Notae Praehistoricae 28-2008 : 11-20

The horses of *Mesvin IV* (Hainaut, B)

Eline VAN ASPEREN

Summary

The horse remains from the Middle Pleistocene site *Mesvin IV* were measured and compared with horse material from other sites in the same geographical area dating from the same time period. The size and morphological characteristics of the fossil horse bones indicate a date in a cold stage of the early Saalian. The development of traits that undergo evolution is also in accordance with this date. Certain features of the dentition and postcranial skeleton can be interpreted as adaptations to cool environments.

Keywords: Prov. of Hainaut (B), Mesvin, *Mesvin IV*, Pleistocene caballoid horses, biostratigraphy.

Samenvatting

De paardenresten van de Midden-Pleistocene site *Mesvin IV* zijn opgemeten en vergeleken met paardenmateriaal van andere sites in dezelfde geografische regio en daterend uit dezelfde tijdsperiode. De afmetingen en morfologische karakteristieken van de fossiele paardenbotten duiden op een datering in een koude fase van het vroege Saalien. De ontwikkeling van kenmerken die evolutie ondergaan zijn in overeenstemming met deze datering. Een aantal kenmerken van het gebit en het postcraniale skelet kunnen geïnterpreteerd worden als aanpassingen aan koude leefmilieus.

Trefwoorden: Prov. Henegouwen (B), Mesvin, *Mesvin IV*, Pleistocene caballoïde paarden, biostratigrafie.

1. Introduction

The site of *Mesvin IV* is situated in fluviatile sediments in the region of Mons. The fluviatile deposits of this region can be divided into four stratigraphic units. The oldest two units, the unit of *Pa d'La l'iau* and the unit of Petit-Spiennes, are attributed to the Elsterian Glaciation. The unit of Mesvin follows these two older units and is older than the lower gravels in the Hélin pit, which are topped by Last Interglacial palaeosols (Van Neer, 1986). The unit of Mesvin thus corresponds to the earlier Saalian, which is in accordance with dates of 250-300 ka BP obtained by uranium-series dating of dental and postcranial remains from the *Mesvin IV* site (Haesaerts, 1978; Cahen *et al.*, 1979; Cahen & Michel, 1986).

At the site, two channels are incised in Tertiary sands. Channel 2 cuts into channel 1, resulting in a partial reworking of the sediments of channel 1 (Van Neer, 1986). Fossil remains and flint artefacts have been recovered from both channels, but the largest concentration of material occurred in the basal gravel of channel 1. Fossils and artefacts collected from the channel 2 deposits are thought to have been reworked from channel 1 (*op. cit.*). The lithic assemblage contains Levallois flakes and bifaces of prondnik type, which is in accordance with a date in the Middle Palaeolithic (Cahen & Michel, 1986).

The faunal assemblage mainly consists of bones of animals which are adapted to cool-temperate or cold environments with open and steppic landscapes (tab. 1), although the presence of *Sus scrofa* could indicate the

Insectivora	*Talpa* sp.
Lagomorpha	*Lepus* sp.
Carnivora	*Alopex lagopus*
	Panthera leo spelaea
Proboscidea	*Mammuthus* cf. *primigenius*
Perissodactyla	*Equus* sp.
	Coelodonta antiquitatis
Artiodactyla	*Sus scrofa*
	Rangifer tarandus
	Megaloceros giganteus
	Cervidae indet.
	Bison priscus

Tab. 1 — Fauna list for *Mesvin IV* (modified from Van Neer, 1986).

existence of localised patches of sheltered woodland (Van Neer, 1986). According to the studies of Van Neer (*op. cit.*), the fossil remains show evidence of limited lateral transport, fragmentation as a result of freeze-thaw cycles, acidic alteration and hydraulic selection of larger bones and larger fragments. The bones are fragmented and show poor surface preservation.

2. Wider context of this study

The horse bones of *Mesvin IV* were studied in the context of a wider study that aims to assess the biostratigraphic potential of Pleistocene horse remains. During the late Middle Pleistocene of north-west and central Europe, the caballoid horse lineage underwent a size reduction and morphological changes over its temporal range. It has proven difficult to date archaeological sites from this period by absolute methods, and biostratigraphy may be crucial in establishing temporal correlations between sites. Horse morphology can be analysed to assess differences and similarities between sites and regions. Morphological variation, especially variation due to climatic oscillations in temperature and humidity – the degree of oceanity / continentality, glacial-interglacial cycles and sea level changes – may provide ways of investigating questions regarding adaptation, the role of migration and the effects and timing of insularity and geographic isolation.

3. Material and methods

A total of 19 horse skeletal remains from *Mesvin IV* were complete enough to be measured (tab. 2). The material is stored in the collections of the Royal Belgian Institute of Natural Sciences, Brussels, Belgium.

Measurements on the metapodials were taken according to Eisenmann (1979) and measurements on the first phalanges follow Dive and Eisenmann (1991). Other bones of the postcranial skeleton were measured according to Von den Driesch (1976). For the dental material, length, width and height, and in the upper third and fourth premolars and upper first and second molars the length of the protocone, were measured according to Musil (1969). Furthermore, the ratio of protoconal length to total length was calculated for upper premolars and molars (protoconal index or IP, Lprot / L x 100 %). Since it is very difficult to distinguish between the third and fourth premolar and between the first and second molar, these are analysed together, as third / fourth premolar and first / second molar respectively. All measurements were taken with vernier callipers and recorded to 0.1 mm. In the following sections, the maxillary dentition will be indicated as P2-4 and M1-3 and the mandibular dentition will be indicated as p2-4 and m1-3. Measurements on the metapodials and the first phalanges will be abbreviated with 'V', e.g. V1 = variable 1. The measurements are listed in tables 3 and 4.

