Available online at www.sciencedirect.com

ScienceDirect

Palaeoworld 29 (2020) 629–635

Palaeoworld

www.elsevier.com/locate/palwor

Qurliqnoria (Bovidae, Mammalia) from the Upper Miocene of Çorakyerler (Central Anatolia, Turkey) and its biogeographic implications

Dimitris S. Kostopoulos [a,*], Ayla Sevim Erol [b], Serdar Mayda [c], Alper Yener Yavuz [d], Erhan Tarhan [e]

[a] *School of Geology, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece*
[b] *Ankara University, Faculty of Languages, History and Geography, Department of Anthropology, Ankara, Turkey*
[c] *Ege University, Faculty of Science, Department of Biology, Izmir, Turkey*
[d] *Mehmet Akif Ersoy University, Faculty of Art & Sciences, Department of Anthropology, Burdur, Turkey*
[e] *Hitit University, Faculty of Art & Sciences, Department of Anthropology, Çorum, Turkey*

Received 11 July 2019; received in revised form 15 October 2019; accepted 23 October 2019
Available online 1 November 2019

Abstract

New bovid material from the Upper Miocene site of Çorakyerler (Çankırı basin, Anatolia, Turkey) is described and compared here. The described taxon is identified as a representative of the stem caprine genus *Qurliqnoria*, previously known from the peri-Tibetan area exclusively. The stronger horn-core divergence, weaker anterior keel, smoother horn-core surface, stronger lateral horn-core curvature, stronger and thicker interfrontal suture, less flexed and less pneumatized frontals, and smaller supraorbital foramina differentiate the Çorakyerler *Qurliqnoria* from the type and only known species of the genus, *Q. cheni* from China, and demand the erection of a new species, *Qurliqnoria chorakensis* n. sp. A review of other late Miocene bovid records allows the recognition of *Qurliqnoria* in Sinap Tepe (Turkey) and Platania (Greece), suggesting a westward propagation of the genus during the Vallesian.
© 2019 Elsevier Ireland Ltd Elsevier B.V. and Nanjing Institute of Geology and Palaeontology, CAS. Published by Elsevier B.V. All rights reserved.

Keywords: Caprini; Artiodactyla; Miocene; Anatolia; Systematics

1. Introduction

Discovered in the early 1970s during a joint German-Turkish mineral exploration project (Sickenberg, 1975), the Çorakyerler fossil site is located in the Çankırı basin of north-central Anatolia (Turkey). The fossil site belongs to the fluvial flood-plain deposits of the Tüglu Formation and the local geological and stratigraphical setting have been provided by Kaymakçi et al. (2001) (see also Güleç et al., 2007; Kaya et al., 2016). During the 2000's the site attracted worldwide interest due to the discovery of important late Miocene hominoid material (e.g., Sevim et al., 2001; Begun et al., 2003; Güleç et al., 2007). Based mainly on biochronological evidence the fauna of Çorakyerler was originally regarded as Vallesian (Becker-Platen et al., 1975) but later tentatively correlated to the early Turolian European Land Mammal Age (MN11; e.g., Köhler, 1987; Ünay et al., 2006). Geraads (2013) further suggested an age slightly earlier than Pikermi, Greece (MN12, recently dated at ~7.3 Ma by Böhme et al., 2017) leaving, however, open the possibility to be even older than Kemiklitepe D, Turkey (7.9–7.6 Ma; Sen et al., 1994). Kaya et al. (2016) magnetostratigraphically correlated the normal interval including the Çorakyerler fossil site with C4n, framing the age of the fauna between 8.11 and 7.64 Ma. Nevertheless, an alternative correlation option of the magnetostratigraphic results of Kaya et al. (2016) would be around the C4An–C4r boundary, showing a better biochronological match with Sinap Tepe, Turkey data and dating the Çorakyerler fauna at about 8.9 Ma.

Systematic palaeontological excavations at the Çorakyerler fossil site under the direction of one of us (ASE) started in 2001 and are still ongoing. Apart from primates, nearly 4000 identifiable fossil mammal remains have been unearthed the last 18 years, representing mainly hipparionin horses, bovids,

* Corresponding author.
E-mail addresses: dkostop@geo.auth.gr (D.S. Kostopoulos), ayla_sevim@yahoo.com (A.S. Erol), serdar.mayda@ege.edu.tr (S. Mayda), alpyenyav@gmail.com (A.Y. Yavuz), erhantarhan@hitit.edu.tr (E. Tarhan).

https://doi.org/10.1016/j.palwor.2019.10.003
1871-174X/© 2019 Elsevier Ireland Ltd Elsevier B.V. and Nanjing Institute of Geology and Palaeontology, CAS. Published by Elsevier B.V. All rights reserved.

