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The northernmost occurrence of the rare Late Pliocene rhinoceros *Stephanorhinus jeanvireti* (Mammalia, Perissodactyla)

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With 5 figures and 2 tables

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Abstract: Two postcranial bones, discovered in the Early Villafranchian (MN 16) strata in the Hambach lignite mine in the Lower Rhine Basin of Northwestern Germany, are attributed to the rare rhinoceros *Stephanorhinus jeanvireti*. The material is compared with the respective elements of *Dihoplus megarhinus* and *Stephanorhinus etruscus*. The Hambach specimens represent the northernmost record of *S. jeanvireti*, indicating that humidity might be the most important ecological factor for the palaeobiogeographic distribution of this species.

Key words: Rhinocerotidae, herbivores, biogeography, morphology, Germany, Lower Rhine Basin, Hambach, Neogene, Villafranchian.

1. Introduction

In the Late Pliocene, rhinoceroses probably were common elements in European mammalian palaeofaunas, like in the Miocene. Nevertheless, their fossil record is relatively scarce, presumably because of their ecological preference of forested habitats and due to the rareness of Late Pliocene fossil sites in Europe, especially in Central and Northern Europe. One of the species which is still poorly known is *Stephanorhinus jeanvireti*. It has only, been reported so far, from the Early Villafranchian (MN 16, Late Pliocene) of Europe and co-occurs during this time with the small *Stephanorhinus etruscus* in France (GUÉRIN 1980 [with discussion in MAZZA 1988]), in Spain (MAZO 1995) and in Romania (RADULESCU & SAMSON 2001; RADULESCU et al. 2003). It is a slender, medium- to large-sized rhinoceros, showing brachydont teeth. The morphology and the proportions of this species are highly similar to those of *Stephanorhinus hundsheimensis* (FORTELIUS et al. 1993; LACOMBAT 2005a), which could be a close relative. It is characteristic for humid climate with forest-dominated environment with also relatively open areas where gramineous plants could be found (MÉON-VILAIN 1972). *S. jeanvireti* is known from the Late Pliocene of the Mediterranean area, and there were no sites recognized from northwestern Europe (Fig. 1). In this paper, we describe two postcranial bones of this species from the Lower Rhine Basin of NW Germany. They are part of recently discovered assemblages of fossil mammals which were excavated in the Frechen and Hambach opencast lignite mines in the West of Cologne (STRAUCH 1994; REUMER 1995; KOLFSCHOTEN et al. 1998; MÖRS et al. 1998; MÖRS 2002). The fossils were usually found in channel fills and therefore consist of disarticulated, but mostly well preserved teeth, jaws, and other bones, like the two rhino bones from the Hambach mine described here.

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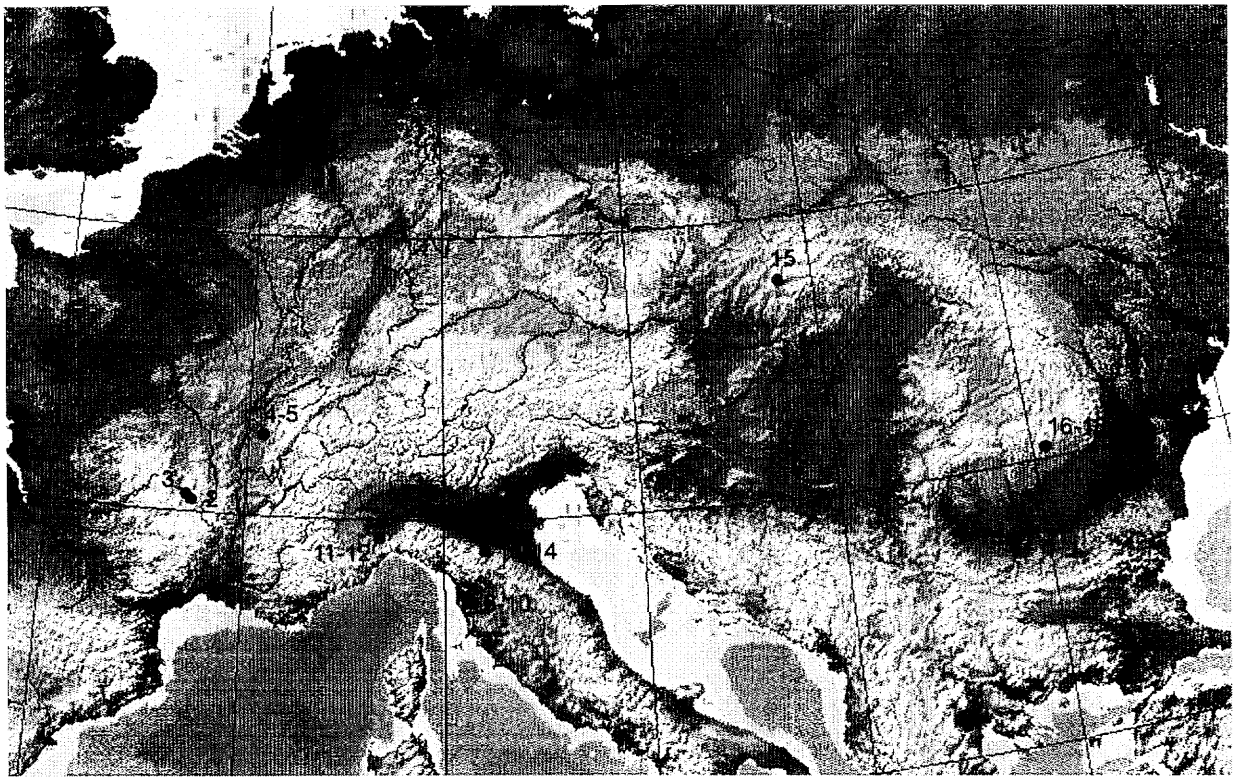

