



General palaeontology, systematics and evolution (Biostratigraphy)

Lower Pleistocene stratigraphy of the Burdur Basin of SW Anatolia

Stratigraphie du Pléistocène inférieur du bassin de Burdur au Sud-Ouest de l'Anatolie

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ABSTRACT

The Burdur Basin is one of the NE-trending extensional orogen-top basins of SW Anatolia hosting alluvial-fan, fluvial and lacustrine deposits from the Late Miocene onward. The remains of *Equus* (*Allohippus*) sp., *Paracamelus* cf. *gigas*, and medium-sized deer (*Cervidae* gen. indet.) from the uppermost reach of the basin-fill succession show an interregional palaeobiogeographical linkage. The composition of fossil associations is typical for the Villafranchian of eastern Europe and central Asia. The architecture of the basin-fill stratigraphy and associated fossil taxa refines the Early Pleistocene regional palaeogeography and biodiversity of Anatolia drawn over the Eurasian migration pattern.

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R É S U M É

Le bassin de Burdur est un des bassins extensifs de sommet d'orogène de direction nord-est du Sud-Ouest de l'Anatolie abritant des dépôts de cônes alluviaux, fluviaux et lacustres à partir de la fin du Miocène. Les restes d'*Equus* (*Allohippus*) sp., *Paracamelus* cf. *gigas* et de cerf de taille moyenne (*Cervidae* gen. indet.) de la partie supérieure de la succession du remplissage sédimentaire montrent une liaison inter-régionale paléobiogéographique. La composition des associations fossiles est typique du Villafranchien de l'Europe de l'Est et de l'Asie centrale. L'architecture de la stratigraphie du remplissage du bassin et les espèces fossiles associées affinent la paléogéographie et la biodiversité régionales du début du Pléistocène de l'Anatolie dessinant un modèle de migration eurasiennne.

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1. Introduction

Terrestrial deposits of the Burdur Basin region (SW Anatolia) contain rare, but unique fossil remains. Thus, there

are some difficulties of regional and interregional stratigraphic correlations to refine regional palaeobiogeographic interferences. Faunal evidence from Anatolian Cenozoic terrestrial basins has the potential to shed light on interregional correlation, because the Anatolian peninsula is a crucial route for faunal migration among Africa, Asia, and Europe during the Neogene. Detailed stratigraphical and biostratigraphical documentation in each basin allows us

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to incorporate interbasinal correlations and contribute to a refined regional palaeobiogeographical reconstruction. Therefore, remains of fossil mammals in the Burdur Basin are a useful tool to compare and correlate neighbourhood basins to refine palaeobiogeographical connections.

The western Anatolian Late Cenozoic is characterized by broad crustal deformation creating several fault bounded basins, with predominantly widespread terrestrial sedimentation. The basins were formed as an array of orogen-top depressions in the hinterland of the Lycian Orogeny and caused by multiple rifting pulses hosting alluvial, fluvial and lacustrine systems (Alçiçek, 2007; Alçiçek et al., 2005, 2012). Documentation of the sedimentary characteristics of the Late Cenozoic terrestrial basins in SW Anatolia and successive terrestrial fossil discoveries allow correlation and reconstruction of Late Cenozoic palaeobiodiversity in eastern Mediterranean.

2. The Burdur Basin

The northeast-trending Burdur Basin rests on the Mesozoic basement of allochthonous limestone and ophiolitic units of Lycian nappes and Eocene–Oligocene parallochthonous sedimentary units. The Neogene sedimentation consists of alluvial, fluvial and lacustrine deposits with volcanic intercalations (Fig. 1). Geological mapping and lithostratigraphic subdivision of the basin was completed by Wedding (1966), and later the studies by Karaman (1986) and Price (1989) proposed a Miocene–Pliocene age for the basin-fill succession. More recently, geologic mapping of the basin and its surroundings were compiled by Şenel (1997, 2002). A summary of the basin stratigraphy was presented by Price and Scott (1989, 1994) suggesting the basin formed in a half-graben setting in the control of a NE-dipping main fault as a result of crustal extension. They proposed an 1100 m thick of basin-fill succession consisting of coarse- to fine-grained clastic deposits and subdivided into Çendik, Akdere and Günalan members in ascending stratigraphic order. The Çendik and Günalan members are dominated by fluvial sediments that laterally pass into alluvial-fan deposits, whereas the Akdere member is restricted to the central basin area and dominated by lacustrine deposits. At the present time, the basin is actively evolving, punctuated by seismic activity along secondary faults confining the present Burdur Lake and causing a shift of its depocentre.

Terrestrial sedimentation in the Burdur Basin started in the Late Miocene in an extensional setting, hosting alluvial-fan, fluvial and palustrine depositional systems (Price and Scott, 1989). The basin has a similar developmental history with a coeval basin array along the Tauride hinterland that has been documented in detail in several basins such as Çameli, Eşen and Çal (Alçiçek, 2007; Alçiçek et al., 2005, 2012). The initial basin subsidence is attributed to a rifting pulse that affected the entire hinterland of the Lycian Taurides. At the initial stage of sedimentation, the marginal alluvial-fans were prograded from basin-bounded fault escarpments into axial fluvial systems. During the Early Pliocene, the resumption of regional extension caused a new pulse of rifting in SW Anatolia and, accompanied by regional humid climatic conditions,

caused more accommodation space for extensive lacustrine basins. The lacustrine environments were gradually shrunk due to denudation and degradation of the surrounding basement rock that caused it to overflow the basin. The fossil locality presented in this paper is surrounded by marginal alluvial-fan to fan-deltaic depositional settings of the uppermost reaches of the basin-fill succession. By the Early Pleistocene, changes in the regional extensional direction were attributed to a third rifting pulse, dissecting the basins by newly generated faults and rearranging basin floors by tilting to establish the present basin configuration and morphology.

