

LATE MIOCENE *CERATOTHERIUM* AND *HIPPARION* (MAMMALIA, PERISSODACTYLA) FROM DÜZYAYLA (HAFİK, SIVAS), TURKEY

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ABSTRACT - The fossil rhinoceros and hipparions from a new, Late Miocene mammalian fauna in Turkey are described. The scant material does not allow a specific determination of the latter. Various indices, often calculated on hipparion teeth and bones and believed to be phylogenetically and stratigraphically important, are critically discussed.

KEYWORDS: RHINOCEROTIDAE, HIPPARION, LATE MIOCENE, TURKEY.

RÉSUMÉ - Les rhinocéros et hipparions fossiles d'une nouvelle faune mammalienne du Miocène terminal de Turquie sont décrits. Le matériel insuffisant ne permet pas la détermination des hipparions. Divers indices, souvent calculés sur les dents et sur les os d'hipparions, considérés comme importants pour la phylogénie et la stratigraphie, sont discutés d'un point de vue critique.

MOTS-CLÉS: RHINOCEROTIDAE, HIPPARION, MIOCÈNE SUPÉRIEUR, TURQUIE.

INTRODUCTION

A new mammalian faunal assemblage has been found in a lignite horizon of the Late Miocene Incesu Formation near Düzyayla, 12 km NW of Hafik and 40 km NE of Sivas, Turkey (Yilmaz 1983) (Fig. 1). According to our observation, the fauna comprises *Ceratotherium neumayri* (OSBORN), *Hipparion* spp, *Deinotherium giganteum* KAUP, *Choerolophodon* sp., *Percrocuta* cf. *eximia* ROTH & WAGNER, *Oioceros* sp., *Helladotherium* sp., and Suidae. The only known micromammals from the lignite are *Apodemus* sp. and *Parapodemus* sp. (De Bruijn et al. 1996: 257). Stratigraphically unspecified sand layers of the Incesu Fm. contain *Hipparion gracile* KAUP (a younger synonym of *H. primigenium* v. MEYER), *Sus* (= *Microstonyx*) *erymanthius* ROTH & WAGNER, *Gazella* sp., and *Giraffa* sp. (Yalçınlar 1955).

The present note concerns *Ceratotherium* and the hipparions of the lignite horizon of the Incesu Fm. The fossil material is deposited in the Natural History Museum, Izmir, Turkey.

STRATIGRAPHY

The Incesu Fm. consists of light-grey sands, conglomerates, mudstones, minor lacustrine

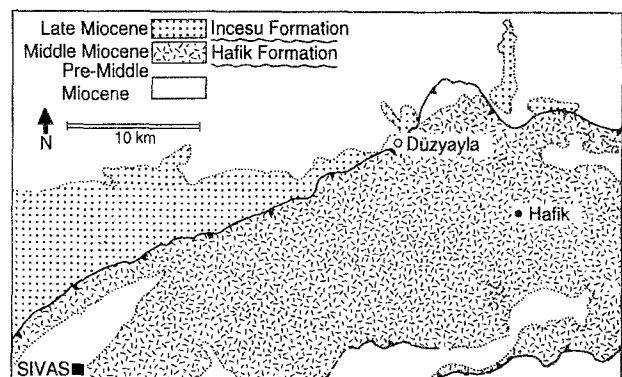


FIGURE 1 - Location map of the fossil site in Düzyayla village. Geological map after Poisson et al. (1995). Carte de localisation du site fossilifère du village de Düzyayla. Carte géologique d'après Poisson et al. (1995).

limestone, and lignite. This unit is considered Late Miocene in age (Atalay 1993; Poisson et al. 1995) (Fig. 2). It rests unconformably on the Hafik Fm. of a contradictory Cenozoic age (Atalay 1993).

DESCRIPTION

CERATOTHERIUM NEUMAYRI

Material - (Tabl. 1; Fig. 3): left P² (SHD-101), right P³ (SHD-102), right P⁴ (SHD-103), left M¹ (SHD-

