

The Late Pleistocene Equids from “Tana delle Iene” (Ceglie Messapica, Brindisi, Southern Italy)

Nicoletta CONTI, Carmelo PETRONIO & Leonardo SALARI

N. Conti, Department of Earth Sciences, “Sapienza” University of Rome, Piazzale Aldo Moro 5, 00185 Roma

C. Petronio, Department of Earth Sciences, “Sapienza” University of Rome, Piazzale Aldo Moro 5, 00185 Roma; Carmelo.Petronio@uniroma1.it

L. Salari, Department of Earth Sciences, “Sapienza” University of Rome, Piazzale Aldo Moro 5, 00185 Roma

KEY WORDS - Mammals, Equids, Late Pleistocene, Southern Italy.

ABSTRACT - The Late Pleistocene equids found in the Tana delle Iene site (Ceglie Messapica, Brindisi, Southern Italy) are described. The morphological and dimensional analysis of the dental remains and of the post-cranial skeleton of *Equus ferus* and *Equus hydruntinus* has been used to try to understand the biochronological congruity in respect to the other taxa found in the site. Some aspects relative to the functional morphology of the limb bones that furnished paleoenvironmental indications have been investigated. These paleoenvironmental indications agree with data obtained from the entire faunal assemblage of the Tana delle Iene site and from other coeval sites of Apulia.

RIASSUNTO - [Gli equidi del Pleistocene Superiore di Tana delle Iene (Ceglie Messapica, Brindisi, Italia meridionale)] - In questa nota sono descritti gli equidi fossili rinvenuti nel sito di Tana delle Iene, una cavità carsica presso Ceglie Messapica che ha restituito una ricca associazione faunistica a vertebrati riferita al Pleistocene Superiore. L'analisi morfologica e dimensionale dei resti dentari e dello scheletro post-craniale di *Equus ferus* e di *Equus hydruntinus* ha cercato di coglierne la congruità biocronologica, rispetto agli altri taxa rinvenuti nel sito. In particolare il grado evolutivo di *E. ferus* sarebbe intermedio tra le forme equine dell'ultimo interglaciale e quelle di dimensioni minori di vari siti dell'Italia centro-meridionale del secondo Pleniglaciale e del Tardoglaciale e coerente con la supposta cronologia del sito, riferibile a 40-60.000 anni BP. Sono stati anche indagati alcuni aspetti relativi alla morfologia funzionale delle ossa degli arti che hanno fornito ulteriori indicazioni paleoambientali: in particolare l'epifisi distale dei metapodiali stretta e con superficie articolare particolarmente robusta di entrambi gli equidi e la III falange abbastanza stretta di *E. ferus* darebbero prova di un suolo relativamente duro e arido. Tali indicazioni ambientali sono confermate anche dai taxa vegetali rinvenuti nei coproliti di *C. crocuta* di Tana delle Iene e sono in sintonia con i dati ricavabili dall'intera associazione faunistica e di altri siti coevi della Puglia.

INTRODUCTION

In the periphery of Ceglie Messapica (Brindisi, Apulia), a karstic cavity filled with continental deposits yielded a rich vertebrate faunal association (Giaccio & Coppola 2000; Conti et al., in prep.). In a preliminary study, Giaccio & Coppola (2000) illustrated the stratigraphy of the site, giving a brief faunal list and naming it “Tana delle Iene” (Burrow of the Hyenas) for some traces of activity referred to *Crocota crocuta*. For the stratigraphy of the karstic cavity, which is now collapsed, the two preceding works are referred to; the species of vertebrates found in the layer named “Stratigraphic Unit 8” (Conti et al., in prep.), which are currently in the “Museo delle Civiltà Preclassiche della Murgia meridionale” (Museum of Pre-classical Civilization of Southern Murgia) in Ostuni (Brindisi) are listed here:

Aves

Accipitridae

Falco sp.

Otis tarda Linnaeus, 1758

Mammalia

Microtus arvalis (Pallas, 1779)

Terricola savii (Longchamps, 1838)

Apodemus sylvaticus (Linnaeus, 1758)

Lepus cf. *Lepus europeus* Pallas, 1778

Vulpes vulpes (Linnaeus, 1758)

Canis lupus Linnaeus, 1758

Crocota crocuta (Erxleben, 1777)

Felis silvestris Schreber, 1777

Equus ferus Boddaert, 1785

Equus hydruntinus Regalia, 1907

Sus scrofa Linnaeus, 1758

Capreolus capreolus (Linnaeus, 1758)

Cervus elaphus elaphus Linnaeus, 1758

Dama dama dama (Linnaeus, 1758)

Bos primigenius Bojanus, 1827

In this paper the two equid species are described, analyzing all the morphometrical aspects that can give additional paleoenvironmental indications along with further data from the faunal association of this and other coeval sites from Apulia.

SYSTEMATICS OF THE GENUS *EQUUS* IN THE MIDDLE AND LATE PLEISTOCENE

The systematics of the various species of the genus *Equus* is essentially based on the morphological characteristics of molars and premolars and of the metapodials because these elements are particularly frequent even if they depend on environmental modifications. The first caballine forms are characterized by their large size, robust and stocky; throughout the Middle Pleistocene the dimensions become smaller although the size of the species in this temporal interval are still defined as medium to medium-large.

Equus ferus Boddaert, 1785

Throughout the years the systematics of caballine species has gone through numerous revisions. In order to underline the existing differences between the domestic forms and the wild ones, in 2003 the International Commission on Zoological Nomenclature proposed that the wild species have to be indicated using the first available name given to a wild population: in the case of the horse, this is *Equus ferus* Boddaert, 1785; the term *Equus caballus* Linnaeus, 1758, however, remains valid to indicate the domestic forms (Gentry et al., 2004).

E. ferus seems to have reached Europe during the Middle Pleistocene (Galerian), probably deriving from earlier forms of *Equus* from central Asia and Mongolia (Azzaroli, 1983; Forsten & Sharapov, 2000). From this point on the species split into numerous chronological and geographical varieties, which some authors consider to be different species or subspecies (*E. f. germanicus*, *E. f. gallicus*, *E. f. gmelini*, etc.), that are distinguished essentially by their size and skeletal proportions. The first representatives of these wild horses (*E. ferus*) appear in Italy in the Middle Galerian (Isernia F.U.) and they are distinguished from the preceding Villafranchian equids by the structures of the enamel in the upper teeth, with a more elongated protocone that tends to assume progressively an asymmetrical conformation, by the metacarpus that is more compressed anterior-posteriorly and by the proportions of the post-cranial skeleton that generally takes on a more slender aspect. The oldest remains ascribed to this species are from Vitinia (Rome) within the Ponte Galeria Formation (Isernia F.U.) (Caloi et al., 1983), with large or medium-large sized forms. The presence in the Galerian of this large-sized horse, with a significantly sized anklebone, seems also confirmed in Monte Oliveto (Siena) (Berzi, 1972), referable to the Isernia F.U. as well. Successively, the horse is found only at the end of the Galerian in the Fontana Ranuccio site (Frosinone) (Cassoli & Segre Naldini, 1982). In the Middle-Late Pleistocene (Early Aurelian), the findings are abundant, especially near Rome. The most important deposits of this area are Polledrara di Cecanibbio (Anzidei et al., 1989), Malagrotta (Caloi & Palombo, 1980; Cassoli et al., 1982), Castel di Guido (Sala & Barbi, 1996), Torre in Pietra (Caloi & Palombo, 1978), Vitinia and the levels of the Aurelia Formation (Caloi et al., 1983). All these deposits are probably referable to MIS 9. The equid occurring in these sites is rather large, and it has more derived characteristics, especially as concerns the teeth. In the Late Pleistocene the findings of *E. ferus* are more frequent in Central and especially Southern Italy, where the species survives until the early Holocene (Petronio et al., 2007). From the Eneolithic onward, *E. ferus* is found in Italy with domestic specimens (*E. caballus*), generally of small size (Petronio et al., 2007), which derived probably from the domestication of wild horses surviving as small groups in the steppes between Ukraine and Turkestan (Forsten, 1993; Eisenmann, 1998).