The locality was discovered by MCA in 1999 during field reconnaissance in the Burdur Basin, and the first fossil discoveries were shown to Gerçek Saraç, who described them as Equidae *Hipparion* sp. and *Giraffidae* indet. in his extensive report on the Anatolian mammal localities (Saraç, 2003). Later, the findings were given to SM who tentatively identified them as *Paracamelus* sp. Then the locality was revisited and new materials were discovered. VVT joined in for further descriptions and he recognized the significance of the specimens for interregional faunal linkage. As *Paracamelus* is rather rare all over Eurasia, the Burdur material is of crucial importance to contribute to basin stratigraphy and interbasinal correlation. The specimens are currently stored in the collection of the Natural History Museum of Ege University in Izmir, Turkey.

3. Systematic palaeontology

Order PERISSODACTYLA Owen, 1848

Family EQUIDAE Gray, 1821

Genus *Equus* Linnaeus, 1758

Equus (*Allohippus*) sp.

Fig. 2d

Material: Left posterior second phalanx of a large monodactyl horse (PV-3504; Fig. 2e).

Description: The bone is wide and relatively short (the ratio of length to mid-shaft width is 0.92; Table 1). Its upper end is slightly narrower than the lower one (the ratio of proximal width to the distal one is 1.1). The width of the diaphysis is noticeably narrower than the proximal and distal ends of the phalanx. The angle of the proximal articular surface relative to its longitudinal axis is 78°. This peculiarity was more typical for *E. (A.) stenonis*, in which such an angle is generally less than in caballoid horses (Gromova, 1949).

The well-developed ligamental fossae for the attachment of the lateral ligaments of the hoof joint weakly go to the front surface, and are bordered by the ridges from shallow median depression on their dorsal surfaces. Gromova (1949) proposed that the posterior phalanges of stenonid-like horses are characterized by a stronger development of these ligamental fossae compared with caballoid horses.

Remarks: Judging by its size, PV-3504 is smaller than most stenonid-like horses (Table 1), but similar to *Equus (A.) pamirensis* from Kuruksay (Tadzhikistan; Sharapov, 1986), *E. (A.) stenonis senezensis*, *Equus (A.) sanmeniensis* (Tologoy, China), and *E. (Equus) nalaiikhaensis* (Eisenmann and Kuznetsova, 2004; Prat, 1980; Sharapov, 1986). It falls within the limits of

Table 1
Measurements of posterior second phalanx of some *Equus*.

Tableau 1

Mesures de la seconde phalange postérieure de quelques *Equus*.

Ph II	<i>Equus</i> sp.	<i>E. liventsovensis</i>	<i>E. major</i>	<i>E. pamirensis</i>	<i>E. stenonis</i> ssp.	<i>E. stenonis vireti</i>	<i>E. stenonis senezensis</i> Prat, 1980	<i>E. bressanus</i>	<i>E. süßenbornensis</i> Italy* Alberdi and Palombo, 2012	<i>E. altidens altidens</i> Italy* Alberdi and Palombo, 2012	<i>E. altidens granatensis</i> Italy Alberdi and Palombo, 2012	
Measurements, mm	Burdur PV-3504	Liventsovka AMZ KP 27212/292	Psekups GIN	Kuruksay Sharapov, 1986*	El Rincon Eisenmann, 2004	Saint-Vallier LD2 LD3 Eisenmann, 2004						
1 Greatest length	44.9	52.3	51.0	48.7; 52.7; 53.6	52.0; 56.0	58; 55	47.3; 49.0	45.8	57.0; 59.0	46.6–48.6–50.5	42.3–45.9–52.7	43.2; 42.5
2 Anterior length	35.1	45.2	43.0	-; -; 42.0	41.0; -	(58);-	-; (36)	-	-	33.5–35.0–53.4	31.4–34.2–39.6	29.4; 32.0
3 Breadth of proximal end	50.3	49.5	53.0	55.4; 55.0; 54.5	52.2; -	-; (57)	-; 54.0	48.0	58.5; 63.2	49.2–51.0–53.4	40.9–45.6–52.0	45; 41.8
4 Antero-posterior diameter of proximal end	30.6	35.0	37.0	32.4; -; 39.0	35.5; 36.0	-; (36)	-; 34.0	32.5	38.0; 42.3	31.5–33.6–36.0	27.5–30.9–36.7	27.3; 27.0
5 Greatest breadth of distal end	45.7	48.6	>47	-; 47.5; 44.4	45.0; -	(51); 52	-; 48.0	42.5	52.5; 57.0	44.4–45.9–47.0	37.0–41.4–46.0	38.0; 34.0
6 Smallest breadth of the diaphysis	41.1	44.3	44.0	43.7; 45.0; 43.2	42.0; -	47; 47	40.0; 44.0	40.0	47.5; 53.0	41.8–43.8–45.7	35.6–39.5–42.6	37.2; 36.0
Index 3/1	1.12	0.95	1.04	1.14; 1.04; 1.02	1.0; -		-; 1.1	1.05	1.03; 1.07	1.03–1.05–1.08	0.93–0.99–1.09	1.04; 0.98
Index 5/1	1.02	0.93	-	-; 0.9; 0.83	0.87; -	-; 0.95	-; 0.98	0.93	0.92; 0.97	0.93–0.94–0.95	0.78–0.9–1.0	0.88; 0.8
Index 6/1	0.92	0.85	0.86	0.90; 0.85; 0.81	0.81; -	0.81; 0.85	0.85; 0.9	0.87	0.83; 0.90	0.87–0.9–0.92	0.74–0.86–0.94	0.86; 0.85
Index 3/5	1.1	1.02	-	-; 1.16; 1.23	1.16; -	-	-; 1.12	1.13	1.1; 1.1	1.03–1.05–1.07	1.0–1.05–1.08	1.02; 0.94

Data in brackets are approximate.

