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Ceratotherium Neumayri (Rhinocerotidae, Mammalia) in the Upper Miocene of Western Anatolia

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Abstract: Rhinocerotidae remains from western Anatolia mostly belong to Ceratotherium neumayri (Osborn) on the basis of osteological and biometrical evidence. The material comes from the known localities of Eşme-Akçaköy (Uşak), Gülpınar (Çanakkale), Kınık (Afyon), Salihpaşalar (Muğla) and Kemiklitepe (Uşak), and from a previously unrecorded locality of Çiçekliköy (İzmir). An early Turolian age (MN 11) for the material from Çiçekliköy and middle Turolian age (MN 12) for the material from Kemiklitepe can be suggested. Fossils indicate that, in western Anatolia, a savanna environment with patches of steppe was existed during the early Late Miocene (Vallesian), and this changed into steppe with mosaics of savanna during the middle-late Late Miocene (Turolian).

Introduction

Several workers have studied the Late Miocene faunal assemblages in western Anatolia (e.g. Ozansoy, 1957; Tekkaya, 1973; Becker-Platen et al., 1975; Heissig, 1975a; Saraç, 1978; Atalay, 1980). In these assemblages Rhinocerotidae are represented by *Ceratotherium neumayri* (Osborn) of Geraards (1988), formerly known as *Rhinoceros pachygnathus (D. neumayri)*, and *Chilotherium* species (Heissig, 1975a). New specimens of *C. neumayri* have been collected from the previously known Miocene localities (Eşme-Akçaköy, Gülpınar, Kınık, Salihpaşalar, Kemiklitepe) and from a newly discovered locality, Çiçekliköy (İzmir) (Figure 1), and investigated osteologically in a comparative way. This study also depends on comparisons with the bones of *C. neumayri (D. neumayri* of Heissig, 1975a, b) which were collected from Turkey by Heissig (1975a, b) and housed in the Bayerische Staatsammlung für Paläontologie und historische Geologie in Munich.

The osteological and biometrical terms used in the text are according to Heissig (1972, 1976). Measurements are given in mm. The materials are deposited in the Natural History Museum (İzmir).

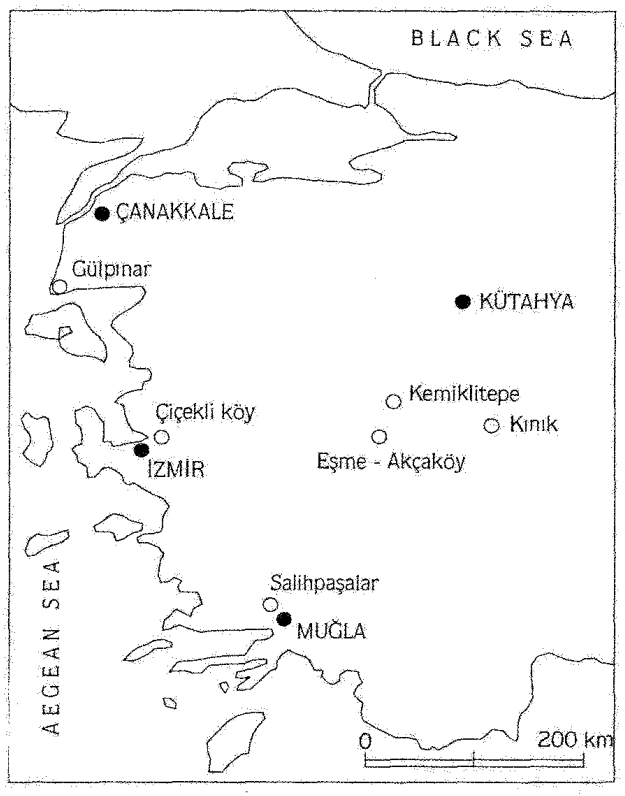

Figure 1. Localities of studied *C. neumayri* in western Anatolia. Çiçekliköy is the first record.

Abbreviations used in this work are: Afyon-Sandıklı-Garkın (ASG), Afyon-Sandıklı-Kınık (ASK), Çanakkale-Ayvacık-Gülpınar (ÇAG), Denizli-Çal-Mahmutgazi (DÇM), İzmir-Bornova-Çiçekliköy (İBÇ), Muğla-Yatağan -Salihpaşalar (MYS), Uşak-Eşme-Akçaköy (UEA), Uşak-Eşme-Kemiklitepe (UEK), Konya-Hatunsaray-Kayadibi (KHK), Fort Ternan-Kenya (FT), Halmyropotamos-Greece (H), Pikermi-Greece (P), Qued el Hamman-Algerie (Q).