Fig. 1. Location of localities with *S. jeanvireti*. 1 – Hambach; 2 – Vialette; 3 – Perrier-Etouaires; 4 – Desnes; 5 – Vincent; 6 – Montopoli; 7 – Gaville; 8 – Capannoli; 9 – Santa Barbara; 10 – Sienne area; 11 – Dusino; 12 – Villafranca d'Asti; 13 – Monte San Pietro; 14 – Pradalbino; 15 – Hajnáčka; 16 – Covrigi; 17 – Groserea; 18 – Cunatesti.

The Late Pliocene (Early Villafranchian) Hambach 11/13 fauna consists mainly of small vertebrates (MÖRS 2002). Most of the material was collected from two smaller channel fills within the Reuver clay (= Öbel beds: KEMNA 2005). The two horizons which yielded the sites Hambach 11 and Hambach 13 are of approximately the same age. The fauna consists of freshwater fishes, salamanders and anurans, turtles and squamates, birds, and both semi-aquatic and terrestrial mammals (MÖRS et al. 1998; HIERHOLZER & MÖRS 2003; DALSÄTT et al. 2006; KERSTING & MÖRS in prep.; KLEIN & MÖRS in prep.), indicating oxygenated waters and currents in what appears a river channel setting in close association with lakes or oxbows, all situated in lowlands (MÖRS 2002). Sedimentological and palaeobotanical evidence support this reconstruction (e. g. UTESCHER et al. 2000; SCHWARZ & MÖRS 2000; HEUMANN & LITT 2002; SCHÄFER et al. 2004; KEMNA 2005). Based on the rodents, the Hambach 11/13 fauna can be correlated with MN 16 (MÖRS et al. 1998; MÖRS 2002). The Late Pliocene age (approx. 2.5 Ma) is also visible in the depleted tetrapod diversity, but the fauna is still characterized by some "Tertiary" faunal elements (e. g. *Andrias, Latonia, Chelydropsis, Pliopetaurista*). The biostratigraphical dating is supported by palaeomagnetic and heavy mineral analysis (KEMNA 2005).

The goal of this paper is to describe the northernmost record of *S. jeanvireti*, for completion of our knowledge of the Neogene large mammal fauna of NW Europe in general and to add palaeobiogeographical data for the species in particular.

2. Material and methods

The rhinoceros remains from Hambach consist of a right astragal (IPB-HaR 1) and a right metacarpal IV (IPB-HaR 5520). IPB-HaR 1 was discovered above a lignite layer together with two fragments of cervid