* Minimal-middle-maximal values.

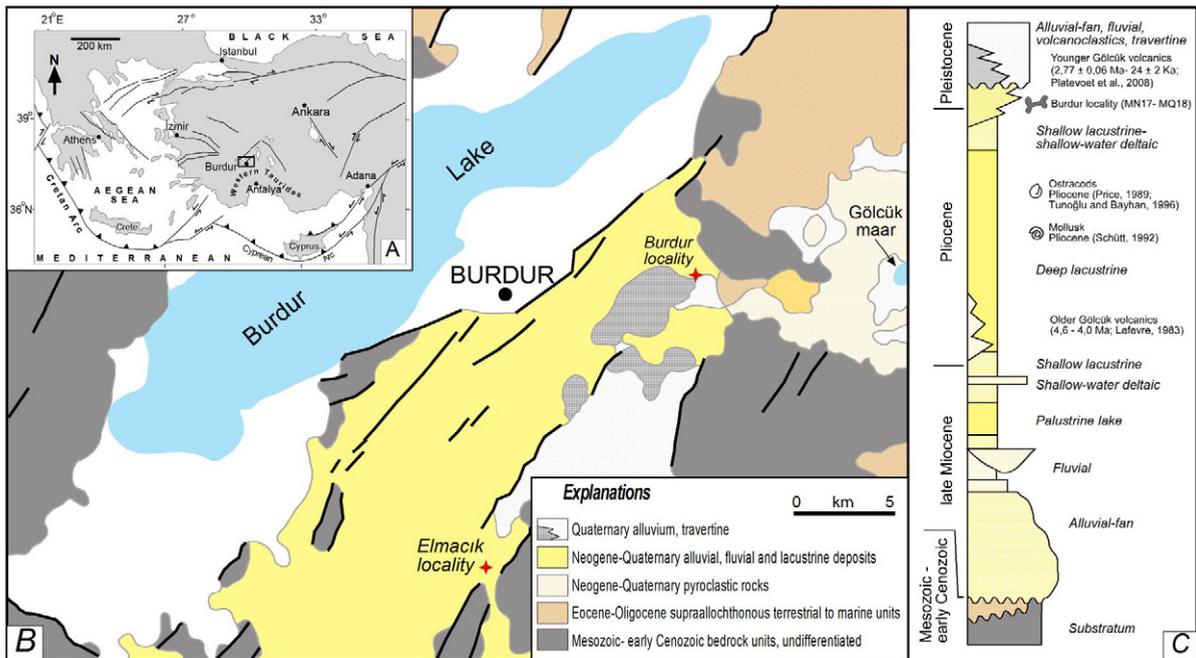


Fig. 1. A. Location map of the eastern Mediterranean showing major structures (after Alçiçek et al., 2005). B. Geological map of the Burdur Basin (based on Şenel, 2002). The fossil locality presented in this study is indicated by an asterisk. C. Composite stratigraphy of the Burdur basin-fill succession, not to scale (based on Karaman, 1986; Price, 1989). The figure refers to Lefevre et al. (1983); Price (1989); Platevoullet et al. (2008); Schütt (1992); Tunoğlu and Bayhan (1996).

Fig. 1. A. Carte de localisation de l'Est de la Méditerranée montrant les structures majeures (d'après Alçiçek et al., 2005). B. Carte géologique du Bassin de Burdur (basée sur Şenel, 2002). La localité fossilifère présentée dans cette étude est indiquée par une astérisque. C. Stratigraphie composite de la succession du remplissage sédimentaire non à l'échelle (basé sur Karaman, 1986; Price, 1989). La Figure fait référence à Lefevre et al. (1983); Platevoullet et al. (2008); Schütt (1992); Price (1989); Tunoğlu and Bayhan (1996).

variability of *E. (Plesippus) altidens* (Alberdi and Palombo, 2012; Fig. 3). It is larger than *E. (Hemionus) hemionus*, *E. (E.) hydruntinus*, and *E. (E.) gmelini* (Kuzmina, 1997), but smaller than *E. (A.) livenzovensis* from Liventsovka and Khapry, *E. (A.) bressanus*, *E. stenonis* ssp. from Olivola, *E. (A.) verae*, and large caballoid horses *E. (E.) mosbachensis*, *E. (E.) uralensis*, and *E. (E.) latipes*. Its measurements fit into the lower limits of *E. (A.) stenonis vireti* from Saint-Vallier, *E. (A.) süssenbornensis*, *E. (A.) stenonis* ssp. from El Rincon and caballoid horses *Equus (E.) lenensis* (Alberdi and Palombo, 2012; Eisenmann, 2004; Kuzmina, 1997; Prat, 1980). The find from Burdur differs from phalanges of hipparions by its larger size and the insignificant restriction of the distal epiphysis of the bone.

PV-3504 differs by its massive proportions from most caballoid horses, onagers, *E. (Plesippus) altidens*, and most stenonid horses. Only phalanges of *E. (E.) latipes* are notable by more robust construction. By this parameter the Burdur specimen is similar to *E. (A.) stenonis vireti*, *E. (A.) pamirensis*, and *E. (A.) major* from Psekups (Fig. 4). Indices of proximal, distal and diaphysis widths are slightly higher than those of other stenonid horses, but similar to them. Generally, they are lower than those of true horses, and are greater than those of donkeys (Table 1). Based on this comparison, we interpreted PV-3504 as a small *E. (Allohippus)* sp. with rather massive distal limb bones. The stratigraphic distribution of such forms is Late Pliocene–Early Pleistocene.