1. Systematic Paleontology

Family : Rhinocerotidae Gray, 1821
Subfamily : Rhinocerotinae Gray, 1821
Tribe : Dicerotini Groves, 1983
Genus : *Ceratotherium* Gray, 1867
Type species : *Ceratotherium simum* (Burchell, 1817)
Ceratotherium neumayri (Osborn, 1900)
Plate I, II All figures

1862 *Rhinoceros pachygnathus* Wagner, Gaudry, p. 177, pl. XXVIII fig. 5, 7

1900 *Atelodus neumayri* n. sp., Osborn, p. 263 fig 16

1975a *Diceros neumayri* (Osborn), Heissig, p. 145

1975b *Diceros neumayri* (Osborn), Heissig, p. 140, p. 289 fig. 53, p. 296 fig. 56, 57, p., 381 fig. 126-131, p., 400 fig. 139, 140, p. 416 fig. 153, p. 426 fig. 157.

1980 *Diceros pachygnathus* (Wagner), Guérin, p. 202, p. 265, tab.54,55, p.327, tab.71

1988 *Ceratotherium neumayri* (Osborn), Geraards, p. 36, p. 23 fig. 5

Material: Carpus, right radial ÇAG-1, right radial MYS-1, left radial UEK-1; right intermedium ÇAG-2, right intermedium İBÇ-1, left intermedium MYS-2;tarsus, right astragalus UEK-2; left calcaneus UEK-3, left calcaneus MYS-3; right central ÇAG-3, left central MYS-4, left central ASK-1; left tarsal-3 UEA-1; left tarsal-4 ÇAG-4.

Radial: (Gülpınar ÇAG-1, Salihpaşalar MYS-1, Kemiklitepe UEK-1)

The radial is large and deep. The proximal intermedium facet is deep and band-shaped. The volar intermedium facet is present. The carpal-2 facet is quite convex in dorso-volar direction. These characteristics are of Rhinocerotini (Heissig, 1972, 1976). The radius facet is triangular-shaped and broad as well as deep in the Salihpaşalar and Kemiktepe bones . The radius facet of the Gülpınar form is narrow. It is concave in medio-lateral direction, and tapers to the volar side. The lateral convexity of the radius facet is prominent.

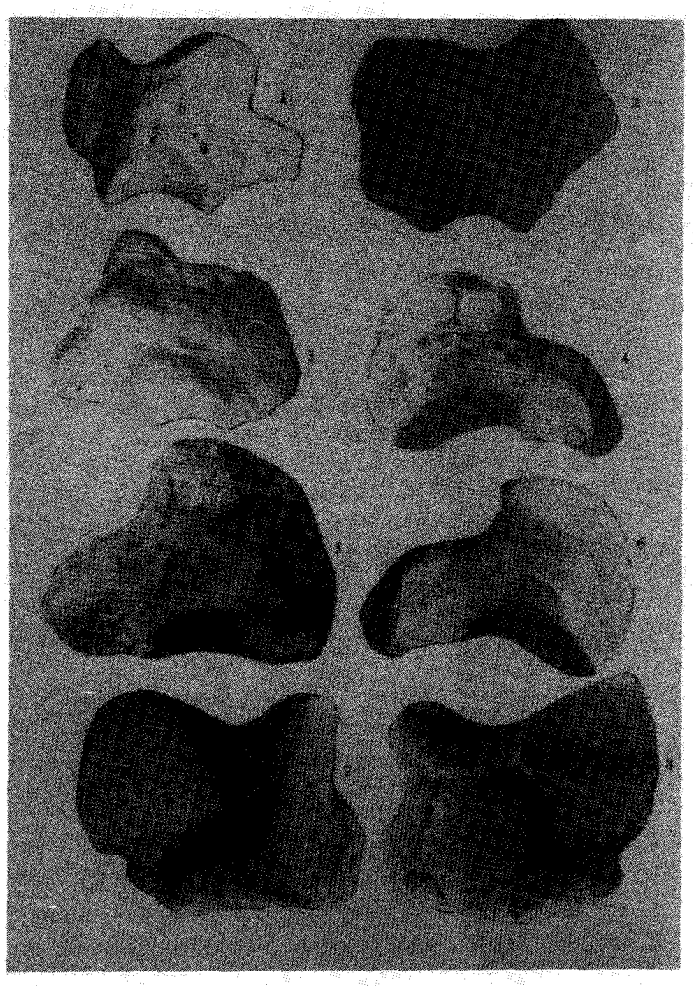

Plate I. *Ceratotherium neumayri* (Osborn, 1900) Figure 1. Left radial (UEK-1) (dorsal view) (x 0.3). Figure 2. Right radial (MYS-1) (dorsal view) (x. 0.3) Figure 3. Right radial (ÇAG-1) (dorsal view) (x 0.4) Figure 4. Left intermedium (MYS-2) (lateral view) (x 0.4). Figure 5.Right intermedium (İBÇ-1) (lateral view) (x 0.5) Figure 6. Right intermedium (ÇAG-2) (lateral view) (x 0.4) Figure 7. Right astragalus (UEK-2) (dorsal view) (x 0.3) Figure 8. Right astragalus (UEK-2) (plantar view) (x 0.3)

On the volar side the radial exhibits three facets for the intermedium. The volar intermedium facet is oval-shaped and unites with the proximal intermedium facet. The distal intermedium facet is high. The proximal and distal intermedium facets are spaced closely.