Skeletal element		*n*
Dentition	p2	1
	p3/4	4
	m1/2	1
	m3	4
	P3/4	1
	M1/2	2
	M3	1
Postcranial skeleton	metacarpal	1
	astragalus	1
	posterior first phalange	1
	second phalange	2
Total number of elements		*19*

Tab. 2 — Number of horse skeletal elements from *Mesvin IV* included in the study.

The dental remains were compared to material from other sites in north-west central Europe dating from the Saalian using scatter plots. For the metacarpal, log ratio diagrams were constructed to compare both the size and the shape of the Mesvin specimen with specimens from other sites. The log ratio technique was introduced for palaeontological material by Simpson (1941). Log ratio diagrams represent various measurements on the same anatomical element in such a way that the vertical distances between the different measurements express their relative sizes (the ratios of their dimensions). Another result of converting absolute measurements to logarithms is an exaggeration of small values and a minimisation of large values, making it easier to compare the ratios of different specimens (Simpson *et al.*, 1960). In order to create a log ratio diagram, all measurements are converted to their logarithms. One specimen or group of specimens is taken as the standard of comparison, representing the base line or reference line of the diagram. In this study, the standard chosen is a sample of *Equus hemionus*, as this is the species most commonly used as a standard for log ratio diagrams of Pleistocene horse remains (e.g. Eisenmann, 1979; Dive & Eisenmann, 1991). For the other specimens or groups of specimens, the difference between their logarithmic values and the logarithmic values of the standard is calculated and plotted on a graph. A line is drawn to connect the values of the different measurements for each specimen or group of specimens, and the closer

Dental element	*Catalogue number*	*L*	*W*	*H*	*Lprot*
p2	F113	36.5	15.8	62.0	
p3		30.6	17.0	27.0	
p4		29.5	18.2	29.5	
p3/4	MSV83 G124	32.4	17.8	54.5	
p3/4	F111	30.5	18.5	46.5	
m1/2	MSV79 F143 MCM396b	29.1	16.9	65.5	
m3	MSV79 E142	36.1	15.7	84.0	
m3	MSV79 F142/152	33.4	14.2	61.5	
m3	MSV83 MCM4006	35.1	15.2	27.5	
m3	MSV79 F131	36.7	15.2	31.0	
P3/4	MSV78 E104	29.8	27.8	77.0	11.8
M1/2	MSV83 G252	31.8	28.5	82.0	15.2
M1/2	MSV79 F132	31.7	33.6	71.5	15.0
M3	MSV78 F102	30.1	24.4	68.0	

Tab. 3 — Measurements on the horse dental elements from *Mesvin IV*.
L=length, W=width, H=height, Lprot=length of the protocone.

the lines are in a vertical aspect, the more similar the size of the specimens. Similarity in the profile of the lines reflects similarity in the proportions of the specimens.

The astragalus and second phalange have not been analysed further due to the lack of comparative material. Furthermore, it is unclear whether there are changes in size and shape in these bones over the Pleistocene and what factors influence their morphology. The comparison of the *Mesvin IV* material with material from other sites is also limited by the low number of remains from *Mesvin IV*. The results of the comparison should therefore be regarded as exploratory.

4. Comparative material

Sites that were selected for comparison are comparable in age and geographical location to the site of *Mesvin IV*. The sites are dated to the cold stages of the early and late Saalian, or oxygen isotope stages (OIS) 10, 8 and 6. The sites are located in the British Isles, western Germany and northern France (tab. 5). The metacarpal is also compared with material from the intra-Saalian temperate stage or OIS 7 and the Eemian Interglacial to identify features that developed under the influence of the prevalent climatic condi-

Element	*Catalogue number*						
Metacarpal	MSV80 E84	V3	V4	V10	V11	V13	V14
		41.6	26.2	51.7	51.4	31.1	31.8
Astragalus	MSV79 F132-85	GH	LmT	BFd			
		63.6	66.2	60.3			
Posterior first phalange	MSV80 F194	V1	V2	V3	V4	V5	V6
		89.6	80.3	40.5	64.8	46.4	52.1
		V7	V8	V9	V10	V11	V12
		58.1	49.4	76.8	60.2	60.7	19.2
		V13	V14				
		15.9	48.8				
Second phalange		GL	SD	Bp	Dp	Bd	
	F131	51.7	47.9	56.7	36.3	50.0	
	MSV-79	51.2	49.9	57.3	37.9	51.4	

Tab. 4 — Measurements on the horse postcranial elements from *Mesvin IV*.

tions. Data on the horse material from these sites is subject of an ongoing study within the larger framework of European late Middle Pleistocene horse biostratigraphy and ecomorphology outlined above, and will be published in full once that study is completed.

For the British Isles, a biostratigraphic framework has been developed for the late Middle Pleistocene, incorporating geological, faunal, floral and malacological evidence (Bridgland, 1994; Schreve, 1997; Bridgland & Schreve, 2001; Penkman *et al.*, 2008). For the mammalian faunas, in particular, each interglacial stage was shown to have a characteristic fauna. Based on the biostratigraphic framework, sites in the British Isles have been correlated with the marine oxygen isotope record. Horse remains from the British Isles prove to be significantly different in morphology between oxygen isotope stages (van Asperen, forthcoming).

The Neuwieder Becken in Germany is a tectonic depression where volcanically active craters developed during the Middle and Late Pleistocene (Bosinski *et al.*, 1986). The craters are infilled with Brockentuff, lava and tephra which was covered with loess in cold periods. During temperate phases, soil formation took place in the loess. The earlier part of the Saalian is represented at Ariendorf, whereas the lower loess layers at Wannen and Schweinskopf date from the later Saalian (Turner, 1990, 1998).