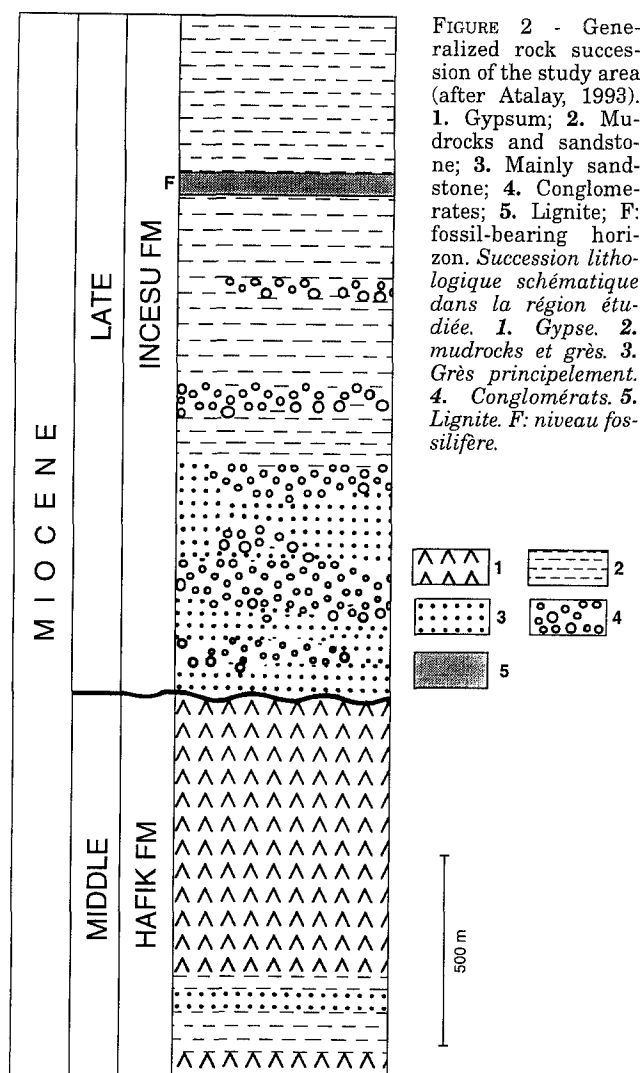


FIGURE 2 - Generalized rock succession of the study area (after Atalay, 1993). 1. Gypsum; 2. Mudrocks and sandstone; 3. Mainly sandstone; 4. Conglomerates; 5. Lignite; F: fossil-bearing horizon. *Succession lithologique schématique dans la région étudiée. 1. Gypse. 2. Mudrocks et grès. 3. Grès principalement. 4. Conglomérats. 5. Lignite. F: niveau fossilifère.*

104), right and left M² (SHD-105 & -106), left M³ (SHD-107), left and right M₂ (SHD 108 & -109), left M₃ (SHD-110), and dental fragments.

The dental nomenclature is according to Heissig (1972), the measurements taken are according to Fortelius (1990).

P² is quadrate with an almost flat buccal wall (Fig. 3.1). There are weak indications of paracone and metacone ribs. The crista is prominent, but the crochet small. The medisinus is long and oblique. The strong mesial cingulum extends from the parastyle to the middle of the lingual surface. There are neither labial nor distal cingula.

In P³⁻⁴ the buccal wall of the ectoloph is flat with a strong paracone rib extending to the ectoloph crest, while the metacone rib is weak (Fig. 3.2-3). There is a prominent crista, a multiple crochet, but a small antecrochet. The medisinus entrance is closed. The prefossette is absent, but the post-

Measurements on upper P² of *Ceratotherium neumayri* from Düzyayla and other localities.

	SHD	KK	DM	P	AS
Measure	101	(Heissig 1975)			NHM
BL	30.0	29	31	33	29
MB	38.5	35	38	-	39.1
DB	40.9	39	43	38	33.6
BH	28.1	-	-	-	14.3

Measurements on upper P³ and P⁴ of *C. neumayri* from Düzyayla and other localities.

	SHD	KK	DM	P	AS	SHD	UE	KK	DM	P
Measure	102	(Heissig 1975)			NHM	103	(Heissig 1975)			
BL	38.5	33	37	34-43	38	41.4	37	42	44	38-49
MB	55.6	49	54	45-60	53	59.2	53	57	62	55-65
DB	-	46	52	48-54	50	-	49	50	55	53-56
BH	42.5	-	-	(62)	16	48	(54)	-	-	71

Measurements on upper M¹ and M² of *C. neumayri* from Düzyayla and other localities.

	SHD	KK	DM	P	AS	SHD	SHD	KK	DM	AK	P
Measure	104	(Heissig 1975)			NHM	105	106	(Heissig 1975)			
BL	50	45	47	40-48	42	52.5	52.7	52	53	61	48-61
MB	66.5	54	63	50-60	60	71.1	69.6	58	66	64	59-66
DB	64.2	49	59	53-56	53	-	65.2	52	59	58	53-55
BH	38.0	-	-	-	19	-	-	-	-	(75)	58-68

Measurements on upper M³ of *C. neumayri* from Düzyayla and other localities.