On the distal side there are three facets for the carpal-1,2,3. The carpal-1 facet is drop-shaped and concave in medio-lateral direction. The carpal-2 facet is trapezoid-shaped and deeply concave in medio-lateral

direction in the Kemiklitepe and Salihpaşalar bones. This facet is narrow in the Gülpınar form. The carpal-2 facet encroaches upon the volar and dorsal surfaces. This facet is separated by acute and parallel ridges from the carpal-3 and carpal-1 facets in the Salihpaşalar and Kemiklitepe bones. The ridges of the Gülpınar form are obtuse and become closer to each other toward the volar side. The carpal-3 facet is wide and concave in medio-lateral direction.

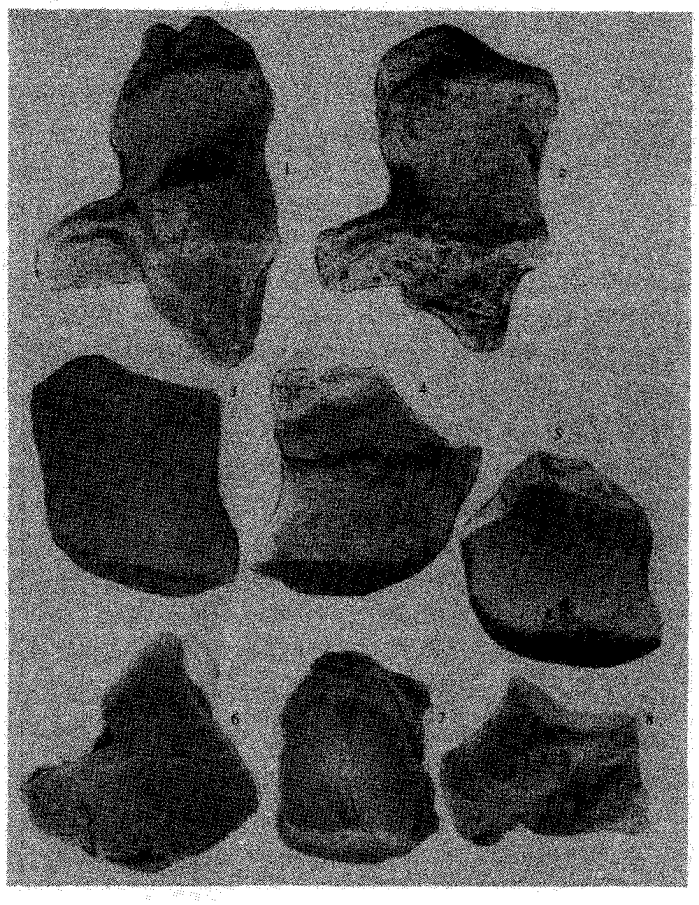

Plate II. *Ceratotherium neumayri* (Osborn, 1990). Figure 1. Left calcaneus (UEK-3) (dorsal view (x 0.25). Figure 2. Left calcaneus (MYS-3) (dorsal view) (x 0.25). Figure 3. Left central (MYS-4) (proximal view) (x 0.4). Figure 4. Right central (ÇAĞ-3) (proximal view) (x 0.5). Figure 5. Left central (ASK-1) (proximal view) (x 0.4). Figure 6. Left tarsal-3 (UEA-1) (proximal view) (x 0.5). Figure 7. Left tarsal-4 (ÇAG-4) (proximal view) (x 0.4). Figure 8. Left tarsal-4 (ÇAG-4) (medial view) (x 0.4).

The medial tuber of the Kemiklitepe and Salihpaşalar has two bulges and located toward the proximal side. This tuber has only one bulge in the Gülpınar specimen

In the Gülpınar *C. neumayri* the dorsal tuber is very prominent and close to the lateral border. It is situated in the middle part of the dorsal surface in the Kemiklitepe and Salihpaşalar specimens.

The lateral projection of the Kemiklitepe bone forms and elbow at right-angles to the lateral surface. It is obtuse and turn backwards in the Gülpınar specimen. The distal profile of the bone presents two arches.

The radials of *C. neumayri* from Kemiklitepe and Salihpaşalar closely agree with the radial of *D. pachygnathus* from Pikermi (Gaudry, 1862; Guérin, 1980) in shape as well as size. *C. neumayri* is larger than *Dicerorhinus primaevus* Arambourg (Arambourg, 1959) from Qued el Hamman (Table 1).

