



General palaeontology, systematics and evolution

## Şerefköy-2, a new Late Miocene mammal locality from the Yatağan Formation, Muğla, SW Turkey

*Şerefköy-2, une nouvelle localité à mammifères du Miocène supérieur de la Formation Yatağan, Muğla, Sud-Ouest de la Turquie*

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### ABSTRACT

Here we report on a new fossil locality, Şerefköy-2, from the Yatağan Basin of southwestern Turkey that preserves a well-sampled, abundant, and diverse mammal fauna. Indeed, after three field seasons, more than 1200 catalogued specimens representing 26 mammal species belonging to 14 genera make the Şerefköy-2 mammalian assemblage one of the richest Late Miocene fauna from Anatolia. Five hipparionines, six bovids, including the rare and enigmatic *Urmitherium rugosifrons* and the presence of *Plioherax graecus*, strongly support affinities with Late Miocene faunas from Samos Island, Greece. Through a consideration of the identified material and the subsequent comparison with material from well-known Balkan and Anatolian faunas, a Middle Turolian (MN12) age for Şerefköy-2 is indicated.

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### R É S U M É

Nous présentons ici une nouvelle localité à fossiles, Şerefköy-2, du bassin de Yatağan dans le Sud-Ouest de la Turquie, qui a fourni une faune abondante et diversifiée de mammifères. En effet, après trois missions de terrain, plus de 1200 spécimens catalogués représentant 14 genres de mammifères distribués en 26 espèces font de Şerefköy-2 une des localités les plus riches du Miocène terminal d'Anatolie. Cinq taxons d'hipparionines, six bovidés, incluant le rare et énigmatique *Urmitherium rugosifrons* et la présence de *Plioherax graecus*, soutiennent une affinité nette avec les faunes fini-miocènes de Samos, Grèce. L'étude du matériel identifié et les comparaisons avec les faunes les mieux documentées des Balkans et d'Anatolie indiquent une corrélation de la faune de Şerefköy-2 avec le Turolien moyen (MN12).

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## 1. Introduction

There are few published Late Miocene mammal fossil localities from the Yatağan Basin of southwestern Turkey. From the mid-1950s until 2000, only six sites have been reported and most faunal lists are based on small local collections. Based on a similar lithostratigraphic sequence of Middle–Upper Miocene deposits, Kostopoulos et al. (2009) suggested a possible correlation between several western Anatolian basins including the Yatağan Basin (Muğla, Turkey) and the Mytilinii Basin (Samos, Greece; Kostopoulos et al., 2003; Koufos et al., 2009; Solounias, 1981). Accordingly, biogeographic similarities between the Turolian mammal faunas of Samos and western Anatolia were proposed (Kostopoulos, 2009a). Features of this bioprovince include multiple hipparionine lineages in combination with palaeotragines and medium to large-sized antelopes including “ovibovine”-like bovids and gazelles, with only a few boselaphines. Notably absent from this bioprovince (Samos plus western Anatolia) is the Turolian cercopithecoid primate, *Mesopithecus*, despite its wide occurrence from the Balkans to central Asia (Heintz et al., 1981; Koufos, 2009a). Here we report on a new fossil locality, Şerefköy-2, in the Yatağan Basin of southwestern Turkey that preserves a well-sampled, abundant, and diverse mammal fauna and offers the chance to test correlations between Greek and Turkish basins as well as to complete our knowledge of the biochronologic framework of western Anatolia.

## 2. History

Anatolia has yielded more than 200 Neogene micro- and macro-mammal faunas with an abundant taxonomic record. However, this abundant fossil record has resulted in comparatively few publications. The Yatağan Basin, a Southeast-trending graben ~15 km wide and ~50 km long located near the town of Muğla on the southern flank of the Menderes Massif (Alçiçek, 2010), includes more than 20 fossil mammal localities and preserves the richest taxonomic record for western Anatolia.

The presence of mammal fossils in this basin has been well known to locals since primeval times (Mayor, 2000). Dr G. Otkun was probably the first to formally collect fossil vertebrates from the basin in 1942 from a locality known as “Akgedik-Bayır” named after “Bayırköy” village located in the center of the Yatağan Basin. The locality occurs in the basal-most part of the upper member of the Yatağan Formation and is considered to be Late Miocene in age, although the exact geographical position of the fossiliferous site has never been mentioned (Atalay, 1980). The Otkun collection was transferred to the Mineral Research and Exploration General Directorate Museum (MTA)–Ankara and subsequently studied by Ozansoy (1951).