At Achenheim, fluvial sediments laid down by the Rhine are covered by a thick sequence of loess. The *loess ancien* is subdivided into *loess ancien inférieur* (units 20d-20a), *loess ancien moyen* (units 20'''-18) and *loess ancien supérieur* (units 17-13). The soils of units 15, 18, 20a and 20e contain an interglacial fauna (Vollbrecht, 1997). The soil development in unit 15 was identified as the Eemian soil.

The age and climatic character of the Lower Travertine at Weimar - *Ehringsdorf* has been the subject of a long-lasting debate (*e.g.* Steiner & Wiefel, 1974; Kahlke *et al.*, 2002; Schreve & Bridgland, 2002; Mania & Mania, 2008). The evidence is here interpreted as indicating a temperate phase of continental character within the Saalian. The travertine sands at Taubach have been firmly dated to the Eemian based on the stratigraphy of the site, faunal and mollusc assemblages and results from absolute dating methods (Steiner, 1977; Brunnacker *et al.*, 1983).

5. Discussion

The horse remains from *Mesvin IV* can be identified as belonging to caballoid horses based on

Country	*Site*	*Stratigraphical layer*	*Age*	*Reference*
United Kingdom	Barling	Upper Gravel	OIS 8	Bridgland *et al.*, 2001
	Ilford	Aveley Silts and Sands	OIS 7	Schreve, 1997
	Crayford	Aveley Silts and Sands	OIS 7	White *et al.*, 2006
	Brundon		OIS 7	Moir & Hopwood, 1939
	Stoke Tunnel	Bone Bed	OIS 7	Schreve, 1997
	Marsworth	Lower Channel layers 2 and 3	OIS 7	Green *et al.*, 1984; Murton *et al.*, 2001
	Oreston Cave		OIS 7	Schreve, 1997
	Hindlow Quarry		OIS 7	Schreve, 1997
	Brighton Black Rock	Coombe Rock	OIS 6	Parfitt *et al.*, 1998
	Marsworth	Lower Channel layer 1	OIS 6	Green *et al.*, 1984; Murton *et al.*, 2001
Germany	Ariendorf	Ariendorf 1	Early Saalian	Turner, 1990, 1998
	Ariendorf	Ariendorf 2	Early Saalian	Turner, 1990, 1998
	Wannen	Wannen 1-2	Late Saalian	Turner, 1990
	Schweinskopf	Schweinskopf 1-5	Late Saalian	Turner, 1990
	Weimar - *Ehringsdorf*	Lower Travertine	Intra-Saalian interglacial	Steiner & Wiefel, 1974
	Taubach		Eemian	Steiner, 1977
France	Achenheim	20e-b (loess ancien inférieur)	Early Saalian	Vollbrecht, 1997
	Achenheim	20a (loess ancien inférieur)	Early Saalian	Vollbrecht, 1997
	Achenheim	20'''-18 (loess ancien moyen)	Early Saalian	Vollbrecht, 1997
	Achenheim	17-15 (loess ancien supérieur)	Late Saalian	Vollbrecht, 1997

Tab. 5 — List of comparative sites and their age.

dental morphology and the shape of the metacarpal. The dentition is similar in size to dental remains from Saalian sites in western Germany and northern France (fig. 1a-d). In the upper dentition, all sites cluster together rather closely. In the lower dentition, the closest similarity in size is with the Ariendorf material. The Schweinskopf lower dental elements are also very similar to the Mesvin and Ariendorf specimens. The dentitions in these three assemblages are characterised by relatively large breadths in the lower dentition. The Achenheim dentition generally has similar or somewhat smaller dimensions while the Wannen material is relatively small and narrow. Tooth width is thought to be related to diet and especially to the volume of food that is taken in, whereas tooth length to a degree reflects body size (Fortelius, 1990; Janis, 1990). In general, overall tooth size seems to be more closely related to the degree of competition for food with species that occupy a similar niche than with climatic factors (Dayan *et al.*, 1991).

Eisenmann (1991) distinguished between three groups of caballoid horses based on dental morphology, particularly the ratio of protoconal length to total length in upper premolars and molars (protoconal index or IP). Type I caballoid horses have short protocones on the P3/4 and long protocones on the M1/2. This morphology occurs in specimens dating from temperate periods with forest-steppe or forest conditions (Eisenmann, 1991; Kuzmina, 1997).

Horses of Type II have relatively long protocones on the P3/4 and relatively short protocones on the M1/2, and are correlated with cold climatic conditions. Finally, type III horses have short protocones both on the P3/4 and the M1/2. These horses occur in cold to cool environments. The connections between dental mor-phology and environment are tentative, as each group has its exceptions. Furthermore, the differences in the protoconal indices between these groups are small. Short protocones are considered to be an adaptation to abrasive food (Orlando *et al.*, 2006). However, the length of the protocone varies with wear, being shorter in well-worn teeth than in young teeth (Forstén, 1996). The Mesvin horses have a low IP on both the premolars and the molars, indicating a cool to cold environment (tab. 6). Their IPs are most similar to the IPs of the horse dental elements from the *loess ancien moyen* at Achenheim and the dentitions from Schweinskopf.