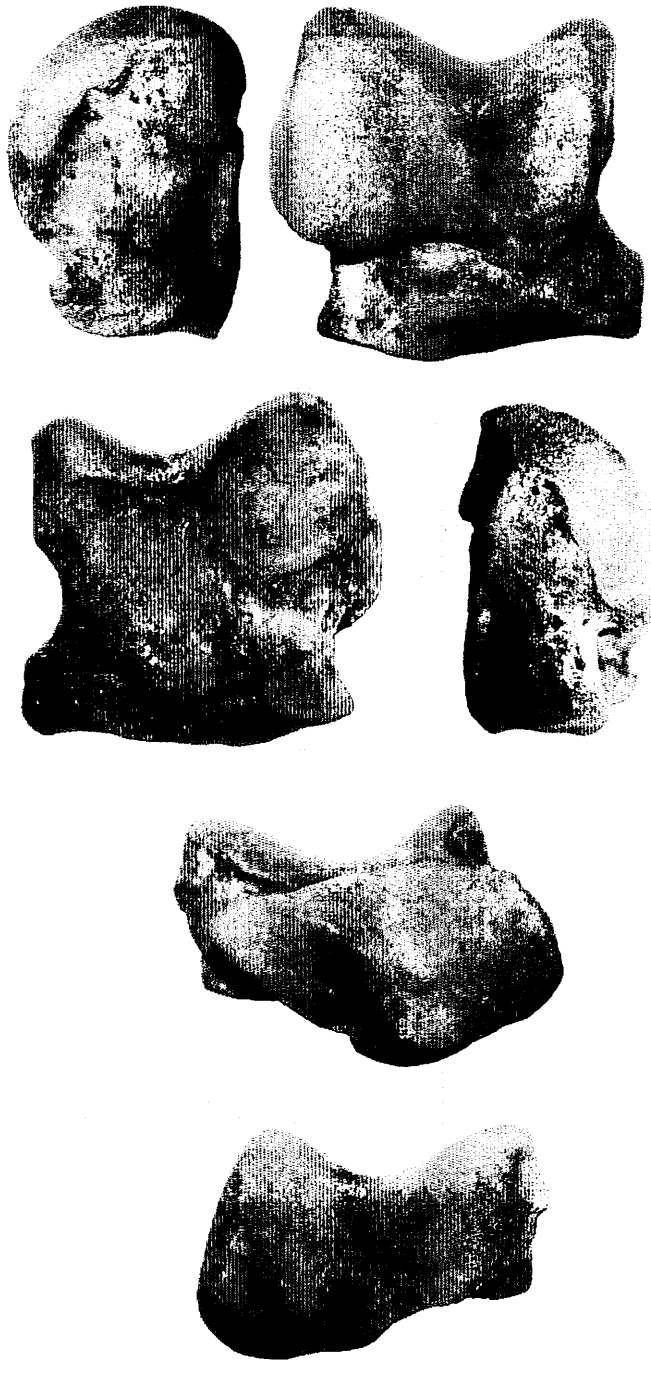

Fig. 2. Astragalus of *S. jeanvireti* of Hambach. Scale is 5 cm.

antlers by BERTRAM WUTZLER in 1998. Since the exact stratigraphic position remained unclear, the specimen could only be assigned to horizon 11/13A. IPB-HaR 5520 was found by FRITZ VON DER HOCHT already in 1990. It is part of the faunal association which was described as Hambach 11 by MÖRS et al. (1998). Both fossil bones are stored in the palaeontological collections of the Steinmann Institute, Rheinische Friedrich-Wilhelms-Universität Bonn. Germany.

Comparison with the specimens from Hambach 11/13 is made with the large and robust Early Pliocene *Dihoplus megarhinus* (previously included in the genera *Dicerorhinus, Stephanorhinus* and *Lartetotherium*. HEISSIG [1999] attributed to the genus *Dihoplus* the *D. schleiermacheri*, supposed to be the closest relative of *D. megarhinus* which should also be included to this genus) and the small *Stephanorhinus etruscus* which appears also in the Early Villafranchian (MAZO 1995).

3. Systematic palaeontology

Order Perissodactyla OWEN, 1848
Family Rhinocerotidae OWEN, 1845
Genus *Stephanorhinus* KRETZOI, 1942

Stephanorhinus jeanvireti GUÉRIN, 1972
Figs. 2, 4

Nomenclatorial note: *Stephanorhinus elatus*, created by CROIZET & JOBERT (1828), is also used in recent papers (e. g. RADULESCU et al. 2003; PALOMBO et al. 2006), but without any proper and detailed clarification of the nomenclature we will use *S. jeanvireti*, a species recognized by the ICZN.

Descriptions and results. – Astragal (IPB-HaR 1, Fig. 2).