Equus hydruntinus Regalia, 1907

The species was named by Regalia (1907) on the base of some remains of a small equid found in Grotta Romanelli, near Otranto. The material collected showed characteristics different from any other equid species

found before: reduced dimensions, the marked slenderness of the limbs, an elevated degree of *microdontia*, with the upper teeth endowed with short protocone and flat interstyler faces, similar to the ass model, and lower teeth with particularly deep lingual and vestibular groove, which is similar to that of *E. stenonis*. Initially, Regalia (1907) recognized in the remains of the small equine a new variety of onager to which he gave the name of *Equus (Asinus) hydruntinus* after the city of Otranto (*Hydruntum*).

Later, Regalia and other authors tried to clarify its systematical position: thus, the small equid has been classified as an ass (Stehlin & Graziosi, 1935; Gromova, 1949), a zebra (Davis, 1980), or considered as a stenonian form (Forsten, 1986, 1999; Forsten & Ziegler, 1995). However, the recent finding of two crania in the Kabazi II site (Crimea) evidenced the phylogenetic affinity between *E. hydruntinus* and the Asiatic *E. hemionus* (Burke et al., 2003); this affinity was subsequently confirmed by a DNA study on the remains found in Crimea and Iran (Orlando et al., 2006).

E. hydruntinus is a form typical of the Late Pleistocene of Europe and the eastern Mediterranean (Eisenmann, 1992). The oldest *E. hydruntinus* specimens excavated in Lunel-Viel (South of France) are about 350 000 years old (Orlando et al., 2006). It is well represented in southern Europe, eastern Europe and in the Ukraine (Radulesco & Samson, 1965; Bonifay 1991), and it is also present in Italy (Caloi, 1994; Rustioni, 1996, 1998). Although in smaller numbers, some remains of this species are also reported from central-northern Europe, from France (Bonifay, 1963, 1991; Prat, 1980) and England (Forsten, 1992), the Caucasus and the Near East (Eisenmann & Mashkour, 1999). The geographic range of *E. hydruntinus*, until now believed to be restricted to Europe, Israel, and Turkey, can be extended towards the East as far as Azerbaijan and Iran (Orlando et al., 2006).

In Italy, the oldest occurrence is found in the "upper gravels" of Sedia del Diavolo (Rome), terminal part of the Middle Pleistocene (MIS 7) (Caloi et al., 1980; Di Stefano et al., 1998). Other remains referable to the same period are those of Montemaggiore (Rieti) (Angelelli, 1983) and Campo Verde (Rome) (Mazza et al., 1992). In the Late Pleistocene, occurrences of *E. hydruntinus* become abundant; less numerous in the warm, initial phases and more numerous during the last Glacial episode, especially in the central-southern part of the Italian peninsula where the lowering of the sea-level caused an emergence of ample, flat, open lands characterized by arid and hard ground, suitable for this species (Caloi, 1994; Rustioni, 1998). As in Spain, Anatolia, Austria and Romania (Radulesco & Samson, 1965; Pucher, 1991; Uerpmann, 2005), the most recent Italian occurrences date back to the beginning of the Holocene (Neolithic) (Petronio et al., 2007).

Stehlin & Graziosi (1935) already noticed how the spreading out of this equid could be influenced by the type of environment, but an essential role was surely played by climate. In fact, by observing the distribution of this species in Romania, France and Italy (Radulesco & Samson, 1965; Prat, 1980; Sala, 1983), one can notice how the frequency of *E. hydruntinus* increases in correspondence with the interstadial, more temperate phases (Caloi, 1994).



Fig. 1 - Tana delle Iene: *Equus hydruntinus*: a) III metacarpal, dorsal view; b) M^{1/2}, B₁, occlusal view, B₂, medial view; *Equus ferus*: c) III metacarpal, dorsal view; d) P^{3/4}, d₁, occlusal view, d₂, medial view. Scale bar = 5 cm.

MATERIALS AND METHODS

In the Tana delle Iene site, among the over 1,000 classified bone remains, 118 were attributed to equids.

E. hydruntinus is represented by a few teeth and metapodials, which are referable to at least 2 individuals (Fig. 1a-b; Tabs. 1, 2). The presence of *E. ferus*, instead, is testified to by a larger number of bone remains, which

represent about the entire skeleton and which can be referable to at least 11 individuals (Fig. 1c-d; Tabs. 3-5). The majority of the bone remains is well preserved; traces of human activities or gnawing of carnivores were not detected, nor any particular pathologies; some exceptions are the traces of contact with fire on a few lower teeth and a proximal portion of radius of *E. ferus*, on which a bone neoformation and bite marks of a carnivore were noticed.

The material was measured according to the method suggested by Eisenmann (1980, 1981, 1986), and compared with the corresponding anatomical parts of living and fossil equids from a dozen localities of Central and Southern Italy, referable to the Middle-Late Pleistocene, Late Pleistocene and early Holocene (Torre in Pietra, Malagrotta, Melpignano, Maglie, S. Sidero, Cardamone, Paglicci, Palidoro, Polesini, S. Maria di Agnano, Romanelli, and Mura), whose osteometric measurements have been directly taken, in part by Dr. Marco Rustioni (unpublished data, for which we are thankful) and in part from the literature (Caloi & Palombo, 1978, 1980; De Giuli, 1983; Corridi, 1987; Bon & Boscato, 1993; Rustioni, 1996, 1998; Azzaroli, 1999; Tagliacozzo, 2003). The Salentinian equine forms coming from various karstic cavities of the Melpignano-Maglie-S. Sidero area and referable to MIS 5a/4 (early Late Pleistocene) (Bologna et al., 1994) have been grouped together ("Melpignano"),

<i>Equus hydruntinus</i>				
Upper cheek teeth				
	L	B	Lp	H
M1/2	25.3*	26.7*	-	53.0
M1/2	25.2 *	23.8	12.2	65.5
Lower cheek teeth				
	L	B	Lpf	H
M3	32.2	-	12.8	-
M3	31.6	-	13.1	-
M3	21.7	-	11.6	-

Tab. 1 - Tana delle Iene, *Equus hydruntinus*: upper and lower cheek teeth. Measurement system (mm) after Eisenmann (1980, 1981); L: occlusal length, B: occlusal breadth, Lp: length of protocone, Lpf: length of postflexid, H: height; *: approximate.

<i>Equus hydruntinus</i>													
Third Metacarpal													
1	2	3	4	5	6	7	8	8'	10	11	12	13	14
215	209	26.4	22.2	40.5	26.4	33.2	11.4	6.4	38.2	37.3	27.8	23.6	25.7
Third Metatarsal													
1	2	3	4	5	6	7	8	8'	10	11	12	13	14
-	217	-	23.8	-	-	-	15.8	-	39.3	36.7*	30.2	26.1	27*

Tab. 2 - Tana delle Iene, *Equus hydruntinus*: limb bones. Measurement system (mm) and symbology after Eisenmann (1986); *: approximate.

maintaining distinctions, however, with the entire skeleton of horse IGF 16328 (better known as “S. Sidero 6”; Azzaroli, 1999), preserved in the Museum of Natural History of Florence, and with the equine remains coming from the filling deposits of the karstic crevices named “S. Sidero 3” (De Giuli, 1983).