	SHD	KK	DM	AK	P	AS
Measure	107	(Heissig 1975)				NHM
BL	61.5	51	53	61	50-58	51
MB	62.1	53	60	60	(43)-63	54
DB	41	35	40	44	37-41	26
BH	46.5	-	-	70	68	11
L.diagonal	68	56	61	68	64-66	59

Measurements on lower M² and M³ of *C. neumayri* from Düzyayla.

	SHD/108	SHD/109	SHD/110
Measure			
BL	47.2	52.0	60.5
LL	48.0	50.3	56.5
MB	33.5	34.3	39.0
DB	31.0	35.4	37.0
BH	31.5	29.5	45.0
LH	25.7	24.0	39.5

TABLE 1 - (BL=basal buccal length; LL= basal lingual length; MB=basal medial breadth; DB= basal distal breadth; BH= buccal height; LH= lingual height; SHD=Sivas-Hafik-Düzyayla; KK= Konya-Kayadibi; DM= Denizli-Mahmutgazi; AS= Ankara-Sinap; AK= Afyon-Kinik; UE= Usak-Esme-Akcaköy; P= Piskermi; NHM= Ege University, Natural History Museum, Izmir).

fossette is large and on P⁴ triangular in shape. There is a strong mesial cingulum, extending from the parastyle to the middle of the lingual surface. There is no labial cingulum.

In M¹⁻² the buccal wall of the ectoloph is flat and slopes linguad (Fig. 3.4-6). There is a weak crista but a strong crochet, which blocks the medisinus; the antecrochet is small. The large and V-shaped medisinus shows a small cusp basally. The shelf-like mesial cingulum extends from the parastyle to the middle of the paracone; the distal cingulum is weakly developed and there is no labial cingulum.

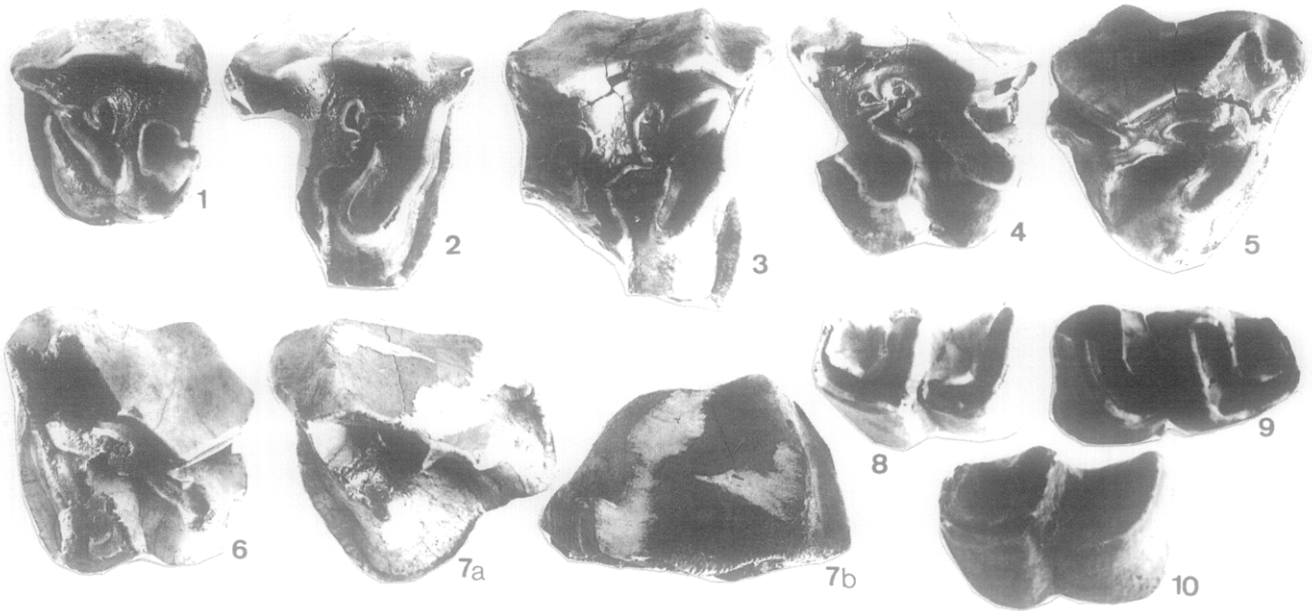


FIGURE 3 - *Ceratotherium neumayri* cheek teeth from Düzyayla. 1. SHD-101, left P², occlusal view [x 0.6]. 2. SHD 102, right P⁴, occlusal view [x 0.6]. 3. SHD 103, right P⁴, occlusal view [x 0.6]. 4. SHD-104, left M¹, occlusal view [x 0.5]. 5. SHD-105, right M², occlusal view [x 0.5]. 6. SHD-106, left M², occlusal view [x 0.5]. 7a. SHD-107, left M³, occlusal view [x 0.5]. 7b. Same specimen, distobuccal view [x 0.5]. 8. SHD-108, left M₂, occlusal view [x 0.5]. 9. SHD-109, right M₂, occlusal view [x 0.5]. 10. SHD-110, left M₂, occlusal view [x 0.5]. *Ceratotherium neumayri*, dents jugales du gisement de Düzyayla.