The trochlea of the astragal is broad and asymmetric and ends above the distal articulation without contact. The trochlea is higher and broader in *D. megarhinus* while it slightly more oblique and less deep in *S. etruscus*. The medial lip is narrow and tight, it merges distally with the corpus. The lateral articular surface is broad and flat, in contact with the proximo-lateral facet of the posterior side. The proximo-lateral articular facet is elliptic and concave. It is composed with proximal and distal lip-shaped edges. The articular surface of the trochlea slightly overflows at the top of the posterior side. The medio-distal articular facet of the posterior side is a broad and flat ellipse. The semi-elliptic latero-distal articular facet of the posterior side is flat and connected with the distal articular surface. The distal tuber of the medial side is very prominent and located in the middle of this side. This location is also found in *D. megarhinus* while it is more posterior in *S. etruscus*. The distal extremity is a relatively narrow and convex articular surface. It shows a medial articular facet which possesses a rounded and convex medial outline, a strongly incurved lateral outline, a rectilinear posterior outline and a slightly rounded anterior outline (more rectilinear in *D. megarhinus* and *S. etruscus*). The lateral articular facet is ellipsoid with a rectilinear lateral outline. The morphology of the astragal from Hambach differs strongly from that of *D. megarhinus* (description in GUÉRIN 1980) and *S. etruscus* (description in MAZZA 1988) in the shape of

Table 1. Biometric data of the astragal of *S. jeanvireti* from Hambach. Comparison with *D. megarhinus* (data from GUÉRIN 1980) and *S. etruscus* (data from MAZZA 1988). Measurements from LACOMBAT (2005b): BM – breadth maximum; Hm – medial height; Lad – length of the distal articulation; Bad – breadth of the distal articulation; Bl – breadth between the lips of the trochlea; BMd – breadth distal maximum; Hl – lateral height; LMd – Length distal maximum; Hmt – medial height of the trochlea; Lm – length medial; Hlt – lateral height of the trochlea; HM – height maximum; Ll – lateral length.

		BM	Hm	Lad	Bad	Bl	BMd	Hl	LMd	Hmt	Lm	Hlt	HM	Ll
HAMBACH IPB-HaR 1		95.90	83.03	45.90	80.63	63.48	85.23	82.22	48.77		61.54	59.41	90.95	45.39
S. jeanvireti (GUERIN, 1980)	N	7		8	8	11	10				12		13	
	Mean	99.70		48.19	77.69	65.18	85.25				64.75		91.04	
	Min	92.00		46.00	70.00	62.00	77.00				60.00		87.00	
	Max	107.50		52.00	85.00	69.00	84.00				72.00		104.00	
D. megarhinus (GUERIN, 1980)	N	32		28	31	32	31				32		32	
	Mean	102.20		49.46	81.81	70.03	87.48				67.61		97.36	
	Min	92.50		43.00	71.00	53.00	78.00				59.00		88.00	
	Max	113.00		58.00	91.00	81.00	99.00				76.00		110.00	
S. etruscus (MAZZA, 1988)	N	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	83.67	70.09	40.74	65.44	53.61	69.12	69.78	43.95	42.99	53.92	53.72	75.52	37.49
	Min	80.60	68.05	36.59	63.88	49.83	66.79	68.25	40.16	34.89	52.22	50.90	73.00	35.90
	Max	86.27	73.79	43.65	67.14	57.35	71.42	71.42	48.60	47.47	56.97	55.00	77.12	39.00

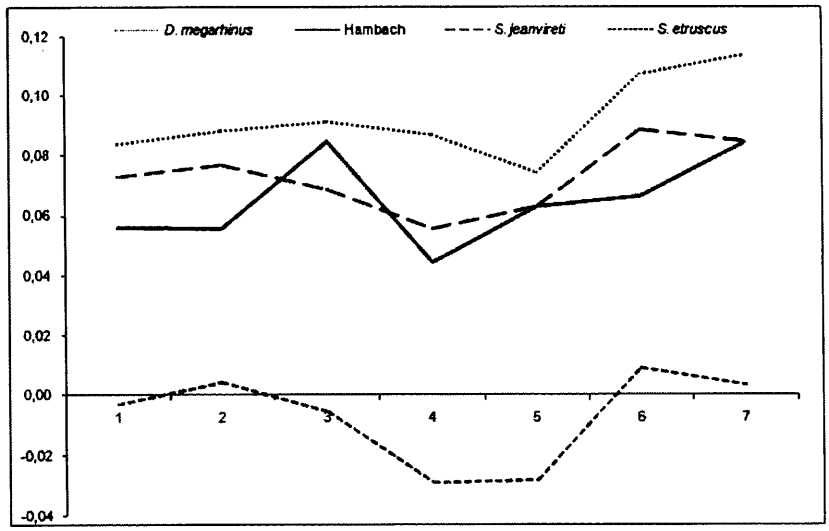

Fig. 3. Ratio diagram of the astragalus of *S. jeanvireti* of Hambach. Comparison with *D. megarhinus*, *S. jeanvireti* (data from GUÉRIN 1980) and *S. etruscus* (data from MAZZA 1988).