giraffids, rhinos, and carnivores. The Çorakyerler bovids have been originally studied by Köhler (1987) based on the initial sparse collection by Sickenberg's team in the early 70's. Güleç et al. (2007), Bibi and Güleç (2008) and Kaya et al. (2016) presented successively updated faunal lists taking into account material from the new expeditions, whereas Geraads (2013) provided a brief description of the bovid material collected around 2000 (collection numbers up to ÇO 450). According to the last author, the bovid fauna includes: *Miotragocerus* (*Pikermicerus*) sp., *Tragoportax*? sp., cf. *Prostrepsiceros* sp., *Criotherium*? sp., *Majoreas* cf. *woodwardi*, *Gazella* sp.?, *Oioceros rothi*, *Protoryx* sp. and "*Plesiaddax*" *inundatus*. Bibi and Güleç (2008) and Kaya et al. (2016) also report *Nisidorcas* and *Protragelaphus*. Although correct in its core, this faunal list remains incomplete, and somewhat misleading in terms of relative composition of the bovid association (e.g., Bibi and Güleç, 2008, table 6).

A study of the Çorakyerler bovid material collected between 2001 and 2018 reveals the presence of an additional new taxon, described and compared here. An exhaustive systematic study of the whole bovid assemblage is in progress.

2. Methodology

The studied material is housed in the Çankırı Museum, Turkey and bears the locality prefix ÇO. The material was studied during summer 2019 in the Dil ve Tarih Coğrafya Fakültesi of Ankara University, Turkey. Standard cranial terminology has been used for descriptions (e.g., Gentry, 1971; Kostopoulos, 2009). Horn-cores have been considered as heteronymously twisted when the right horn-core follows an anticlockwise torsion. All linear measurements are in mm; angles are in degrees (°). The term 'oblique angle' (sensu Wang et al., 2019) is used here to describe the angle of the greater basal axis of the horn-core compared to the sagittal plane.

3. Systematic palaeontology

Family Bovidae Gray, 1821

Subfamily Antilopinae Gray, 1821 (sensu Kingdon, 1982)

Tribe Caprini Gray, 1821

Genus *Qurliqnoria* Bohlin, 1937

Emended diagnosis: Small caprine-like bovids with moderately long, slender, anteriorly keeled and weakly twisted heteronymously horn-cores set on short pedicles; horn-core compression moderate to strong; backward curvature weak; lateral curvature (outward flaring) moderate to strong; greater basal axis of the horn-core at a large angle compared to the sagittal plane; supraorbital foramina small associated by shallow furrows; postcornual grooves large.

Type species: *Qurliqnoria cheni* Bohlin, 1937.

Qurliqnoria chorakensis n. sp.

(Figs. 1, 2)

Etymology: from the type locality of Çorakyerler.

Holotype: ÇO 3226, part of cranium with right horn-core and palate; Fig. 1.

Paratypes: ÇO 3534, frontlet; ÇO 895 frontlet; Fig. 2.

Repository: Çankırı Museum, Turkey.

Type locality: Çorakyerler, Turkey.

Differential diagnosis: A species similar in size to the type species *Q. cheni*, from which it differs in the stronger horn-core divergence, weaker anterior keel, less intensively grooved horn-core surface, horn-cores curved laterally more than caudally, stronger horn-core compression, stronger and thicker interfrontal suture, less flexed and pneumatized frontals, and smaller supraorbital foramina.

Occurrence: Late Vallesian–Early Turolian of Anatolia.

Description:

A single partial cranium and two frontlets discovered during the 2004 to 2017 Çorakyerler excavations represent the only evidence of this taxon in the site (Figs. 1, 2). The holotype (Fig. 1) belongs to a mature individual (M1 in mid wear, M3 in initial wear stage). Measurements are given in Table 1.

The frontals are slightly raised between the horn-cores; they form a 110–130° angle along the sagittal plane. The interfrontal suture is strong, complicated and constricted all along its length as far as the supraorbital foramina (Fig. 2A, D, E). The fronto-parietal suture, is narrower, simpler and 'T' shaped (Fig. 2E). The frontal area outlined by these two sutures is moderately to strongly depressed (Fig. 2E). The fronto-nasal dorsal profile is smoothly concave (Fig. 1A). The postcornual groove is large, oval shaped and deep (height: 11.7–15.5 mm; width: 6.4–8.0 mm; deepness: 3.3–6.0 mm; Fig. 2B). The supraorbital foramina are small (height: 5.0–6.0 mm; width: 2.0–3.0 mm), not sunken into depressions, moderately wide apart (see Table 1), and associated rostrally by short weak furrows (Fig. 2A, D). The orbits are rather small, rounded and not projecting laterally; their anterior margin is placed above the M3 (Fig. 1A). A large, rounded and fairly deep lachrymal depression occupies the posterodorsal side of the face in lateral view, extending rostrally to above the P4 (Fig. 1A). The horn-cores are inserted directly above the orbits on very short pedicles (Figs. 1A, 2A–C). Their major basal axis is obliquely set compared to the sagittal plane (oblique angle ≥45°; maximum measured oblique angle: 67° but possibly exaggerated by taphonomic deformation; Table 1, Figs. 1B, 2B, E). The horn-cores appear slightly heteronymously twisted and strongly divergent from the base up, curved mostly laterally and to a lesser degree caudally (Figs. 1A, 2C, E). They are moderately spaced near the base (Table 1) but 150 mm above, the distance between their medial sides already reaches 230 mm (Fig. 2A, B, D). No one of the available specimens is preserved above the ~150 mm in length (measured along the antero-medial surface) but we estimate that the total length may well have exceeded 200 mm. A weak anterior keel descending rostro-medially is present, associated by a series of distinct striations on the mid horn-core surface, both rostrally and caudally