The osteometric measurements of the living equids have been taken from Eisenmann (1979, 1980, 1981, 1991a, b, 2003). The estimate of the withers height was carried out by multiplying the lateral length of the tibia by the coefficient of Kiesewalter (1889) and the length of the metacarpus by the coefficient by the same author as modified by Eisenmann (2003). The weight estimate was calculated starting from the distal breadth of the metacarpus, according to the methodologies proposed by Eisenmann & Sondaar (1998).

OBSERVATIONS AND COMPARISONS

Equus hydruntinus

Molars and premolars of this species generally have larger dimensions (Tab. 1) with respect to the average (Fig. 2); the upper ones have interstylar faces with a flattened trend, simple pilasters that do not have a tendency to double and short protocone that have the typical form defined “horse hoof” by Stehlin & Graziosi (1935). In the double knot of the lower jugal teeth, metaconid and metastylid are roundish, symmetrical and have subequal

dimensions; the lingual flexid in general assumes the aspect defined stenonian-like by Eisenmann (1981); unlike in asses, the vestibular groove is generally deep on molars.

The metapodials have a slender, thin shape; epiphyses, especially the proximal ones, do not protrude very much from the body of the diaphysis. The third metacarpal (Tab. 2; Fig. 3) is of average size and has a slender form that comes closer to the hemionines and to the asses, but it does not show a lengthening of the articular carina in the ventral face; moreover, it has a thick, robust keel with condyles that are shortened and more compact, which is an aspect that could indicate a greater disposition to running because when the articulations are subject to prolonged, lasting strain, they tend to become more robust in order to minimize blows and traumas (Caloi, 1994). The third metatarsal is of modest dimensions (Tab. 2; Fig. 4).

Equus ferus

The best-represented skeletal portion is the cranium (53% of the finds comprises teeth: 14% upper, 39% lower), and the least-represented is the fore limb with 11% of the total.

Upper molars and premolars of this species have protocones that are generally long (an average of 11.7 mm); the protocone index (IP) ranges between 24.1 and 33.5 in P², 34.8-43.0 in P^{3/4}, 36.6 in M^{1/2} and 44.4-53.5 in M³; the plis caballin is present in the majority of the cases in which it has been possible to observe the occlusal surface; the folding of the fossettes is relatively elevated. Usually, a simple enamel is observed in species feeding on hard vegetation, while a more complicated enamel is found in species feeding on a softer one (Gromova, 1949).

<i>Equus ferus</i>				
Upper cheek teeth				
	L	B	Lp	H
P2	31.9	24.9	10.7*	-
P2	38.3	28.2	9.9	-
P2	39.9	27.2	9.6	-
P3/4	31.9	26.1	11.1	-
P3/4	27.1	25.1	10.4	-
P3/4	30.0	24.9	12.9	-
M1/2	29.2	25.1	10.7	-
M3	28.2	20.6	15.1	21.2*
M3	26.6	21.2	11.8	64.0
M3	26.8	21.3	13.6	-

Tab. 3 - Tana delle Iene, *Equus ferus*: upper cheek teeth. Measurement system (mm) after Eisenmann (1980); L: occlusal length, B: occlusal breadth, Lp: length of protocone, H: height; *: approximate.

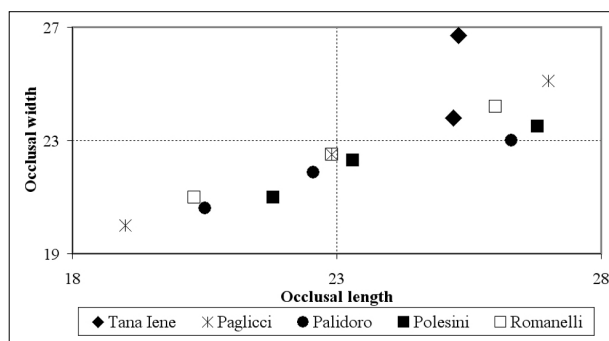


Fig. 2 - Scattergram of occlusal breadth versus occlusal length of M^{1/2} of *Equus hydruntinus* from Tana delle Iene compared with the minimum, mean and maximum lengths of *Equus hydruntinus* from some sites of the Late Pleistocene of Central and Southern Italy.

In the row of lower teeth it was noticed that the caballine folding is found in 84% of the premolars and in 88% of the molars; the lingual flexid is caballine-type in 68.5% of the cases, in one case it is intermediate between the caballine-type and the hemione-type, and in the remaining cases it is steronian-type. Considering only the mandibles or mandible portions, the postflexid index (IF) decreases from the premolars to the molars, and within the molars it is higher in M₂, than in the majority of the examined horses from Central and Southern Italy, except for the remains of Melpignano (Fig. 5). Considering also the isolated teeth, it was noticed that the index of the

postflexid is usually higher in the horses of the Apulian sites (Adriatic margin) than in Latium ones (Tyrrhenian margin) (see Rustioni, 1998).

Moreover, in both the upper and lower dental rows an occlusal breadth, generally lower than average, is

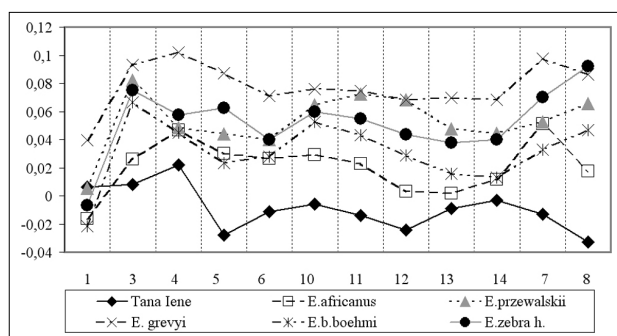


Fig. 3 - Ratio diagrams (according to Simpson) of decimal logarithmic differences between lengths of the third metacarpal of *Equus hydruntinus* from Tana delle Iene and the living species of the genus *Equus* compared with *Equus hemionus onager* (0). Measurement system and symbology according to Eisenmann (1986).

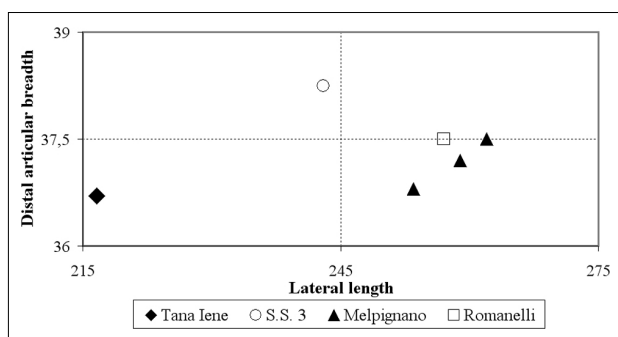


Fig. 4 - Scattergram of lateral length versus distal articular breadth of the third metatarsal of *Equus hydruntinus* from Tana delle Iene compared with the minimum, mean and maximum lengths of *Equus hydruntinus* from some sites of the Late Pleistocene of Apulia.