C. neumayri differs from Aceratherini and Elasmotherini. In Aceratherini, a deep groove is present on the dorsal surface above the carpal-2 facet, and the volar intermedium facet is absent as in Elasmotherini (Yan and Heissig, 1986; Heissig, 1976). In Elasmotherini the distal intermedium facet is small (Heissig, 1976).

The Kemiklitepe and Salihpaşalar specimens resemble Rhinocerotini type 1 from Nagri and Chinji (Siwalik-Pakistan) which has a large carpal-2 facet and parallel ridges of the distal facets. On the other hand these ridges become closer to each other toward the volar side in the Gülpınar form as in *D. neumayri* from Eşme -Akçaköy (Heissig, 1975b) and in Rhinocerotini type 2 from Chinji (Heissig, 1972). *C. neumayri* is more like the recent *Dicerorhinus sumatrensis* (Fischer) in which lateral height is equal to medial height (Hooijer, 1971).

Intermedium: (Gülpınar ÇAG-2, Salihpaşalar MYS-2, Çiçekliköy İBÇ-1)

The intermedium articulates with the ulna volarly. The carpal-4 facet is deep and concave. These characteristics belong to Rhinocerotini (Heissig, 1972). The radius facet has the shape of a half cylinder, and tapers to the medial side in the Salihpaşalar bone. This facet encroaches upon the dorsal surface. The radius facet from Salihpaşalar has a volar appendix, which is absent in the Gülpınar and Çiçekliköy bones.

On the medial side there are three facets for the radial. The proximal radial facet is drop-shaped and slightly convex in dorso-volar direction in the Salihpaşalar form. This facet is far from the volar radial facet in the Gülpınar bone. The volar radial facet is oval -shaped and flat, and meets distally the carpal-3 facet in the Salihpaşalar specimen. It is isolated in the Gülpınar and Çiçekliköy bones. The distal radial facet is semioval-shaped and high.

	UEK-1	MYS-1	CAG-1	UEA	P	Q
a) Maximum width	86	-	82	(71)[1]	85.5[2]	61[3]
b) Lateral height	62	-	59	49	62.25	-
c) Medial height	61	60	-	-	-	55
d) Middle height	46	47	43	39	-	-
e) Maximum diameter	65	55	-	(48)	56.25	-
f) Width/diameter of the radius facet	54/58	52/52	-	47/47	52.75/49.75	-
g) Width/diameter of the carpal-I facet	10/21	14/27	11/-	-	-	-
h) Width/diameter of the the carpal-2 facet	38/33	32/36	25/-	32/31	-	
ı) Width/diameter of the carpal-3 facet	33/32	-/31	28/-	31/34	-	
b/a	0.72	-	0.71	0.69	0.72	

Table 1. Biometric values of radial of Rhinocerotinae UEK, MYS, ÇAG, *C. neumayri* (this study).

1) *D. neumayri* (Heissig, 1975b); 2) *D. pachygnathus* (Guèrin, 1980); 3) *D. primaevus* (Arambourg, 1959)

On the lateral side there are two facets for the ulnar, which are spaced closely. The proximal ulnar facet is small. The distal ulnar facet is deep, lobe-shaped and transversely concave in the Salihpaşalar and Gülpınar bones. This facet is high in the Çiçekliköy specimen. The distal ulnar facet is equal in dorso-volar diameter to that of the carpal-4 facet.

The distal surface of the bone is divided into the facets for the carpal-3 and carpal-4. In the Salihpaşalar intermedium the division is nearly transverse. It is diagonal in the Gülpınar and Çiçekliköy bones.

The volar process is flat and square-shaped.

The dorsal surface is triangular-shaped in the Gülpınar and Çiçekliköy bones and quadrate-shaped in the Salihpaşalar form.

The intermedium of *C. neumayri* from Salihpaşalar resembles that of *D. neumayri* from Mahmutgazi (Heissig, 1975b) and *D. pachygnathus* (Gaudry, 1982; Guérin, 1980) in shape as well as size (Table 2). *C. neumayri* from Gülpınar and Çiçekliköy coincides with that of Garkın described by (Heissig, 1975b).

The materials studied differ from Aceratherini and Teleoceratini. In Aceratherini the dorsal surface is narrow, the carpal-4 facet is shallow, the ulnar facets are far from each other, and the articulation of the ulna with the intermedium is absent (Yan and Heissig, 1986; Heissig, 1989). In Teleoceratini the distal ulnar facet is small (Heissig, 1972).

Astragalus: (Kemiklitepe UEK-2)

The astragalus is much broader than high. The calcaneus facet-2 is large. The lateral part of the trochlea extends farther proximally and distally than the medial part of the trochlea. The above characteristics belong to Rhinocerotini (Heissig, 1972). The fibula facet becomes narrower towards the proximal side. The axis of the trochlea is nearly straight.

