fraas, 1870; Guérin, 1980[b]; Cerdeño, 1993). To the contrary of fossil record from above mentioned European sites, however, the both astragali from Dúbravka-Pole show a connection of calcaneal facets 1 and 2 what is missing in compared specimens from western Europe. On the other hand, the configuration of posterior facets (or articular surfaces) is variable (Hooijer, 1966) and these can be isolated or fused what is documented in material from French site of Baigneaux (Cerdeño, 1993). Probably, the fusion of facets demonstrates an intraspecific variability (Geraads & Saraç, 2003), observed also in Asian species *B. perimense* (Heissig, 1972). According to Guérin (1980[b]), the height and the antero-posterior dimension of *B. brachypus* astragalus represent 64.4% and 56.1% of average bone width. The right astragalus from Slovak site shows 67.2% and 50.9% values.

The entirely preserved left cuboid is relatively massive, more or less flat bone (Fig. 4). Its anterior surface of the irregular trapezoidal shape is formed by a tuberosity. A substantial part of the cuboid dorsal surface consists of both the larger irregular semicircular and the posterior small triangular calcaneal facets, bordered on the medial side by a large convex triangular astragalar facet. Also plantar surface of the bone consists of a large longitudinal rounded one – a facet for the Mt IV sin. Whereas a tuberosity forms the cuboid lateral side, the medial one has anterior and posterior navicular and fused cuneiform more or less semicircular facets separated by a wide distinct groove. The anterior navicular facet borders on that for the astragalus and the larger anterior cuneiform one borders on that for the metatarsal. The posterior navicular and cuneiform facets are isolated from other bone facets. A tuber is developed on the cuboid posterior side. The height of cuboid from La Grive represents 60.7% of its length (Guérin, 1980[b]), whereas cuboid from Dúbravka-Pole shows 47.5% value only.

The right navicular is more damaged than the left one. The both bones are flat and relatively wide, resembling a rounded rhombus. The dorsal surface of the bones consists of large convex to concave simple astragalar facet, running posteriorly into the navicular tuber. A large cuneiform facet (fused facets for the intermedial and lateral cuneiforms; in *B. perimense* are separated) forms nearly the whole plantar side of both navicular bones. That is flat to faintly convex. A small trapezoidal cuboid facet is developed in posterior part of the navicular lateral side, fused through a blunt border with the large plantar cuneiform facet. Another small circular- to square-shaped facet (for the medial cuneiform) is present in the posterior side of the both bones under the navicular tuber. The both navicular bones from the site under study are relatively narrower (the width represents only 70.4% (dext.) and/or 70.7% (sin.) of the bone length) (Fig. 4) than these from Sansan, La Grive, and Steinheim (82.6% according to Guérin, 1980[b]).

The medial cuneiform (*cuneiforme* I) is missing in the fossil record. The preserved left intermedial cuneiform (*cuneiforme* II) is small, low, and wide damaged bone with the irregular rounded navicular facet and the larger concave plantar facet for the Mt II sin. The oval facet for the medial cuneiform, partly fused with the navicular facet only, is very small, smaller than the round facet for the lateral cuneiform, situated more anteriorly. The left lateral cuneiform (*cuneiforme* III) is large and flat bone with large trilobate facets for both the navicular and the Mt III sin.