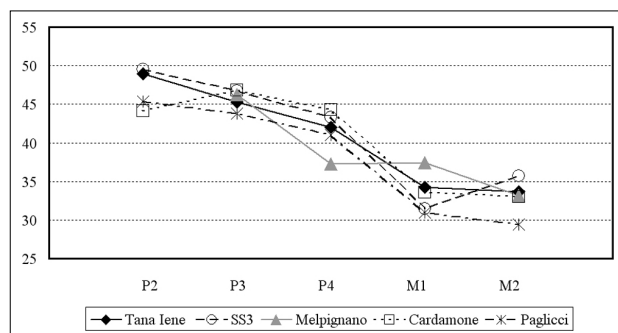


Fig. 5 - Mean of postflexid index of *Equus ferus* from Tana delle Iene and some sites of the Late Pleistocene of Apulia.

<i>Equus ferus</i>				
Lower cheek teeth				
	L	B	Lpf	H
P2	37.8	19.1	14.9	52.4*
P2	37.2	19.0	14.6	-
P2	35.3	15.1	14	32.6
P2	32.1	17.5	13.8	-
P3/4	32.1*	13.4*	17.4*	37.3*
P3/4	24.6*	12.2	13.5	32.2*
P3/4	33.0	15.7	16.4	-
P3/4	32.4	15.6	15.9	-
P3/4	32.3	13.2	17.1	40.1
P3/4	31.5	13.8	15.0	-
P3/4	30.0	13.1	13.4	-
P3/4	29.5	13.2	15.5	53.9
P3/4	29.4	14.4	13.7	-
P3/4	28.5	11.2	15.0	68.8
M1/2	32.8	11.7	13.9	-
M1/2	32.5	13.0	14.8	-
M1/2	32.4	13.0	11.9	-
M1/2	30.2	11.4	14.9	71.9
M1/2	30.0	11.3	15.8	-
M1/2	29.9	13.6	15.2	57.8
M1/2	29.7	11.3	13.7	-
M1/2	24.6	-	14.1	-
M3	32.6	-	-	-
M3	32.1	-	-	-
M3	31.8	-	-	-
M3	31.7	-	-	-
M3	31.3	-	13.5	-
M3	30.8	-	-	-
M3	30.8	-	13.1	-
Mandibles				
	L	B	Lpf	
P2	32.1	15.4	14.6*	
P3	28.9*	13.0	15.1	
P4	27.3*	11.9	16.0	
P2	32.2*	16.1	14.3	
P3	28.2*	13.0	15.9	
P4	26.6	11.6	15.1	
M1	27.0	8.8	14.6	
M2	27.2	9.3	14.0	
M3	-	-	13.2	
P2	36.4	17.8	13.7	
P3	30.9	13.8	14.0	
M1	28.0	9.8	12.4	
M2	29.2	9.7	12.8	
P3	31.2	14.1	14.2*	
P4	29.2	11.3	12.8	
M1	27.9	9.8	13.8	
M2	27.2	-	10.1	

Tab. 4 - Tana delle Iene, *Equus ferus*: lower cheek teeth and mandibles. Measurement system (mm) after Eisenmann (1981); L: occlusal length, B: occlusal breadth, Lpf: length of postflexid, H: height, *: approximate.

recorded, the only exception being the anterior premolar (Tab. 3; Fig. 6); lastly, a small-sized M_3 , also lengthwise, was recorded (Tab. 4; Fig. 7).

The tibia is medium-large sized (Tab. 5; Fig. 8), whereas the metapodials are medium-small sized (Tab. 5; Fig. 9), and they are morphologically close to *E. przewalskii*, but they have a relatively narrow distal articulation considering the supra-articular breadth and,

even more, the distal articular breadth; they also have a reduced articular keel and a more noticed internal condyle with respect to the articular keel (Fig. 10). These characteristics seem to point out an adaptation to running on hard grounds.

The estimated average weight of these equids is 448.5 kg, while the withers height ranged between 137.3 and 150.0 cm (average of 143.7 cm). Relatively to the weight

<i>Equus ferus</i>													
Third Metacarpal													
1	2	3	4	5	6	7	8	8'	10	11	12	13	14
230	221	40.1	29.2	-	-	-	18.1	-	54.6	53.5	38.6	31.5	-
226	219	35.2	27.2	50.8	31.0	41.8	14.5	6.0*	48.6	49.3	33.5*	25.4	28.2
-	-	38.6	29.5	53.0*	36.6*	44.8	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	54.1	54.9	39.8	30.5	32.9
Tibia													
1	2	3	4	5	6	7	8	9	10				
362	344	50.0	36.2	99.6	82.3	52.9	83.2	-	-				
Astragalus							Calcaneum						
1	2	3	4	5	6	7		1	2	3	4		
70*	67.7	72.8	33.3	61.1	-	57*		-	-	-	47.0		
69.9	71.0	70.8	-	59.0	41.0	-							
64.8	67.4	68.2	31.7	56.1	40.8	59.0							
63.6	63.9	65.1	29.0	54.6	35.3	54*							
60.9	63.7	60.0	29.4	53.2	34.9	53*							
Third Metatarsal													
1	2	3	4	5	6	7	8	8'	10	11	12	13	14
274*	-	36.4	27.7	-	-	-	-	-	44.5*	-	-	-	-
Anterior First Phalanges													
1	2	3	4	5	6	7	8	9	10	11	12	13	14
96.9	89.5	40.4	62.8	42.8	54.1	61.8	55.7	82.5	73.0	72.7	15.6	15.0	50.9
95.3	83.1	40.0	66.2	42.7	53.4	57.1	50.7	83.2	72.5	74.7	13.6	13.1	49.8
92.4	82.3	39.2	63.2	45.0	52.2	55.0	48.8	85.4	70.7	69.2	20.1	16.5	48.8
86.8	78.1	36.5	56.1	37.5	47.2	55.5	49.4	74.7	60.9	65.0	16.1	11.6	45.2
Posterior First Phalanges													
1	2	3	4	5	6	7	8	9	10	11	12	13	14
90.5	82.4	38.6	61.7	37.8	50.2	53.1	47.6	79.7	66.9	67.5	16.3	15.4	47.9
86.6	78.6	37.9	61.7	42.4	48.6	44.9	40.0	77.0	63.1	63.1	15.4	16.5	46.0
84.0	75.8	36.3	53.2	34.5	46.6	51.3	47.9	73.5	63.2	62.8	11.9	-	45.7
90.5	82.4	38.6	61.7	37.8	50.2	53.1	47.6	79.7	66.9	67.5	16.3	15.4	47.9
Second Phalanges							Third Phalanges						
1	2	3	4	5	6	7	1	2	3	4	5	6	7
55.0	39.4	45.2	57.7	36.6	51.8	-	58.6	68.6*	48.3*	-	-	-	-
52.8	39.3	46.9	56.9	34.2	-	-	49.8	51.6	43.0	-	-	-	118.3
49.1	36.2	52.7	58.6	36.1	55.4	-	50.7*	-	-	-	-	-	-
							-	-	49.3	78.8	29.1	54.9	166*
							-	-	44.0	67.4	25.0	50.0	134*

Tab. 5 - Tana delle Iene, *Equus ferus*: limb bones. Measurement system (mm) and symbology after Eisenmann (1986); *: approximate.

estimate, the horses of the Middle-Late Pleistocene and those of S. Sidero 6 and S. Sidero 3 were heavier than the horses of the Lateglacial and of the early Holocene (S. Maria di Agnano: 438 kg, Mura: 336 kg).