Order ARTIODACTYLA Owen, 1848

Family CAMELIDAE Gray, 1821

Genus *Paracamelus* Schlosser, 1903

Paracamelus cf. *gigas* Schlosser, 1903

Fig. 2a–c

Material: Fragments of the right radius (PV-3501; Fig. 2a), right tibia (PV-3502; Fig. 2b) and a left astragalus (PV-3500; Fig. 2c) presumably belonging to one individual of a large camelid.

Descriptions: *Radius*. The distal part of a radial bone of a large animal (Table 2). The medial ridge of the distal articular surface is perpendicular to the width of the bone. The medial facet (to the navicular bone) is not narrowed towards its back. The medial facet (for the semilunar bone) is narrower than the medial and lateral ones.

Tibia. The articular surface of the condylus lateralis is narrowed in the anterior–posterior direction, its antero-posterior diameter is less than its width and less than the anteroposterior diameter of the condylus medialis. The width of the proximal epiphysis is 138.3 mm (Table 3).

Astragalus. The astragalus extends distally. The width of the distal block is greater than the proximal at 10 mm. The inner surface of the bone is bent substantially at its posterior side. The cuboid fossa is rather large. A large malleolar eminence is below the middle of the outer surface of the bone. The tubercle of the inner ridge is located below the malleolar eminence. The proximal block is significantly asymmetrical; its lateral crest is distinctly above

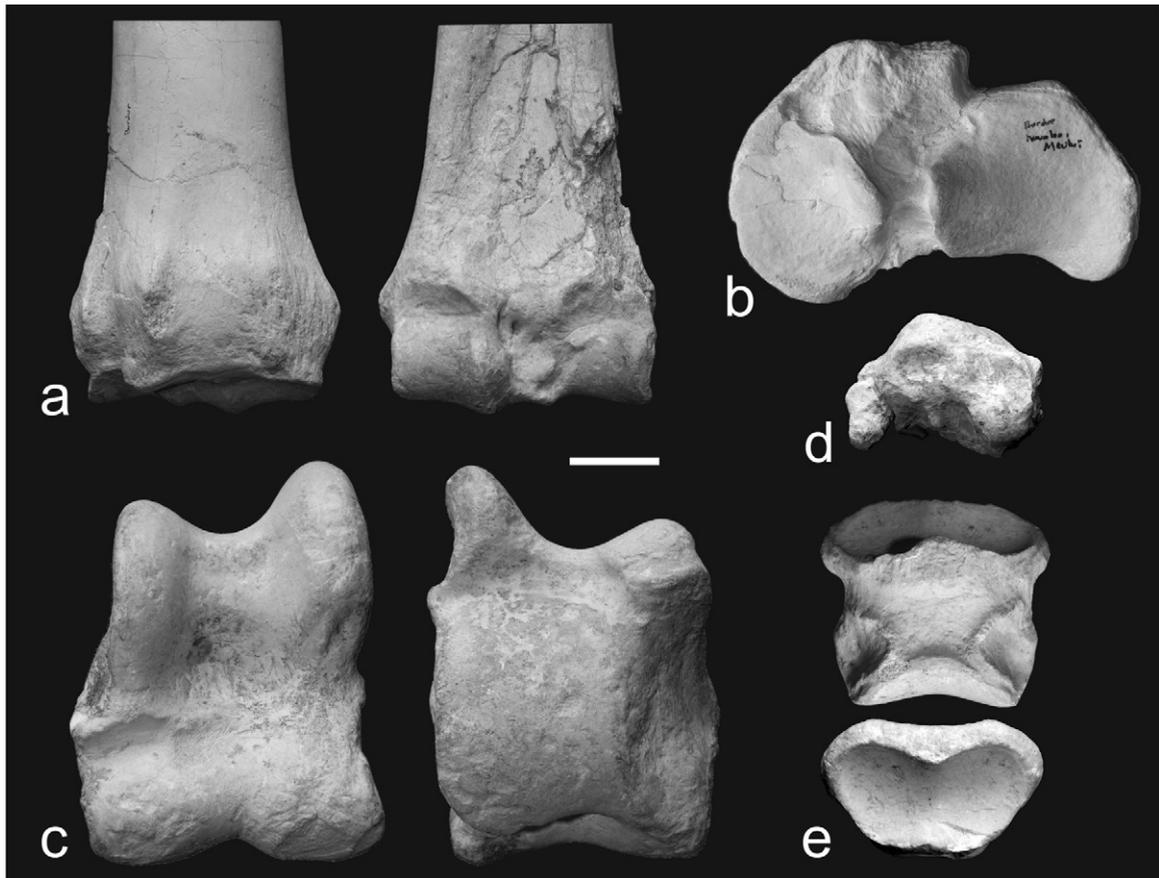


Fig. 2. *Paracamelus cf. gigas*; a: anterior and posterior views of the radius (PV-3501); b: tibia (PV-3502); c: anterior and posterior views of the astragalus (PV-3500); Cervidae indet.; d: radius (PV-3503); *Equus* sp.; e: anterior and proximal views of the second phalanx (PV-3504). Scale bar; a: 4 cm; b, d and e: 2 cm.

Fig. 2. *Paracamelus cf. gigas*, a: vues antérieure et postérieure du radius (PV-3501); b: tibia (PV-3502); c: vues antérieure et postérieure de l'astragale (PV-3500); Cervidae indét.; d: radius (PV-3503); *Equus* sp.; e: vues antérieure et postérieure de la seconde phalange (PV-3504). Barres d'échelle; a: 4 cm; c: 3 cm; b, d et e: 2 cm.

the medial one (Table 4). On the lower block a medial crest is well defined on its external part.