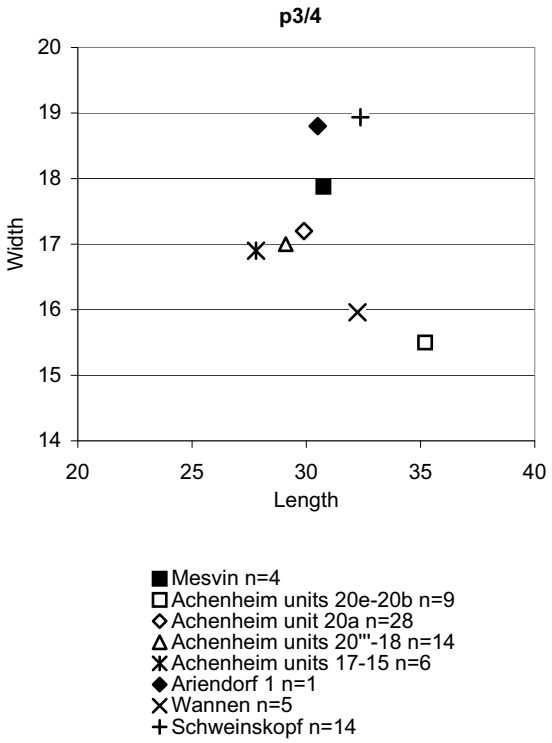

Fig. 1a — Scatter plot of the lengths and widths of lower third and fourth horse premolars from various Saalian sites (Mesvin: this study; Achenheim: Forstén, 1996; Ariendorf, Wannen and Schweinskopf: author, unpublished data).

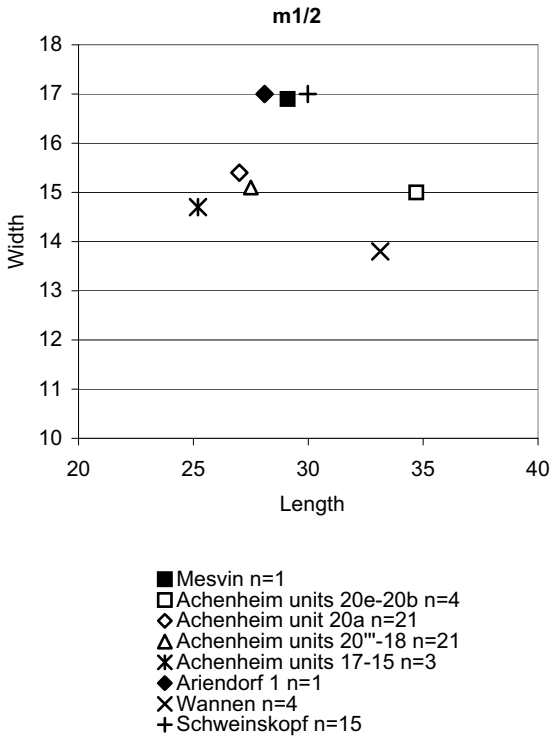

Fig. 1b — Scatter plot of the lengths and widths of lower first and second horse molars from various Saalian sites (Mesvin: this study; Achenheim: Forstén, 1996; Ariendorf, Wannen and Schweinskopf: author, unpublished data).

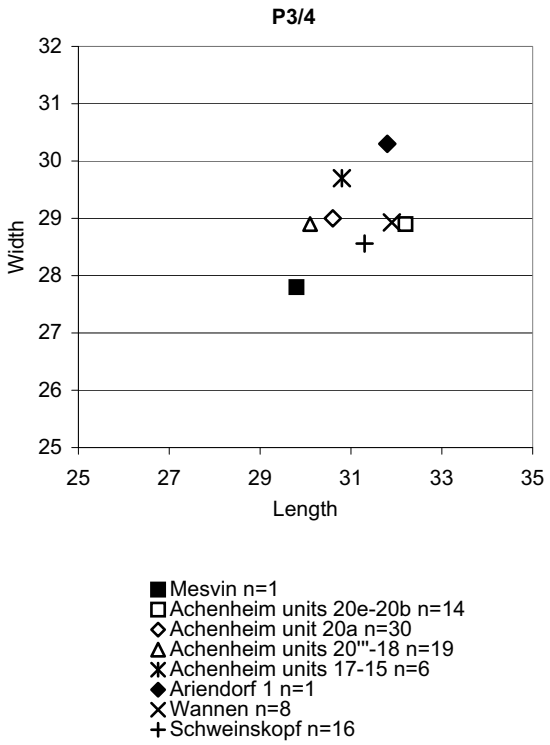

Fig. 1c — Scatter plot of the lengths and widths of upper third and fourth horse premolars from various Saalian sites (Mesvin: this study; Achenheim: Forstén, 1996; Ariendorf, Wannen and Schweinskopf: author, unpublished data).

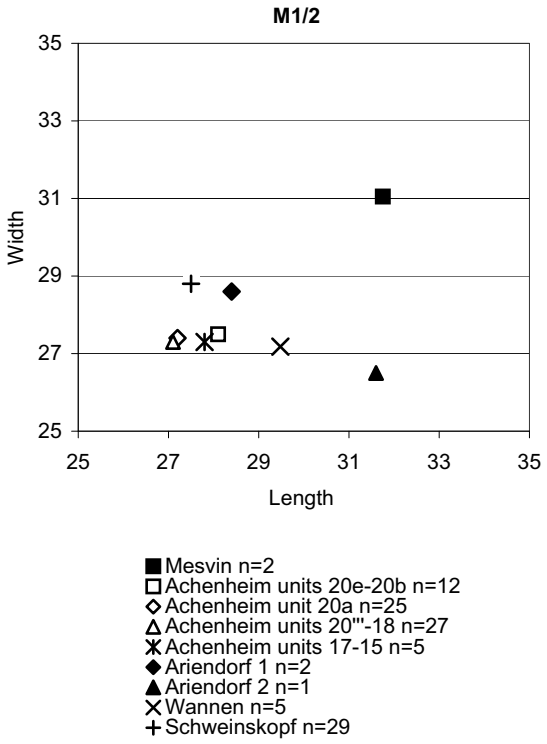

Fig. 1d — Scatter plot of the lengths and widths of upper first and second horse molars from various Saalian sites (Mesvin: this study; Achenheim: Forstén, 1996); Ariendorf, Wannen and Schweinskopf: author, unpublished data).