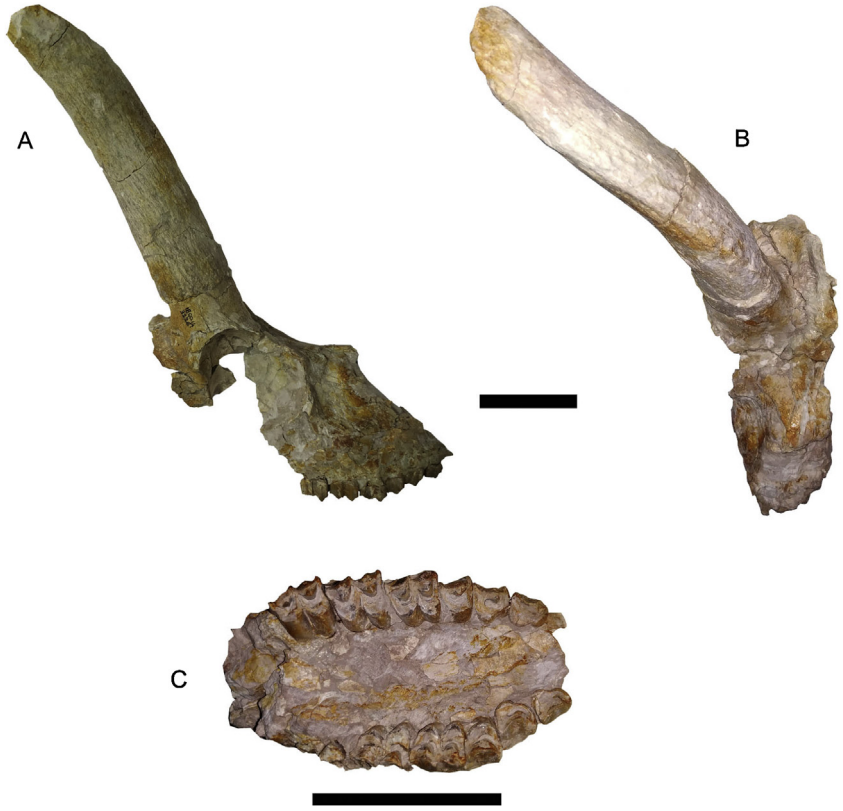


Fig. 1. *Qurliqnoria chorakensis* n. sp. from Çorakyerler (Late Miocene, Turkey). Holotype partial cranium ÇO 3226 in lateral (A), dorsal (B), and palatal (C) view. Scale bar = 5 cm.



Fig. 2. *Qurliqnoria chorakensis* n. sp. from Çorakyerler (Late Miocene, Turkey). Paratype frontlet ÇO 3534 in rostral (A), caudal (B), and lateral (C) view; and ÇO 895 in rostral (D) and dorsal (E) view. Scale bar = 5 cm.

Table 1
Cranial and horn-core measurements of *Qurliqnoria chorakensis* n. sp. from Corakyerler, Turkey. All measurements apart from the oblique angle are in mm. Values in brackets are probably affected by taphonomic deformation.

	ÇO 3534		ÇO 895		ÇO 3226
Bi-orbital width	113.4				
Length of frontals			81.0		
Width of skull at the lateral edges of the horn-core bases	115.1		122.8		
Width of braincase just behind the horn-cores	72.5		72.9		
Internal horn-core distance (base)	30.2		34.0		
Distance of supraorbital foramens	40.5		42.1		
	right	left	right	left	right
Max horn-core diameter at the base	48.1	50.5	50.2	48.8	46.5
Min horn-core diameter at the base	29.1	26.4	28.8	27.8	30.8
Max horn-core diameter at 7 cm above the base	36		40		39
Min horn-core diameter at 7 cm above the base	29		26.9		25.7
Oblique angle	(67°)	60°	(65°)	60°	45°

(Figs. 1B, 2A, E). The posterior surface of the horn-cores is flattened, the anterior one is more convex. The basal horn-core compression is strong, ranging from 52.3% to 66.2% (mean: 58.5%).

