The Bulgarian Chalicotheriidae (Mammalia): an update

Denis GERAADS¹, Nikolaï SPASSOV² & Dimitar KOVACHEV³

Abstract
All available chalicotheriid material from the late Miocene Bulgarian localities is revised. It belongs to three taxa: Ancylotherium pentelicum, Chalicotherium cf. goldfussi and Kalimantsia bulgarica, the former being the most common. The new material of A. pentelicum increases its known variability, but there is still no evidence of evolutionary changes in this species, as the smaller size of the fossils from Hadjidimovo might be explained by sexual dimorphism. On the basis of its forearm and manus morphology, we challenge the view that Ancylotherium was a leaf-eater.

Key-words
Chalicotheriidae, Mammalia, Bulgaria, late Miocene.

INTRODUCTION
More than 40 late Miocene mammalian localities are known in southwestern Bulgaria, along the Mesta and Struma rivers, which flow south through Greece to the Aegean sea. They have been referred recently to several lithostratigraphic complexes (see faunal lists, revised stratigraphy of the Struma localities and map in SPASSOV et al., in press a). The richest areas are Hadjidimovo and Kalimantsi. Hadjidimovo, in the Mesta valley, consists of a main fossiliferous locality (Hadjidimovo-1), which is one of the richest sites of the whole Eastern Mediterranean, and 2 other minor spots, all of them of Turolian age (SPASSOV, 2000). At Kalimantsi, more than 10 sites that are certainly not exactly contemporaneous have been recognized, but all of them are also of Turolian age (SPASSOV et al., in press) and there is no evidence of Vallesian assemblages, in contrast to previous opinions (KOJUMDGIEV et al., 1982). The Kalimantsi and Hadjidimovo faunas are becoming increasingly better known, after the classic monograph of BAKALOV & NIKOLOV (1962), and following the recent systematic studies on the carnivores (KOVACHEV, 1988), Suidae (KOSTOPOULOS et al., 2001), Bovidae (GERAADS et al., 2003 ; SPASSOV & GERAADS, 2004 ; SPASSOV et al., 2004), hipparions (HRISTOVA et al., 2002a, b), and Cercopithecidae (KOFOŠ et al., 2003).

A new Chalicotheriidae, Kalimantsia bulgarica, was recognized at Kalimantsi (GERAADS et al., 2001) and described together with some other chalicotheriid remains. The present paper is a systematic survey of all available Bulgarian chalicotheriid material, sorted by localities. All of them are of Turolian age, since the lowest fossiliferous level at Kalimantsi, which yielded the tooth referred to Metaschizotherium fraasi by NIKOLOV (1972), has an early Turolian, and not Vallesian, fauna. Upper teeth are in uppercase, lower teeth in lowercase. Measurements are in mm. Unless otherwise indicated, all material is kept in the Museum of Paleontology (branch of the NMNH, Sofia), Assenovgrad.

SYSTEMATIC STUDY

Order Perissodactyla OWEN, 1848
Family Chalicotheriidae GILL, 1872
Sub-family Schizotheriinae HOLLAND & PETTERSON, 1913
Genus Ancylotherium GAUDRY, 1863

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**Ancylotherium pentelicum** *(GAUDRY & LARTET, 1856)*

**Strumyani-1**
The medial half of a right talus (FM-2027, NMNH Sofia) is the only chalicothere remain from the new locality of Strumyani-1 (= Ilindentsi). The tibial facet is very rounded, the navicular facet is strongly convex transversely, and narrows sharply laterally. This preserved part of the talus does not significantly differ from other Bulgarian tali (see below, and GERAADS et al., 2001), and we refer it to *Ancylotherium*. Their measurements are given in Table I.

**Hadjidimovo-Tumbichkite (HD-2)**
From this locality, which is distinct from the main Hadjidimovo locality (HD-1), we have a duplex of very large size, HD-2-713 (Table II), probably gnawed by a hyena, and both rami (lacking the symphyseal part) of a lower jaw, HD-2-712 (Pl. I, fig. 5).

The depth of the mandibular ramus decreases regularly from rear to front, and the lower border is almost straight, as in a specimen from Pikermi, whereas that from Veles is convex below the premolars *(GAREVSKI & ZAPFE, 1983, resp. figs 5B and 4B)*. The anterior edge of the ascending ramus is extremely oblique, as in the Pikermi specimen, and therefore quite distinct from the American genera *Moropus* and *Tylocephalonyx* *(COOMBS, 1978, 1979)*. The level of the rear part of the symphysis is intermediate between both other specimens. The mandible is broken anteriorly at the level of a hole, 37 mm before p2 (Pl. I, fig. 5b). This hole is clearly homologous with the similarly located “Sediment erfülltes Loch” mentioned by *GAREVSKI & ZAPFE* (1983), on the Veles specimen, and attributed by them to a canine alveolus. This interpretation is, in our opinion, hardly tenable, as already surmised by *COOMBS* (1989), because no mental foramen is visible behind it, and this hole must be the mental foramen itself.

