

On the age of the Late Miocene localities of the Kalimantsi fossiliferous area based on *Cremohipparion* (Perissodactyla, Equidae) skull morphology polymorphism

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HRISTOVA L. 2012. On the age of the Late Miocene localities of the Kalimantsi fossiliferous area based on *Cremohipparion* (Perissodactyla, Equidae) skull morphology polymorphism. – *Historia naturalis bulgarica*, **20**: 143-150.

Abstract. A large sample of hipparion fossils, collected by D. Kovachev from the late Miocene localities near the village of Kalimantsi (SW Bulgaria), is stored in the Assenovgrad palaeontological museum. In the absence of data on the exact location for most specimens, it is difficult to make a correlation between the fossils and the stratigraphy of each of the known localities. The specificity of *Cremohipparion mediterraneum* skull morphology and its stage-of-evolution provide information about the probable chronologic range of the localities near Kalimantsi. Based on this information, we estimate the age of the Kalimantsi localities to be correlative between the age of Hadzhidimovo-1, or end of the early Turolian, to about the age of Pikermi, or the middle Turolian. This correlation supports previous assumptions based on the entire fauna appearance.

Key words: SW Bulgaria, Late Miocene, Kalimantsi, *Cremohipparion*

Introduction

A large sample of fossil mammals, collected from the area of Kalimantsi village by D. Kovachev, is stored in the Assenovgrad palaeontological museum (branch of the NMNH – Sofia). About 10 different fossiliferous outcroppings are known from the area, scattered over a vertical distance of about 100 m (SPASSOV et al., 2006). Unfortunately, there are no data about the exact locality for most finds and it is difficult to correlate the fauna with the stratigraphy of the localities and thus to estimate the temporal span of the localities. Kalimantsi-1 was thought to be of Vallesian age on the basis of species identification (NIKOLOV 1972, 1985). The new revisions and field survey (SPASSOV et al, 2006; TZANKOV et al., 2005) changed the former biochronological concepts: all Kalimantsi localities are of Turolian age and there is no evidence of Vallesian faunas there. According to recent data, Kalimantsi-1 seems to belong to the uppermost part of the green clays of the Gradishte Lithocomplex and most probably is of early Turolian age. The age has been based upon the stratigraphy and the presence of a metatarsal fragment of a small hipparion species of uncertain species affiliation. The stratigraphic position of the locality and more coherent sediments support the suggested presence of *C. macedonicum*, a

small-sized hipparion species described from several Vallesian and early Turolian Greek localities. Kalimantsi-2 (Peshternik ravine) may be of approximately the same age. There are no hipparion skulls excavated from Kalimantsi-1. The studied hipparion skull material is from Kalimansti-2, as well as from other fossiliferous outcroppings which are supposed to be of middle Turolian age and belong to the Strumyani Genetic Lithocomplex (SPASSOV et al., 2006).

Material and methods

This study includes skulls of *Cremohipparion mediterraneum* collected by D. Kovachev, now stored at the Palaeontological museum, Assenovgrad. The hipparion skull remains from the Kalimantsi area are poorly preserved; in most cases only the cheek region remains, and often they are crushed and deformed to some degree, preventing the investigation of all morphological details (K10109, K10151, K10135, K10136, K10114, K10112, K10137).

There are 7 juvenile and 7 (K10145, K10111, K10142, K10140, K10108, 10177, 10146) adult skulls of *Cremohipparion* that are comparatively well preserved. Location of the preorbital fossa in relation to the orbit and development of the caninus (= intermediate) fossa are the most important taxonomic features for the goal of this study. During the ontogeny, the length of the preorbital fossa undergoes little morphological change (HRISTOVA, 2009). Preorbital fossa morphological changes that do occur with ontogeny are its overall increase in size and dorsoventral depth; both increase with age. Despite these changes, *Cremohipparion* juveniles and adults are clearly distinguished from other juvenile and adult hipparion species. The presence and shape of the caninus (= intermediate) fossa also does not depend on the individual age of the specimens. Therefore these features could be used for some taxonomic conclusions and estimation of the relative degree of evolution for *Cremohipparion* populations.