Remarks: The available remains do not allow a definite identification of the Burdur camel fossils to either

Paracamelus or *Camelus*. However, the large size and some indices show similarities to large camels like *P. gigas*, which are known from the Sea of Azov region, Azerbaijan, north-western Mongolia, Kazakhstan, and China (Bajgusheva,

Table 2
Measurements of radius of some *Paracamelus* and *Camelus*.

Tableau 2
Mesures du radius de quelques *Paracamelus* et *Camelus*.

Radius	<i>P. cf. gigas</i>	<i>P. gigas</i>	<i>P. alutensis</i>	<i>P. alexjevi</i>	<i>P. trofimovi</i>	<i>C. bactrianus ferus</i>	<i>C. bactrianus domesticus</i>
Measurements, mm	Burdur PV-3501	Teilhard de Chardin and Trassaert, 1937	Liventsovka; Titov, 2008	Odessa; Khaveson, 1954; Logvinenko, 2000 ^a	Kuruksay; Sharapov, 1986	Khaveson, 1954	Eastern Europe, Middle Ages ^a
Greatest breadth of facies articularis distalis	104.3	102	60.8–67.9–74.0	74.0 –80.6–88.0	99	82.5	81.0; 83.0
Greatest breadth of distal end	119.15	–	78.6; (83)	87.0 –94.3–102.0	113.5	–	99.0–104.7–120.0

Data in brackets are approximate.

^a Minimal-middle-maximal values.

Table 3

The comparison of some Eurasian camels' tibia measurements.

Tableau 3

Comparison de mesures de tibia de quelques chameaux eurasiens.

Tibia	<i>P. cf. gigas</i>	<i>P. gigas</i>	<i>P. alexejevi</i>	<i>P. alutensis</i>	<i>C. bactrianus ferus</i>	<i>C. bactrianus domesticus</i>
Measurements, mm	Burdur	Honan, Yang-Shao-Tsun; Zdansky, 1926	Odessa Haveson, 1954 Logvinenko, 2000	Liventsovka, Titov, 2008	Haveson, 1954	Eastern Europe, Middle Ages
Greatest breadth of the proximal end	138.3	148.0	118.0–(121.9)–127.0	99.0	120.0	123.5–126.75–130.0
Greatest antero-posterior depth of the proximal end	> 86.9		117.0–(123.2)–130.0	103.0–(108.0)–115.0		127.0; 127.0

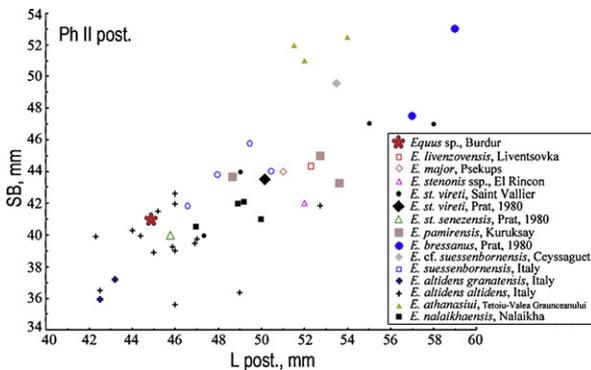
**Fig. 3.** The ratio of the smallest breadth (SB) of the diaphysis of the second phalanx to its maximal posterior length (L. post.) in some Pleistocene Eurasian monodactyl horses.

Fig. 3. Rapport entre la plus petite largeur (SB) de la diaphyse de la seconde phalange et sa longueur maximale postérieure (L. post.) chez certains chevaux monodactyles eurasiens du Pléistocène.

1971; Belajeva, 1937; Teilhard de Chardin and Trassaert, 1937; Titov, 2008b; Zdansky, 1926) (Fig. 5). Taking into consideration the reliable data of the Khapry fauna (Middle Villafranchian; Sea of Azov Region, Russia) the real period of *P. gigas* existence in eastern Europe is accepted as Late

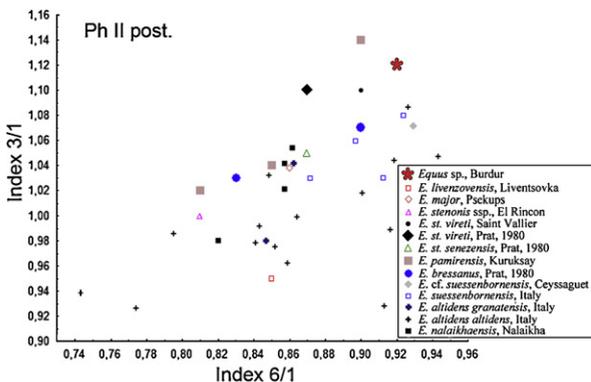
**Fig. 4.** The ratio of the indices of the second phalanges of some Pleistocene Eurasian monodactyl horses. Index 3/1 – the ratio of proximal end breadth to the greatest (posterior) length. Index 6/1 – the ratio of smallest diaphysis breadth to the greatest (posterior) length.

Fig. 4. Rapport des indices des secondes phalanges de certains chevaux monodactyles eurasiens du Pléistocène. Index 3/1 – rapport entre la largeur de la terminaison proximale et la plus grande longueur (postérieure). Index 6/1 – rapport entre la largeur de la plus petite diaphyse et la plus grande longueur (postérieure).