During 1965–1969, a joint project called “Lignite Deposit Exploration in Turkey” and conducted by a group of German and Turkish geologists, led to the discovery of new fossil mammal localities throughout western and central Anatolia including four of them from the Yatağan Basin (Becker-Platen, 1970; Sickenberg et al., 1975). The richest

of these was “Eski Bayırköy” which is located close to original Bayırköy locality even though it has a quite different faunal list and was considered to be somewhat younger (Fig. 1; Sickenberg et al., 1975). Most of the material recovered from “Eski Bayırköy” was transferred to museums and institutions in Germany and Switzerland and is still housed there; unfortunately it seems to be mixed with the old collection of “Bayırköy” fauna in the MTA museum. Within this rich collection, only bovids (Köhler, 1987), equids (Staesche and Sondaar, 1979), and carnivora (Schmidt-Kittler, 1976) have been described so far.

In the mid-1970s, Atalay, from the MTA–Ankara, studied the geology and biostratigraphy of Yatağan region and located four new rich mammalian localities referred to as Salihpasalar–Kemikalan, Salihpasalar–Karaağaç, Şerefköy and Madenler, all of which were found in the redbed unit of the lower member of the Upper Miocene Yatağan Formation, (Atalay, 1980). Of these, Salihpasalar–Kemikalan, situated 5 km to the east of Salihpasalar village, was the most productive. Specimens from these localities are housed at the MTA Museum (Kemikalan, Karaağaç, Şerefköy and Madenler) and at the Ege University Natural History Museum (EUNHM; Kemikalan, Karaağaç, Şerefköy). The faunal assemblages for these sites are characterized by a large diversity of bovids and giraffids (Kaya et al., 2008).

The new Şerefköy-2 locality, situated near the Şerefköy village 9 km east of Yatağan town, has the richest and most diverse fauna after Kemikalan (Atalay, 1980; Kaya, 1991; Kaya et al., 2008). It shares almost all the same common faunal elements with Kemikalan, with the exception of *Hyxtrix primigenia*, which is known in Şerefköy-1 (van Weers and Rook, 2003). In the early 1990s, a EUNHM team led by Dr T. Kaya conducted fieldwork at Şerefköy and Kemikalan localities which led to publication of preliminary results describing the occurrence of *Cremohipparion matthewi*, *Diceros neumayri* (Kaya, 1991) and *Protragelaphus skouzesi* (Geraads and Güleç, 1999).

In the summer of 2007, a team of the Natural History Museum of the Ege University of Izmir (EUNHM: TK, SM, AT and SK) discovered a new locality, Şerefköy-2, situated 9 km to the east of Yatağan town, 1 km to the northwest of Şerefköy village and 450 m to the north of Şerefköy locality. Preliminary collections in the summer of 2007 resulted in over 200 fossil specimens. In the summers of 2008 and 2009, the project was expanded to the current international collaboration including Turkish, American, French and Greek members. Systematic fossil collection at Şerefköy-2 has resulted in the recovery of 1200 specimens stored in the EUNHM and preliminary results concerning the Şerefköy-2 geology and fauna are discussed here.

## 3. Geology and stratigraphy

The Yatağan Basin is one of the western Anatolian Neogene depressions situated on the southern flank of the Menderes Massif (Alçiçek, 2010) (Fig. 1). The sedimentary succession in the basin was first described and dated by Becker-Platen (1970), who considered it to be a single formation and divided it into the Turgut, Sekköy, Yatağan and