The upper toothrow P2-M3 is 71.8 mm long (P2-P4 length: 30.7–31.7 mm; M1–M3 length: 42.7 mm). The upper premolars are not shortened compared to the molars (premolar to molar length ratio: 71.9%). The P3 has strong parastyle and paracone rib, and it appears wider distally in occlusal view (Fig. 1C). The P4 is rather simple with a strong parastyle (Fig. 1C). The upper molars have strong parastyle and paracone rib and a thinner mesostyle. On the M3 the metastyle is equal to the mesostyle. The lingual crescents are angular and there are no basal pillars (Fig. 1C).

Comparison: The saber-like, anteriorly keeled and compressed horn-cores and the slightly raised frontals easily affiliate the Çorakyerler taxon to the 'protoryxoid' bovids, a group of Late Miocene genera cluster around *Protoryx* Major (Gentry, 1971; Kostopoulos, 2009). Nevertheless, the particular horn-core morphology (moderately long, slightly heteronymously twisted, strongly divergent and with large oblique angle) in association with their relatively smaller size sharply differentiate them from any known genus of the Greco-Irano-Afghan province. The very same features bring the Çorakyerler taxon closer to a set of Chinese taxa from 'Qaidam (=Tsaidam) fauna' originally described by Bohlin (1937) and recently revised by Wang et al. (2019). Although similar in overall size and horn-core compression (55–59%; data from Wang et al., 2019), *Olonbulukia* Bohlin, 1937 differs from the Çorakyerler taxon in the parallel trending and more widely spaced horn-cores on the frontals with a clear posterior curvature and no lateral projection (=outward flaring). In *Olonbulukia*, the supraorbital foramina are placed into large tear-shaped supraorbital pits, the postcornual grooves take a lower position and the interfrontal suture is not thickened. *Tossunnoria* Bohlin, 1937 also has similarly compressed horn-cores (53–57%; data from Wang et al., 2019) but it differs from the Çorakyerler taxon in the much more anteroposteriorly extended, relatively shorter and stronger keeled horn-cores, the stronger raised and more pneumatized frontals, and the absence of postcornual grooves. The Çorakyerler taxon matches *Qurliqnoria* Bohlin, 1937 in the short pedicles, the large postcornual grooves close to the horn-core bases, the slightly raised but thick and pneumatized frontals, the small supraorbital foramina extending into shallow furrows and the rather slender, well striated horn-cores, keeled anteriorly and weakly twisted heteronymously, significantly diverging in frontal view and curving laterally, and set on the frontals at a wide angle to the sagittal plane. The single known species *Qurliqnoria cheni* Bohlin, 1937 appears more archaic than the Çorakyerler taxon in the less diverging and less compressed horn-cores with weaker outward flaring but is possibly more advanced in the likely more strongly flexed and more pneumatized frontals, the more intense surface grooving, and the larger supraorbital foramina. Hence, we suggest referring the Çorakyerler taxon to a new species of *Qurliqnoria*: *Qurliqnoria chorakensis* n. sp.

4. Discussion

According to Wang et al. (2011) and Wang et al. (2019) *Qurliqnoria* from Qaidam in northeastern Tibet comes from Tuosu Fauna dated at about 12–10 Ma, though Wang et al. (2013a) restrict this range to 11.15–9.98 Ma. The genus is also known from the neighboring Wuzhong Fauna of Ganhegou Formation dated at around the end of the same time interval (~10 Ma). Dmitrieva and Serdyuk (2011) also refer *Qurliqnoria* sp. (mistakenly spelled *Quirliqnoria*) from Kholu fauna, Tuva, Russia, considered as late Vallesian–early Turolian. Deng et al. (2011) and Wang et al. (2013b) report *Qurliqnoria* sp. from sites ZD0604, ZD0745, and ZD1202 of Zanda Formation, in southwestern Tibet, ranging between 5.29 and 3.31 Ma, and thus expanding significantly the chronological range of the genus up to the end of Early Pliocene. Deng et al. (2011) and Wang et al. (2019) suggest that *Qurliqnoria* emerged from an endemic Middle Miocene stem caprine assemblage shaped during the Middle Miocene along the rising north Tibetan Plateau. According to the same authors, *Qurliqnoria* remained restricted to this geographic area (extended up to South Siberia) until its replacement by its alleged descendant the chiru (*Pantholops* Hodgson; see also Gentry, 1968) during the early Pleistocene (Ruan et al., 2005). The discovery of *Qurliqnoria* at Çorakyerler highlights the first

Table 2
Morphometrical comparison between the type species and the west records of *Qurliqnoria*. * according to data provided by Gentry (2003). Length measurements in mm; angle measurements in degrees (°).