	MYS-2	ÇAG-2	İBÇ-1	ASG	DÇM	P
a) Maximum diameter	74	72	-	72[1]	80[1]	75[2]
b) Dorsal width	59	56	43	(57)	-	53.5
c) Dorsal height	52	59	57	57	58	50
d) Width/diameter of the radius facet	49/49	-/38	-/39	-/40	-/42	-
e) Width/diameter of the carpal-4 facet	31/48	33/42	30/40	30/39	37/47	-
b/a	0.79	0.77	-	0.79	-	0.71

Table 2. Biometric values of intermedium of Dicerotini: MYS, ÇAG, İBÇ, *C. neumayri* (this study).

1) *D. neumayri* (Heissig, 1975b); 2) D. pachygnathus (Guèrin, 1980)

The calcaneus facet-1 is quadrate-shaped and deeply concave proximally, and extends half the height of the astragalus. Distally it forms a protruding right-angle bend corresponding to the astragalus facet-1 on the calcaneus. The calcaneus facet-2 is oval-shaped and situated vertically. The calcaneus facet-3 is more elongated.

The tarsal-4 facet is shoe-shaped and transversely deep. It is oblique in position, dorsally convex, and plantarly extremely concave. The central facet is trapezoid-shaped and convex in dorso-plantar direction, and concave in medio-lateral direction.

The Kemiklitepe astragalus is similar to *D. neumayri* from Kınık and Mahmutgazi (Heissig, 1975b) in shape as well as size, and larger than *Paradiceros mukirii* Hooijer from Fort Ternan (Hooijer, 1968), *Dicerorhinus orientalis* (Schlosser) from Halmyropotamos (Melentis, 1970) and *D. primaevus* (Arambourg, 1959) (Table 3).

The Kemiklitepe *C. neumayri* differs from Elasmotherini, Teleoceratini and Aceratherini. In Elasmotherini the tarsal-4 facet is convex in all direction, and the calcaneus facet-2 is small and generally joins the calcaneus facet-3 (Heissig, 1976). In Teleoceratini the astragalus is flat and large (Heissig, 1972). In Aceratherini the astragalus is low and the axis of the tronchlea is oblique (Yan and Heissig, 1986).

Calcaneus:(Salihpaşalar MYS-3, Kemiklitepe UEK-3)

The calcaneus is massive. The processus calcaneus is short. A small fibula and a large tibia facets join the astragalus facet-1. These characteristics are of Rhinocerotini (Heissig, 1972). The tuber calcanei forms dorsally a wide hump which tapers medially. Behind this hump are situated lateral, medial and proximal rugosities. The medial rugosities are stronger than the lateral ones.

Proximally the astragalus facet-1 forms a protruding right-angle bend corresponding to the deeply concave calcaneus facet-1 on the astragalus. This facet is concave distally, and has a distal appendix in the Salihpaşalar bone. The astragalus facet-2, which is oval-shaped and concave, occupies almost the entire sustentaculum tali. It is separated from the calcaneus facet-1 by a narrow and deep groove. The astragalus facet-3 is drop-shaped and long. The sustentaculum tali forms an elbow at right-angles with the medial side of the bone.

The tarsal-4 facet is trapezium-shaped, curved medially and concave in dorso-plantar direction.

The calcaneus of *C. neumayri* closely agrees with those of *D. neumayri* from Mahmutgazi and Garkın (Heissig, 1975b) in shape as well as size. *C. neumayri* is larger than *P. mukirii* (Hooijer, 1968) and *D. primaevus* (Arambourg, 1959) (Table 4).

The relevant bones differ from Aceratherinae and Elasmotherini. In Aceratherinae the tibia facet is generally absent and the fibula facet is large (Heissig, 1972). In Elasmotherini the plantar rugosities below the tuber calcanei are strongly developed (Heissig, 1976).

Table 3. Biometric values of astragalus of Rhinocerotinae. UEK, *C. neumayri* (this study).

	UEK-2	ASK-2	DÇM-1	FT	H	Q
a) Maximum width	108	103[1]	103[1]	70-81[2]	-	90[4]
b) Width of the trochlea	96	98	97	63-75	67[3]	-
c) Middle diameter	53	53	54	-	-	-
d) Distal width	83	87	90	57-69	85	-
e) Height/width of the calcaneus facet-1	49/55	57/53	52/60	-	45/44	-
f) Height/width of the calcaneus facet-2	42/32	44/34	39/26	-	47/39	-
g) Lateral height	96	96	92	59-69	78	-
h) Medial height	83	83	82	60-74	76	79
i) Middle height	71	78	73	-	-	-
i) Width of the fibula facet above/below	09/17	08/22	06/22	-	-	-
h/a	0.76	0.80	0.79	0.85/0.91	-	0.87

1) D. neumayri (Heissig, 1975b); 2) P. mukirii (Hooijer, 1968); 3) *D. orientalis* (Melentis, 1970); 4) *D. primaevus* (Arambourg, 1959).