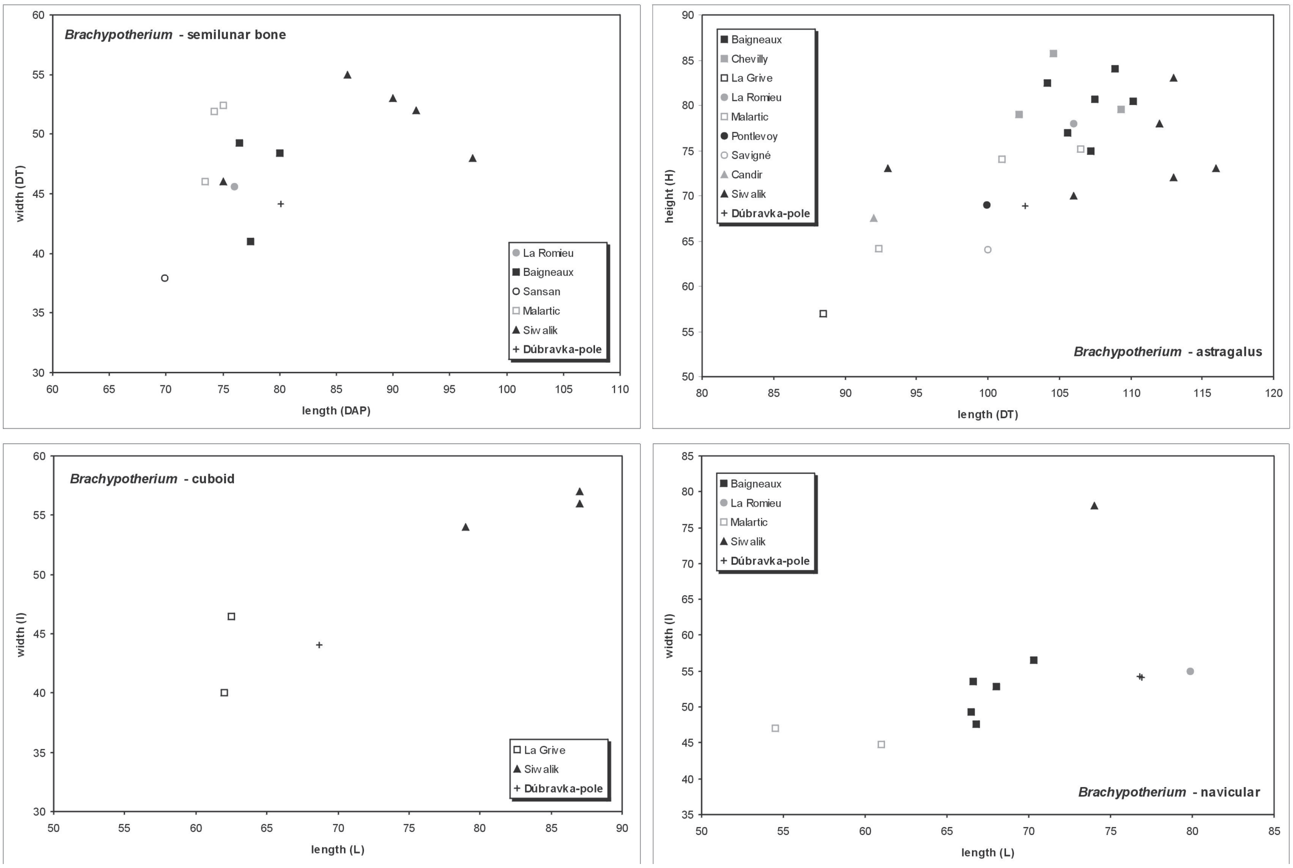
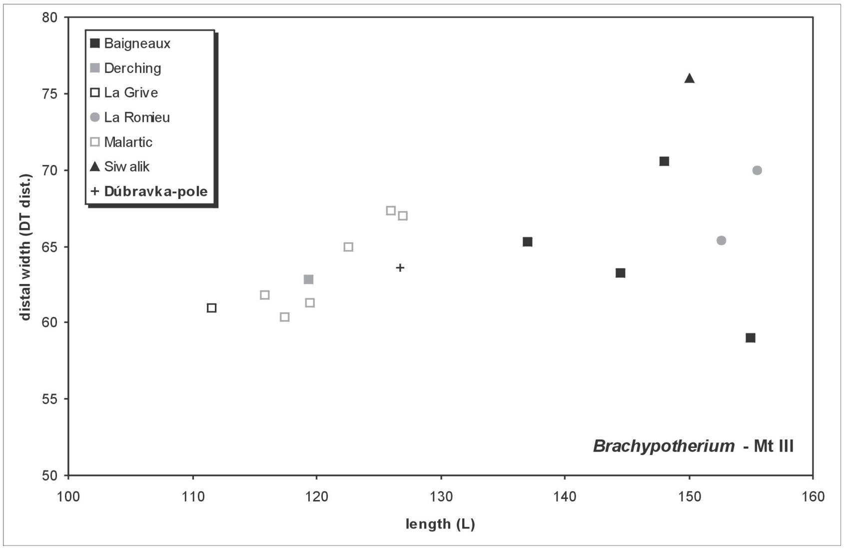


Fig. 4. Bivariate plot of measurements of *Brachypotherium* carpal and tarsal bones from selected Miocene sites of Eurasia (data source: Heissig, 1972; Guérin, 1980[b]; Cerdeño, 1993; Geraads & Saraç, 2003).