On the specimen from Pikermi *(GAREVSKI & ZAPFE, 1983*, Table I: Comparative measurements of talus

<table>
<thead>
<tr>
<th></th>
<th>Maximum width</th>
<th>Medial height</th>
<th>Lateral height</th>
<th>Medial depth (A-P)</th>
<th>Depth distal facet (A-P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strumyani, FM-2027</td>
<td>-</td>
<td>71</td>
<td>-</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Kalimantsi, K-708</td>
<td>110</td>
<td>68</td>
<td>70</td>
<td>77</td>
<td>58</td>
</tr>
<tr>
<td>Kalimantsi, K-608</td>
<td>102.5</td>
<td>62.5</td>
<td>61</td>
<td>67</td>
<td>45</td>
</tr>
<tr>
<td>Pinaryaka (Turkey) *</td>
<td>101</td>
<td>70</td>
<td>61</td>
<td>57</td>
<td>48</td>
</tr>
<tr>
<td>Salıhpasalar (Turkey) *</td>
<td>108</td>
<td>65</td>
<td>63</td>
<td>-</td>
<td>46</td>
</tr>
<tr>
<td>Pikermi, Vienna, Athens**</td>
<td>105-122</td>
<td>70-79</td>
<td>62-78</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pikermi, BM M11431</td>
<td>112</td>
<td>76.5</td>
<td>75</td>
<td>76</td>
<td>-</td>
</tr>
<tr>
<td>Pikermi, BM M11432</td>
<td>104.5</td>
<td>69.5</td>
<td>64</td>
<td>65</td>
<td>-</td>
</tr>
</tbody>
</table>

* From SARAÇ et al., 2002; ** N = 3, from ROUSSIAKIS & THEODOROU, 2001

Table II: Comparative measurements of duplex

<table>
<thead>
<tr>
<th></th>
<th>Max. length</th>
<th>Length phal.1</th>
<th>Prox. width</th>
<th>Distal width phal. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD-2-713</td>
<td>-</td>
<td>-</td>
<td>73</td>
<td>71</td>
</tr>
<tr>
<td>HD-662</td>
<td>-</td>
<td>112.5</td>
<td>57</td>
<td>52.5</td>
</tr>
<tr>
<td>K-711</td>
<td>-</td>
<td>-</td>
<td>ca. 70</td>
<td>63</td>
</tr>
<tr>
<td>Pinaryaka *</td>
<td>178-182</td>
<td>122-124</td>
<td>72-74</td>
<td>-</td>
</tr>
<tr>
<td>Pikermi, Halmyropotamos, Samos **</td>
<td>159-182</td>
<td>-</td>
<td>68-70.5</td>
<td>-</td>
</tr>
</tbody>
</table>

* N = 2, from SARAÇ et al., 2002
** N = 5, from ROUSSIAKIS & THEODOROU, 2001
pl. 5B), the mental foramen is closer to p2, partly because this tooth is larger, but the overall difference between the Pikermi and Veles specimens is slight (contra GAREVSKI & ZAPFE, 1983). The mental foramen is slightly more anterior in Moropus (COOMBS, 1978, fig. 3; 2004, fig. 15.2A).

The lower teeth from HD-2 (Pl. I, fig. 5c) are less worn than those of the other specimens, but their dimensions are similar. There is a continuous cingulum on the buccal side. Otherwise, they do not much differ from those of Moropus, except that the second lobe of m3 is not significantly longer than the first, and is more symmetrical. The p2 is smaller than at Veles.

Measurements:
Depth of mandible behind m3 = 102; before m1 = 86; before p2 = 47.
Occlusal length p2-p4 = 70; m1-m3 = ca. 156; p2-m3 = ca. 225
p2 = 15.5 x 10.3; p3 = 27.6 x 16; p4 = 31.2 x 23.1
m1 = 42.5 x 24.5; m2 = 52.7 x 28.6; m3 = 59.4 x 31.1.

Hadjidimovo-1

From the main Hadjidimovo locality, GERAADS et al. (2001) have already described a good deal of cranial material, and mentioned a duplex HD-662 (measurements: Table II), perhaps associated with a 3rd phalanx HD-661. HD-664 is a 1st phalanx (L max = 93; prox. width = 55.5). There is also a mandibular fragment, HD-669 (m1 = 42.7 x 22.2).