Comparisons are made with skulls from samples of the species *C. proboscideum*: Samos – type specimen (after STUDER, 1911 and SONDAAR, 1971), materials from the Geological Institute, Münster, Germany (WEHRLI, 1941), Ravin des Zouaves -5 (KOUFOS, 1987a) and *C. mediterraneum*: samples from Hadzhidimovo-1 (HRISTOVA et al., 2002; HRISTOVA, 2009), Karaslari (SPASSOV et al., in prep.), Perivolaki (VLACHOU et al., 2006) and Pikermi (KOUFOS, 1987b, 1987c). The two species are members of a specific phylogenetic lineage. The locality RZO-5 is probably the earliest one with remains of *C. proboscideum*, dated to early Turolian, MN11 at ~8.2 Ma (KOUFOS, 1987a; VLACHOU & KOUFOS, 2009). The locality Hadzhidimovo-1 could be dated to the late MN11 – MN11/MN12 boundary (SPASSOV, 2002). The locality Perivolaki has an age about 7.3-7.1 Ma (VLACHOU & KOUFOS, 2006). The latest locality with *C. mediterraneum* is Pikermi and it is of uppermost middle Turolian age, MN 12 (KOUFOS, 1987b, 1987c; VLACHOU & KOUFOS, 2009).

Abbreviations

Assenovgrad Palaeontological Museum – APM; Geological Institute, Münster – GIM; Muséum National d'Histoire Naturelle – MNHN; Naturhistorisches Museum, Bern, Switzerland – NHMB; Naturhistorisches Museum Wien – NHMW; Universität Wien – UW; Hadzhidimovo – HD; Kalimantsi – KAL; Karaslari – KAR; Perivolaki – PER; Pikermi – PIK

Description

Of the seven juvenile skulls with well preserved facial region, three have a caninus (= intermediate) fossa. Among them, specimen K10109 (Fig. 1) the M1 of which does not reach the occlusal surface, is remarkable. Its preorbital bar length is 11 mm wide. The preorbital fossa is extremely developed for a juvenile individual – its depth is 23 mm, length is 57.8 mm, height – 49 mm. The preserved part of the caninus fossa shows that it was deep; the bar between the two fossae is pronounced, about 9 mm wide. The degree of development of these features is as in the skulls of the same individual age from the sample of *C. mediterraneum* from Hadzhidimovo (MN11/12). There are no data on juvenile skulls of *C. mediterraneum* with so short preorbital bar and well developed caninus fossa from other localities. Due to the lack of published data about juvenile skulls of *C. proboscideum*, the development of these characters in the earlier ontogenetic stages is not known for this species, and therefore no comparison is possible for the time being.

The skulls of the seven adult specimens are medium-sized (tooth row length about 137-46 mm), the preorbital bar is wider than 20 mm (21.8-32 mm), the posterior border of the preorbital fossa is almost straight. Three of them have a weak caninus fossa. These features could be observed on the skulls of *C. mediterraneum* samples from almost all localities yielding this species (HD, PIK, KAR).

Discussion

The species *Cremohipparion mediterraneum* belongs to one of the most specialized hipparion lineages: *C. proboscideum* – *C. mediterraneum*. There are two opposite views on the direction of evolution in the lineage. BERNOR et al. (1996, 2011), claim that the Pikermi fauna is correlated with the lower Middle Maragheh boundary (MN11/MN12?) and is older than RZO-1 and the bulk of the Samos faunas; therefore the more primitive form is *C. mediterraneum*. VLACHOU & KOUFOS (2006) support the idea that the age of Pikermi is middle Turolian and that *C. mediterraneum* is more evolved than *C. proboscideum*. These authors note that if Pikermi is dated to the MN11/MN12 boundary then the majority of the Greek Late Miocene localities should be dated to the Vallesian, which is not supported by the evolutionary character of the fauna. I share the opinion of the Greek colleagues.