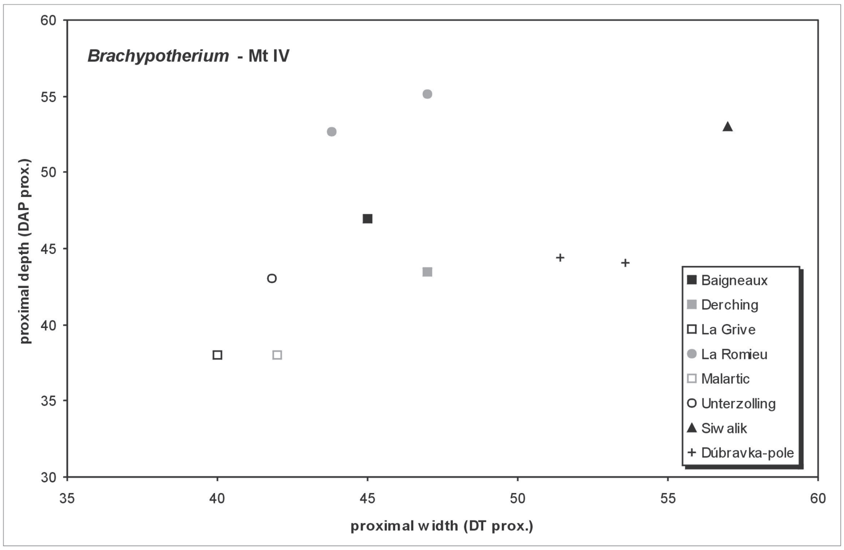


Fig. 5. Bivariate plot of measurements of *Brachypotherium* metatarsal bones from selected Miocene sites of Eurasia (data source: Heissig, 1972; Guérin, 1980[b]; Cerdeño, 1993).

A lateral incisure is distinctly developed. Small rounded cuboid facet is situated posteriorly and dorsally, fused through an edge with the navicular facet. The bilobate facet for the Mt II sin. is similarly fused with the plantar facet for the Mt III sin. The facet for the Mt IV sin. is not distinctly developed. The anterior bone side consists of a tuberosity. The both cuneiforms are smaller than those of *B. perimense* from Pakistan (cf. Heissig, 1972).

From metatarsal bones, only Mt II sin., Mt III dext. et sin., and Mt IV dext. et sin. were found (Fig. 2d-h). The second left metatarsus, glued from several parts, is larger and more robust than Mt IV. Convex articular surface for the intermedial cuneiform is the largest, plantarly narrowed. The articular surface for the lateral cuneiform consists of two, distinctly bordered lobes connected by a narrow part and orientated more laterally. There is also a small rounded facet for the medial cuneiform. Whereas Mt III dext. is preserved fragmentary, consisting more or less only of diaphyseal part and distal epiphysis, the left third metatarsus has been preserved entirely. The bone is longer the Mt II and Mt IV, but relatively short, very wide, with a flat diaphysis of the semi-elliptical cross-section. The proximal epiphysis consists of large, slightly convex trilateral facet for the lateral cuneiform, and two more or less semicircular small articular surfaces for the Mt IV on the lateral side, separated by a large semicircular notch. On the medial side, two indistinct longitudinal facets for the Mt II are present. A small keel is developed in distal part of diaphyseal plantar side. The distal epiphysis consists of large trochlea with a weak central crest; the lateral tuber is more robust than the medial one. Based on the calculated index of gracility, Mt III sin. from the Dúbravka-Pole site (39.2) shows a similarity mostly with those from Malartic (36.8–40.0; cf. Cerdeño, 1993) (Fig. 5). The both fourth metatarsal bones are damaged, but preserved entirely. The large articular surface for the cuboid forms an irregular rounded rectangle, lined by two separated semicircular facets for the Mt III (the plantar facet for Mt III is missing in *B. perimense*). The lateral margin of the proximal epiphysis consists of distinct tuberosity. The flat diaphysis with more or less elliptical cross-section is more latero-plantarly rotated. The distal trochlea with a weak central crest is dorsally narrowed, bordered more or less by both the dorsal and the lateral tuber. The plantar one is missing. From the metric viewpoint,

Tab. 2. The comparison of m3 measurements of *Lartetotherium* from Dúbravka-Pole with m3 measurements of other Middle Miocene taxa of European rhinoceroses (data source: Guérin, 1980[2]).
H – molar height (metaconid height), HI – hypsodonty index (H x 100 / L), L – molar length, TAL – length of molar talonid basin, TAW – width of molar talonid basin, TRL – length of molar trigonid basin, TRW – width of molar trigonid basin, W – molar width.