the lips of the trochlea, in the shape and the position of the articular facets and in the shape of the distal extremity. The dimension (Tab. 1) and the proportions (Fig. 3) of the astragal are similar to that of *S. jeanvireti* studied by GUÉRIN (1980) and significantly different from the larger *D. megarhinus* and the smaller *S. etruscus*.

Metacarpal (IPB-HaR 5520, Fig. 4).

The metacarpal IV is a long, slender and incurved bone. It is much more massive in *D. megarhinus* and much shorter in *S. etruscus*. The proximal articular surface is a concave triangle. The articular facet for the metacarpal V is long and thin but slightly damaged. It should apparently take the whole lateral side of the proximal extremity. The antero-proximal facet of the medial side is semi-elliptic, in contact with the proximal articular surface. The posterior-proximal articular facet is a rounded facet located much lower than the previous one and turned to the posterior side. The shaft of the diaphysis is flat and ellipsoid while it is more angular in *D. megarhinus* and thinner in *S. etruscus*. The length, robustness (Fig. 5) and the location of the articular facets differ from *D. megarhinus* (GUÉRIN, 1980) and from *S. etruscus* (MAZZA, 1988) and correspond to the average of the intraspecific variations of *S. jeanvireti* (see also Tab. 2).

4. Conclusions

Stephanorhinus jeanvireti is, so far, restricted to the Early Villafranchian (MN 16) of Europe. It is mainly found in the Mediterranean area (Fig. 1) in Romania: at Groserea, Covrigi and Cunatesti (RADULESCU & SAMSON 2001; RADULESCU et al. 2003), in Italy: at Villafranca d'Asti, Dusino (with the restriction of Roatto, CAMPANINO et al. 1994), Lower Valdarno Basin (Montopoli), in the lignite level of the Upper Valdarno (Santa Barbara, Gaville, Capannoli), at Sienne, Monte San Pietro and Pradalbino (SACCO 1895; GUÉRIN 1980; RUSTIONI 1992), in France: at Vialette, Desnes, Vincent and Perrier-Etouaires (GUÉRIN 1980; LACOMBAT 2005a) and in Slovakia at Hajná ka (FEJFAR 1964; SABOL et al. 2006). Some localities of the same age like Kvabebi in Georgia (HEMMER et al. 2004; VEKUA et al. 2005), as well as Udunga and Nizhnavodyanoy in Russia (BAJGUSHEVA et al. 2001, VISLOBOKOVA 2005) possess undetermined or misattributed species of *Stephanorhinus* which could correspond to *S. jeanvireti*. The presence of *S. jeanvireti* in Hambach represents the northernmost occurrence of this species and its first citation in Germany. The northernmost occurrence of *S. jeanvireti* was located before in Slovakia at Hajnáčka (Fig. 1). The climatic and environmental settings of Hambach 11/13 (MÖRS et al. 1998; SCHÄFER et al. 2004) are similar to those found in Vialette (MÉON-VILAIN 1972) and in Europe in general at this time (FORTELIUS et al. 2001) and imply that *S. jeanvireti* should be pledged to humidity and not to the latitude or/and temperature. However, the few localities where *S. jeanvireti* occurs imply to handle this affirmation with care. The review of some rhinoceros from Pliocene localities of Central Europe and maybe Asia with such humid conditions should yield *S. jeanvireti* and bring new data on the palaeobiogeography and the phylogeny of this species which might have an Asian origin (GUÉRIN 1980: 598; LACOMBAT 2007, and see above) and which was not restricted to Mediterranean Europe like it was previously thought.

Fig. 4. Metacarpal IV of *S. jeanvireti* of Hambach 11. Scale is 4 cm.