Element	*Site*	*Layer*	*IP*	*n*	*Source*
P3/4	*Mesvin IV*		39.6	1	This study
	Achenheim	20e-b	49.2	4	Nobis, 1971
	Achenheim	20a	49.7	10	Nobis, 1971
	Achenheim	20'''-18	42.0	9	Nobis, 1971
	Achenheim	17-15	45.9	2	Nobis, 1971
	Ariendorf	1	44.7	1	Author, unpublished data
	Wannen	1-3	47.0	8	Author, unpublished data
	Schweinskopf	1-5	40.9	16	Author, unpublished data
M1/2	*Mesvin IV*		47.5	2	This study
	Achenheim	20e-b	48.6	5	Nobis, 1971
	Achenheim	20a	47.2	13	Nobis, 1971
	Achenheim	20'''-18	51.1	8	Nobis, 1971
	Achenheim	17-15	48.9	2	Nobis, 1971
	Ariendorf	1	50.0	2	Author, unpublished data
	Ariendorf	2	43.7	1	Author, unpublished data
	Wannen	1-3	50.5	5	Author, unpublished data
	Schweinskopf	1-5	47.3	29	Author, unpublished data

Tab. 6 — Comparison of protoconal indices for various Saalian sites.

Two log ratio diagrams were constructed to compare the size and shape of the *Mesvin IV* metacarpal with metacarpals from cold stage and interglacial sites (fig. 2a and fig. 2b). The *Mesvin IV* metacarpal is highly similar in shape to the metacarpals from other cold stage sites. The features that distinguish the *Mesvin IV* specimen most from all other specimens are a relatively broad but not deep diaphysis (V3 and V4). During late Middle and Late Pleistocene horse evolution, the supra-articular width of the distal end (V10) decreases relatively to the articular width (V11). In this characteristic, the *Mesvin IV* metacarpal is less advanced than the specimens from all other sites, except for the specimens from the *loess ancien moyen* at Achenheim. Horse remains from the British Isles dating from OIS 6 are similar in shape to the horse remains from continental Europe, but much smaller in size. This is probably due to the severe climatic conditions in Britain during this oxygen isotope stage.

Compared to interglacial remains, the Mesvin metacarpal has a broad but not deep diaphysis. The distal diaphysis is not strongly developed. The supra-articular distal width is somewhat larger relative to the articular width of the distal epiphysis than in the interglacial specimens. These differences can be interpreted as adaptations to differing environmental conditions. The robusticity of the Mesvin metacarpal is an adaptation to a cool and dry climate. In horses, limb broadness is often associated with relatively small diaphyseal depths (Eisenmann & Bekouche, 1986). The dryness of the climate is also reflected in the poor development of the distal epiphysis, which is an adaptation to relatively firm substrates (Kuzmina, 1997; Bignon & Eisenmann, 2006).