taxon / site	L	W	H	TRL	TRW	TAL	TAW	HI
Haploaceratherium tetradactylum	42.00-50.00	22.00-28.00	33.50-37.00	-	-	-	-	69.80-80.50
Aceratherium incisivum	40.00-53.50	23.00-33.00	32.00	-	-	-	-	69.60
Alicornops simorrensis	35.00-49.50	20.50-30.00	39.00	-	-	-	-	78.80-90.70
Brychypotherium sp.	54.00-64.00	30.00-32.00	-	-	-	-	-	-
Dicerorhinus steinheimensis	34.00-34.50	20.00-23.00	-	-	-	-	-	-
Dihoplus schleiermacheri	46.00-55.50	29.00-36.50	47.00	-	-	-	-	84.70
Lartetotherium sansaniense	39.00-47.00	21.50-26.00	33.50-37.00	-	-	-	-	75.30-78.70
Dúbravka-Pole	39.86	24.15	28.55	19.05	21.50	19.80	23.38	71.63

the both Mt IVs from Slovak site are more similar to these from Malartic, Unterzolling, and Derching than to those from La Romieu, which are longer and narrower (Fig. 5).

Within the fossil record, hindlimb phalanges are represented only by proximal ones of the third and the fourth right and left digit, medial ones of the both fourth digits, and distal ones of all right digits and the third and the fourth left digit. Similarly to forelimb phalanges, also these ones are short and wide, with distinct tuberosities especially in their proximal parts.

The rest of the *Brachypotherium* fossil record consists of rib fragments and large amount of indeterminate bone fragments.

Infratribus Rhinoceroti Gray, 1821
Genus *Lartetotherium* Ginsburg, 1974

1974 – Ginsburg L., Les faunes de Mammifères burdigaliens et vindoboniens des bassins de la Loire et de la Garonne, Mém. BRGM, 78 (1974), 153–167.

Locus typicus: Sansan (Middle Miocene, MN 6), France.
Occurrence: Early to Late Miocene of Europe and Africa.

Characteristic of genus: In general, strongly horned representative of Rhinocerotini with low crowned cheek teeth and medium sized incisors. The upper premolars are molarised with basal fusion of the lingual cusps (paramolariform). These retain strong metacone rib on the outer wall and have lost the lingual cingulum. In the molars the protocone constriction is rather weak in contrast to all other tribes. The p1 is double-rooted or single rooted with a tendency to split the lengthened and longitudinally grooved root at the tip. The lower molars and premolars with long paralophid are similar to first Elasmotheriini but more brachyodont. The skull is broad and probably shorter, than in compare to recent *Dicerorhinus sumatrensis* and African species, bearing only a single subterminal horn on the nasals or another one on the forehead. Limbs are long and massive with three toes in the fore foot (modified according to Heissig, 1999).

Lartetotherium sp.

1986: *Brachypotherium* cf. *goldfussi* Kaup. – Holec: 225–226.
1996: *Brachypotherium* cf. *goldfussi* Kaup. – Holec & Sabol: 521–522.
2004: *Brachypotherium* sp. – Sabol, Joniak & Holec: 71, 79.

Material: fragment of the right hemimandible with m3 dext. (KGP: MS 33/1–2). The measurements are in Tab. 2.

Description: The right hemimandible fragment consists only of two parts of the mandible ramus with a convex lateral side. The missing medial one was probably more flattened. Posteriorly, this fragment with preserved a remain of m2´s posterior root and the complete, still not fully erupted m3 dext., is more narrow. Mandible height under the preserved molar is estimated to be 54 mm. Relatively thin-walled enamel outer part of the third lower molar is only preserved in trigonid and talonid basins. The rest of the unworn tooth crown consists probably of rather chemically than mechanically attacked inner part of enamel (or dentine resp.?). The paraconid is only indicated, forming a "link" between relatively long, positionally lower situated arched paralophid (longer than in acerathere rhinoceroses) and more straight long protolophid. The protoconid is somewhat higher than the metaconid and both these cusps are connected by slightly damaged arched metalophid that is approximately as long as the protolophid. The posterior protoconid-metaconid wall is perpendicular. The funnel-shaped trigonid basin is opened lingually and this opening is V-shaped. The semi-lunar hypolophid borders the posterior and the buccal part of the talonid basin. It runs from the mesoconid through the hypoconid