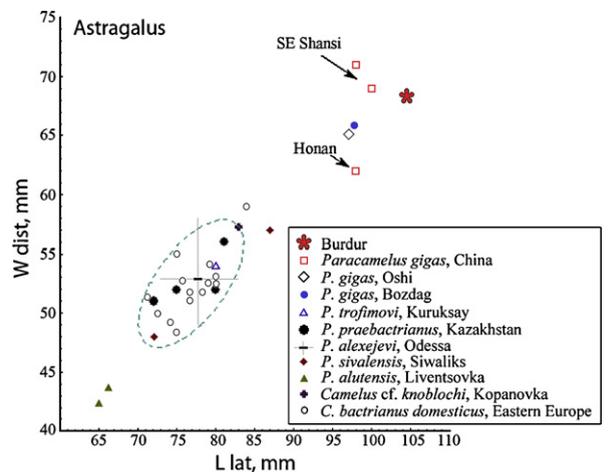
**Fig. 5.** The ratio of the distal breadth (W) of the astragalus to its maximal lateral length (L lat.) in some Plio-Pleistocene camels.

Fig. 5. Rapport entre la largeur distale (W) de l'astragale et sa longueur latérale maximale (L lat.) chez certains camélidés du Plio-Pléistocène.

Pliocene (= early Early Pleistocene) (Titov, 2008b). Unfortunately, the ages of other localities of the giant camel very often have no exact stratigraphic position. The discovery of the astragalus in the conglomerates of Bozdağ (Azerbaijan) (Burchak-Abramovich and Akhundov, 1960) is dated as Upper Apheronian, which corresponds with the late Late Villafranchian. The astragalus from locality Oshi (Northwest Mongolia) is dated as Late Neogene (Belajeva, 1937).

Remains of giant camel are known from several localities from the territory of China. The exact age and location of teeth of a giant camel from Honan Province, which are holotypes for the genus and species *Paracamelus gigas* (Schlosser, 1903), is unknown. More numerous finds of giant camel bones come from SE Shansi (Teilhard de Chardin and Trassaert, 1937), from the province of Honan, Yang-Shao-Tsun (localities 102, B, D; Zdansky, 1926), from Sangan River valley, west of Beijing (Teilhard de Chardin and Piveteau, 1930), and from the Chouk'outien (Zhoukou-dian) 'Lower Cave' site (Young, 1932). The dating of these localities falls in different periods in the Late Pliocene–Early Pleistocene. At various times, the presence of *P. gigas* was indicated in the early Middle Villafranchian faunas of Youhe and Nihewan (Burchak-Abramovich and Akhundov, 1960; Haveson, 1954). In recent reports, this

Table 4

The comparison of some Eurasian camels' astragalus measurements.

Tableau 4

Comparaison de mesures d'astragale de quelques chameaux eurasiens.

Astragalus	<i>Paracamelus</i>					<i>Camelus</i>						
	<i>P. cf. gigas</i>		<i>P. gigas</i>		<i>P. trofimovi</i>	<i>P. aguirre</i>	<i>P. alexejevi</i>	<i>P. sivalensis</i>	<i>P. praebactrianus</i>	<i>C. knoblochi</i>	<i>C. bactrianus domesticus</i>	
Measurements, mm	Burdur	SE Shansi Teilhard de Chardin and Trassaert, 1937	Honan, Yang-Shao-Tsun Zdansky, 1926	Oshi Belajeva, 1937	Bozdag Burchak- Abramovich and Akhundov, 1960	Kuruksay Sharapov, 1986	Venta del Moro	Odessa Haveson, 1954	Siwaliks	Kazakhstan	Kopanovka	Eastern Europe
Greatest length medial	90.0		88.5	88.5	91.0	72.5; 80.5	80.0	68–(73.3)–78	81.0	67–(72.6)–78.5	80.7	67–70.8–75
Greatest length lateral	104.25	100.0; 98.0	98.0	97.0	>96	80.0; -		73–(77.9)–83	87.0	72–(77.8)–81	(83)	71.2–76.8–84
Minimal length at the constriction	77.8		75.5	76.0	~76	60.0; 67.0	71.5	58–(62.1)–67	66.0	58–(61.1)–63	67.0	57.3–59.4–63
Greatest depth of the lateral half	59.0	48.0; 49.0	(52)	50.0	55.5	48.0; 51.0		43–(45.75)–49		46.0; 51.0	47.1	41–43.2–47.2
Breadth of the distal end	68.5	69.0; 71.0	62.0	65.0	>63	54.0; 55.0	60.5	49–(52.9)–58	57.0	51–(53.3)–56	57.2	48.4–52.5–59

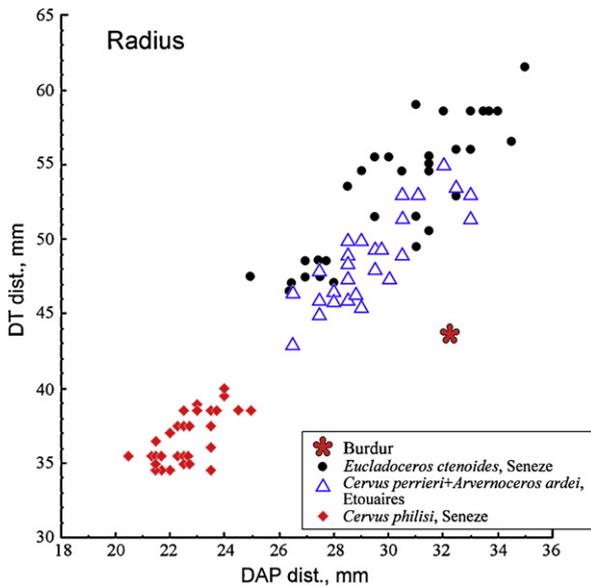


Fig. 6. The ratio of the distal maximal breadth (DT dist.) to the greatest anteroposterior depth of the distal end (DAP dist.) of some Plio-Pleistocene deer.

Fig. 6. Rapport entre la largeur distale maximale (DT dist.) et la plus grande distance antéro-postérieure de la terminaison distale (DAP dist.) chez certains cerfs du Plio-Pléistocène.

camel species is a member of the Xiashagou fauna, which is dated as 0.8 to 2.0 Ma (Deng et al., 2008).