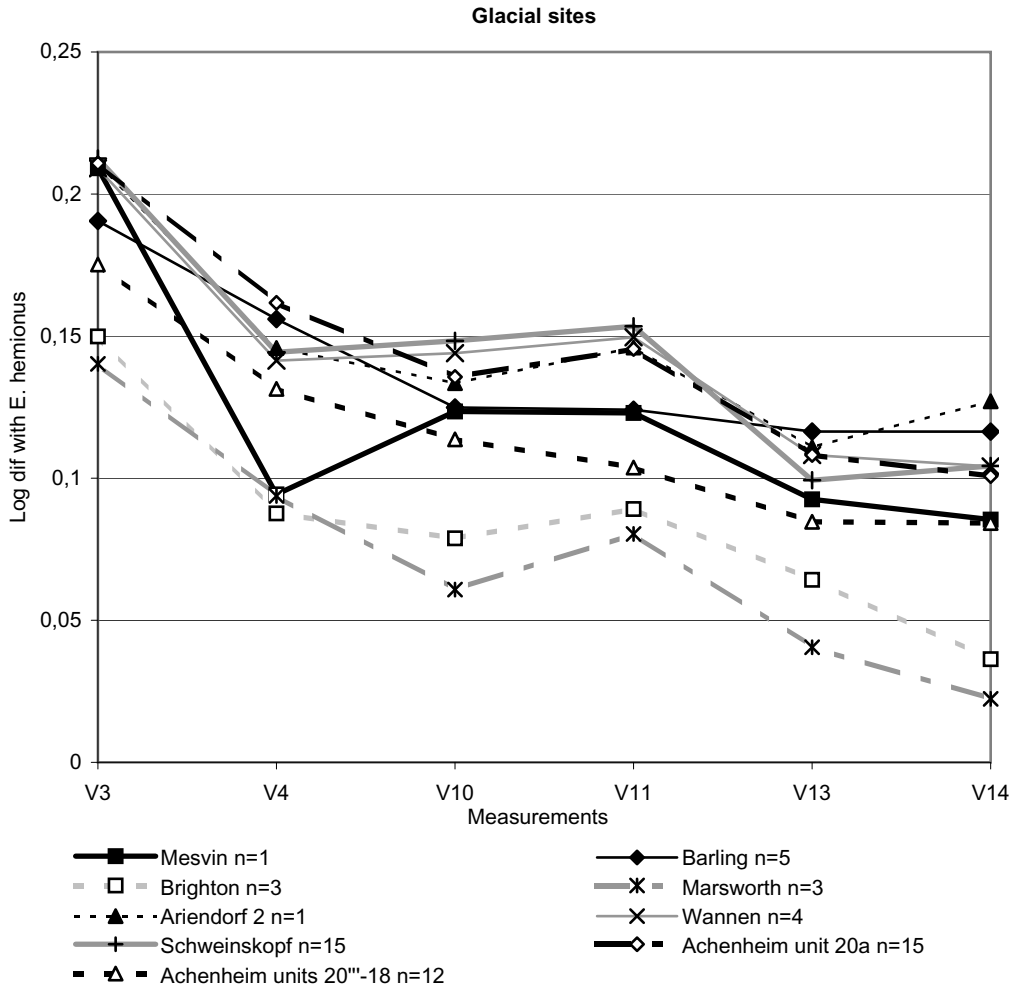

Fig. 2a — Log ratio diagram of metacarpals from *Mesvin IV* and the glacial phases of the Saalian. Reference line: *Equus hemionus* (Eisenmann, 1979); Mesvin: this study; Achenheim: Cramer, 2002; Barling, Brighton, Marsworth, Ariendorf, Wannen and Schweinskopf: author, unpublished data.

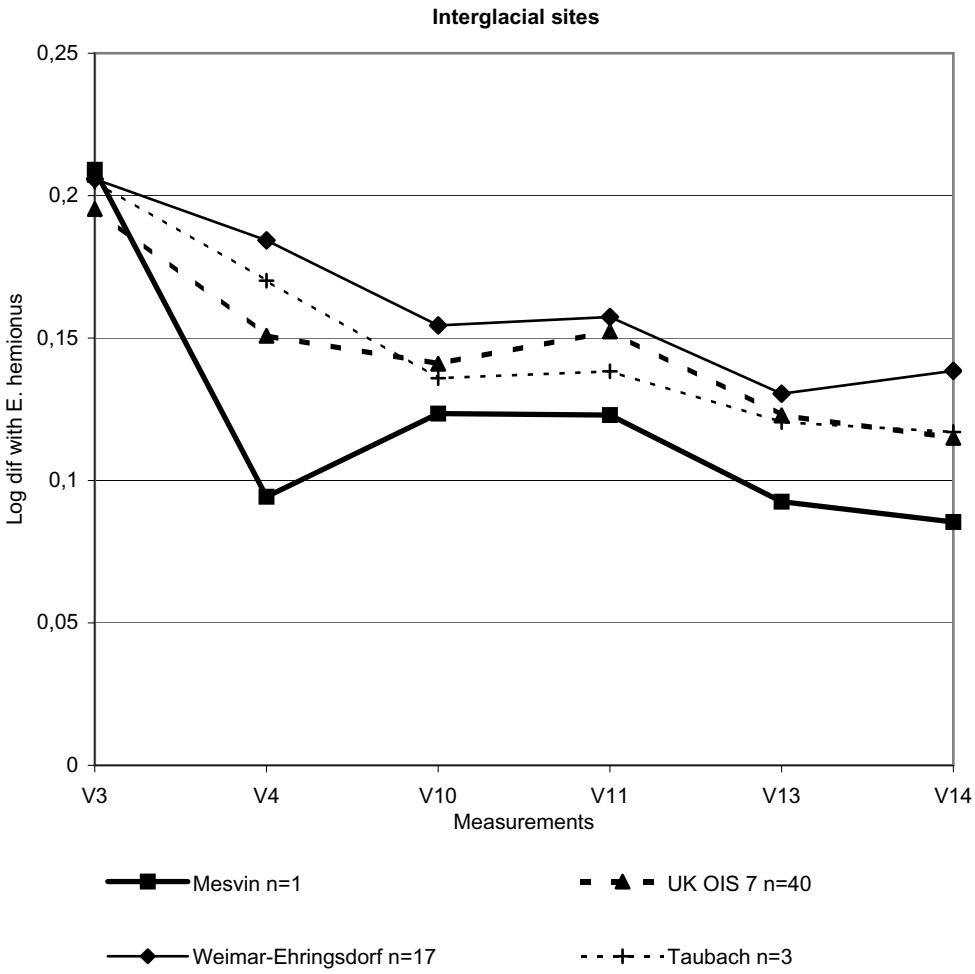

Fig. 2b — Log ratio diagram of metacarpals from *Mesvin IV* and the interglacial phases of the Saalian. Reference line: *Equus hemionus* (Eisenmann, 1979); Mesvin: this study; United Kingdom OIS 7 sites, Weimar - *Ehringsdorf* and Taubach: author, unpublished data.

6. Conclusion

Pending a better knowledge of the *Mesvin IV* mammoth remains and a better understanding of mammoth evolution during the Saalian, the horse remains are the most promising material to use for biostratigraphic purposes (Van Neer, 1986). The characteristics of the Mesvin horse specimens firmly place them with other Saalian sites of the same geographical area. Furthermore, the material shows adaptations to cool or cold climatic conditions both in the dentition and in the postcranial skeleton. It is more difficult to identify from which cold substage of the Saalian the site dates, not least because the subdivision of the Saalian and the attribution of the comparative sites to these subdivisions are highly debated. However, the *Mesvin IV* specimens appear to be more similar to material from sites that are thought to date from the early Saalian rather than to material from late Saalian sites. The somewhat more ancestral character of the distal diaphysis of the Mesvin metacarpal is in accordance with this trend. This study of the horse remains therefore corroborates the evidence from the stratigraphy of the site and the results from absolute dating techniques.