Cremohipparion proboscideum is an early Turolian (MN11) species with an extremely narrow preorbital bar – in all well preserved skulls its width is less than 20 mm (KOUFOS, 1987a; STUDER, 1911; SONDAAR, 1971; STUDER, 1911; VLACHOU & KOUFOS, 2009; WEHRLI, 1941). There are two fossae on its cheek – the preorbital fossa and the caninus fossa. Both are well developed, deep and are separated with a pronounced bar. The posterior border of the preorbital fossa is slightly curved – about its middle portion the lower part overhangs the posterior pocket. Unfortunately, no skull remains from juvenile individuals have been described in the papers which allow no comparison with the juvenile *C. mediterraneum* specimens.

Some of the characters of *C. proboscideum* are preserved in the earlier samples of *C. mediterraneum*. Most probable the earliest sample of this species is from the locality Hadzhidimovo-1 (HRISTOVA et al., 2002) and similarities with *C. proboscideum* are well

visible. About half of the specimens have a shorter preorbital bar, the preorbital fossa is deep, with well developed borders. The caninus fossa exists in ca. 77 % (juvenile) to 87 % (adults) of the well preserved skulls. The subnasal fossa is not as deep as in *C. proboscideum* and is well delineated only posteriorly but the bar between the two fossae is well developed. The skulls with a shorter preorbital bar have slightly curved posterior border of the preorbital fossa as in *C. proboscideum*.

The specimen of *C. cf. mediterraneum* from the locality Perivolaki (VLACHOU et al. 2006) shares the same skull morphology as some specimens from Hadzidimovo-1. The preorbital fossa is situated closer to the orbit, the posterior border is curved. A faint caninus fossa is present. Because of the great intraspecific variability in the species, a single skull permits no observations on the distribution of the different types of the taxonomically important characters in the population. As a consequence it is impossible to conclude about the degree of evolution of the population as a whole. The age of the locality was defined as earliest Middle Turolian (VLACHOU & KOUFOS, 2006).

Probably the latest sample of *C. mediterraneum* is from Pikermi (KOUFOS, 1987b, 1987c). According to VLACHOU & KOUFOS (2006) “*H. mediterraneum* is a medium sized form [...] with deep and triangular to oval anteroventrally oriented preorbital fossa and a small, weakly developed canine fossa in front of the posterior one that becomes almost invisible when the skull is deformed or crushed”. In fact, in the sample from Hadzidimovo and Karaslari there are some well preserved skulls without caninus fossa. There are also several deformed specimens in which the caninus fossa could not be observed. However, the bar between the two facial fossae is recognisable despite of damage and deformation and is thus indicative for the presence of a caninus fossa. Probably not all specimens from Pikermi had a caninus fossa, as in the samples from HD, KAL and KAR.

The preorbital bar in *C. mediterraneum* PIK and KAR is wider than 19-20 mm, even in the juvenile specimens. From Pikermi there is only one specimen with a preserved shallow caninus fossa, PIK 259 (MNHN), while in KAR there are several specimens with this character present. The caninus fossa on the specimens from both localities is less developed than in the HD sample. The posterior border on the skulls from PIK stored at NHMW and UW is straight. Judging from published photos, only specimen PIK 259 (MNHN) has a slightly curved posterior border of the preorbital fossa. In this sample the archaic characters of *C. proboscideum* are almost missing.

Observations on the evolution within the *C. proboscideum* – *C. mediterraneum* lineage with the gradual disappearance of the primitive skull characters permits defining the stratigraphic position of the Kalimantsi fossiliferous spots in relation to the well known localities. The juvenile skull (K10109) of *Cremohipparion mediterraneum* from the area of Kalimantsi village displays primitive morphological characters similar to *C. proboscideum* or the earliest sample of *C. mediterraneum* (HD-1), such as short preorbital bar, deep and large preorbital fossa, well developed caninus fossa, pronounced bar between the two fossae. All of these characters are well expressed despite the young individual age of the specimen. It differs from the Perivolaki skull in the expressiveness of the preorbital fossa and the bar between it and the caninus one. It seems logical to assume that the skull most probably comes from one of the lower stratigraphic levels, close to the KAL-1: KAL-2 (Peshternik ravine), or KAL - Bukovets. This sets the lower limit for the formation of the localities at a time close to the age of Hadzidimovo-1. At the same time, most of the skulls