	Q. cheni Bohlin, 1937	*Q. chorakensis* n. sp.	*Q. bohlini* (Ozansoy, 1965) type	*Qurliqnoria* * Locality 49, Middle Sinap	*Qurliqnoria* Platania
Largest basal horn-core diameter	39.1–48.4 (mean: 43.1)	46.5–50.5 (mean: 48.8)	41.5	42.4	36.2–41.9 (mean: 39.7)
Basal horn-core compression	62–73%	52–66%	79%	63%	70–73%
Oblique angle	44–56.5° (mean 51.5°)	45–60° (mean ~55°)	≥ 45°	–	45–60° (mean 54.5°)
Outward flaring	weak-moderate	strong	weak	–	moderate
Anterior keel	strong	moderate	strong	moderate-weak	only distally
Horn-core surface	intensively grooved	moderately grooved	moderately grooved	–	weakly grooved
Postcornual grooves	large-deep	large-deep	large-deep	–	large-shallower
Supraorbital foramens	moderate	small	small	–	small
Supraorbital furrows	–	moderately wide-shallow	moderately wide-shallow	–	very narrow-shallow
Frontal flexion	–	110–130°	~130°	–	~137°

— but not the only — evidence of the genus far outside its presumed place of origin, and together with available chronological data, leads to a more complex zoogeographic scenario.

In an unpublished MTA report and a series of following papers, Ozansoy (1956, 1957, 1965) listed but did not describe the new species of both *Qurliqnoria* and *Olonbulukia* from the marl horizons of Middle Sinap, Turkey. The material on which they are based is unknown and the proposed species obviously represent *nomina nuda* (see also Sen, 2003). Nevertheless, Ozansoy (1956, 1957) also reports from the Lower and Middle Sinap horizons '*Antilope* gen. et sp. indet. II', by reference to Bohlin's, 1937 taxon, material on which it appears to establish later *Capra bohlini* Ozansoy, 1965. '*Capra*' *bohlini* is also suggested by Gentry (2003) as a likely match for some new material from Locality 49 of Middle Sinap, described under '*Pseudotragus* aff. *capricornis*' (Table 2). The generic affiliations of '*Capra bohlini*' have already been called into question by Bouvrain et al. (1994) and a re-examination of the holotype frontlet in MNHN, Paris (a not registered specimen from Middle Sinap partly illustrated by Ozansoy, 1965, pl. 8, fig. 1, and marked by the prefix TRQ, as most material of the Ozansoy's collection in Paris, and the label 1955-15-31; DSK pers. obs. and additional illustrations provided by D. Geraads) indicates strong similarities with *Q. chorakensis* and *Qurliqnoria* in general (Fig. 3, Table 2): small size (especially compared to other 'protoryxoid' bovids), small supraorbital foramina, large postcornual grooves, short pedicles, weakly flexed frontals, and well-divergent, weakly curved backward and gently flaring outward horn-cores with large oblique angle (≥45°), weak heteronymous torsion, fairly strong anterior keel, and moderate to strong surface grooving (especially anteriorly and posteriorly). We propose therefore *Qurliqnoria* as a most reliable affiliation for the Ozansoy's taxon. Several unpublished horn-core specimens from Middle Sinap in MNHN, Paris, Maden Tetlik ve Arama (MTA) Museum in Ankara and the Natural History Museum of Ege University in Izmir, likely belong to the same species and a complete revision is needed.

Q. bohlini differs from *Q. chorakensis* in the slightly smaller size (Table 2), less divergent, less outward flaring, less compressed and stronger keeled horn-cores. In most respects — apart from the smaller supraorbital foramina and the less acute anterior keel — *Q. bohlini* stands morphologically closer to the type species *Q. cheni* from Qaidam. Ozansoy's type series of *Q. bohlini* includes specimens from both the Lower and Middle Sinap (Ozansoy, 1957, 1965) suggesting a large chronological range covering most of the Vallesian but likely older than 9.5 Ma (e.g., Kappelman et al., 2003), and thus fairly contemporaneous with the Qaidam and Wuzhong records. Gentry's Locality 49 taxon of Middle Sinap, probably represents the same genus; an attribution to the species level is not feasible at the moment, though horn-core compression (~63%) appears closer to the Çorakyerler taxon (Table 2). Locality 49 of Middle Sinap is magnetochronologically dated between 9.2 and 9.0 Ma (Kappelman et al., 2003), an age that might be proved not much older than that of Çorakyerler.

Tekkaya (1974) also referred to as a new genus and species, '*Sinapocerus ozansoyi*', some horn-cores from Middle Sinap, but did not illustrate nor describe the taxon, which apparently becomes another *nomen nudum*. According to Tekkaya (1974) the horn-cores of '*Sinapocerus ozansoyi*' are fully comparable to those of *Antilope* gen. et sp. indet. of Ozansoy from Middle Sinap and therefore good candidates for *Qurliqnoria* as well (D. Geraads, pers. com. to DSK, October 2019).