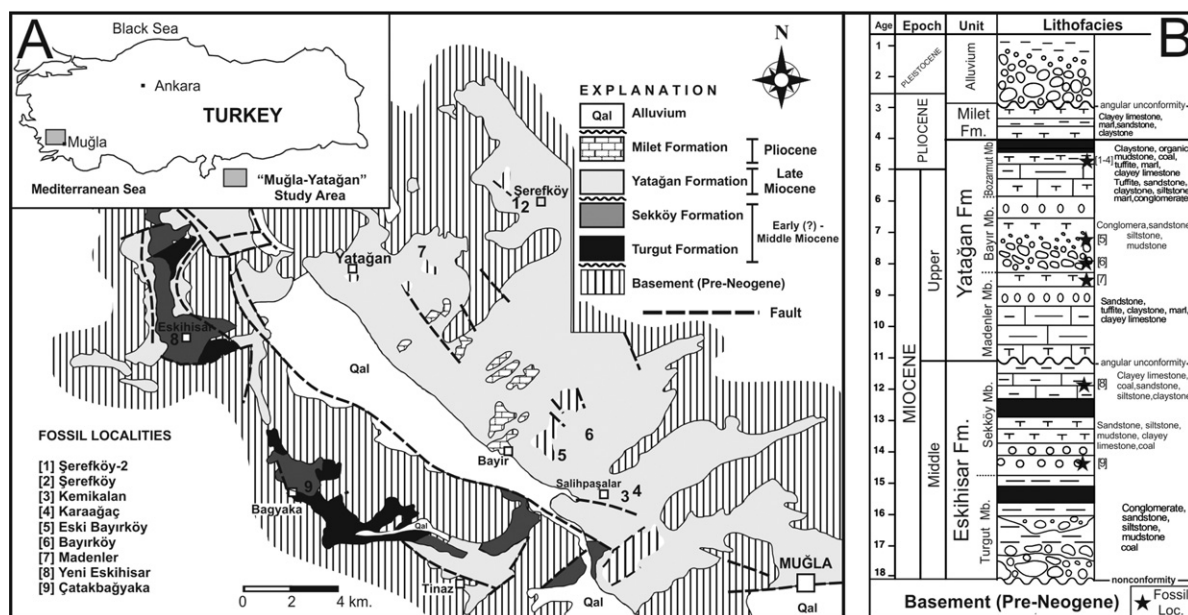


Fig. 1. Geological map (A; modified after Inaner et al., 2008) and lithostratigraphy (B) of the Yatağan Basin with fossil mammal localities.

Fig. 1. Carte géologique (A; modifié d'après Inaner et al., 2008) et lithostratigraphie (B) du bassin de Yatağan, avec les localités à mammifères fossiles.

Milet members. More recently, Atalay (1980) has revised this lithostratigraphy and distinguished three units:

- the Eskihsar Formation, including the Turgut and Sekkøy members;
- the Yatağan Formation, including Madenler, Bayır and Bozarmut members;
- the Millet Formation (Fig. 2). All of the Neogene units are overlain unconformably by Quaternary alluvium.

The fossil bearing redbed unit outcrops in the Şerefköy-2 fossil locality area as the Yatağan Formation reaching up to 100 m thickness and overlies the metamorphic rock units of the Menderes Massif. The redbed unit is a typical upward fining succession that is slightly tilted toward the south by neotectonic deformations. The unit includes alternating conglomerates, sandstones, siltstones and mudstones representing an alluvial flood plain depositional environment with braided stream channels (Fig. 2). Conglomerates are fine to coarse-grained with subangular to subrounded gravel of pebble to cobble grade. These deposits are matrix to clast-supported, moderately to poorly sorted and filled with a poorly sorted matrix of sand, granule and fine gravel with a lateral extent of several hundreds of meters. The bulk of the unit leans against the basin-margin with a normal fault contact to the north. The single-storey paleochannels vary between 10–60 m in width and 1.5–3 m in depth and generally lacked both grading and stratification with limited lateral extent. The coarse-grained, conglomeratic facies consisting of single-storey fluvial paleochannels and alternating mudstone facies are interpreted to comprise deposits from stream-dominated distal alluvial fans.

#### 4. Fauna

**CARNIVORA:** Şerefköy-2 preserves a carnivoran assemblage typical for the Late Miocene (Turolian) of Eastern Mediterranean (Table 1). With the exception of *Paramachairodus*, all reported taxa have already been listed

Table 1  
Preliminary faunal list for Şerefköy-2.

Tableau 1  
List préliminaire de la faune de Şerefköy-2.