Since our 2001 paper, we have been able to examine several unpublished deciduous tooth series from Samos in the Musée Cantonal de Géologie, Lausanne (MCGL). All of them are remarkably alike; the only variable feature is the lingual closure of the median valley of DP2: it is open on S59, S60, S65, but blocked by a wall connecting the protocone and hypocone on S61 and S64. HD-634 from Hadjidimovo is intermediate (Pl. I, figs 1-3). Even size is remarkably homogeneous: all 7 measurable DP3s (4 from Samos, 2 from Hadjidimovo, 1 from Pikermi) have lengths in the 30-33 mm range. A DP3 from Samos Quarry A in the American Museum of Natural History is slightly shorter (27.9 mm), probably because it is strongly worn (M. COOMBS, pers. comm.).

The best new specimens from Hadjidimovo are an associated set of three left metacarpals, McII-McIV, with the trapezoid still attached, and perhaps even fused with McII (Pl. I, fig. 4). An unnumbered magnum is perhaps of the same individual.

The trapezoid is more triangular in proximal view than the one from Pinaryaka (SARAÇ et al., 2002) and the volar articulation is less spherical (measurements: Table III). The dorsal, non-articular, part of the magnum is less reduced than at Pinaryaka; this seems to agree with the less broadened dorsal part of the trapezoid, but it is also reduced on a specimen from Pikermi (ROUSSIAKIS & THEODOROU, 2001, fig. 24.3) in which the trapezoid is not so broad (measurements: Table IV). The trapezoid of Ancylotherium is quite distinct from that ofTylocephalonyx (COOMBS, 1979, fig. 13) by its almost spherical scaphoid articulation, allowing extreme carpal flexion.

The massiveness of the McII varies strongly (compare SCHaub, 1943, fig. 17a, from Samos, and ROUSSIAKIS & THEODOROU, 2001, fig. 25.5, from Pikermi), but the HD specimen is still more slender than the latter. It is also, like the other metacarpals, smaller than all other published specimens from Pinaryaka, Samos, and Pikermi (Table V).

As at Pinaryaka and Pikermi (in both sites associated metacarpals are known), the McIII is longer than the McIV, whereas they are of the same length in the Samos specimen described by SCHaub (1943). It is also more slender than in the other sites, the proximal end being narrower, and especially more so than at Pinaryaka. There is a single, long facet for the unifrom; parallel and distal to it is also a single, long facet for the McIV; both are similar to the specimen from Pinaryaka (SARAÇ et al., 2002). The McIV is also slender, but has a stronger proximo-lateral process than in the other sites. The proximal surface is less oblique than at Samos.

On the whole, this hand from Hadjidimovo is noticeable by its rather small size and slenderness. Since the sample from other localities is not exceedingly small, the difference is likely to be significant, but might well be due to sexual dimorphism, especially because the teeth are

<table>
<thead>
<tr>
<th>Table III: Comparative measurements of trapezoid</th>
</tr>
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<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>HD-518</td>
</tr>
<tr>
<td>Pinaryaka *</td>
</tr>
<tr>
<td>Pikermi, Samos**</td>
</tr>
</tbody>
</table>

* From SARAÇ et al., 2002
** N = 7, from ROUSSIAKIS & THEODOROU, 2001

<table>
<thead>
<tr>
<th>Table IV: Comparative measurements of magnum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>HD, no N°</td>
</tr>
<tr>
<td>Pinaryaka *</td>
</tr>
<tr>
<td>Pikermi, Samos**</td>
</tr>
</tbody>
</table>

* From SARAÇ et al., 2002
** N = 3, from ROUSSIAKIS & THEODOROU, 2001
not smaller than in other sites, and because both duplexes from Hadjidimovo are also strongly dimorphic.

Kalimantsi
Besides the talus already mentioned in our 2001 paper, the only new specimens are a new talus K-708 (Pl. I, fig. 6; measurements: Table I), a duplex K-711 (measurements: Table II), and a first phalanx. All these fossils come from the main levels of Kalimantsi, with a middle Turolian fauna.

A complete upper tooth series from Kalimantsi (most probably from the middle Turolian level) had been illustrated by Bakalov (1955) and by Bakalov & Nikолов (1962, pl. 15, fig. 1). A DP3 from the basal level of this locality (KAL-1, early Turolian) was figured by Nikолов (1972, fig. 1) as an M2 of Metaschizotherium fraasi. Its length was given by Nikолов (we could not find this tooth in the Sofia University) as 34.8 mm, which would make it a trifle larger than the other DP3s, but we refer it to A. pentelicum.