A far more westward and fairly isochronous record comes from the newly discovered Platania fossil site in Northern Greece, yielding a late Vallesian–early Turolian vertebrate fauna (Vasileiadis et al., 2019). *Tragoreas*? aff. *oryxoides* frontlets from this site can be attributed to *Qurliqnoria* with certain confidence based on the small size, small supraorbital foramina associated by narrow weak furrows, short pedicles, large postcornual grooves, weak frontal flexion, weak heteronymous horn-core torsion, clear outward horn-core flaring, strong compression, and large oblique angle (Table 2). The Platania *Qurliqnoria* appears morphologically closer to the Çorakyerler taxon as concerns horn-core oblique angle, torsion and divergence but differs in the less deep postcornual grooves, weaker horn-core compression (similar to *Q. cheni*), and smoother



Fig. 3. *Qurliqnoria bohlini* (Ozansoy, 1965) from Middle Sinap, (Late Miocene, Turkey). Holotype frontlet in MNHN, Paris (suffix TRQ/1955-15-31 – no catalogue number) originally illustrated by Ozansoy (1965, pl. 8, fig. 1) in rostral (A), lateral (B), and caudal (C) view. Note that the distal part of the left horn-core is restored to a greater length compared to the illustration by Ozansoy (courtesy of D. Geraads). Scale bar = 5 cm.

grooved horn-core surface; more material is certainly needed for appreciating its species status.

5. Conclusions

In contrast with the opinion of Wang et al. (2019), *Qurliqnoria* does not seem to fit the hypothesis of a strictly endemic peri-Tibetan radiation. The similarities between the Tibetan *Q. cheni* and the Anatolian *Q. bohlini* suggest close phylogenetic relationships and allow assuming a mid Vallesian westward propagation of the genus. The south pan-Asian geographic range of *Qurliqnoria*, matches that of the rhino *Chilotherium* Ringström, the giraffid *Samotherium* Major, the ovibovine-like bovids *Plesiaddax* Bohlin, *Urmiatherium* Bohlin, and *Sinotragus* Bohlin, as well as that of some hyaenid taxa, which altogether attest the existence of some kind of biogeographic relations between China and the Balkans during the Late Miocene. In this respect, *Qurliqnoria* could be added to the list of taxa involved in the 'Late Miocene Middle Asiatic Province' proposed by Geraads et al. (2002). This idea of a common biogeographic province of open-like environments, previously put forward by Kurtén (1952), partly contradicts the results of Deng's (2006) analysis (restricted, however, on the Greek and Chinese records), which suggests that the gradually increased diversity and similarity between the *Hipparion* faunas at the edges of this area do not necessarily imply similar environments and proposes that from the late Vallesian onwards the East Asian fauna extended into Europe. Furthermore, the East and West chronological ranges of the Late Miocene taxa of wide Asiatic distribution, indicate that their expansion does not correspond to a single event but to diachronous ones. As the vast majority of Late Miocene mammal associations from the West and East remains distinct at the species level at least (Deng, 2006), a more selective dispersal between China and Anatolia may be presumed, involving taxa of higher ecological tolerance (Samartín, 2012).

Within Anatolia, and based on available but not adequate chronological data, *Q. bohlini* and *Q. chorakensis* seem to be succeeding in time. From the morphological point of view, the former may stand as a possible antecedent of the later, whereas the relationships of the Locality 49 of Middle Sinap and Platania *Qurliqnoria* remain uncertain.

If the Tibetan stem caprines represent ideal candidates for the ancestry of some living Caprini (e.g., Gentry, 1968; Deng et al., 2011; Wang et al., 2019, fig. 6), the Anatolian *Qurliqnoria* might also meet the morphological and geographic requirements of the hypothetical ancestral stock of the *Ammotragus-Arabitragus* lineage, by the fairly short, obliquely set on the frontals, anteriorly keeled and flaring outward horn-cores, the short pedicles and the small supraorbital foramens associated by narrow-shallow furrows. Molecular evidence dates the split of the *Ammotragus-Arabitragus* clade between 5 and 9 Ma (Ropiquet and Hassanin, 2005) in accordance with Anatolian records of *Qurliqnoria*. This hypothesis implies, however, a long ghost lineage, and requires a thorough in-depth study, which is beyond the scope of this paper.

Acknowledgements

Çorakyerler excavations are supported by the Turkish Ministry of Culture and Tourism, the General Directorate of Cultural Heritage and Museums, Ankara University, and the Turkish Historical Society; we are thankful to all of them. Thanks are also due to Wei Dong for fruitful comments and Denis Geraads for valuable suggestions, and information concerning Turkish specimens in his knowledge.

References

Becker-Platen, J.D., Sickenberg, O., Tobien, H., 1975. 3. Vertebraten-Lokalfaunen der Türkei und ihre Altersstellung. In: Sickenberg, O. (Ed.), Die Gliederung des höheren Jungtertiärs und Altquartärs in der Türkei nach Vertebraten und ihre Bedeutung für die internationale Neogen-Stratigraphie. Geologisches Jahrbuch B15, 47–100.

Begun, D.R., Güleç, E.S., Geraads, D., 2003. Dispersal patterns of Eurasian hominoids: implications from Turkey. Deinsea 10, 23–39.