	MYS-3	UEK-3	DÇM	ASG	FT	Q
a) Maximum height	153	-	147[1]	151[1]	105-115[2]	132[3]
b) Widthof the sustentaculum	98	92	96	116	55-60	76
c) Articular height	85	86	75	86	-	-
d) Width/diameter of the tuber calcanei	67/80	-	52/79	64/80	39-41/51-61	-
e) Width/diameter of the corpus	55/71	54/68	41/63	50/68	-	-
f) Width/length of the tarsal-4 facet	-/54	46/47	36/53	36/53	25-27/39-64	-
b/a	0.64	-	0.65	0.76	0.52-0.52	0.57

Table 4. Biometric Values of calcaneus of Rhinocerotinae. MYS, UEK, *C. neumayri* (this study).

1) *D. neumayri* (Heissig, 1975b); 2) *P. mukirii* (Hooijer, 1968) 3) *D. primaevus* (Arambourg, 1959).

Central: (Gülpınar ÇAG-3, Salihpaşalar MYS-4, Kınık ASK-1)

The bone is quadrate-shaped and transversely deeper than wide. The astragalus facet is saddle-shaped and slightly concave transversely.

The tarsal-1 facet is semioval-shaped and bent plantarly. The tarsal-2 facet is circular, and has a poorly developed concavity on the medial side in the Salihpaşalar material. It is quadrate-shaped in the Kınık specimen. The tarsal-3 facet is triangular-shaped, and forms a weak wavy structure.

There is a single, undivided facet for the tarsal-4 on the lateral side. The tarsal-4 facet unites proximally with the astragalus facet and distally with the tarsal-3 facet. This facet is dorsally narrow and plantarly wide in the Gülpınar bone. The plantar part of the tarsal-4 facet is constricted in the middle part of the Kınık and Salihpaşalar bones. In these bones the dorsal part of the tarsal-4 facet joins the tarsal-3 facet. The lateral incision is shallow in the Salihpaşalar and Kınık specimens. It divides the tarsal-3 facet into two unequal parts. The plantar part is narrow and shows tapering in the plantar direction. The dorsal part is rounded and wide. The lateral incision is not distinct in the Gülpınar form.

The lateral projection is short and obtuse in the Salihpaşalar and Kınık specimens. That from Gülpınar is long and sharp.

The dorsal surface of the bone is smooth. The medio-dorsal tuber is band-shaped, and continues along the medial surface. The medio-plantar tuber is well developed in the Salihpaşalar specimen.

The central of *C. neumayri* from Gülpınar appears to correspond with that of *D. neumayri* from Kayadibi (Heissig, 1975b) in shape as well as size. The Salihpaşalar and Kınık specimens are similar to *D. neumayri* from Mahmutgazi (Heissig, 1975b). The relevant bones are larger than *D. pachygnathus* and *D. orientalis* (Guérin, 1980; Melentis, 1970) (Table 5).

	MYS-4	ASK-1	ÇAG-3	KHK	DÇM	P	H
a) Makixum width	67	55	61	60[1]	66[1]	49.5[2]	52[3]
b) Posterior width	55	-	-	52	52		-
c) Maximum diameter	72	61	59	62	66	65	65
d) Dorsal height	29	27	25	32	27	-	25
e) Plantar height	35	-	27	41	33	30	32
f) Middle height	24	22	24	26	23	-	24
g) Width/diameter of the tarsal-3 facet	51/56	49/54	41/-	52/52	45/53	-	-
h Width/diameter of the proximal surface	62/51	50/43	55/46	61/48	64/47	-	-
d/c	0.40	0.44	0.42	0.51	0.40	-	0.38

Table 5. Biometric values of central of Rhinocerotinae. MYS, ASK, ÇAĞ, *C. neumayr* (this study).

1) *D.neumayri* (Heissig, 1975b); 2) *D. pachygnathus* (Guerin, 1980); 3) *D. orientalis* (Melentis, 1970).

C. neumayri differs from *Chilotherium intermedium* (Lydekker) from Dhok Pathan (Siwalik) and *Dicerorhinus scheiermacheri* (Kaup) from Montredon (Guèrin, 1980). In *C. intermedium* the lateral incision is deep (Heissig, 1972). In *D. scheiermacheri* the lateral border of the proximal surface is flat. *C. neumayri* differs from Sansan *Hoploaceratherium tetradactylum* (Lartet) which is characterized by the presence of a central of semilunar-shaped (Ginsburg and Heissig, 1989).

Tarsal-3 (Eşme-Akçaköy UEA-1)

The bone has slightly convex proximal and distal facets. There is no metatarsal-IV facet. These characteristics compare with Rhinocerotini (Heissig, 1972). The tarsal-3 is triangular-shaped, high and as broad as deep. The central facet is triangular-shaped. The lateral incision is shallow and situated in the middle of the lateral border of the central facet.