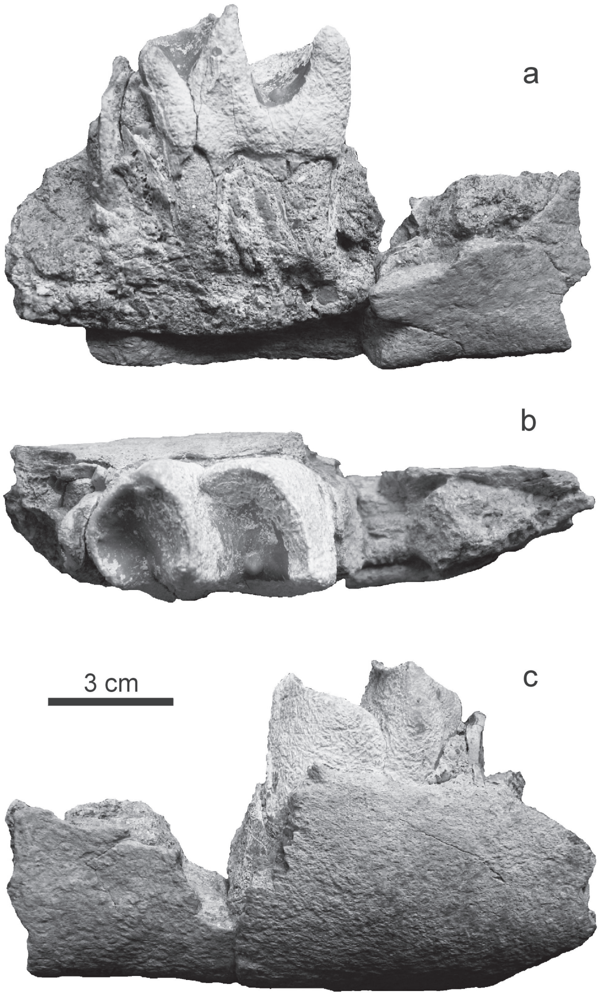


Fig. 6. ***Lartetotherium*** **sp., right hemimandible fragment with m3, Middle Miocene (Early Sarmatian, Late Astaracian, MN 7/8), Dúbravka-Pole; lingual (a), occlusal (b), and buccal (c) view.**

and the hypoconulid up to the distinctly developed entoconid with a very short anterior crest. The hypolophid is separated from the posterior trigonid wall by the distinct buccal groove of the external syncline (ectoflexid). The talonid basin is deeper than the trigonid one, opened lingually, with a small accessory cusp at the bottom of the basin's U-shaped lingual opening. Only a short posterior basal cingulum is visible, running obliquely up from the postero-buccal crown margin towards the entoconid. The lingual cingulum is absent and the buccal one probably too. The anterior and the posterior roots are preserved only like "phantoms", substituted by coarse-grained sediment and bowed posteriorly. Since the tooth is still not fully erupted and unworn, it belonged to a young animal.

4. DISCUSSION

A basic morpho-metric analysis of postcranial remains from Dúbravka-Pole unambiguously demonstrates their assignation to *Brachypotherium* – a conservative genus of Miocene large hornless teleoceratine rhinoceros, known more or less only in two (chrono-)species from the territory of Europe (*B. brachypus* and *B. goldfussi*). The distinguishing of both species is, however, often highly difficult because of relatively rare fossil record (Codrea, 1991). Although Viret (1961) draws a distinction between *B. brachypus* and *B. goldfussi* in smaller dentition and more primitive astragalus morphology of the former, Guérin (1980[b]) use rather nomenclatorical name "gr. *brachypus – goldfussi*" or retain a determination in the open nomenclature (*Brachypotherium* sp.). For that reason, the species determination of found fossils is often based also (or only) on the geological settings and stratigraphical data when Middle Miocene remains are attributed to *B. brachypus* and Late Miocene ones to *B. goldfussi*.