Carnivora	Felidae	<i>Machairodus giganteus</i> <i>Felis attica</i> <i>Paramachairodus orientalis</i>
	Hyaenidae	<i>Adcrocuta eximia eximia</i>
	Ursidae	? <i>Ursavus</i> sp.
	Mustelidae	<i>Parataxidea</i> cf. <i>maraghana</i>
Hyracoidea	Pliohyracoidea	<i>Pliohyrax graecus</i>
Perissodactyla	Rhinocerotidae	<i>Diceros neumayri</i> <i>Dihoplus</i> sp.
	Chalicotheriidae	<i>Ancylotherium pentelicum</i>
	Equidae	<i>Cremohipparion</i> sp. type 1 <i>Cremohipparion</i> sp. type 2 "Hipparion" sp. type 1 "Hipparion" sp. type 2 <i>Hippotherium brachypus</i>
Artiodactyla	Suidae	<i>Microstonyx major</i>
	Bovidae	<i>Urmitherium rugosifrons</i> <i>Gazella</i> sp. <i>Sporadotragus</i> sp. <i>Skoufotragus</i> sp. <i>Palaeoryx</i> sp.
	Giraffidae	<i>Palaeotragus rouenii</i> <i>Samotherium</i> sp.
Tubulidentata	Orycteropodidae	<i>Orycteropus gaudryi</i>
Proboscidea	Gomphotheriidae	<i>Choerolophodon pentelici</i>
	Deinotheriidae	<i>Deinotherium</i> sp.

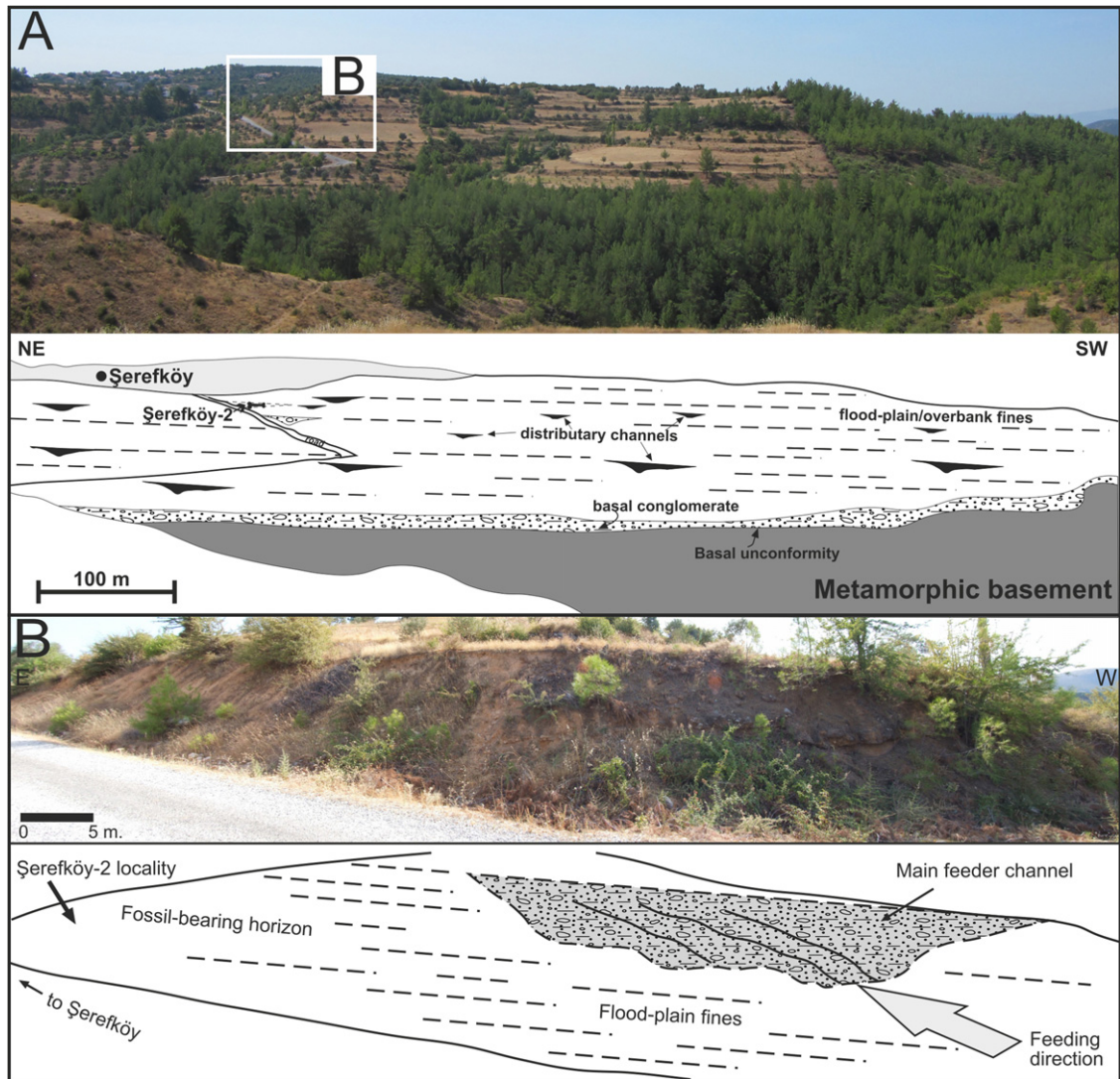


Fig. 2. Panoramic view of the Şerefköy fossil locality (A) and the sketch showing the main rock units cropped out in the Şerefköy locality (B).