On the medial side there are two distal facets for the metatarsal-II and one proximal facet for the tarsal-2. The metatarsal-II facets are spaced closely. The dorsal one is concave and the plantar one is convex. These facets are equal, oval-shaped and separated from the metatarsal-III facet by an acute ridge. The tarsal-2 facet is more elongated, and widens towards the plantar side. It is anteriorly convex and posteriorly concave.

On the lateral side there are two facets for the tarsal-4. The plantar one is oval-shaped, large and convex. The dorsal one is small and convex. There is a protuberance between the proximal and distal lateral incisions.

The metatarsal-III facet forms a weakly developed, wavy and convex swell. The lateral incision is shallow and divides the lateral border of metatarsal-III facet into two unequal parts.

The dorsal surface is high and roughened. It bears a lot of foraminas in the middle part.

The Eşme-Akçaköy bone closely resembles *D. neumayri* from Kayadibi (Heissig, 1975b), but it is less small. *C. neumayri* is larger than *D. orientalis* and *D. primaevus* (Melentis, 1970; Arambourg, 1959). (Table 6). The tarsal-3 of *C. neumayri* is similar to Rhinocerotini type I from Chinji which has equal and rounded metatarsal-II facets (Heissig, 1972). *C. neumayri* also resembles *Dicerorhinus leakeyi* Hooijer from Rusinga (Kenya), however, in *D. leakeyi* the width (55) is nearly twice the dorsal height (27) (Hooijer, 1966). If compared with *Chilotherium* from Shansi (China), in the latter the width (44) is nearly three times the height (15) (Ringström, 1924).

Tarsal-4: (Gülpınar ÇAG-4)

The bone is high. The plantar tuber is strongly developed, and turn laterally. The matatarsal-IV facet is slightly deep. The plantar central facet is not isolated. These characteristics belong to Rhinocerotini (Heissig, 1972). The proximal surface consists of two facets for the astragalus and calcaneus. The astragalus facet is kidney-shaped and concave in all directions. Its plantar border rises gradually. The calcaneus facet is kidney-shaped, concave transversely and convex laterally. These facets are equal in width and depth. A shallow groove separates these facets. The groove extends obliquely than transversely, and is located in the middle part of the proximal surface.

On the medial side the dorsal central facet is narrow, band-shaped and convex. The plantar central is tongue-shaped and concave. The dorsal tarsal-3 facet is large, semioval-shaped and separated from the metatarsal-IV facet by an acute ridge. The plantar tarsal-3 facet is small. The metatarsal-III facet is absent.

The metatarsal-IV facet is triangular-shaped and separated from the plantar tuber by a deep groove.

The Gülpınar bone fits on *D. neumayri* from Garkın (Heissig, 1975b). It is smaller than the Mahmutgazi specimen (Heissig, 1975b) and larger than *P. mukirii* and *D. primaevus* (Table 7).

Table 6. Biometric values of tarsal-3 of Rhinocerotinae. UEA, *C. neumayri* (this study).

	UEA-1	KHK	ASG	H	Q
a) Maximum width	53	521	611	532	533
b) Maximum diameter	50	51	(55)	53	60
c) Dorsal height	27	29	30	25	21.5
d) Plantar height	30	31	-	-	-
e) Middle height	25	26	28	-	-
f) Width/diameter of the central facet	51/50	48/49	55/-	42/48	-
g) Width/diameter of the metatarsal-III facet	53/47	52/41	61/44	51/47	-
c/a	0.54	0.55	0.49	0.47	0.40

1) *D. neumayri* (Heissig, 1975b); 2) *D. orientalis* (Melentis, 1970); 3) *D. primaevus* (Arambourg, 1959).

Table 7. Biometric values of tarsal-4 of Rhinocerotinae. ÇAG, *C. neumayri* (this study).

	ÇAG-4	ASG	DÇM	FT	Q
a) Maximum diameter	67	73[1]	77[1]	64[2]	-
b) Dorsal width	54	44	44	41	39[3]
c) Plantar width	49	55	58	-	-
d) Dorsal height	44	43	47	43	48
e) Plantar height	61	69	68	-	-
f) Width/diameter of the proximal surface	47/44	47/-	51/-	-	-
g) Width/diameter of the astragalus facet	23/43	24/47	24/52	-	-
h) Width/diameter of the calcaneus facet	24/44	35/49	30/50	-	-
ı) Width/diameterof the metatarsal-IV facet	45/41	43/37	43/41	-	-
d/b	0.81	0.97	1.06	1.04	1.23

1) *D. neumayri* (Heissig, 1975b); 2) *P.mukirii* (Hooijer, 1968); 3) *D. primaevus* (Arambourg, 1959).