M³ is triangular in shape (Fig. 3.7a-b). The buccal wall of the ectometaloph is flat with a prominent paracone rib. The metacone has a bulge at the base; it is flat towards the top. There is a strong crochet. The mesiodistal entrance is open. There is a shelf-like mesial cingulum at least 19 mm high, but no labial cingulum.

In M₁₋₂ the protoconid and hypoconid buccal walls are rounded (Fig. 3.8-9). In cross-section the trigonid and talonid basins are U- to V-shaped, respectively. The entrance of the trigonid basin is narrow and V-shaped, it is close to the base of the tooth. There is a very faint mesial cingulum, a weak distal cingulum, but neither labial nor lingual cingula.

M₃ resembles M₁₋₂ (Fig. 3.10), but the distal cingulum is more pronounced. There is a sharply inflected hypolophid.

The *Ceratotherium* teeth from Düzyayla resemble those from the Turolian of Kinik, Mahmutgazi (Heissig 1975), and Pikermi (Geraads 1988) in size and hypsodonty, in the weak inclination of the paracone and metacone ribs, in the presence of a crochet, and in the strongly developed mesial cingulum. They are larger than the teeth from the Vallesian of Esme Akçaköy or Sinap (Tabl. 1). The teeth are rugose and devoid of cement. The high crowns and flat buccal surface of the teeth indicate that *C. neumayri* was a grazer (Heissig 1975, 1996).

Ceratotherium neumayri occurs from the Vallesian of Esme Akçaköy (Heissig 1975), Çobanpınar (Ozansoy 1965), and Sinap (Saraç 1994), to and including the Turolian of Kinik, Mahmutgazi, Kemiklitepe, Kayadibi, and Gülpınar (Heissig 1975, 1996; Geraads 1994; Kaya 1994), and Pikermi, Samos, Pentalophos-1, and Maragheh (Geraads 1988; Geraads & Koufos 1990). Its stratigraphic range includes mammalian zones MN 9 to MN 13 (Heissig 1996). The *Ceratotherium* material from Anatolia indicates a single lineage that increased in body size (Heissig 1975, 1996; Kaya 1994). *Ceratotherium neumayri* from Düzyayla is large (Tabl. 1), corresponding in size to the Turolian forms, supporting a Turolian age of the find.

HIPPARION SPP.

The *Hipparion* sample from Düzyayla consists of isolated teeth and a few fragmentary limb bones. Incomplete and scarce, it is difficult to identify to species. The material appears to belong to two, possibly three, different species, but because of overlap in size the taxa are difficult to sort out. The peripheral teeth (upper and lower P2 and M3), when plotted in scattergrams on their basal width to basal length (measured at the neck of the tooth, not 1 cm above the neck), seem to form two swarms of observations: a swarm of more common, large specimens and another of a few small specimens. However, intermediate specimens are indi-

cated among the teeth as well as among the few limb bones.

The teeth are morphologically uniform, rather low-crowned (crown mesostyle/metaconid height in little worn P^{3-4} <47 mm, M_{1-2} 47 mm, and M_3 43-46 mm), with a low to high plication count and single to four-branched pli caballin (total number of visible plications on the occlusal surface, including plis caballins, range in P^3 - M^2 14-35 plications), and a moderate to long protocone (range in P^3 - M^2 5.7-9.3 mm), in P^2 often with an anterior tip reaching towards the protoconule. The hypocone is but slightly or not at all indented lingually. A hypostylar lake may occur (left M^{1-2} , SHD-52). In the premolars the parastyle may be grooved, the mesostyle barely so; in the molars the styles are simple or the parastyle barely grooved at the top (Fig. 4.1-3). The prefossette may open into the postprotoconal groove and the fossettes may be confluent; this is more common in the premolars, especially P^2 , in early wear. The few lower cheek teeth are typically hipparionid (Fig. 4.4-5), with a variable protostylid and occasional ectostylid (M_{1-2} SHD-35, -36; M_3 SHD-24). The ectoflexid may be deep in the premolars (SHD-30, -31), seldom shallow in the molars (little worn M_3 , SHD-24).