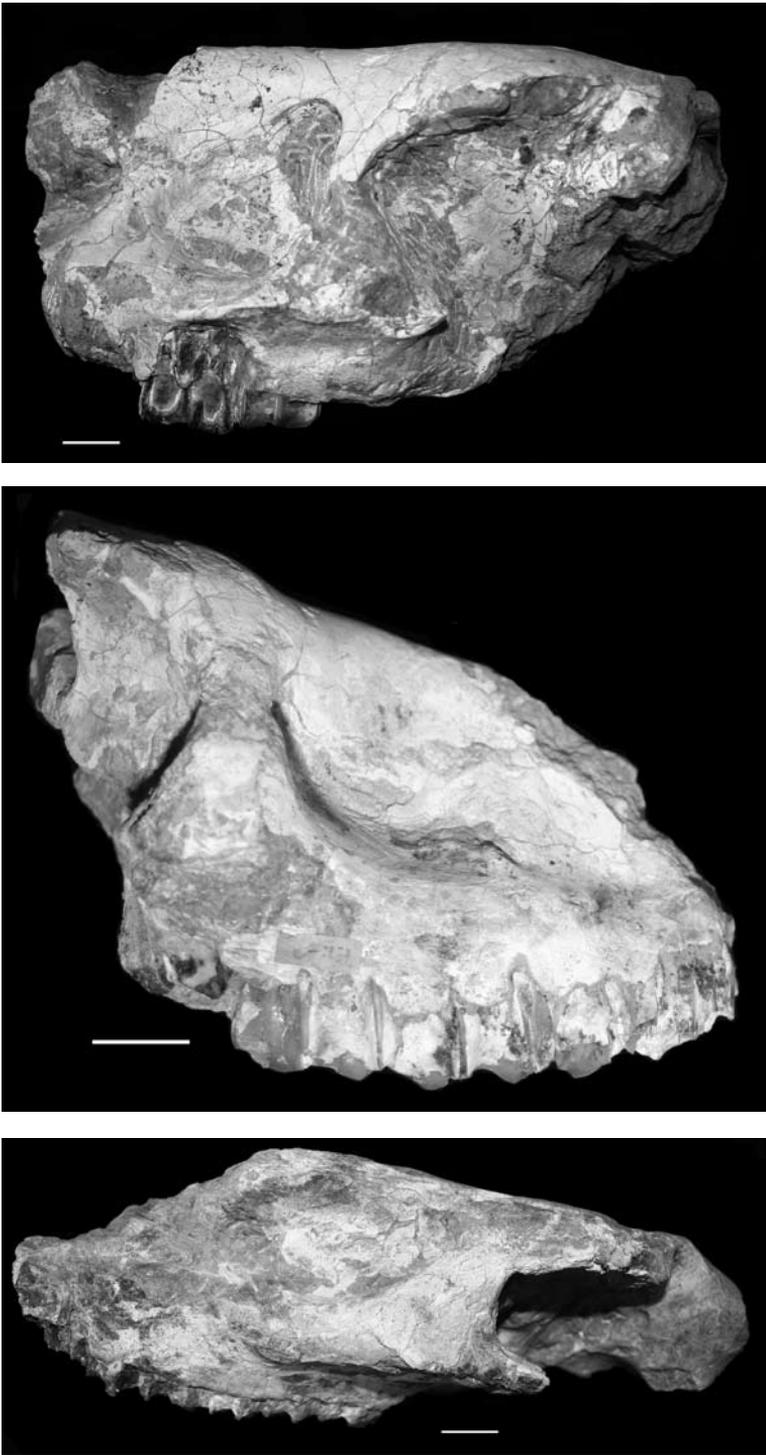


Fig. 1. Skulls of *Cremobiparion mediterraneum* from the Kalimantsi fossiliferous area: juvenile K10109 (A); juvenile K10151 (B); adult K10140 (C). Scale bars – 2 cm.

have a wider preorbital bar and an almost straight posterior border of the preorbital fossa. This could be observed on the sample of *C. mediterraneum* from Hadzhidimovo-1 (about 50% of the specimens), but is more typical for the latest sample of this species – that from Pikermi (about 90%). Therefore the upper limit could be placed at the time level of Pikermi.