Fig. 2. Vue panoramique (avec croquis) de la localité de Şerefköy-2 (A) et détails (avec croquis) (B) présentant les principales unités à l'affleurement sur la localité de Şerefköy (B).

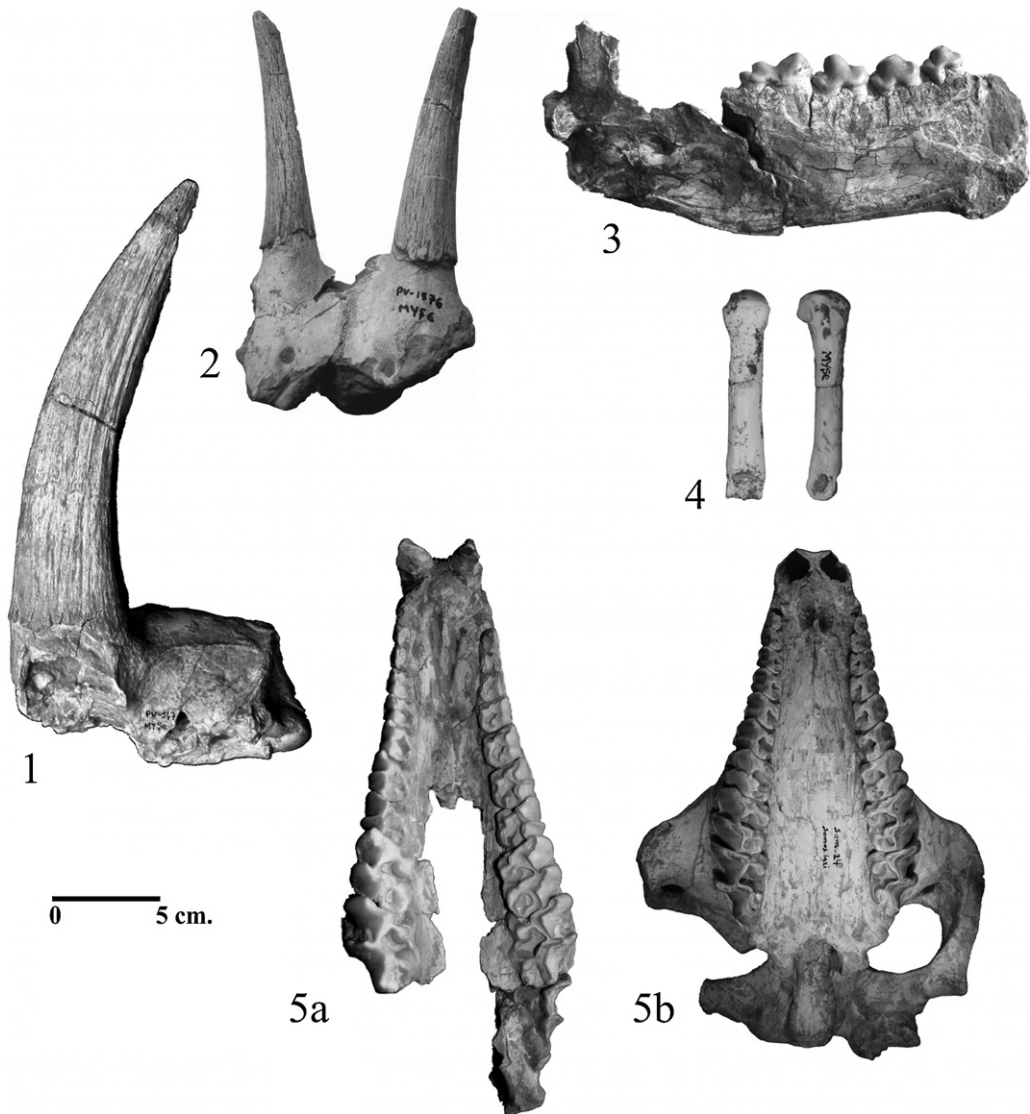
for the Samos fauna (Koufos, 2009a). The large bone-cracking hyaenid, *Adcrocuta eximia* was mainly reported from several Late Vallesian to Late Turolian (MN10-13) localities ranging from Spain to China (Turner et al., 2008). The Şerefköy-2 mandible (Fig. 3) fits well within the size range given for the more common Turolian subspecies of *A. e. eximia* and clearly differs from the Late Vallesian form *A. e. leptorlycha* in having more robust premolars.