The comparison of the fossil record from the Slovak site under study with that of various European and Asian sites, supported also by calculated indices and statistics (Fig. 7, Tab. 3), indicates the assignation of fossils from Dúbravka-Pole rather to *B. brachypus* than to other *Brachypotherium* species. Since no dental material of this rhinoceros has been found at the site, the studied postcranial material is determined as *B.* cf. *brachypus* only. This determination is also supported by data on the site stratigraphy. Initially, the sediments at Dúbravka-Pole (Dúbravska hlavica) were considered to be of the Late Badenian age (Ondrejičkova, 1987; Baráth et al., 1994; Hyžný 2011[a,b]), or even slightly younger (cf. Holec & Sabol, 1996; Sabol et al., 2004). This "assumption" was validated by the foraminiferal assemblages analysis, pointing the sandy deposits with invertebrate fossils to the Early Sarmatian (Serravallian) (Hyžný & Hudáčková, 2012; Hyžný et al., 2012). Also marine sediment obtained from fossil remains under study contained a hyposaline foraminiferal microfauna typical for the shalow marine water. Foraminiferal shells are recrystallized, predominantly represented by specimens of *Elphidium* accompanied by ones of *Quinqueloculina* and *Flintina* genera. This foraminiferal association is more similar to those from locality 4.8 Dúbravka-Pektenová lavica (PL)/Dúbravka-Pecten bed (8) (Hyžný et al., 2012). From the viewpoint of large mammal mega-zones biostratigraphy, the fossiliferous deposits with fossils of *Brychypotherium* are thus correlated with MN 7/8 biozone (Late Astaracian).

The next rhinoceros find from the site under study (*Lartetotherium* sp.) is also in good agreement with this Early Sarmatian age of vertebrate fossiliferous sediments. The found mandible fragment with m3, originally also attributed to *Brachypotherium* (Holec, 1986), differs from other Dúbravka-Pole rhinoceros fossils, not only by different fossilization, but mainly by morphological and metric characteristics of preserved lower molar. The presence of long paralophid and the absence of basal cingula exclude its assignation to aceratherine rhinoceroses. Likewise, smaller molar dimensions do not allow its determination as *Brachypotherium*, what is supported also by distinctly developed ectoflexid as well as by absence of lingual and probably also buccal basal cingulum. From the morphological point of view, the molar most corresponds with m3s of *Lartetotherium sansaniense*, *Dicerorhinus steinheimensis*, and *Dihoplus schleiermacheri*. From the metric viewpoint, however, it most corresponds to the former one (Tab. 2), when m3s of *Dicerorhinus* are smaller and m3s of *Dihoplus* are larger with higher hypsodonty index (HI = 84.7). On