Acknowledgements

I am grateful to the curators of various museums who kindly provided access to material in their care. In particular, I would like to thank I. Jadin at the Royal Belgian Institute of Natural Sciences, Brussels, Belgium, who helped me in accessing and studying the Mesvin collection.

I thank T. P. O'Connor for discussions and helpful advice, and for his comments upon an earlier version of this paper.

This research was supported by the European Commission under the Marie Curie Actions of the Sixth Framework Programme (PALAEO, MEST-CT-2005-020601).

References

BIGNON O. & EISENMANN V., 2006. Western European Late Glacial horse diversity and its ecological implications. In: M. MASHKOUR (ed.), *Equids in time and space, Papers in honour of Véra Eisenmann, Proceedings of the 9th conference of the International Council of Archaeozoology, Durham, August 2002*, Oxford: 161-171.

BOSINSKI G., KRÖGER K., SCHÄFER J. & TURNER E., 1986. Altsteinzeitliche Siedlungsplätze auf den Osteifel-Vulkanen. *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz*, 33: 97-130.

BRIDGLAND D. R., 1994. *Quaternary of the Thames*, London.

BRIDGLAND D. R. & SCHREVE D. C., 2001. River terrace formation in synchrony with long-term climatic fluctuation: supporting mammalian evidence from southern Britain. In: D. MADDY, M. G. MACKLIN & J. C. WOODWARD (eds), *River basin sediment systems: archives of environmental change*, Lisse: 229-248.

BRIDGLAND D. R., PREECE R. C., ROE H. M., TIPPING R. M., COOPE G. R., FIELD M. H., ROBINSON J. E., SCHREVE D. C. & CROWE K., 2001. Middle Pleistocene interglacial deposits at Barling, Essex, England: evidence for a longer chronology for the Thames terrace sequence. *Journal of Quaternary science*, 16: 813-840.

BRUNNACKER K., JÄGER K.-D., HENNIG G. J., PREUSS J. & GRÜN R., 1983. Radiometrische Untersuchungen zur Datierung mitteleuropäischer Travertinvorkommen. *Ethnographisch-Archäologische Zeitschrift*, 24: 217-266.

CAHEN D., HAESAERTS P., VAN NEER W. & VAN PAMEL P., 1979. Un outil en os du Paléolithique Inférieur dans la nappe alluviale de Mesvin. *Helinium*, 19: 105-127.

CAHEN D. & MICHEL J., 1986. Le site paléolithique moyen ancien de Mesvin IV (Hainaut, Belgique). *Supplément du Bulletin de l'Association Française pour l'Étude du Quaternaire*, 1986: 89-102.

CRAMER B., 2002. *Morphometrische Untersuchungen an quartären Pferden in Mitteleuropa*, Unpublished PhD thesis, Eberhard-Karls-Universität Tübingen.

DAYAN T., SIMBERLOFF D., TCHERNOV E. & YOM-TOV Y., 1991. Calibrating the paleothermometer: climate, communities, and the evolution of size. *Paleobiology*, 17: 189-199.

DIVE J. & EISENMANN V., 1991. Identification and discrimination of first phalanges from Pleistocene and modern *Equus*, wild and domestic. In: R. H. MEADOW & H.-P. UERPMANN (eds), *Equids in the ancient world, Volume II*, Wiesbaden: 278-315.

EISENMANN V., 1979. Les métapodes d'*Equus* sensu lato (Mammalia, Perissodactyla). *Géobios*, 12: 863-886.

EISENMANN V., 1991. Les chevaux quaternaires européens (Mammalia, Perissodactyla), Taille, typologie, biostratigraphie et taxonomie. *Géobios*, 24: 747-759.

EISENMANN V. & BEKOUCHE S., 1986. Identification and discrimination of metapodials from Pleistocene and modern *Equus*, wild and domestic. In: R. H. MEADOW & H.-P. UERPMANN (eds), *Equids in the ancient world, Vol. I*, Wiesbaden: 117-163.

FORSTÉN A., 1996. The Pleistocene horses from Achenheim, near Strasbourg (Alsace, France), and a comparison with contemporaneous finds. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, 201: 163-177.

FORTELIUS M., 1990. Problems with using fossil teeth to estimate body sizes of extinct mammals. In: J. DAMUTH & B. J. MACFADDEN (eds), *Body size in mammalian paleobiology*, Cambridge: 207-228.

GREEN C. P., COOPE G. R., CURRANT A. P., HOLYOAK D. T., IVANOVICH M., JONES R. L., KEEN D. H., MCGREGOR D. F. M. & ROBINSON J. E., 1984. Evidence of two temperate episodes in late Pleistocene deposits at Marsworth, UK. *Nature*, 309: 778-781.

HAESAERTS P., 1978. Contexte stratigraphique de quelques gisements paléolithiques de plain air de moyenne Belgique. *Bulletin de la Société Royale Belge d'Anthropologie et de Préhistoire*, 89: 115-133.

JANIS C. M., 1990. Correlation of cranial and dental variables with body size in ungulates and macropodoids. In: J. DAMUTH & B. J. MACFADDEN (eds.), *Body size in mammalian paleobiology*, Cambridge: 255-299.

KAHLKE R.-D., MAUL L. C., MEYRICK R. A., STEBICH M. & GRASSELT T., 2002. The Quaternary sequence from the late Middle to Upper Pleistocene site of Weimar-Ehringsdorf. In: R. A. MEYRICK & D. C. SCHREVE (eds), *The Quaternary of Central Germany*, London: 163-177.