The only mustelid from Şerefköy is *Parataxidea* cf. *maraghana*, which originated in Old World, and has been known in Eurasia from Early-Late Turolian localities from Samos, Greece to China (Koufos, 2009b). Felids are relatively well represented and grouped into three size classes. The small feline from Şerefköy-2 looks most similar to a lynx-like felid from Pikermi which was referred to *Felis attica* that has also been recorded from various Early-Late Turolian Eurasian localities (Roussiakis,

2002). The other felids are the medium and large-sized machairodonts, *Paramachairodus orientalis* and *Machairodus giganteus* respectively. Sympatry of two machairodont felids was also recorded from other Turolian localities (Salesa et al., 2006).

A single record of an ursid is the distal part of a fibula of an *Ursavus*-sized species.

**HYRACOIDEA:** the most remarkable discovery at Şerefköy-2 is a hyracoid skull (MYSE-PV1500) referred here to *Pliohyrax graecus* (Fig. 3). This well-preserved skull is morphologically similar to that of *P. graecus* from Samos (NMB-21) (Fischer and Heizmann, 1992). However, compared to all other large pliohyracids from Eurasia, MYSE-PV1500 differs by its broader M2 and M3 (M<sup>2</sup> Length = 37.9 mm and Width = 31.9 mm; M<sup>3</sup> Length = 45.0 mm) which are large compared to those of Anatolian (Kemiklitepe, Garkın, Eşme-Akçaköy,



**Fig. 3.** Fossil material found at Şerefköy-2: two horncores of *Skoufotragus* male (1) and female (2), *Adcrocuta eximia eximia* mandible (3), *Orycteropus gaudryi* metapodial (4) and the *Pliohyrax* skull from Şerefköy-2 (5a; MYSE-PV1500) in comparison with the one from Samos (5b; Sa24-NHM Basel, Switzerland).  
**Fig. 3.** Matériel fossile de la localité de Şerefköy-2 : deux chevilles osseuses de *Skoufotragus* mâle (1) et femelle (2), une mandibule de *Adcrocuta eximia eximia* (3), un métapode attribué à *Orycteropus gaudryi* (4) et le crâne de *Pliohyrax* de Şerefköy-2 (5a; MYSE-PV1500), comparé avec celui de Samos (5b; Sa24-NHM Bâle, Suisse).

Kayadibi), Greek (Pikermi, Samos and Halmyropotamos) and Spanish (Casablanca) specimens (Baudry, 1994; Heissig, 1999; Hünermann, 1985; Koufos, 2009c; Melentis, 1966; Pickford, 2009; Pickford and Fischer, 1987; Pickford et al., 1997). This general evolutionary trend in the European *Pliohyracoidea* – best quantified by the increase in the upper molar dimensions compared to premolar ones due to mesiodistally elongated ectoloph – has already been recorded in the enigmatic Pliocene forms, *Sogdohyrax* from Tadjikistan and *Kvabebihyrax* from Georgia (Dubrovo, 1978; Vekua, 1972). Furthermore, the most recent studies synonymized *Sogdohyrax* with *Pliohyrax* (Pickford, 2009; Qiu et al., 2002). We agree with this conclusion given the similarities of *Sogdohyrax* with the Şerefköy-2 material.

**PERISSODACTYA:** the hipparionine remains of Şerefköy-2 are well represented by more than 630 specimens and constitute more than 50% of the whole fauna by number of identified specimens (NISP). We may well distinguish four or possibly five hipparionine species in terms of dental and postcranial morphology and size: two small-sized (types 1 and 2), two medium-sized (types 1 and 2) and a large-sized species. The small-sized species is referred here to *Cremohipparion*. The medium-sized species is herein simply referred to as species of “*Hipparion*” while the large form is referred here as *Hippotherium brachypus*.

The first small-sized form (*Cremohipparion* sp. type 1) is characterized by a moderately long and broad muzzle.