Bibi, F., Güleç, E.S., 2008. Bovidae (Mammalia: Artiodactyla) from the late Miocene of Sivas, Turkey. Journal of Vertebrate Paleontology 28, 501–519.

Bohlin, B., 1937. Eine tertiäre Saugetier-Fauna aus Tsaidam. Palaeontologia Sinica, Series C 14, 1–111.

Böhme, M., Spassov, N., Ebner, M., Geraads, D., Hristova, L., Kirscher, U., Kötter, S., Linnemann, U., Prieto, J., Roussiakis, S., Theodorou, G., Uhlig, G., Winklhofer, M., 2017. Messinian age and savannah environment of the possible hominin *Graecopithecus* from Europe. PLoS One 12 (5), e0177347, http://dx.doi.org/10.1371/journal.pone.0177347.

Bouvrain, G., Sen, S., Thomas, H., 1994. Un nouveau genre d'antilope dans le Miocène supérieur de Sinap Tepe en Turquie. Revue de Paléobiologie 13 (2), 375–380.

Deng, T., 2006. Paleoecological comparison between late Miocene localities of China and Greece based on *Hipparion* faunas. Geodiversitas 28, 499–516.

Deng, T., Wang, X.M., Fortelius, M., Li, Q., Wang, Y., Tseng, Z.J., Takeuchi, G.T., Saylor, J.E., Säilä, L.K., Xie, G.P., 2011. Out of Tibet: Pliocene wooly rhino suggests high-plateau origin of ice age megaherbivores. Science 333, 1285–1288.

Dmitrieva, E.L., Serdyuk, N.V., 2011. Hippotraginae (Bovidae, Artiodactyla, Mammalia) from the late Miocene of Tuva. Paleontological Journal 45, 665–673.

Gentry, A.W., 1968. The extinct bovid genus *Qurliqnoria* Bohlin. Journal of Mammalogy 49, 769.

Gentry, A.W., 1971. The earliest goats and other antelopes from Samos Hipparion Fauna. Bulletin of the British Museum (Natural History), Geology 20, 229–296.

Gentry, A.W., 2003. Ruminantia (Artiodactyla). In: Fortelius, M., Kappelman, J., Sen, S., Bernor, R.L. (Eds.), Geology and Paleontology of the Miocene Sinap Formation, Turkey. Columbia University Press, New York, pp. 332–379.

Geraads, D., 2013. Large mammals from the Late Miocene of Çorakyerler, Çankırı, Turkey. Acta Zoologica Bulgarica 65 (3), 381–390.

Geraads, D., Güleç, E., Kaya, T., 2002. *Sinotragus* (Bovidae, Mammalia) from Turkey and the Late Miocene Middle Asiatic Province. Neues Jahrbuch für Geologie und Paläontologie Abhaldungen 8, 477–489.

Gray, J.E., 1821. On the natural arrangement of vertebrose animals. London Medical Repository 15, 296–310.

Güleç, E.S., Sevim, A., Pehlevan, C., Kaya, F., 2007. A new great ape from the late Miocene of Turkey. Anthropological Science 115, 153–158.

Kappelman, J., Dincan, A., Feseba, M., Lunkka, J.P., Ekart, D., Mcdowell, F., Ryan, T.M., Swisher III, C.C., 2003. Chronology. In: Fortelius, M., Kappelman, J., Sen, S., Bernor, R.L. (Eds.), Geology and Paleontology of the Miocene Sinap Formation, Turkey. Columbia University Press, New York, pp. 41–68.

Kaya, F., Kaymakçi, N., Bibi, F., Eronen, J.T., Pehlevan, C., Erkman, A.C., Langereis, C.G., Fortelius, M., 2016. Magnetostratigraphy and paleoecology of the hominid-bearing locality Çorakyerler, Tuğlu Formation (Çankırı Basin, Central Anatolia). Journal of Vertebrate Palaeontology 36 (2), e1071710, http://dx.doi.org/10.1080/02724634.2015.1071710.

Kaymakçi, N., Özelik, Y., White, S.H., van Dijk, P.M., 2001. Neogene tectonics of the Çankırı Basin (north Central Turkey). Türkiye Petrol Jeologları Dernegi Bülteni 13, 27–56.

Kingdon, J., 1982. Bovids. East African Mammals. An Atlas of Evolution in Africa. Academic Press, London, volume C, part 3, 404 pp.; volume C, part 4, 358 pp.

Köhler, M., 1987. Boviden des türkischen Miozäns (Känozoikum und Braunkholen der Türkei. 28). Paleontología i Evolució 21, 133–246.

Kostopoulos, D.S., 2009. 14. Bovidae. In: Koufos, G.D., Nagel, D. (Eds.), The Late Miocene Mammal Faunas of the Mytilinii Basin, Samos Island, Greece: new collection. Beiträge zur Paläontologie 31, 305–349.