The tarsal-4 of *C. neumayri* differs from Elasmotherini. In Elasmotherini, except for *Caemontodon oettingenae* Heissig from Chinji, the calcaneus facet does not extend to the lateral surface (Heissig, 1976). *C. neumayri* differs from *Brachypotherium perimense* (Falconer and Cautley) from Dhok Pathan (Siwalik) and *Aprotodon fatehjangense* (Pilgrim) from Chinji. In *B. perimense* the plantar central facet is isolated, the metatarsal-IV facet is deep, and the dorsal surface is flat. In *A. fatehjangense* the astragalus facet is larger than the calcaneus facet, and the central facet joins the dorsal tarsal-3 facet (Heissig, 1972).

Occurrences: *C. neumayri* which is known in the Late Miocene faunas, is widely spread in western Anatolia (e.g. Kınık, Gülpınar, Salihpaşalar), Samos, Pikermi, Saloniki, Pentalophos-1 (Greece) and Maragha (İran) (Heissig, 1975a; Arambourg and Piveteau, 1929; Bernor, 1978; Geraads 1988; Geraards and Koufos, 1990; Kaya, 1991). However, its early occurrence in Turkey is in early Vallesian Eşme-Akçaköy (MN 9). The Çiçekliköy fauna is in early Turolian age (MN 11), on the basis of faunal evidence other than *C. neumayri*. A middle Turolian age (MN 12) for the Kemiklitepe fauna can be suggested on the grounds of the characteristics of *C. neumayri*, and other elements.

The correlation chart of the Late Miocene fauna with *C. neumayri* is shown in Figure 2. The time scale is to Steininger et al. (1989).

Paleoecology

During the Late Miocene time most of the Middle Miocene genus and species were extinct and replaced primarily by *Ceratotherium, Chilotherium, Hipparion* and *Ancylotherium*.

Figure 2. Correlation chart for the Late Miocene mammalian faunas with *C. neumayri*.

Geologic time (m.y.)	Tethys Stages	Faunal Units (Fahlbusch, 1976)	Mammal Faunal Zones (Mein, 1975)	Fauna Groups (Becker-Platen et al. 1975)	This report
- 5					
	Messinian		13	Amasya	
		Turolian	12	Kınık	Kınık Salihpaşalar Kemiklitepe
				Garkın	-
			11		Gülpınar
				Kayadibi	Çiçekliköy
	Tortonian				
		Vallesian	10		
- 10			9	Eşme-Akçaköy	Eşme-Akçaköy

In the Vallesian fauna of Eşme-Akçaköy, *Anchitherium* sp. *Chalicotherium* cf. *goldfussi* Kaup, *Hipparion ankyranum* Ozansoy, *Chilotherium (Subchilotherium) intermedium* (Lydekker) and *Ch. (Acerorhinus) zernovi* (Borissiak) (Ozansoy, 1957; Heissig, 1975a; Staesche and Sondaar, 1979), which accompany *C. neumayri*, indicate savanna (open woodland)-steppe conditions.

In the Turolian faunas *C. neumayri* occurs together with other Perissodactyla elements, such as *H. matthewi* Abel, *H. mediterraneum* Hensel, *Ancylotherium pentelicum* Gaudry and Lartet, *Ch. (Ch.) habereri* (Schlosser) and *Ch. (Ch.) schlosseri* (Weber) (Heissig, 1975a; Atalay, 1980; Kaya, 1986, 1991), which as a whole point to steppe environment with patches of savanna.

It seems that during the Turolian there was no significant barrier that would result in an isolation of *C. neumayri*. This compares with the uniform distribution of *Hipparion* species, such as *H. matthewi*, *H. mediterraneum*, and *A. pentelicum*.

The habitat of *C. neumayri* is open country and shrub (Heissig, 1975a). Teeth of this form are highly crowned, and the buccal surface of the teeth is smooth. These characteristics indicate that *C. neumayri* fed with hard grass, i.e. it is a grazing form.

C. neumayri, as a predominating element in all the above faunas, suggests that a savanna environment with patches of steppe existed during the early Late Miocene (Vallesian). During the middle-late Late Miocene (Turolian), this changed into a steppe with mosaics of savanna.

The implied Turolian environmental conditions are compatible with a dry and cool climate of this age suggested by Akyol and Akgün (1990), on the basis of palinological and floral evidence.

Results

C. neumayri from the lower Vallesian of Eşme-Akçaköy (MN 9) is characterized by small sized and primitive forms.

In the early Turolian Gülpınar and Çiçekliköy (MN 11) faunas *C. neumayri* is represented by small-to medium-sized forms. It coincides with the forms of Garkın (Afyon) and Kayadibi (Konya) faunas described by Heissig (1975b).

C. neumayri in the middle Turolian Kınık, Salihpaşalar and Kemiklitepe (MN 12) faunas is a large-sized form. The highest evolution level of this species is middle Turolian. It corresponds to the elements of the Mahmutgazi (Denizli) (Heissig, 1975b) and Pikermi (Greece) faunas.

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