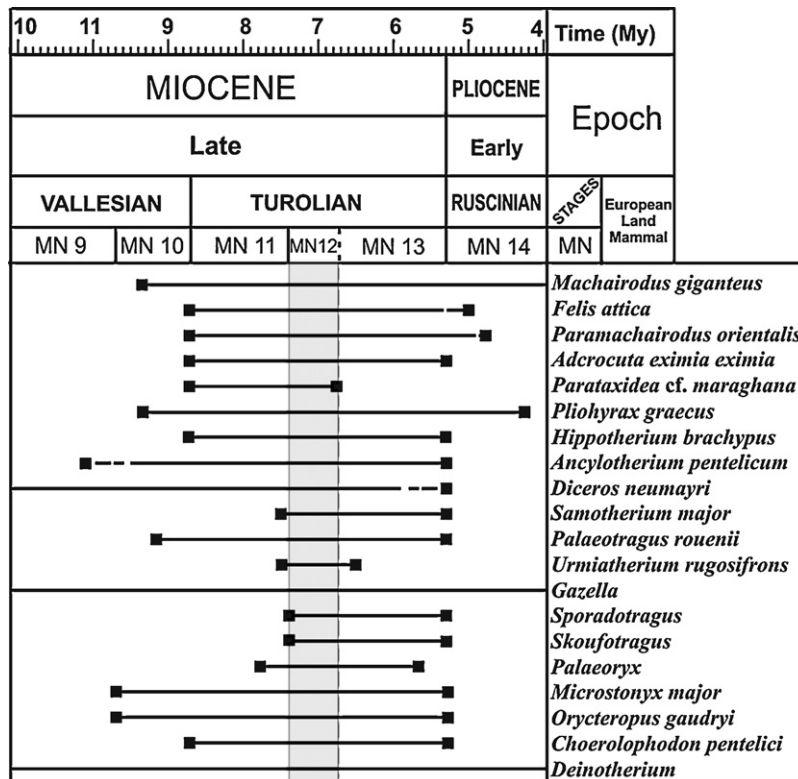


Fig. 4. Biostratigraphic range of some taxa and biochronologic interpretation of the Şerefköy-2 fauna.

Fig. 4. Distribution biostratigraphique de quelques taxons et interprétation biochronologique de la faune de Şerefköy-2.

The other small-sized form (*Cremohipparion* sp. type 2) is characterized by a short symphysis and narrower muzzle compared to type 1. The medium-sized hipparions are common with abundant postcrania. The medium-sized type 1 form is characterized by a short and broad muzzle. The medium-sized type 2 form (with more elongated muzzle than the medium-sized type 1 form) has some metrical similarities with *Cremohipparion mediterraneum* including elongated metapodials. The large-sized form cannot be differentiated from *H. brachypus*. In sum, the Şerefköy-2 hipparions are consistent with an Early-Middle Turolian age (Fig. 4).

The rhinocerotid fossils from Şerefköy-2 constitute ~6% of the Şerefköy-2 fauna by NISP and include two species. *Diceros neumayri* which is the most common species in Anatolia (such as Sinap, Akkaşdağı, Gülpınar and Kemiklitepe A/B) and Southeast Europe during the Late Miocene is represented by only postcranial specimens (Antoine and Saraç, 2005; Kaya, 1994; Kaya and Forsten, 1999). An additional astragalus, which has a subcircular sustentacular facet and a wide contact with the distal calcaneal facet, shares these characters with *Dihoplus pikermiensis* from Samos. Until more diagnostic material is collected and studied, the second rhino taxon is tentatively assigned to *Dihoplus* sp.

Limited numbers of chalicotheres remains are similar in size to *Ancylotherium pentelicum* which is known from several Turolian localities in the eastern Mediterranean (Kaya, 1991; Saraç et al., 2002).

**ARTIODACTYLA:** in general, the artiodactyl association of Şerefköy-2 points to a middle Turolian age. *Microstonyx major* (here represented by five specimens including a dorso-ventrally crushed skull) is a widespread polymorphic large suine, present in most Turolian faunas from Spain to northern China. Its first occurrence probably dates back to the Latest Vallesian and it is still present at the end of the Turolian (Liu et al., 2004).