Conclusions

Samples of *C. mediterraneum* from different geological ages show a different development of the taxonomic characters and different combinations between these characters. The evolution of the species *C. mediterraneum* in time demonstrates an increasing number of individuals with wider preorbital bar and individuals without caninus fossa. The presence of specimens with morphological features similar to *C. proboscideum* could be used as an indicator for an early age of the given samples of *C. mediterraneum*.

We believe that specimen K10109 displays primitive skull characters and is best correlated as being from the lower Kalimantsi levels (the level near the river bank), as well as that the lower fossiliferous spots such as KAL-2 and KAL-Bukovets are close to the age of Hadzhidimovo-1, and were formed at a time around the early/middle Turolian boundary. The age of the earliest locality near Kalimantsi (KAL-1) could be of a close age, if not earlier – about the latest early Turolian or at the early/middle Turolian boundary. The uppermost localities could be about the age of Pikermi, the uppermost middle Turolian age. This conclusion confirms correlations by previous authors (SPASSOV, 2002; SPASSOV et al., 2006; TZANKOV et al. 2005; GERAADS & SPASSOV, 2009).

Acknowledgements

My visit to Naturhistorisches Museum Wien was financed by the European Union (Synthesys grant AT-TAF-2283). I am pleased to thank those who provided access to collections in their care: G. Daxner-Höck (Naturhistorisches Museum Wien); D. Nagel, W. Raba and E. Iordanova (Universität Wien). Many thanks to D. Kovachev (curator at APM) and his staff for their assistance and hospitality and to N. Spassov for his useful comments on the manuscript. I am very thankful to Prof. R. Bernor for improving the English text and for his valuable reviewer's comments on the manuscript.

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Received: 15.04.2010

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**Относно възрастта на късномиоценските находища в района
на с. Калиманци на базата на черепната
морфология на *Cremhipparion* (*Perissodactyla*, *Equidae*)**

Латинка ХРИСТОВА

(Резюме)

В Палеонтологичния музей в Асеновград се съхранява голямо количество материали от находищата от района на с. Калиманци, ЮЗ България. За голяма част от образците липсват данни за конкретното находище, от което са събрани. Това не позволява да се направи корелация между намерените фосили и стратиграфската позиция на всяко от находищата и да се определи времето, през което са образувани. Един от видовете хипариони, описани от района, е *Cremhipparion mediterraneum*. Специфичните морфологични особености на лицевата част на черепа позволяват да се направят някои изводи за „еволюционния етап на развитие“, на който се намират извадките от този вид от различни находища на Балканите, а това от своя страна позволява да се направят заключения за времето, през което са образувани находищата в района на Калиманци.

В процеса на еволюция на *C. mediterraneum* се наблюдават постепенни промени във фациалната морфология. Извадките на *C. mediterraneum* от находища с по-ранна възраст (ранен туролий) показват наличието на по-голям процент индивиди с морфологични особености, близки до тези на по-ранния вид *Cremhipparion proboscideum*. При тези с по-късна възраст (среден туролий) се наблюдават промени в морфологията, свързани с постепенно увеличаване на дистанцията между предорбиталната ямка (*fossa preorbitalis*) и орбитата, постепенна редукция на междинната ямка (*fossa caninus*), скъсяване на носната изрезка и др. Сред черепите на *C. mediterraneum* от района на с. Калиманци има и череп на млад индивид с морфологични особености, които са характерни за *C. proboscideum* и са представени само в по-ранните извадки на *C. mediterraneum*. Има и голям брой черепи с белези, характерни за по-късните популации на вида. Това дава възможност да се потвърдят направените в предишни публикации заключения за наличието сред находищата от района на такива с възраст късен ранен туролий и среден туролий.