Kurtén, B., 1952. The Chinese *Hipparion* fauna. Societas Scientiarum Fennica, Commentationes Biologicae 13 (4), 1–82.

Ozansoy, F., 1956. Ankara çevresi Neogeninin jeolojik katlari ve memeli fossil faunarali hakkinda. M.T.A. derleme, rop. No. 2357, Ankara (neşredilmemiş) (in Turkish; unpublished report).

Ozansoy, F., 1957. Faunes de mammifères du Tertiaire de Turquie et leur révision stratigraphique. Bulletin of the Mineral Research and Exploration Institute of Turkey 49, 29–48.

Ozansoy, F., 1965. Etude des gisements continentaux et des mammifères du Cénozoïque de Turquie. Mémoires de la Société Géologique de France 44, 1–92.

Ropiquet, A., Hassanin, A., 2005. Molecular evidence for the polyphyly of the genus *Hemitragus* (Mammalia, Bovidae). Molecular Phylogenetics and Evolution 36 (1), 154–168.

Ruan, X.D., He, P.J., Zhang, J.L., Wan, Q.H., Fang, S.G., 2005. Evolutionary history and current population relationships of the chiru (*Pantholops hodgsonii*) inferred mtDNA variation. Journal of Mammalogy 86 (5), 881–886.

Samartín, I., 2012. Historical biogeography: Evolution in time and space. Evolution: Education and Outreach 5, 555–568.

Sen, S., 2003. History of paleontologic research in Neogene deposits of the Sinap Formation, Ankara, Turkey. In: Fortelius, M., Kappelman, J., Sen, S., Bernor, R.L. (Eds.), Geology and Paleontology of the Miocene Sinap Formation, Turkey. Columbia University Press, New York, pp. 1–22.

Sen, S., de Bonis, L., Dalfes, N., Geraads, D., Koufos, G., 1994. The late Miocene mammal localities of Kemiklitepe, Turkey: 1. stratigraphy and magnetostratigraphy. Bulletin du Muséum National d'Histoire Naturelle Section C 16 (1), 5–17.

Sevim, A., Begun, D.R., Güleç, E., Geraads, D., Pehlevan, C., 2001. A new late Miocene hominid from Turkey. American Journal of Physical Anthropology 32 (Suppl), 134–135.

Sickenberg, O., 1975. Die Gliederung des höheren Jungtertiärs und Altquartärs in der Türkei nach Vertebraten und ihre Bedeutung für die internationale Neogen-Stratigraphie. Geologisches Jahrbuch B15, 1–167.

Tekkaya, I., 1974. The Bovidae fauna of Middle Sinap of Turkey. Türkiye Jeoloji Kumuru Bülteni 17, 173–186.

Ünay, E., de Bruijn, H., Suata-Alpaslan, F., 2006. Rodents from the Upper Miocene Hominoid locality Çorakyerler (Anatolia). Beiträge zur Paläontologie 30, 463–467.

Vasileiadis, N., Tsoukala, E., Kostopoulos, D.S., 2019. The late Miocene bovids from Platania (Drama basin, Greece) with description of a new species of *Palaeoryx*. Geobios 55, 57–76.

Wang, S.Q., Yang, Q., Zhao, Y., Li, C.X., Shi, Q.Q., Zong, L.Y., Ye, J., 2019. New *Olonbulukia* material and its related assemblage reveal an early radiation of stem Caprini along the north of the Tibetan Plateau. Journal of Paleontology 93 (2), 385–397.

Wang, X.M., Xie, G.P., Li, Q., Qiu, Z.D., Tseng, Z.J., Takeuchi, G.T., Wang, B.Y., Fortelius, M., Rosenström, F.A., Wahlquist, H., Downs, W.R., Zhang, C.F., Wang, Y., 2011. Early explorations of Qaidam Basin (Tibetan Plateau) by Birger Bohlin — reconciling classic vertebrate fossil localities with modern biostratigraphy. Vertebrata PalAsiatica 49, 285–310.

Wang, X.M., Li, Q., Qiu, Z.D., Xie, G.P., Wang, B.Y., Qiu, Z.X., Tseng, Z.J., Takeuchi, G.T., Deng, T., 2013a. Neogene mammalian biostratigraphy and geochronology of the Tibetan Plateau. In: Wang, X.M., Flynn, L.J., Fortelius, M. (Eds.), Fossil Mammals of Asia, Neogene Biostratigraphy and Chronology. Columbia University Press, New York, pp. 274–292.

Wang, X.M., Li, Q., Xie, G.P., Saylor, J.E., Tseng, Z.J., Takeuchi, G.T., Deng, T., Wang, Y., Hou, S.K., Liu, J., Zhang, C.F., Wang, N., Wu, F.X., 2013b. Mio-Pleistocene Zanda Basin biostratigraphy and geochronology, pre-Ice Age fauna, and mammalian evolution in western Himalaya. Palaeogeography, Palaeoclimatology, Palaeoecology 374, 81–95.