KUZMINA I. E., 1997. *Horses of North Eurasia from the Pliocene till the present time*. Russian Academy of Sciences, Proceedings of the Zoological Institute, 273 (ed. N. K. VERESCHAGIN), Saint-Petersburg. [In Russian with English summary].

MANIA D. & MANIA U., 2008. La stratigraphie et le Paléolithique du complexe saalien dans la région de la Saale et de l'Elbe. *L'Anthropologie*, 112: 15-47.

MOIR J. R. & HOPWOOD A. T., 1939. Excavations at Brundon, Suffolk (1935-37). *Proceedings of the Prehistoric Society*, 5: 1-32.

MURTON J. B., BAKER A., BOWEN D. Q., CASELDINE C. J., COOPE G. R., CURRANT A. P., EVANS J. G., FIELD M. H., GREEN C. P., HATTON J., ITO M., JONES R. L., KEEN D. H., KERNEY M. P., MCEWAN R., MCGREGOR D. F. M., PARISH D., ROBINSON J. E., SCHREVE D. C. & SMART P. L., 2001. A late Middle Pleistocene temperate-periglacial-temperate sequence (Oxygen Isotope Stages 7-5e) near Marsworth,

Buckinhamshire, UK. *Quaternary Science Reviews*, 20: 1787-1825.

MUSIL R., 1969. Die Equiden-Reste aus dem Pleistozän von Süßenborn bei Weimar. In: H. WEHRLI (ed.), *Das Pleistozän von Süssenborn*, Berlin: 617-666.

NOBIS G., 1971. *Vom Wildpferd zum Hauspferd, Studien zur Phylogenie pleistozäner Equiden Eurasiens und das Domestikationsproblem unserer Hauspferde*. Fundamenta Reihe B, Band 6, Köln.

ORLANDO L., MASHKOUR M., BURKE A., DOUADY C. J., EISENMANN V. & HÄNNI C., 2006. Geographic distribution of an extinct equid (*Equus hydruntinus*: Mammalia, Equidae) revealed by morphological and genetical analysis of fossils. *Molecular Ecology*, 15: 2083-2093.

PARFITT S. A., OWEN F. & KEEN D. H., 1998. Pleistocene stratigraphy, vertebrates and Mollusca, Black Rock, Brighton. In: J. B. MURTON, C. A. WHITEMAN, M. R. BATES, D. R. BRIDGLAND, A. J. LONG, M. B. ROBERTS & M. P. WALKER (eds), *The Quaternary of Kent and Sussex, Field guide*, London: 146-150.

PENKMAN K., COLLINS M., KEEN D. & PREECE R., 2008. *British aggregates: An improved chronology of using amino acid racemisation and degradation of intracrystalline amino acids*. English Heritage research department report series 6/2008.

SCHREVE D. C., 1997. *Mammalian biostratigraphy of the later Middle Pleistocene in Britain*, Unpublished PhD thesis, London University.

SCHREVE D. C. & BRIDGLAND D. R., 2002. Correlation of English and German Middle Pleistocene fluvial sequences based on mammalian biostratigraphy. *Geologie en Mijnbouw*, 81: 357-373.

SIMPSON G. G., 1941. Large Pleistocene felines of North America. *American Museum Novitates*, 1136: 1-28.

SIMPSON G. G., ROE A. & LEWONTIN R. C., 1960. *Quantitative zoology*, Revised edition, New York.

STEINER W., 1977. Das geologische Profil des Travertin-Komplexes von Taubach bei Weimar. *Quartärpaläontologie*, 2: 83-118.

STEINER W. & WIEFEL H., 1974. Die Travertine von Ehringsdorf bei Weimar und ihre Erforschung (Zur Geschichte der geologischen Forschung in Weimar, Teil I). In: H.-D. KAHLKE (ed.), *Das Pleistozän von Weimar-Ehringsdorf, Teil I*, Abhandlungen des Zentralen Geologischen Instituts, Paläontologische Abhandlungen Heft 21, Berlin: 11-60.

TURNER E., 1990. Middle and Late Pleistocene macrofaunas of the Neuwied Basin Region (Rhineland-Palatinate) of West Germany. *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz*, 37: 133-403.

TURNER E., 1998. Pleistocene deposits and archaeological horizons in the Ariendorf gravel quarry, Lower Central Rhineland, Germany. In: N. ASHTON, F. HEALEY & P. PETTITT (eds), *Stone Age archaeology, Essays in honour of John Wymer*, Oxbow Monograph, 102, Lithic studies society occasional paper, 6, Oxford: 114-123.

VAN ASPEREN E. N., FORTHCOMING. Caballoid horses and late Middle Pleistocene biostratigraphy of the British Isles. *Quaternaire*.

VAN NEER W., 1986. La faune Saalienne du site Paléolithique moyen de Mesvin IV (Hainaut, Belgique). *Supplement du Bulletin de l'Association Française pour l'Étude du Quaternaire*, 26: 103-111.

VOLLBRECHT J., 1997. *Untersuchungen zum Altpaläolithikum im Rheinland*, Universitätsforschungen zur prähistorischen Archäologie 38, Bonn.

VON DEN DRIESCH A., 1976. *A guide to the measurement of animal bones from archaeological sites*. Peabody Museum bulletin 1, Cambridge.

WHITE M., SCOTT B. & ASHTON N., 2006. The Early Middle Palaeolithic in Britain: archaeology, settlement history and human behaviour. *Journal of Quaternary science*, 21: 525-541.

Eline van Asperen
Marie Curie EST Research Fellow
PALAEO - Biology S Block
University of York
York YO10 5DD
United Kingdom
ENvanAsperen@palaeo.eu