In Fig. 11 the data relative to the horses for which both estimates are available are reported: the position of the equids from Tana delle Iene testifies to their small size, which is proportionate to the equivalent weight; the “gigantic horses” of S. Sidero 6 and S. Sidero 3 have a slightly larger size even compared with the horses of the Middle-Late Pleistocene of Torre in Pietra, followed by the horses of the Melpignano area. On the other hand, the horses from Cardamone, slightly smaller than those from Tana delle Iene, seem heavier; therefore, they have a more

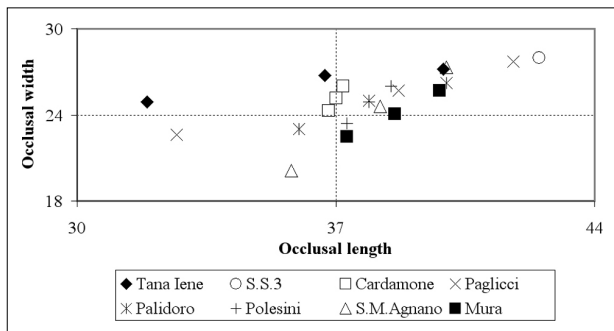


Fig. 6 - Scattergram of occlusal breadth versus occlusal length of P₂ of *Equus ferus* from Tana delle Iene compared with the minimum, mean and maximum lengths of *Equus ferus* from some sites of the Late Pleistocene of Central and Southern Italy.

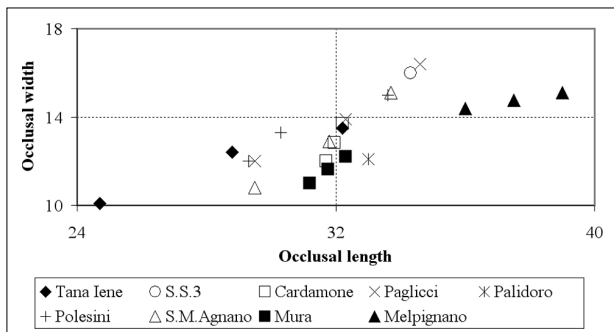


Fig. 7 - Scattergram of occlusal breadth versus occlusal length of M₃ of *Equus ferus* from Tana delle Iene compared with the minimum, mean and maximum lengths of *Equus ferus* from some sites of the Late Pleistocene of Central and Southern Italy.

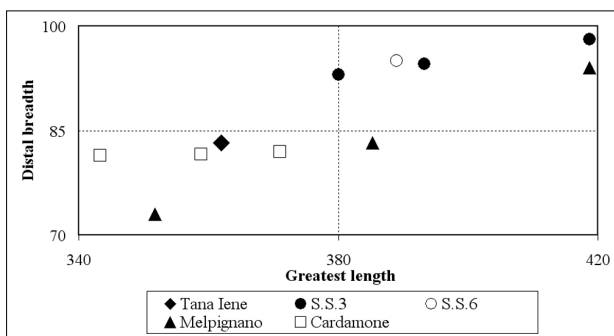


Fig. 8 - Scattergram of greatest length versus distal breadth of the tibia of *Equus ferus* from Tana delle Iene compared with the minimum, mean and maximum lengths of *Equus ferus* from some sites of the Late Pleistocene of Apulia.

full-bodied appearance because they probably lived in a colder phase of the last Glacial episode (at Cardamone *E. ferus* is associated with a fauna comprising *Mammuthus primigenius* and *Coelodonta antiquitatis*).

In Fig. 12, the lengths of the protocone of the upper premolars and molars, the lengths of the limb bones, the lengths of the proximal anterior and posterior phalanges and the breadth of the ungual phalanx are reported by means of the Ratio diagrams (according to Simpson) of decimal logarithmic differences with respect to *E. h. onager*. A relatively short protocone of *E. ferus* from Tana delle Iene can be noticed, especially in the premolars, as in the recent Tarpan (*E. ferus*); in *E. przewalskii*, instead, the protocone of the molars has larger dimensions. All the examined Pleistocene horses from Central and Southern Italy, with the exception of the population from Palidoro, have the same characteristic. Instead, in western Europe during the Late Pleistocene, horses with protocone of the molars and of the premolars with a length similar to the protocone of *E. przewalskii* were spread out, as well as horses with the same characteristics of the equids of Tana delle Iene and horses with relatively shorter protocone (Eisenmann, 1991b). It is yet unclear whether the relative length of the protocone in the upper premolars and molars can be considered a particular evolutive trend of the caballine forms of the genus *Equus* or, instead, whether it should be considered an adaptive character (Gromova, 1949; Forsten, 1988; Eisenmann, 1991b).

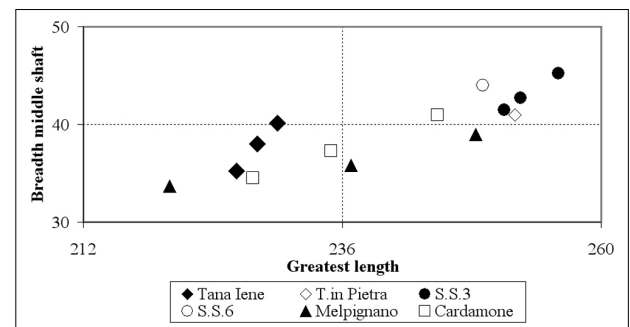


Fig. 9 - Scattergram of greatest length versus breadth in middle of shaft of the third metacarpal of *Equus ferus* from Tana delle Iene compared with the minimum, mean and maximum lengths of *Equus ferus* from some sites of the Middle-Late and Late Pleistocene of central and southern Italy.

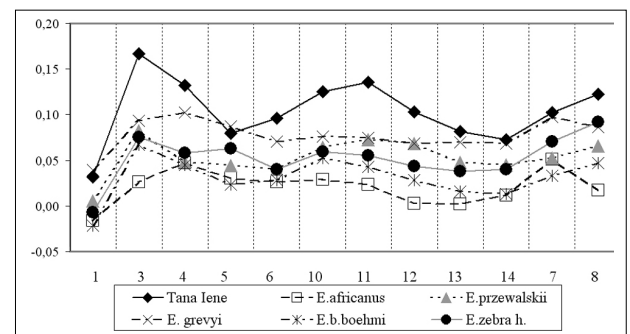


Fig. 10 - Ratio diagrams (according to Simpson) of decimal logarithmic differences between lengths of the third metacarpal of *Equus ferus* from Tana delle Iene and the living species of the genus *Equus* compared with *Equus hemionus onager*. Measurements system and symbology according to Eisenmann (1986).

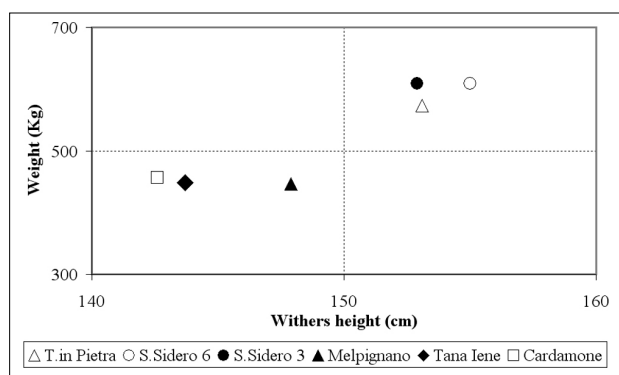


Fig. 11 - Scattergram of mean withers height versus weight of *Equus ferus* from Tana delle Iene and some sites of the Middle-Late and Late Pleistocene of central and southern Italy.