Family CERVIDAE Goldfuss, 1820

Cervidae gen. indet.

Fig. 2d

Material: *Radius*. Incomplete right radius (PV-3503; Fig. 2d), lacking its proximal part, of a medium-sized deer.

Description: In the distal epiphysis of the bone at the anterior surface there are two well-defined longitudinal ridges with a groove between them. The lower end of the bone is fused with the distal end of the ulna at its lateral posterior surface. The boundary between them at the articular surface is presented in the form of a crack. Ridges on the distal articular surface are splayed relative to the anteroposterior diameter of the distal epiphysis. The width of the facet for the navicular bone is approximately equal to the width of the facet for the lunate bone.

Remarks: The dimensions of the radius are larger than those of *Cervus (Rusa) philisi*, *Crozetoceros ramosus*, and are similar to those of the Late Pliocene–Early Pleistocene deer *Eucladoceros* and *Arvernoceros* (Heintz, 1970; Table 5). But the Burdur specimen differs by the larger anteroposterior diameter of the distal part of the radius (Fig. 6). The exact determination of the specimen is difficult due to the lack of a developed diagnostic system of the postcranial bones of deer, and the absence of published data about postcranial bones of other Asiatic Plio-Pleistocene deer such as *Praemegaceros*, *Sinomegaceros*, *Axis*, and *Elaphurus*.

4. Discussion

Stratigraphy and palaeoenvironmental changes in the Burdur Basin show an overall tectono-sedimentary

interaction from the Late Miocene onward with a close relation with coeval neighboring basins. In the early basin evolution stage, by the Late Tortonian, the basin was subsided to attract a transition of coarse-clastic alluvial-fans into the axial fluvial systems. The Pliocene of the basin was signified by denudation and degradation of surrounding basement rocks and resulted in the deposition of fining upward sequences from alluvial-fan, fluvial into lacustrine deposits, implying widespread humid conditions that were sustained up to the Late Pliocene, comparable with neighbouring lacustrine basins. In the Pleistocene, reactivated extension rearranged the basin configuration. Uplift tilted the former basin-fill that was unconformably overlain by fluvial deposits.

Because fossil camel remains from Turkey are rare, the locality of bones of camels. The Anatolian Camelidae localities were reported by Saraç (2003) as *Paracamelus* cf. *alexjevi* from Gülyazi (Early Pliocene MN16, Sickenberg et al., 1975), *Paracamelus* cf. *alutensis* from Sarıkoltepe (Early Pleistocene MN17, Kostopoulos and Şen, 1999), *Paracamelus* sp. from Yukarısöğütünü (Late Pliocene MN17, Becker-Platen and Sickenberg, 1968; Sickenberg et al., 1975) and Camelidae gen. indet. noted from Upper Pleistocene of Sinap Tepe (Sen, 1990). Van der Made et al. (2002, 2003) reported *Paracamelus* cf. *aguirrei* from Çobanpınar (Late Miocene MN13, Ozansoy, 1965) as one of the oldest Old World camels. But recently that specimen was withdrawn because the fossil probably came from a nearby archaeological site, but was stored with the Çobanpınar material. The state of fossilization together with its colour and matrix do not fit those of the fossils collected from Çobanpınar (Şen, 2010).

In general, the history of camel evolution and distribution in Eurasia is known (Haveson, 1954). Although Camelidae remains are not very common in the Late Cenozoic of Eurasia, several papers were dedicated to the question of the latest extent of its ancient representatives (Harris et al., 2010; Likius et al., 2003; Pérez-Lorente et al., 2009; Titov, 2008a; Titov and Logvynenko, 2006; van der Made et al., 2006). As suggested by Honey et al. (1998), Camelidae dispersed through North America during the mid-Eocene and migrated into Eurasia via the Bering land-bridge caused by sea-level fall in the Late Miocene. The earliest Camelidae finds in Eurasia are from the zone MN12–13 localities Pavlodar (Kazakhstan), Sinyavskaya and Novocherkask (Russia), Eupatoria, Odessa and Yablonya (Ukraine), and MN13 from Venta del Moro and Librilla (Spain) (Morales et al., 1980; Pickford et al., 1995; Titov and Logvynenko, 2006). These large animals quickly dispersed over Eurasia, occupying ‘savanna’ type biotopes. Apparently, the earliest Eurasian camels were typical members of Late Miocene hipparion communities (Titov, 2008a).

The camel *Paracamelus khersonensis* (= *alexjevi*) was typical of the Ruscinian (= Early Pliocene) fauna of the northern Black Sea region. Similar forms are known from Turkey and northern Africa. In western Asia, *P. praebactrianus* was common during this time. The Middle Pliocene (Early Villafranchian) record of camels is rather fragmentary. Only from Kazakhstan a very large *P. longipes* is known. In the Late Pliocene, camels were the most

Table 5

The comparison of radius measurements of some Plio-Pleistocene deer.

Tableau 5

Comparaisons de mesures de radius de quelques cerfs plio-pléistocènes.