Several small fossil samples from a number of Turkish localities comprising *Hipparion* are kept in the Dept. of Paleoanthropology, University of Ankara, Turkey. Although mentioned in the literature, the faunas of these localities have not been fully analysed. The localities represented are: Kuyutarla, Akkirma, Gökdere, and Küçük Yozgat near Elmadag (see Tschachtli 1942; Senyürek 1952, 1953; Erol

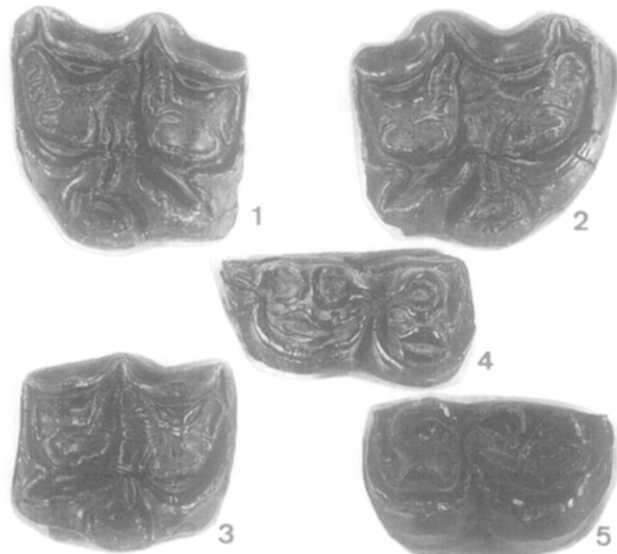


FIGURE 4 - *Hipparion* sp. cheek teeth from Düzyayla [x 1.3]. 1. SHD-49, left upper M1-2, occlusal view. 2. SHD-38, right upper P3-4, occlusal view. 3. SHD-50, right upper M1-2, occlusal view. 4. SHD-32, right lower M1-2, occlusal view. 5. SHD-28, left lower P 3-4, occlusal view. *Dents jugales du gisement de Düzyayla.*

1957); Yassiören and Kayınçak (Sinap, Ankara) (see Ozansoy 1955), Çobanpınar (Ankara, Evcı) (Ozansoy 1961); Kizilasma, Taskinpasa and Pasabagi (Kayseri, Ürgüp) (see Senyürek 1952 footnote, 1953). As in the material from Düzyayla, the *Hipparion* samples from these localities, referred to as *H. gracile*, mainly consist of isolated teeth and a few bones; in some cases the samples are unfortunately evidently mixed. Larger samples, e.g. from Esme Akçaköy, Kayadibi, Kinik, and Garkin, have been described by Staesche & Sondaar (1979), from Kemiklitepe by Koufos & Kostopoulos (1994), and from Gülpınar by Kaya (1982) and Forsten & Kaya (1995). Common to all the samples is the uncertain taxonomic status of the hipparions represented in them, due to the presence of several species difficult to separate objectively. Even the large samples from the classical quarries on Samos, representing skulls and limb bones commonly referred to and used for comparison, have not been definitely identified as to species.

By plotting the teeth and limb bones in scattergrams, we tried to compare the sample from Düzyayla with the materials mentioned above. We here presume the presence of two differently sized taxa in the sample.

On their basal breadth plotted to length the peripheral cheek teeth (upper and lower P2, SHD-1, -3, -2, -4, -6, -7, -8, -9, and SHD-22; upper and lower M3, SHD-13, -14, -16, -17, -18, -19, -20, and SHD-23, -24, -74) group together with the large specimens from Kemiklitepe, Gökdere, Küçük Yozgat, Akkirma, Kizilasma, and Çoban Pınar. A single upper P2 (SHD-5; basal l. 24.4 mm, basal br. < 16.5 mm) is small, even approaching the teeth of the dwarf species *Hipparion matthewi* ABEL in size. The rest of the cheek teeth do not group together into different size categories; they span the whole range for all measured characters (Tabl. 2,3).

The articular breadth of five distal metapodial fragments (SHD-82, -83, -84, -85, -86) varies between 38.1 mm and 42.6 mm, one specimen (SHD-88) measures 33.5 mm. The larger bones are comparable to the large ones from Sinap, Küçük Yozgat, Gökdere, Kuyutarla, Gülpınar, and Kemiklitepe. The small specimen resembles metapodials from Gülpınar, referred to as *H. schlosseri-dietrichi* ANTONIUS-(WEHRLI) (Forsten & Kaya 1995). In the MT III distal fragment (SHD-82) the keel is prominent: at an articular breadth of 39.5 mm, the keel diameter measures 38.8 mm. The fragment may be compressed laterally. A proximal MT III (SHD-81), with a mid-shaft width of approx. 28.7 mm, may belong to either size category; a facet for the inner cuneiform is present.