As concerns the post-cranial bones, a relation between some morphological elements and the environmental characteristics was attempted, by comparing them with the osteology and the ecological characteristics typical of the current genus *Equus*: relative length of the limb bones and openness of the environment, breadth of the ungual phalanges and type of ground, proportion of the metapodials and hygrometry (Eisenmann & Guérin, 1984; Eisenmann, 1984, 1991a). Also, it is known that the distal segments of the limbs (radius, tibia, metapodials) of the hemiones, which live in open lands, are relatively longer than those of Burchell's zebras, which live in more vegetated environments (Eisenmann & Guérin, 1984; Eisenmann, 1984). It is also known that the hemiones, the asses and Burchell's zebras, which live on hard grounds but not in the mountains, have the III phalanges narrower than the kiang and the horse of Przewalskii, which run most of the year on relatively soft ground (sandy or snowy) (Eisenmann, 1984, 1991a); the metapodials of the equids that live in arid environments (kiang, hemiones, asses) are relatively slimmer and weaker than those of the equids that live in more humid environments (horses, zebras) (Eisenmann & Guérin, 1984; Eisenmann, 1984, 1991a).

In Fig. 12 it can be observed that the horse of Tana delle Iene had proportions of the limb bones like a cursorial species, typical of open lands (Eisenmann & Guérin 1984; Eisenmann, 1984, 1991a), with relatively long tibia, but with small metapodials, compensated by a considerable length of the first phalanges. *E. przewalskii* has almost the same proportions of the onager and its skeletal design is about specular to that of the Tarpan and the Arabian horse. Moreover, the horse of Tana delle Iene, like S. Sidero 6, has a relatively narrow III phalanx, therefore, adapted to a hard but not rocky ground, typical of steppe and prairie environments (Eisenmann, 1984, 1991a), confirming what was highlighted by the analysis of the distal extremities of the metapodials and in particular by the metacarpus (Fig. 10). The other horses instead have a relatively larger ungual phalanx. Lastly, in the other cases, the information given by the functional morphology of the III phalanx would point out the presence of relatively soft grounds (prairie, humid prairies). The relative robustness of the metapodials of the equids of Tana delle Iene, highlighted also in Fig. 9, testifies to the probable presence of moderately arid environments.

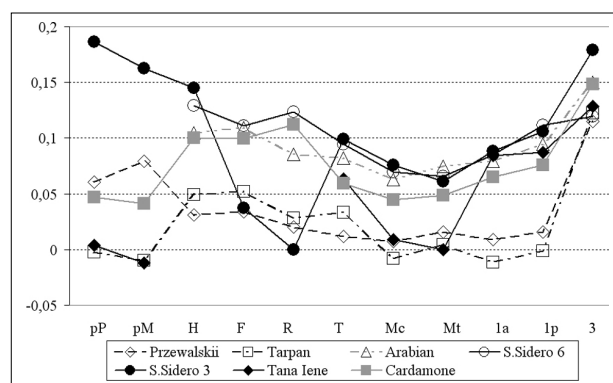


Fig. 12 - Ratio diagrams (according to Simpson) of decimal logarithmic differences between relative lengths of the protocone of the upper cheek teeth and the limb bones and breadth of the third phalanx of *Equus ferus* from Tana delle Iene and the living and fossil horses from some sites of the Late Pleistocene of Apulia compared with *Equus hemionus onager*. pP = protocone of the premolars; pM = protocone of the molars; H = humerus; F = femur; R = radius; T = tibia; Mc = third metacarpal; Mt = third metatarsal; 1a = anterior first phalanx; 1p = posterior first phalanx; 3 = third phalanx. Measurements according to Eisenmann (1980; 1986).

CONCLUSIONS

The morphological and dimensional characteristics of fossil equids found in the deposit allow us to make some inferences on the environment surrounding the site of Tana delle Iene. Particularly the narrow distal epiphysis of the metapodials with the articular surface being particularly strong in both equids and the quite narrow III phalanx of *E. ferus* could suggest a relatively hard and arid ground, likely steppe or prairies. These paleoenvironmental indications are also confirmed by the vegetal taxa found in the coprolites of *C. crocuta* (Petrucci et al., 2005): the pollen content, in fact, indicates an open land, rich in grassy vegetation (Cichorioideae, Gramineae, Chenopodiaceae, *Artemisia*, Caryophyllaceae and other Asteroidae), with sporadic mesophile and thermophile trees.

Further information on the environment surrounding the site comes from the entire faunal assemblage of Tana delle Iene that, nevertheless, also indicates diversified environments, probably connected to the morphology of the Murge plateau. This plateau, in the surroundings of Ceglie Messapica, is about 300 m above the sea level and then it levels down towards the sea through a series of slopes and ample terraces. The hyena, the wolf and the red fox are ubiquitous species and do not provide precise ecological indications, whereas the occurrence of *Felis silvestris* indicates the presence of forests, probably in high altitudes, inhabited also by *Bos primigenius* and by cervids. The presence of the hare, arviculids, and the bustard, as well as the presence of the equids, points out the presence of more or less ample areas with steppe-prairie vegetation, probably in the plains, whereas the few remains of *Sus scrofa* may suggest the presence of marginal, probably coastal, swampy areas.

Finally, it was noticed that from the Middle-Late and Late Pleistocene to the Holocene the size of some species, such as *Vulpes vulpes* (Petronio et al., 2006),

Capra ibex (Bartolomei & Sala, 1972), *B. primigenius* (Petronio et al., 2008) and *E. ferus* (Eisenmann, 1991; Forsten, 1991, 1993; Caloi, 1994; Eisenmann & David, 2002), diminished, in both the dental structures and in the dimensions of the limbs. The development of the wild horses of Central and Southern Italy seems to have a fairly constant trend although some variation between the different anatomical parts was noticed: from the medium/large-sized and large-sized horses of the Middle-Late Pleistocene, as in Malagrotta and Torre in Pietra (Caloi & Palombo, 1978, 1980), through the equine faunas of Melpignano (excepted the equine forms of S. Sidero 3 and S. Sidero 6 - De Giuli, 1983; Azzaroli, 1999), which are referable to MIS 5a/4 (Bologna et al., 1994), the trend evolves to the small-sized specimens of the Lateglacial and of the early Holocene, as in Santa Maria di Agnano (Salari, in study) and Grotta delle Mura (Bon & Boscato, 1993). Therefore, the morphological and dimensional characteristics of the dental structures and of the bone limbs of *E. ferus* of Tana delle Iene show an intermediate evolutive degree between the equine forms of Melpignano and the reduced-sized ones from several sites of the second Pleniglacial and Lateglacial. This evolutive degree is also coherent with the supposed biochronology of the site, referable to 40-60.000 years BP (Conti et al., in press). The anomalous position of *E. ferus* of S. Sidero 3 and S. Sidero 6, instead, can be more easily explained by hypothesizing a degree of endemism that could have altered the size of this population; it can also be hypothesized that the equids found in the filling deposits of these karstic cavities chronologically precede, but just slightly (MIS 5e/d?, 5c/b?), the remaining faunas of the area of Melpignano-Maglie-S. Sidero.