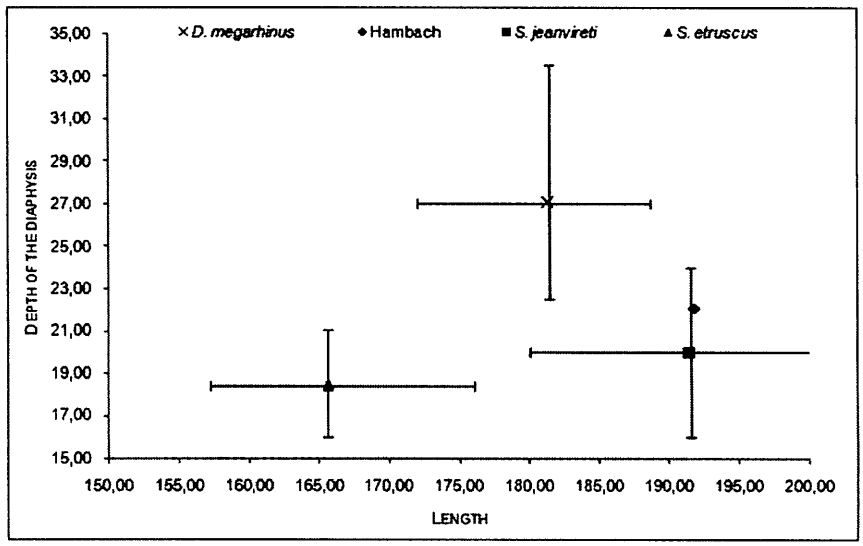

Fig. 5. Robustness of the metacarpal IV of *S. jeanvireti* of Hambach 11. Comparison with *D. megarhinus*, *S. jeanvireti* (data from GUÉRIN 1980) and *S. etruscus* (data from MAZZA 1988).

Table 2. Biometric data of the metacarpal IV of *S. jeanvireti* from Hambach 11. Comparison with *D. megarhinus* (data from GUÉRIN 1980) and *S. etruscus* (data from MAZZA 1988). Measurements from LACOMBAT (2005b): L – length; Bp – proximal breadth; Dp – proximal depth; Bdia – breadth of the diaphysis; Ddia – depth of the diaphysis; Bd – distal breadth; Bad – breadth of the distal articulation; Dd – distal depth.

	HAMBACH IPB-HaR 5520	*S. jeanvireti* (GUERIN, 1980)				*D. megarhinus* (GUERIN, 1980)				*S. etruscus* (MAZZA, 1988)			
		N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max
L	191.80	9	191.50	180.00	201.00	9	181.33	172.00	189.00	5	165.60	157.00	176.00
Bp	41.59	9	51.17	45.50	57.00	8	51.00	48.00	54.00	5	39.40	37.00	43.00
Dp	44.33	9	43.39	41.00	46.50	7	42.07	36.50	47.00	6	37.50	32.00	41.00
Bdia	39.52	9	39.94	37.00	45.00	9	39.22	34.00	46.00	7	34.00	30.00	39.00
Ddia	22.11	9	24.00	20.00	28.00	8	27.06	22.50	33.50	7	18.43	16.00	21.00
Bd	45.82	4	47.50	43.00	50.00	9	49.72	44.50	53.00	7	40.29	33.00	46.00
Bad	40.81	9	45.17	38.00	53.00	9	43.28	41.00	49.00	5	33.60	32.00	36.00
Dd	46.82	9	46.72	44.50	48.00	8	44.06	40.00	47.00	7	36.57	34.00	39.00

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References

BAJGUSHEVA, V. S., TITOV, V. V. & TESAKOV, A. F. (2001): The sequence of Plio-Pleistocene mammal faunas from the south Russian Plain (the Azov Region). – Bolletino de la Societá Paleontologica Italiana, **40** (2): 133-138.

CAMPANINO, F., FORNO, M. G., MOTTURA, A., ORMEZZANO, D. & SALA, B. (1994): *Stephanorhinus jeanvireti* (GUÉRIN) 1972 (Rinocerotidae [sic!], Mammalia) from Roatto near Villafranca d'Asti, NW Italy. Revision of the specimen from Dusino. – Bolletino del Museo Regionale di Scienze Naturali, Torino, **12** (2): 439-499.

CROIZET, J. B. & JOBERT, A. (1828): Recherches sur les ossements fossiles du département du Puy-de-Dôme. – 224 pp.; Clermont (Thibaud-Landriot).

DALSÄTT, J., MÖRS, T. & ERICSON, P. G. P. (2006): Fossil birds from the Miocene and Pliocene of Hambach (NW Germany). – Palaeontographica, (A), **277**: 113-121.

FEJFAR, O. (1964): The Lower Villafranchian vertebrates from Hajnáčka near Filákovo in Southern Slovakia. – Rozpravy Ústředního Ústavu Geologického, **30**: 1-116.