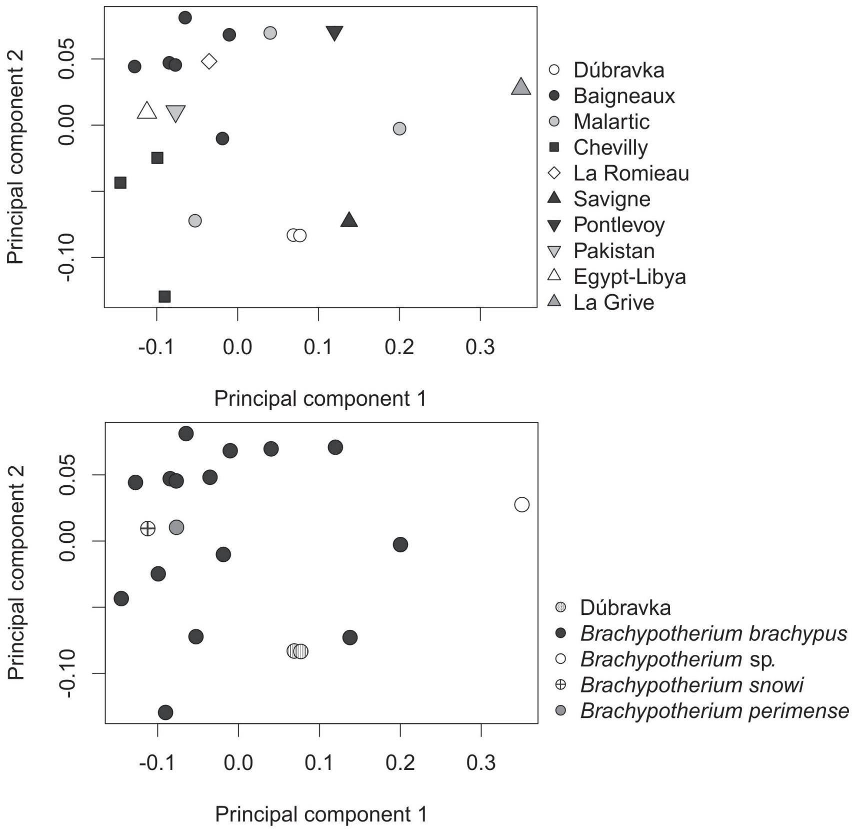


Fig. 7. PCA analysis of found fossils from Dúbravka-Pole site compared with the fossil record of *Brachypotherium* species from Europe, Asia, and Africa (see also Appendix 1). Astragali under study are within the range of *B. brachypus*, although showing somewhat smaller dimensions (see also Fig. 4). Analysis showed a distinct negative correlation between PC1 and maximum bone height (H), whereas PC2 indicates changes in the morphology of astragali, related with a relation between H and the distal transverse dimension of articulation surface (DTDa). A correlation (PC2) between the maximum transverse dimension (TD) and H is positive, whereas between DTDa and the distal transverse dimension (DTD) is negative.

the other hand, the hypsodonty index of Dúbravka-Pole molar is somewhat lower (HI = 71.63) than the one calculated for m3s of *L. sansaniense* (HI = 75.3–78.7) (cf. Guérin, 1980[b]). Based on that, the mandible fragment with m3 from Dúbravka-Pole is determined only as *Lartetotherium* sp., although in all probability it belongs to *L. sansaniense* since it is only species of the genus known from MN 6 to MN 9 Miocene period of Europe.

Brachypotherium and *Lartetotherium* were probably relatively common taxa in the European Middle Miocene and their common occurrence is known for example from Sansan, La Grive, or Massenhausen (Guérin, 1980[b]; Heissig, 1999), but also from Asia (Geraads & Saraç, 2003) and the Late Neogene of Africa (Hooijer & Patterson, 1972; Prothero & Schoch, 2002). It indicates a sympatric coexistence without a mutual competition. The genus *Brachypotherium* can be used as a good palaeoecological indicator (Codrea, 1991) for a swampy habitat in a well-forested landscape. European Miocene species are considered to be a marsh or lake dweller (Geraads & Saraç, 2003), representing an equivalent of modern hippopotamus because of their short limbs and stout body (Guérin, 1980[a]). To the contrary, a careful analysis of the faunal composition in the Miocene of Pakistan revealed, that the genus might have also preferred an intermediate environment between rain forest and steppe (Heissig, 1972, 1999). This is confirmed by the general co-occurrence with the proboscidean *Deinotherium*, which had similar preferences (Heissig, 1999) and fossils of which were also found in Late Badenian sediments (MN 6) of Devínska Nová Ves sites (Zapfe, 1954; Thenius, 1952; Tóth, 2010). *Brachypotherium* may have preferred a vegetation type higher above the groundwater table, whereas *Lartetotherium* lived probably close to water, in swamps or may have had rather a broad adaptation (Heissig, 1999).

Based on the rhinoceros record as well as on the analysis of marine invertebrate assemblages from deposits of Dúbravka-Pole (Hyžný, 2011[a], 2012; Hyžný & Hudáčková, 2012; Hyžný et al.,

Tab. 3. A relation between correlation coefficients (TD, H, DTDa, DTD; see also Tab. 1) and principal components PC1 to PC4. The correlation coefficient between PC1 and maximum height (H) is negative, indicating a decrease of PC1 amount in relation to the increasing of H.

Brachypotherium **- Statistics**	**PC1**	**PC2**	**PC3**	**PC4**
maximum transverse dimension (TD)	-0,407	0,099	0,654	-0,630
maximum height (H)	-0,830	0,314	-0,442	0,128
distal transverse dimension of articulation surface (DTDa)	-0,184	-0,832	-0,357	-0,383
distal transverse dimension (DTD)	-0,333	-0,446	0,500	0,664

Appendix 1. Dataset for the statistics of *Brachypotherium* astragali. Data source: Guérin (1980, 2000), Cerdeño (1993); Cerdeño & Hussain (1997); Geraads & Saraç, (2003).

Brachypotherium, astragalus	KGP: MS 33/22	KGP: MS 33/23	La Grive (n)	Baigneaux 1	Baigneaux 2	Baigneaux 3	Baigneaux 4	Baigneaux 5	Baigneaux 6
maximum transverse dimension (TD)	102.60	NA	88.50 (2)	107.20	104.20	110.20	105.60	107.50	108.90
maximum height (H)	68.90	69.00	57.00 (1)	75.00	82.50	80.50	77.00	80.70	84.00
antero-posterior dimension of astragalus trochlea (APDi)	55.60	56.00	49.63 (4)	54.90	51.00	59.10	47.50	57.50	56.40
distal transverse dimension of articulation surface (DTDa)	NA	84.80	75.50 (2)	83.40	78.50	79.70	78.00	79.60	79.50
distal transverse dimension (DTD)	NA	79.80	77.25 (2)	88.40	85.70	89.50	85.30	89.70	93.00