ACKNOWLEDGEMENTS

We wish to thank the "Soprintendenza per i beni Archeologici per la Puglia", particularly Mariantonia Gorgoglione, and Donato Coppola of the "Museo delle Civiltà Preclassiche della Murgia Meridionale" of Ostuni, who allowed the access to the fossils. We also wish to acknowledge Véra Eisenmann, one anonymous referee and Johannes Pignatti for the useful suggestions that improved the quality of the manuscript.

REFERENCES

- Angelelli F. (1981). Cenni preliminari sulla fauna quaternaria di Fara Sabina (Rieti) conservata nel museo del Servizio Geologico d'Italia. *Bollettino del Servizio Geologico d'Italia*, 102: 3-12.
- Anzidei A.P., Angelelli A., Arnoldus-Huyzendveld A., Caloi L., Palombo M.R. & Segre A.G. (1989). Le gisement Pléistocène de la Polledrara di Cecanibbio (Rome, Italie). *L'Anthropologie*, 83 (3): 749-782.
- Azzaroli A. (1983). Quaternary mammals and the "end Villafranchian" dispersal event - a turning point in the history of Eurasia. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 44: 117-139.
- Azzaroli A. (1999). Notes on some middle and late Pleistocene Equids of Italy. *Bollettino della Società Paleontologica Italiana*, 38 (1): 97-108.
- Bartolomei G. & Sala B. (1972). Nuovi dati paleontologici e paleoecologici sugli stambecchi cacciati dagli uomini preistorici di alcuni giacimenti italiani dell'ultimo glaciale e del primo postglaciale. *Una Vita per la Natura*, WWF: 101-120.
- Berzi A. (1972). An Early Middle Pleistocene fauna at Monte Oliveto (S.Gimignano, Siena, Italy). *Palaeontographia Italica*, 68: 29-33.
- Bologna P., Di Stefano G., Manzi G., Petronio C., Sardella R. & Squazzini E. (1994). Late Pleistocene mammals from the Melpignano (LE) "Ventarole": preliminary analysis and correlations. *Bollettino della Società Paleontologica Italiana*, 33 (2): 265-274.
- Bon M. & Boscato P. (1993). Analisi paleontologica e paleoecologica di macro e micromammiferi dei livelli romanelliani e mesolitici della Grotta delle Mura (Monopoli, Bari). *Quaternaria Nova*, 3: 53-104.
- Bonifay M.-F. (1963). Présence d'*Equus hydruntinus* dans la grotte de Rigabe (Var). *Annales de Paléontologie*, 49: 159-170.
- Bonifay M.-F. (1991). *Equus hydruntinus* Regalia minor n.ssp. from the Caves of Lunel Viel (Hérault, France). In Meadow R.H. & Uerpmann H.-P. (eds.), *Equids in the ancient world*. Vol. II. L.R. Verlag, Wiesbaden: 178-216.
- Burke A., Eisenmann V. & Ambler G. (2003). The systematic position of *Equus hydruntinus*, an extinct species of Pleistocene equid. *Quaternary Research*, 59: 459-469.
- Caloi L. (1994). Il genere *Equus* nell'Italia centrale. *Studi Geologici Camerti*, Vol. Spec. "Biostratigrafia dell'Italia centrale", parte b: 469-486.
- Caloi L., Cuggiani M.C., Palmarelli A. & Palombo M.R. (1981). La fauna a vertebrati del Pleistocene medio e superiore di Vitinia (Roma). *Bollettino del Servizio Geologico d'Italia*, 102: 41-76.
- Caloi L. & Palombo M.R. (1978). Anfibi, rettili e mammiferi di Torre del Pagliaccetto (Torre in Pietra, Roma). *Quaternaria*, 20: 315-428.
- Caloi L. & Palombo M.R. (1980). Resti di mammiferi del Pleistocene medio di Malagrotta (Roma). *Bollettino del Servizio Geologico d'Italia*, 100: 141-188.
- Caloi L., Palombo M.R. & Petronio C. (1980). La fauna quaternaria di Sedia del Diavolo (Roma). *Quaternaria*, 22: 177-209.
- Cassoli P.F., De Giuli C., Radmilli A.M. & Segre A.G. (1982). Giacimento del Paleolitico inferiore a Malagrotta (Roma). *Atti Istituto Italiano Preistoria Protostoria*, 23: 531-549.
- Cassoli P.F. & Segre Naldini E. (1984). Nuovo contributo alla conoscenza delle faune villafranchiane e del Pleistocene medio del bacino di Anagni (Frosinone). *Atti Istituto Italiano Preistoria Protostoria*, 23: 115-118.
- Corridi C. (1987). Le faune pleistoceniche del Salento. 2 - La fauna di fondo Cattie, Maglie, Lecce. *Quaderni Museo Comunale Paleontologia di Maglie*, 3: 5-74.
- Davis S.J. (1980). Late Pleistocene and Holocene equid remains from Israel. *Zoological Journal Linnean Society*, 70: 289-312.
- De Giuli C. (1983). Le faune pleistoceniche del Salento: 1. La fauna di S. Sidero 3. *Quaderni Museo Comunale Paleontologia di Maglie*, 1: 45-84.
- Di Stefano G., Petronio C. & Sardella R. (1998). Biochronology of the Pleistocene mammal Faunas from Rome urban area. *Il Quaternario*, 11 (2): 191-196.
- Eisenmann V. (1979). Les métapodes d'*Equus* sensu lato (Mammalia, Perissodactyla). *Géobios*, 12 (6): 863-886.
- Eisenmann V. (1980). Les chevaux (*Equus* sensu lato) fossiles et actuels: crânes et dents jugales supérieurs. *Cahiers de Paléontologie*, Paris, 186 pp.
- Eisenmann V. (1981). Étude des dents jugales inférieures des Equus (Mammalia, Perissodactyla) actuels et fossiles. *Palaeovertebrata*, 10 (3-4): 127-226.
- Eisenmann V. (1984). Sur quelques caractères adaptatifs du squelette d'*Equus* et leurs implications paléocéologiques. *Bulletin Muséum National Histoire Naturelle de Paris*, S. 4, 6/C (2): 185-195.
- Eisenmann V. (1986). Comparative Osteology of Modern and Fossil Horses, Alf-asses and Asses. In Meadow R.H. & Uerpmann H.-P. (eds.), *Equids in the ancient world*, L.R. Verlag, Wiesbaden: 67-116.
- Eisenmann V. (1991a). Proportion squelettiques de chevaux quaternaires et actuels. *Geobios*, M.S., 13: 25-32.