The astragali (SHD-75, -76) may represent two taxa: SHD-75 is medium-sized, resembling those

tooth and measure	N	range	mean	
P2	basal length	6	28.3-34.1	31.2+.86
	basal breadth	8	20.1-24.6	22.7+.54
P3-4	basal length	13	20.8-26.0	22.6+.40
	basal breadth	13	21.5-25.9	24.2+.42
M1-2	basal length	16	19.0-21.4	20.2+.20
	basal breadth	16	21.1-24.7	22.9+.33
M3	basal length	7	20.7-23.7	21.9+.34
	basal breadth	6	19.8-21.9	20.6+.30

TABLE 2 - Statistics on the upper cheek teeth of *Hipparion* sp. from Düzyayla (in mm.). *Données statistiques sur les dents jugales supérieures d'Hipparion sp. de Düzyayla.*

tooth and measure	N	range	mean	
P2	basal length	1	28.1	
	basal breadth	1	16.2	
P3-4	basal length	6	20.8-25.7	23.0+.67
	basal breadth	6	12.9-16.5	14.6+.48
M1-2	basal length	6	18.5-22.3	20.9+.55
	basal breadth	6	12.8-14.5	13.5+.23
M3	basal length	3	26.3-30.8	28.5+1.1
	basal breadth	3	11.0-11.7	11.3+.17

TABLE 3 - Statistics on the lower cheek teeth of *Hipparion* sp. from Düzyayla (in mm.). *Données statistiques sur les dents jugales inférieures d'Hipparion sp. de Düzyayla.*

from Gülpınar, Küçük Yozgat, Kayınçak, and Gökdere, while SHD-76, although badly damaged, seems distally as broad as the largest bones from Gülpınar, Kemiklitepe, even Çalta. It may be antero-posteriorly distorted, however.

The phalanges (two proximal phalanges, SHD-89, -93; three second phalanges, SHD-90, -91, -95) are medium-sized and comparable to those from Gökdere, Kizilasma, Sinap, and Gülpınar; SHD-93, a proximal fragment, is smaller, but still inside the range of the medium-sized hipparions. The volar ligamental scars of the proximal phalanges are typical of *Hipparion*, with a short V-scar, a rugose central scar, and distal sublimis scars (see Camp & Smith 1942, Figs 29,30).

It appears that from Düzyayla there are a medium-to small *Hipparion* species and a large one; the latter seems the more common of the two. The taxonomic status of the two species from Düzyayla is not clear and we therefore leave them as *Hipparion* sp.

DISCUSSION

De Bruijn et al. (1996, Fig. 20.2; Table 20.1), on the basis of the two murines, place the lignite fauna from Düzyayla in mammal zone MN 12 or Middle Turolian. A Turolian age is supported also by the large *Ceratotherium neumayri*, by the presence of *Helladotherium*, and by sporomorph data from the lignite of Düzyayla (in prep.). Mammal zone MN 12 is spanned by the classical faunas of Samos

(Q1, Q4, and Q5; Mein 1990) with *H. matthewi*, *H. schlosseri-dietrichi*, *H. sp.* with a double preorbital fossa, *H. (aff. brachypus HENSEL)*, and *H. proboscideum* STUDER, all characterized on their skulls, while the taxonomic status of the limb bones in most cases is unknown. *Hipparion* sp. from Düzyayla, represented only by isolated teeth and fragmentary limb bones, cannot be compared with the species above.

Certain indices, calculated on the cheek teeth (hypsodonty and protoconal index) and limb bones (metapodial keel index) of *Hipparion*, are believed to have increased orthogenetically (unidirectionally and progressively) and therefore to indicate the evolutionary level of these horses and to be useful for the relative dating of finds (Sen et al. 1978; Staesche & Sondaar 1979; Koufos & Kostopoulos 1994; but see Forsten 1981, 1982). Notwithstanding the late stratigraphic age of the fauna, the hypsodonty index (P3-M2 10 x crown height:basal length) in the hipparion(s) from Düzyayla does not impress: the observed range in unworn or little worn P³⁻⁴ is 18.7-21, in P₃₋₄ 19.1, and in M₁₋₂ 20.9. These values are comparable to those of Vallesian forms (Forsten 1978). The protoconal index (P³-M² 100 x protoconal length: occlusal length) has an observed range of 21.2-39.7 (P³⁻⁴ mean 25.9, M¹⁻² mean 30.9). Within this range fall most Old World *Hipparion*, the stratigraphically early as well as the late ones.