The earliest records of the slender palaeotragine *Palaeotragus rouenii* are also known from Late Vallesian sites of the Black Sea-Aegean region but the species becomes more frequent and maximally distributed during the Middle-Late Turolian (Kostopoulos and Koufos, 2006). *Samotherium* from Şerefköy-2 represents a large morphotype, dimensionally similar to *S. major* from the upper fossiliferous horizons of Samos, Greece and Kemiklitepe A/B, Turkey. According to Kostopoulos (2009b) *S. major* replaces the smaller *S. boissieri* at the beginning of the Middle Turolian, ca. 7.5 My ago. These Şerefköy-2 giraffids make up ~6% of the fauna by the number of identified specimens (NISP).

The Bovidae (at ~12% by NISP) are the second most common elements of the Şerefköy-2 fauna after the hipparionines. Both *Sporadotragus* and *Gazella* are common Turolian faunal elements with a rather wide temporal distribution. Their co-occurrence at Şerefköy-2 with *Skoufotragus* (Fig. 3) and *Palaeoryx* is, however, rather indicative of a Middle Turolian age, which is in full agreement with the presence of *Urmiatherium rugosifrons*, known until now only from the main fossil horizons of

Samos (Kostopoulos, 2009c). Indeed, the artiodactyl association of Şerefköy-2 looks very similar to the so-called “Dominant Bovid Assemblage” of Samos, dated to ca. 7.2–7.0 My (Kostopoulos, 2009c).

**TUBULIDENTATA:** this is the least known element of the Şerefköy-2 fauna represented by only a single recovered metapodial (Fig. 3). However, this specimen is morphologically and metrically consistent with *Orycteropus gaudryi* which is present but rare in Anatolia (Mahmutgazi, Kayadibi, and Kemiklitepe A/B) and Greece (Samos, Pikeremi) during the whole Turolian (Lehmann et al., 2005, 2006; Saraç, 2003).

**PROBOSCIDEA:** despite the small number of specimens referred to this order, two taxa can clearly be distinguished. The most common gomphothere of the Southeast Mediterranean during the Late Miocene, *Choerolophodon pentelici*, is represented by right metacarpals belonging to a juvenile individual. Some additional molar fragments also display the typical morphology of this taxon. The second taxon, represented by a quite slender MCIII and a large astragalus appears to be a specimen of *Deinotherium*. Although the sympatry of both taxa is not a common case in the rich Miocene faunas of the Southeast Mediterranean, it has been recorded from the Late Vallesian (Sinap, Yulafli and Kalfa) to Early-Middle Turolian localities (Pikeremi, Samos, Halmyropotamos) (Geraads et al., 2005; Konidaris and Koufos, 2009; Sanders, 2003).

## 5. Conclusions

Although the rich fossil sites of the Yatağan Basin have been known for almost 70 years, they have received limited attention despite some previous reports of faunal remains (Atalay, 1980; Saraç, 2003). With over than 1200 catalogued specimens including 14 mammal genera and 26 species collected during three field seasons, the Şerefköy-2 fauna is one of the richest Turolian faunas from Anatolia in terms of both diversity and abundance. It is comparable only to Akkaşdağı (Karadenizli et al., 2005) and Kemiklitepe (Sen et al., 1994). As it includes representatives of most of the common mammal taxa from the Turolian, the Şerefköy-2 fauna has the potential to illuminate Late Miocene paleobiology and paleoecology.

Similarities to the fauna of Samos are evident in terms of both taxonomic composition and the relative abundances of these taxa (e.g., ~50% hipparionine and ~12% bovid) although some Samos localities have a much larger giraffid component (Koufos et al., 2011). Most of the medium-sized herbivores (equids and bovids) in the Turkish fauna are considered to be either grazers or mixed-feeders (Koufos et al., 2009; Merceron et al., 2006; Solounias et al., 1999) indicating at least somewhat open environments clearly dominated by mosaic habitats; i.e. woodlands/bushlands combined with open areas including a wealthy herbaceous layer dominated by graminoids with forbs. The amphibious type adaptation for the giant hyrax of the Eurasian Neogene (Pickford, 2009), suggests the existence of well-watered spots (ponds, lakes or swamps) in the basin. Moreover, the dominant occurrence of felids and a single ursid taxon, which is a rare element of Turolian faunas, indicate a closed environment or at least mosaic habitats. The presence of

*Deinotherium* and *Ancylotherium*, which are assumed to share the same kind of habitat, is also consistent with this conclusion. The stratigraphic occurrence of the identified material and the subsequent comparison with those of well-known Greek and Anatolian faunas indicate a Middle Turolian (MN12) age for Şerefköy-2 (Fig. 4).

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