- Eisenmann V. (1991b). Le chevaux Quaternaires Europeens (Mammalia, Perissodactyla). Taille, Typologie, Biostratigraphie et Taxonomie. *Geobios*, 24 (6): 747-759.
- Eisenmann V. (1992). Origins, dispersals and migrations of Equus (Mammalia, Perissodactyla). In Von Koenigswald W. & Werdelin L. (eds.), Mammalian migrations and dispersal events in the European Quaternary. *Courier Forschungsinstitut Senckenberg*: 161-170.
- Eisenmann V. (1998). Quaternary horses: possible candidates to domestication. *Atti U.I.S.P.P.*, XIII, 6(1): 27-36, Forlì.
- Eisenmann V. (2003). Gigantic horses. In Pectulescu A. & Stiucă E. (eds), Advances in Vertebrate Paleontology "Hen to Panta", a tribute to Constantin Rădulescu and Petre Mihai Samson. Romanian Academy, "Emil Racovitza" Institute of Speleology, Bucharest: 31-40.
- Eisenmann V. & David F. (2002). Évolution de la taille des chevaux d'Arcy-sur-Cure et de quelques autres chevaux quaternaires. *Gallia Préhistoire*, XXXIV suppl.: 97-102.
- Eisenmann V. & Guérin C. (1984). Morphologie fonctionnelle et environnement chez les Périssodactyles. *Geobios*, M.S., 8: 69-74.
- Eisenmann V. & Kuznetsova T. (2004). Early Pleistocene equids (Mammalia, Perissodactyla) of Nalaikha, Mongolia, and the emergence of modern *Equus* Linnaeus, 1758. *Geodiversitas*, 26 (3): 535-561.
- Eisenmann V. & Mashkour M. (1999). The small equids of Binagady (Azerbaijan) and Qazvin (Iran): *E. hemionus binagadensis* nov. subsp. and *E. hydruntinus*. *Geobios*, 32: 105-122.
- Eisenmann V. & Sondaar P. (1998). Pliocene vertebrate locality of Çalta, Ankara, Turkey. 7. *Hipparion*. *Geodiversitas*, 20 (3): 409-439.
- Forsten A. (1986). A review of the Süssenborn horses and the origin of *Equus hydruntinus* Regalia. *Quartärpaläontologie*, 6: 43-52.
- Forsten A. (1988). Middle Pleistocene replacement of stenoid horses by caballoid horses - ecological implications. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 65: 23-33.
- Forsten A. (1991). Size decrease in Pleistocene - Holocene true or caballoid horses of Europe. *Mammalia*, 55: 407-419.
- Forsten A. (1992). Mitochondrial-DNA timetable and the evolution of *Equus*: Comparison of molecular and paleontological evidence. *Annales Zoologici Fennici*, 28: 301-308.
- Forsten A. (1993). Size decrease in Late Pleistocene - Holocene caballoid horses (genus *Equus*) intra- or interspecific evolution? A discussion of alternative. *Quaternary International*, 19: 71-75.
- Forsten A. (1999). A review of *Equus stenonis* Cocchi (Perissodactyla, Equidae) and related forms. *Quaternary science Review*, 18: 1373-1408.
- Forsten A. & Sharapov S. (2000). Fossil equids (Mammalia, Equidae) from the Neogene and Pleistocene of Tadzhikistan. *Geodiversitas*, 22 (2): 293-314.
- Forsten A. & Ziegler R. (1995). The horses (Mammalia, Equidae) from the early Würmian of Villa Seckendorff, Stuttgart - Bad Cannstadt, Germany. *Stuttgarter Beiträge Naturkunde*, S.B., 224: 1-22.
- Gentry A., Clutton-Brock J. & Groves C.P. (2004). The naming of wild animal species and their domestic derivatives. *Journal of Archaeological Science*, 31: 645-651.
- Giaccio B. & Coppola D. (2000). Note preliminari sul contesto stratigrafico e paleoecologico del sito "Tana delle Iene" (Ceglie Messapica, Brindisi, SE Italia). *Il Quaternario*, 13: 5-20.
- Gromova V.I. (1949). Histoire des chevaux (genre *Equus*) de l'Ancien Monde. *Trudy Paleontologicheskogo Instituta Akademja Nauk SSSR*, 7: 1-373.
- Kiesewalter L. (1889). Skelettmessungen an Pferden als Beitrag zur theoretischen Grundlage der Beurteilungslehre des Pferdes. Diss. Leipzig.
- Mazza P., Mozzi-Cecchi J. & Rustioni M. (1992). Vertebrate remains from Campo Verde, Latium, Central Italy. *Antropologia contemporanea*, 15: 65-83.
- 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 analyses of fossils. *Molecular Ecology*, 15: 2083-2093.
- Petronio C., Bellardini F., Arzarello M., Bedetti C., Bellucci L., Cipullo A., Di Stefano G., Pandolfi L., Pavia M., Petrucci M., Sardella R. & Salari L. (2008). The deposit of the Late Pleistocene from Avetrana (Taranto, Southern Italy): biochronology and palaeoecology. *Il Quaternario*, 21 (2): 409-422.
- Petronio C., Di Canzio E. & Salari L. (2007). The Late Pleistocene and Holocene Mammals in Italy: new biochronological and paleoenvironmental data. *Palaeontographica*, Abt. A, 279: 147-157.
- Petronio C., Petrucci M. & Salari L. (2006). La volpe nel Pleistocene superiore della Puglia: indicazioni paleoambientali. *Bollettino del Museo Civico Storia Naturale di Verona*, 30: 59-78.
- Petrucci M., Giardini M. & Sadori L. (2005). Analisi pollinica di coproliti di iena macchiata (*Crocota crocuta*, Erxleben) dell'ultimo glaciale della Puglia. *Informatore Botanico Italiano*, 37, (I parte c): 932-933.
- Prat F. (1980). Les Équidés villafranchiens en France. Genre *Equus*. *Cahiers du Quaternaire*, 2, CNRS, Paris.
- Pucher E. Von (1991). Erstnachweis des Europäischen Wildesels (*Equus hydruntinus* Regalia, 1907) im Holozän Österreichs. *Annalen der Naturhistorisches Museum Wien*, 92/B: 31-48.
- Rădulescu C. & Samson P. (1965). Sur la presence de *Hydruntinus hydruntinus* (Regalia) en Roumanie. *Quaternaria*, 7: 219-234.
- Regalia E. (1907). Sull'*Equus (Asinus) hydruntinus* Regalia della Grotta di Romanelli (Castro, Lecce). *Archivio per l'Antropologia e l'Etnologia*, 37: 375-390.
- Rustioni M. (1996). On *Equus hydruntinus* from Grotta Polesini (Rome, Latium, Central Italy) and Grotta Paglicci (Foggia, Apulia, Southern Italy). *Il Quaternario*, 9(2): 731-736.
- Rustioni M. (1998). Il cavallo e l'idruntino del Salento (Puglia, Italia meridionale) nel quadro degli equidi del Pleistocene superiore dell'Italia. *Quaderni Museo Comunale Paleontologia di Maglie*, 5: 93-121.
- Sala B. (1983). Variation climatiques et séquences chronologiques sur la base des variations des associations fauniques à grands mammifères. *Rivista di Scienze Preistoriche*, 38: 161-180.
- Sala B. & Barbi G. (1996). *Descrizione della fauna*. In Radmilli A.M. & Boschian G. (eds.), Gli scavi a Castel di Guido. Il più antico giacimento di cacciatori del Paleolitico inferiore nell'Agro Romano. I.I.P.P., Firenze: 49-90.
- Stehlin H.G. & Graziosi P. (1935). Ricerche sugli Asinidi fossili d'Europa. *Mémoires de la Société Paléontologique Suisse*, 56: 1-73.
- Tagliacozzo A. (2003). Archeozoologia dei livelli dell'Epigravettiano finale di Grotta Romanelli (Castro, Lecce). Strategie di caccia ed economia di sussistenza. In Fabbri P.F., Ingravalle E. & Mangia A. (eds.), Grotta Romanelli nel centenario della sua scoperta (1900-2000). Congedo, Galatina (LE): 169-216.
- Uerpmann H.P. (2005). Betrachtungen zum Verhältnis zwischen Wildpferd (*Equus ferus*) und Hydruntinus (*Equus hydruntinus*) im Jungpleistozän und Holozän auf der Iberischen Halbinsel. *Munibe*, 57: 351-358.

Manuscript received 13 January 2009

Revised manuscript accepted 29 October 2010