FORTELIUS, M., ERONEN, J., LIU, L., PUSHKINA, D., TESAKOV, A., VISLOBOKOVA, I. & ZHANG, Z. (2006): Late Miocene and Pliocene large land mammals and climatic changes in Eurasia. – Palaeogeography, Palaeoclimatology, Palaeoecology, **238**: 219-227.

FORTELIUS, M., MAZZA, P. & SALA, B. (1993): *Stephanorhinus* (Mammalia, Rhinocerotidae) of the western European Pleistocene, with a special revision of *Stephanorhinus etruscus* (FALCONER, 1868). – Palaeontographia Italica, **80**: 63-155.

GUÉRIN, C. (1972): Une nouvelle espèce de rhinocéros (Mammalia, Perissodactyla) à Vialette (Haute-Loire, France) et dans d'autres gisements du Villafranchien inférieur européen: *Dicerorhinus jeanvireti* n. sp. – Documents des laboratoires de Géologie de la faculté des sciences de Lyon, **49**: 53-150.

– (1980): Les rhinocéros (Mammalia, Perissodactyla) du miocène terminal au Pléistocène supérieur en Europe occidentale. Comparaison avec les espèces actuelles. – Documents des Laboratoires de Géologie de Lyon, **79** (2): 433-759.

HEISSIG, K. (1999): Family Rhinocerotidae. – In: RÖSSNER, G. E. & HEISSIG, K. (Eds.): The Miocene Land Mammals of Europe, 175-188; Munich (Pfeil).

HEMMER, H., KAHLKE, R.-D. & VEKUA, A. K. (2004): The Old World puma – *Puma pardoides* (OWEN, 1846) (Carnivora: Felidae) – in the Lower Villafranchian (Upper Pliocene) of Kvabebi (East Georgia, Transcaucasia) and its evolutionary and biogeographical significance. – Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, **233**: 197-231.

HEUMANN, G. & LITT, T. (2002): Stratigraphy and palaeoecology of the Late Pliocene and Early Pleistocene in the open-cast mine Hambach (Lower Rhine Basin). – Netherlands Journal of Geosciences/Geologie en Mijnbouw, **81** (2): 193-199.

HIERHOLZER, E. & MÖRS, T. (2003): Cypriniden-Schlundzähne (Osteichthyes: Teleostei) aus dem Tertiär von Hambach (Niederrheinische Bucht, NW-Deutschland).- Palaeontographica, **A 269** (1-3): 1-38.

KEMNA, H. A. (2005): Pliocene and Lower Pleistocene stratigraphy in the Lower Rhine Embayment, Germany. – Kölner Forum für Geologie und Paläontologie, **14**: 1-121.

KOLFSCHOTEN, T. VAN, MEULEN, A. VAN DER & BOENIGK, W. (1998): The late Pliocene rodents (Mammalia) from Frechen (Lower Rhine Basin, Germany). – Mededelingen Nederlands Instituut voor Toegepaste Geowetenschappen TNO, **60**: 161-172.

LACOMBAT, F. (2005a): *Stephanorhinus jeanvireti*. – In: LACOMBAT, F. (Ed.): Les Grands Mammifères Fossiles du Velay. Les Collections Paléontologiques du Plio-Pléistocène du Musée Crozatier, Le Puy-en-Velay. – Annales des amis du Musée Crozatier, **13-14**: 50-51.

– (2005b): Les rhinocéros fossiles des sites préhistoriques de l'Europe méditerranéenne et du Massif Central. Paléontologie et implications biochronologiques. – B.A.R. International Series, **1419**: 1-175.

– (2007): Phylogeny of the genus *Stephanorhinus* in the Plio-Pleistocene of Europe. – Hallesches Jahrbuch für Geowissenschaften, **23**: 63-64.

MAZO, A. V. (1995): *Stephanorhinus etruscus* (Perissodactyla, Mammalia) en el Villafranquiense inferior de Las Higueruelas, Alcolea de Calatrava (Ciudad Real). – Estudios Geologicos, **51**: 285-290.

MAZZA, P. (1988): The Tuscan Early Pleistocene rhinoceros *Dicerorhinus etruscus*. – Palaeontographia Italica, **75**: 1-87.

MÉON-VILAIN, H. (1972): Analyse palynologique de la flore du gisement villafranchien de Vialette (Haute-Loire). – Documents des laboratoires de Géologie de la Faculté des Sciences de Lyon, **49**: 151-156.