Radius	Cervidae gen.	<i>Eucladoceros s. senesensis</i>	<i>Arvernoceros ardei + Cervus perrieri</i>	<i>Arvernoceros cf. verestchagini</i>	<i>Cervus (Rusa) philisi</i>	<i>Cervus (Rusa) philisi</i>
Measurements, mm	Burdur	Seneze, Heintz, 1970	Etuer, Heintz, 1970	Apollonia, Croitor and Kostopoulos, 2004	Seneze, Heintz, 1970	Liventsovka
Distal maximal breadth	43.7	45.6–53.3–61.5	43.0–48.7–55.0	75.0	34.5–36.8–40.0	39.7–41.8–45.2
Greatest antero-posterior depth of the distal end	32.15	25.0–30.4–35.0	26.5–29.3–33.0	60.7	20.5–22.66–25.0	23.8–26.01–28.2
Distal articular breadth	36.0	–	–	–	–	–
Distal articular depth	24.4	–	–	–	–	–
Breadth of the radial condyle	14.3	–	–	–	–	–

varied, and were widely distributed in eastern Europe, Asia and Africa. In the Black Sea region and possibly in the Middle East, the small camel *Paracamelus alutensis* was common in the Middle and Late Villafranchian faunas. At the same time in different parts of Asia lived larger forms of camels – *P. gigas* (China, Kazakhstan, Mongolia), and *P. trofimovi* (Tajikistan). In the Middle Villafranchian of the Sea of Azov fauna, two forms were found, the small camel *P. alutensis* and the large *P. cf. gigas* (Bajgusheva, 1971; Bajgusheva et al., 2001; Titov, 2008b). From the Pinjor beds of the upper Sivaliks from Pakistan and India remains of “*Camelus*” (= *Paracamelus*) *sivalensis* are known (Nanda, 2002).

The late Early Pleistocene history of Eurasian camels is insufficiently known. There are only fragmentary remains from eastern Europe and the Middle East. In the early Middle Pleistocene, the genus *Paracamelus* was replaced throughout Eurasia by representatives of the genus *Camelus*.

Monodactyl horses, also immigrants of North American origin, became common in Eurasia in the terminal Late Pliocene–early Early Pleistocene at the Gauss–Matuyama boundary, or even in the upper part of the Gauss chron (beginning of Middle Villafranchian; Agusti et al., 2001; Lindsay et al., 1980). Although there is evidence that they started to appear in Eurasia sometime earlier (in the Early Villafranchian of France and Greece; Lacombat et al., 2008). During the Late Pliocene–Early Pleistocene monodactyl horses displaced hipparions in Eurasia. But this process occurred gradually and unevenly. During the Middle–Late Villafranchian, stenonid-like horses *Allohippus* were common.

In contrast to the Miocene, Plio-Pleistocene localities with large mammals are quite rare in Turkey. In limited localities, the systematically studied equid records have come from Sarikoltepe (Early Pleistocene; Kostopoulos and Şen, 1999), Gülyazi (Late Pliocene, Bernor and Lipscomb, 1991), Denizli (Erten et al., 2005) and Çal (Alçiçek et al., 2012) as *Equus stenonis*, *Plesiohipparion huangheense*, and *E. süssenbornensis* and *E. hydruntinus*, respectively. It is worth to note that a new *Equus hydruntinus* teeth were discovered by MCA in the alluvial-fan deposits of uppermost reach of the Acigöl basin-fill succession to the west of

the Burdur basin, as another important correlation material for Burdur equids. *Equus* sp. was recorded at the localities of Kamişli, Yukari Söğütönü (Early Pleistocene, Sickenberg et al., 1975) and Dursunlu (early Middle Pleistocene, Howell et al., 1999), but this material has not been studied in detail, and only presented as faunal lists. The limited fossils from Yukari Söğütönü in the collections of MTA (General Directorate of Mineral Research and Exploration, Ankara/Turkey) museum show one type of equid that has close similarities with the small *E. altidens* forms and the more advanced Dursunlu (early Middle Pleistocene) equids are similar to those of *E. mosbachensis* and *E. cf. altidens* (Yiğit, 1998). The few equid fossils from the Çobanisa (late Early Pleistocene, Mayda, 2004) and Kamisli localities are closely comparable with a medium-sized *E. stenonis*. In conclusion, the currently available limited data on the Turkish Plio-Pleistocene equids show close resemblance with southern European forms in having small to medium-sized forms dominant during the Early Pleistocene and larger forms at the beginning of the Middle Pleistocene.

We should also provide a note on the Elmacık fauna 30 km to the southwest of Burdur locality (Fig. 1), located at the same stratigraphic level and mostly composed of large mammals that were mainly assigned to “Mastodon” by Kahraman (2009). However, the preliminary reports from this locality surely do not give us an adequate picture of a “Mastodon” type proboscidean. On the contrary, we are now sure that there is also an Elephantinae, most likely a primitive “southern elephant” that inhabited the Burdur Basin during the Late Pliocene–Early Pleistocene (see the mandible on page 98 of Kahraman, 2009). These changes the age considerably from that given in preliminary reports of this fauna as “Mio-Pliocene” and in accordance with the faunal age of the Burdur locality introduced in this paper. Further to the southwest, in the village of Hasanpaşa near Tefenni, another well preserved lower molar of a “southern elephant” *Mammuthus meridionalis* together with a *Gazella* sp. were found in coal-bearing fluvio-lacustrine deposits (Sickenberg et al., 1975). The age of the fauna (MN16–17) and stratigraphic position of the locality are in concordance with both further Burdur and Elmacık localities.

5. Conclusions

Recent discoveries of *Equus (Allohippus)* sp. and *Paracamelus* cf. *gigas* remains allow the confirmation of a Late Pliocene–Early Pleistocene age for the uppermost reaches of the Burdur Basin succession. The first remains of a large camelid from this layer on the territory of Anatolia expand the known distribution of that form. The combination of *Paracamelus*, *Equus (Allohippus)* and a medium-sized deer show the typical Middle–Late Villafranchian association, that typical of eastern Europe, and western and central Asia. Taking into consideration the recent data on the dating of the Chinese localities of the Xiashagou fauna with *P. gigas* (0.8–2.0 Ma; Deng et al., 2008) and the presence of medium-sized *stenonis*-like horse with massive distal limb bones, we tend to think that the Burdur association is most likely to be correlated with European localities of the early Late Villafranchian.

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