Brachypotherium, astragalus	Chevilly 1	Chevilly 2	Chevilly 3	La Romieau	Malartic 1	Malartic 2	Malartic 3	Savigne	Pontlevoy
maximum transverse dimension (TD)	109.30	102.20	104.60	106.00	92.40	101.00	106.50	100.00	99.90
maximum height (H)	79.60	79.00	85.70	78.00	64.20	74.00	75.00	64.00	69.00
antero-posterior dimension of astragalus trochlea (APDi)	58.40	61.70	55.50	59.00	NA	NA	53.30	50.30	54.60
distal transverse dimension of articulation surface (DTDa)	84.00	93.50	89.10	79.00	79.00	75.50	85.20	83.60	75.30
distal transverse dimension (DTD)	94.40	95.80	92.00	88.00	83.40	87.00	97.50	89.20	82.80

Brachypotherium, astragalus	Pakistan		Egypt, Lybia (n)	Çandir
maximum transverse dimension (TD)	108.83	106.20	108.75 (2)	92.00
maximum height (H)	74.83	80.80	82.00 (1)	67.50
antero-posterior dimension of astragalus trochlea (APDi)	NA	54.00	59.00 (2)	NA
distal transverse dimension of articulation surface (DTDa)	NA	83.70	82.25 (2)	NA
distal transverse dimension (DTD)	NA	NA	92.75 (2)	NA

2012), the palaeoenvironment can be characterized as a near-shore one with shallow sand or mud bottom covered by seagrass meadows and with assumed salinity changes (from brackish to hypersaline), surrounding swamps and (open?) forested land.

So far, the genus *Brachypotherium* is represented by 6 to 7 species: *B. brychypus* from the Middle Miocene of Europe (MN 6–MN 7/8), *B. goldfussi* from the Late Miocene of Europe (MN 9), *B. perimense* from the Middle to Late Miocene of Asia (Siwalik), *B. snowi* from the Early Miocene of Africa, *B. heinzelini* from the Early to Middle Miocene of Africa, *B. lewisi* from the Late Miocene to Pliocene of Africa, and probably *B. americanum* from the early Middle Miocene of North America (Heissig, 1972, 1999; Hooijer & Patterson, 1972; Guérin, 1989). Guérin (1989) mentions also *B. stehlini* from the Early Miocene of Europe (MN 4–MN 5). The genus *Lartetotherium* is known from the European Miocene only by one species *L. sansaniense* (MN 5–MN 9) (Heissig, 1999), although Prothero & Schoch (2002) made a mention of another one (*L. tagicum*) from the Early Miocene. *L. sansaniense* become extinct in Europe without descendants (Heissig, 1999), but in Africa it evolved into the Late Miocene *L. leakeyi* (Prothero & Schoch, 2002).

5. CONCLUSION

Based on the morphological and metric analysis of fossil vertebrate remains found during the surface prospection of Dúbravka-Pole, two taxa of Middle Miocene rhinoceroses have been distinguished. The bigger amount of collected fossils, representing fragments of postcranial skeleton probably of one specimen, belongs to large teleoceratine *Brachypotherium* cf. *brachypus*. The second taxon, *Lartetotherium* sp., was determined by the only find of mandible fragment with m3. The both rhinoceros taxa lived in swampy to forested (mixed deciduous (open?) forest with presence of more thermophilous elements) land at the shore of shallow brackish sea (or lagoon?) with coastal hydrophilous and swamp vegetation during the Early Sarmatian (MN 7/8). They probably substituted MN 6 *Haploaceratherium – Dicerorhinus* assemblage in the territory of Devínska Kobyla and together with other Sarmatian vertebrate fossil record from Nováky coal mine and Košice-Bankov represent these an evidence of some intermittent faunal migrations during changing environmental conditions, caused by both the climate and the palaeotopography.

Acknowledgements: The research for this paper was carried out with financial support from the Slovak Research and Development Agency under contacts APVV-0280-07 and APVV-0099-11. The authors also gratefully acknowledge the helpful comments and suggestions of C. Guérin, E. Billia, and A. Ďurišová. Their gratitude goes also to Mr. Stanislav Antalík for English language review.

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