The keel index (100 x distal keel diameter:distal articular breadth) of three MC III from Düzyayla varies between 76.3-82.1 (mean 79.9). This range is included in the MC range of the hipparions from the Vallesian of Höwenegg (*H. primigenium*, MC range 69.6-83.6) and Santiga (*H. sp.*, 75.6-81.1), from the Turolian of Piera (*H. sp.*, 72.3-84.1) and Arquillo (La Fontana and Valdecebro) (*H. gromovae* VILLALTA & CRUSAFONT, 75.1-84.8), from the latest Miocene of Polgardi (*H. primigenium*, 72.95-82.6), and from the Pliocene of Çalta (*H. cf. crassum* GERVAIS, 72.9-80.6). The keel index range of MC III from Düzyayla is even comprised in the range of *Equus* sp. (72.6-81.1) from the Middle Pleistocene of Lunel Viel.

None of the three indices (the hypsodonty, protocone, and keel index), believed to be phylogenetically and stratigraphically significant, gives any clues whether as to the stage of evolution or the relative age of the hipparions from Düzyayla. The indices, evidently, cannot (and should not) be used for dating faunas with hipparions as they do not show progressive, orthogenetic increase (Forsten 1982).

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REFERENCES

- ATALAY Z. 1993 - Sivas'in batısı ve güneybatısındaki karasal Neojen cökellerinin stratigrafisi ve cökeltme ortamları. Cumhuriyet University, Science Institute, Geology, Sivas. Ph. D. Thesis (unpublished), 234 p. [in Turkish].
- CAMP C.L. & SMITH N. 1942 - Phylogeny and functions of the digital ligaments of the horse. *Memoirs of the University of California*, 13: 69-124.
- DE BRULJN H., VAN DAM J.A., DAXNER-HÖCK G., FAHLBUSCH V. & STORCH 1996 - The genera of the Murinae, endemic insular forms excepted, of Europe and Anatolia during the Late Miocene and Early Pliocene. In BERNOR R.L., FAHLBUSCH V. & MITTMANN H.W. (eds), *The Evolution of Western Eurasian Neogene Mammal Faunas*: 253-260. Columbia University Press, N.Y.
- EROL O. 1957 - The mammalian fossil beds of Küçükoyzgat-Karaçahasan of Elmadagi (SW of Ankara, Turkey). *Ankara Üniversitesi, Dil ve Tarih Coğrafya Fakültesi Dergisi*, 15, 4 p.
- FORSTEN A. 1978 - *Hipparion primigenium* (v. MEYER, 1829), an early three-toed horse. *Annales Zoologici Fennici*, 15: 298-313.
- FORSTEN A. 1981 - Causes and implications of hypsodonty in horses. *International Symposium "Concept and Method in Paleontology"*, Barcelona: 147-152.
- FORSTEN A. 1982 - Indices in equid systematics and phylogeny. *Annales Zoologici Fennici*, 19: 183-191.
- FORSTEN A. & KAYA T. 1995 - The hipparions (Mammalia, Equidae) from Gülpınar (Çanakkale, Turkey). *Paläontologische Zeitschrift*, 69: 491-501.
- FORTELIUS M. 1990 - Rhinocerotidae from Pasalar, Middle Miocene of Anatolia (Turkey). *Journal of Human Evolution*, 19: 489-508.
- GERAADS D. 1988 - Révision des Rhinocerotinae (Mammalia) du Turolien de Pikermi. Comparaison avec des formes voisines. *Annales de Paléontologie*, 74: 13-41.
- GERAADS D. 1994 - Les gisements de mammifères du Miocène supérieur de Kemiklitepe, Turquie: Rhinocerotidae. *Bulletin du Muséum National d'Histoire naturelle*, 16, C, 1: 81-95.
- GERAADS D. & KOUFOS G. 1990 - Upper Miocene Rhinocerotidae from Pentalophos-1, Macedonia, Greece. *Palaeontographica*, A., 210: 151-168.
- HEISSIG K. 1972 - Paläontologische und geologische Untersuchungen im Tertiär von Pakistan 5. Rhinocerotidae (Mamm.) aus den unteren und mittleren Siwalik-Schichten. *Abhandlungen der Bayerischen Akademie von Wissenschaften, math.-nat.Kl.*, N.F. 152, 112 p.