MÖRS, T. (2002): Biostratigraphy and paleoecology of continental Tertiary vertebrate faunas in the Lower Rhine Embayment (NW-Germany). – Netherlands Journal of Geosciences/Geologie en Mijnbouw, **81** (2): 177-183.

MÖRS, T., KOENIGSWALD, W. VON & HOCHT, F. VON DER (1998): Rodents (Mammalia) from the late Pliocene Reuver Clay of Hambach (Lower Rhine Embayment, Germany). – Mededelingen Nederlands Instituut voor Toegepaste Geowetenschappen TNO, **60**: 135-160.

PALOMBO, M.-R., VALLI, A. M. F., KOSTOPOULOS, D. S., ALBERDI, M.-T., SPASSOV, N. & VISLOBOKOVA, I. (2006): Similarity relationships between the Pliocene to Middle Pleistocene large mammal faunas of Southern Europe from Spain to the Balkans and the North Pontic Region. – In: KAHLKE, R.-D., MAUL, L. C. & MAZZA, P. (Eds.): Late Neogene and Quaternary Biodiversity and Evolution: Regional Developments and Interregional Correlations. Proceedings of the 18th International Senckenberg Conference (VI International Palaeontological Colloquium in Weimar). – Courier Forschungsinstitut Senckenberg, **256**: 329-347.

RADULESCU, C. & SAMSON, P.-M. (2001): Biochronology and evolution of the Early Pliocene to the Early Pleistocene mammalian faunas of Romania. – Bollettino della Società Paleontologica Italiana, **40** (2): 285-291.

RADULESCU, C., SAMSON, P.-M., PETCULESCU, A. & STIUCĂ, E. (2003): Pliocene large mammals of Romania. – Coloquios de Paleontologia, Vol. Extr., **1**: 549-558.

REUMER, J. W. F. (1995): Insectivora (Mammalia: Soricidae, Talpidae) from the Late Pliocene of Frechen, Germany. – Deinsea, **2**: 9-15.

RUSTIONI, M. (1992): On Pliocene tapirs from France and Italy. – Bollettino della Società Paleontologica Italiana, **31** (3): 269-294.

SABOL, M., KONEČÝ, V., VASS, D., KOVÁČOVÁ, M., ĎURIŠOVÁ, A. & TÚNYI, I. (2006): Early Late Pliocene site of Hajná ka (Southern Slovakia) – geology, palaeovolcanic evolution, fossil assemblages and palaeoenvironment. – In: KAHLKE, R.-D., MAUL, L. C. & MAZZA, P. (Eds.): Late Neogene and Quaternary Biodiversity and Evolution: Regional Developments and Interregional Correlations. Proceedings of the 18th International Senckenberg Conference (VI International Palaeontological Colloquium in Weimar). – Courier Forschungsinstitut Senckenberg, **256**: 261-274.

SACCO, F. (1895): Le rhinocéros de Dusino (*Rhinoceros etruscus* FALC., var. *astensis* SACC.). – Archives du Muséum d'Histoire naturelle de Lyon, **6**: 1-31.

SCHÄFER, A., UTESCHER, T. & MÖRS, T. (2004): Stratigraphy of the Cenozoic Lower Rhine Basin, northwestern Germany. – Newsletters on Stratigraphy, **40** (1/3): 73-110.

SCHWARZ, J. & MÖRS, T. (2000): Charophyten aus dem oberpliozänen Reuverton des Braunkohlen-Tagebaus Hambach (Niederrheinische Bucht, Deutschland). – Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, **215**: 297-319.

STRAUCH, F. (1994): Ein pliozäner Cerviden-Rest aus dem Tagebau Frechen, Rheinland. – Neues Jahrbuch für Geologie und Paläontologie, Monatshefte, **1994**: 129-142.

UTESCHER, T., MOSBRUGGER, V. & ASHRAF, A. R. (2000): Terrestrial climate evolution in northwest Germany over the last 25 million years. – Palaios, **15**: 430-449.

VEKUA, A., LORDKIPANIDZE, D., AGUSTI, J. & OMS, O. (2005): The Pliocene mammal site of Kvabebi (Eastern Georgia): new field-campaigns and age determination. – Geophysical Research Abstract, **7**: 08450.

VISLOBOKOVA, I. (2005): On Pliocene faunas with Proboscideans in the territory of the former Soviet Union. – Quaternary International, **126-128**: 93-105.

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