- HEISSIG K. 1975 - Rhinocerotidae aus den Jungtertiär Anatoliens. *Geologisches Jahrbuch*, 15: 145-151.
- HEISSIG K. 1996 - The stratigraphical range of fossil rhinoceroses in the Late Neogene of Europe and the Eastern Mediterranean. In BERNOR R.L., FAHLBUSCH V. & MITTMANN H.-W. (eds), *The Evolution of Western Eurasian Neogene Mammal Faunas*: 339-347. Columbia University Press, N.Y.
- KAYA T. 1982 - Gülpınar (Çanakkale) *Hipparion*'lerinin odontolojik özellikleri. (Odontological variation of the hipparions from Gülpınar, Çanakkale). *Türkiye jeoloji kurumu bülteni*, 25:127-135 [in Turkish].
- KAYA T. 1994 - *Ceratotherium neumayri* (Rhinocerotidae, Mammalia) in the Upper Miocene of Western Anatolia. *Turkish Journal of Earth Sciences*, 3: 13-22.
- KOUFOS G.D. & KOSTOPOULOS D.S. 1994 - The Late Miocene mammal localities of Kemiklitepe, Turkey. 3. Equidae. *Bulletin du Muséum National d'Histoire naturelle*, 16: 41-80.
- MEIN P. 1990 - Updating of MN Zones. In LINDSAY E.H., FAHLBUSCH V. & MEIN P. (eds), *European Mammal Chronology*: 73-90. Plenum Press, N.Y.
- OZANSOY F. 1955 - Sur les gisements continentaux et les mammifères du Néogène et du Villafranchien d'Ankara (Turquie). *Compte Rendus de l'Académie des Sciences de Paris*, 240: 992-994.
- OZANSOY F. 1961 - Résultats essentiels de l'étude de la succession faunique de la région d'Ankara (Turquie). *Bulletin of the Mineral and Exploration Institute of Turkey*, 56: 50-60.
- OZANSOY F. 1965 - Étude des gisements continentaux et des mammifères du Cénozoïque de Turquie. *Mémoires de la Société géologique de France*, N.S. 44, 92 p.
- POISSON A., GUEZOU J.C., ÖZTÜRK A., INAN S., TEMİTZ H., GÜRŞOY H., KAVAK S.K. & ÖZDEN S. 1995 - The Central Anatolian basins in Turkey. General evolution. The Sivas Basin as an example. *Geology of the Aegean Congress*: 113-134.
- SARAÇ G. 1994 - The biostratigraphy and palaeontology of the Rhinocerotidae (Mammalia, Perissodactyla) of the continental Neogene sediments in the Ankara region. Ankara University, Ph.D. Thesis, 217 p. (unpublished).
- SEN S., SONDAAR P.Y. & STAESCHE U. 1978 - The biostratigraphic application of the genus *Hipparion* with special references to the Turkish representatives. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, Amsterdam*, B, 81: 370-385.
- SENYÜREK M.S. 1952 - A study of the Pontian fauna of Gökdere (Elmadagi), south-east of Ankara. *Türk Tarih Kurumu Belleten*, 16(64): 449-492.
- SENYÜREK M.S. 1953 - List of localities of mammalian fossils of Pontian age in the Vilayet of Kayseri. *Ankara Üniversitesi, Dil ve Tarih Coğrafya Fakültesi Dergisi*, 11(2): 171-176.
- STAESCHE U. & SONDAAR P.Y. 1979 - *Hipparion* aus dem Vallesium und Turolium (Jungtertiär) der Türkei. *Geologisches Jahrbuch*, B 33: 35-79.
- SÜMERGEN M., ÜNAY E., SARAÇ G., DE BRULJN H., TERLEMEZ I. & GURBÜZ M. 1990 - New Neogene rodent assemblages from Anatolia (Turkey). In LINDSAY E.H., FAHLBUSCH V. & MEIN P. (eds), *European Mammal Chronology*: 61-72. Plenum Press.
- TSCHACHTLI B.S. 1942 - Küçük Yozgat civarında bulunan memeli hayvanat fasilleri. *M.T.A. Enstitüsü Mecmua*, 7 (2/27): 322-324 [in Turkish].
- YALÇINLAR I. 1955 - Sivas bölgesinin 1/100 000 Sivas 61/1, 62/2, 61/4 paftalarına ait jeolojik rapor. Maden Tetkik ve Arama report (unpublished). Ankara [in Turkish].
- YILMAZ A. 1983 - Tokat (Dumanlıdag) ile Sivas (Çeltekdagi) dolaylarının temel jeolojik özellikleri ve ofiyolitli karışığın konumu. *Maden Tetkik ve Arama Enstitüsü Bülteni*, 99, 18 p. [in Turkish].

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