Gorna Sushitsa
This is known in the literature as a single locality, but recent survey there by N.S. and D.G. revealed at least 4 different fossiliferous spots, over a vertical distance of at least 40 meters (Spassov et al., in press a). Thus, the

<table>
<thead>
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<th>Table V: Comparative measurements of McII</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length</td>
<td>Proximal width</td>
<td>Proximal depth</td>
</tr>
<tr>
<td>HD-518</td>
<td>ca. 215</td>
<td>72</td>
<td>75.5</td>
</tr>
<tr>
<td>Pikermi, Samos.*</td>
<td>233-251</td>
<td>87-100</td>
<td>87-99</td>
</tr>
<tr>
<td>Maragha, MNHN</td>
<td>-</td>
<td>82</td>
<td>92</td>
</tr>
</tbody>
</table>

* N = 3, from Roussiakis & Theodorou, 2001

| Table VI: Comparative measurements of McIII |   |   |   |   |
|--------------------------------------------|----------------|----------------|----------------|
|                | length         | proximal depth | min. width      | distal artic.  |
|                |                |                | of shaft        | width          | depth          |
| HD-528         | 245            | 67             | 48.5            | 63             | 66.5           |
| Pinaryaka *    | 288            | 78             | 61              | 75             | 84             |
| Samos (Schaub, 1943) | 276        | 72             | 59              | 65             | 83             |
| Pikermi N = 3-4 ** | 279-296       | 74-84          | 64-69           | 75-80          | 77-96          |
| Maragha, MNHN  | -              | 79             | 60              | -              | -              |

* From Saraç et al., 2002. These McIII/IV are from the right side, not left as indicated by mistake; ** from Roussiakis & Theodorou, 2001

| Table VII: Comparative measurements of McIV |   |   |   |   |
|--------------------------------------------|----------------|----------------|----------------|
|                | length         | proximal depth | min. width      | distal artic.  |
|                |                |                | of shaft        | width          | depth          |
| HD-527         | 226            | ca. 60         | 42              | 60             | 64             |
| Pinaryaka *    | 270            | 74             | 56              | 63             | 77             |
| Samos (Schaub, 1943) | 274        | 68             | 54              | 62             | 79             |
| Pikermi, Samos. ** | 244-279       | 66-73          | 43-60           | 50-78          | 67-84          |

* From Saraç et al., 2002; ** N = 5, from Roussiakis & Theodorou, 2001
exact provenance of the maxilla figured by Bakalov and
by Bakalov & Nikолов (1962, pl. 15, fig. 2) is unknown,
but all localities are probably of Turolian age.

DISCUSSION

The upper dentition of *A. pentelicum* is known by a few
specimens only. Both the Kalimantsi and Gorna Sushitsa
tooth rows are less worn that the specimen from Pikermi
figured as *Rhinoceros pachygnathus* by Wagner (1857),
but more so than the one in Athens described by Thenius
(1953) from the same locality. Garevsky (1974) briefly
described a skull from Veles-Karaslari with most of the
upper dentition. There are some differences between
these various specimens, mainly in the development of
accessory spurs and cingulum, and in the relative size
of the premolars. The Athens premolars have a crochet
and a crista, which enclose a medifossette on P4. These
spurs are absent on the Bulgarian specimens. The P4
from Kalimantsi is almost as broad as M1, whereas the
others are narrower. On the molars, the lingual closure
of the median valley is less complete in the Bulgarian
specimens, except HD-633, than in the one in Athens. The
latter also has a stronger mesio-lingual ridge from the top
of the protocone to the cingulum (note that Thenius’ fig. 1
is incorrect in that there is no wear facet in this area).
These differences might denote an advanced evolutionary
stage of the Pikermi form over the Bulgarian ones, but
they might fit into individual variation as well.

*Ancylotherium pentelicum* has a restricted geographic
range, from Veles in Macedonia to Maragha in Iran (Fig.
1). It is therefore a typical element of the Balkano-Iranian
province. There are a few mentions outside this range;
some of them are also of earlier age, but definite specific

Fig. 1: Late Miocene Eastern Mediterranean localities with *Ancylotherium.*
Identification is difficult. It has been reported from Molayan in Afghanistan (Brunet et al., 1984) but details have yet to be published. The names Huanghotherium anlungense Tong, Huang & Qu, 1975, and Gansuwodon pingliangense Wu & Chen, 1976 might be synonymous, and synonymous with A. pentelicum as well, but each of these Chinese Turollian forms is known by two upper molars only. A manus from Novoukrainka (MN11 ?; Korotkevich & Sulimski, 1990) was figured and perhaps correctly referred to A. pentelicum by Korotkevich (1988, pl. 12, fig. a). According to M. Coombs (pers. comm.), a digit II of the manus figured by Pidoplichko (1959), actually the first mention of Ancylotherium from this site, does belong to A. pentelicum. A talus from the early Vallesian of Los Valles de Fuentidueña (Alberdi et al., 1981) does not differ from those of Ancylotherium, but a specific identification is risky. Thus, the earliest definite occurrence of the species might be at Pentalophos (Bonis et al., 1999). Only the study of these early forms would tell us if the lineage has undergone any significant changes in the upper Miocene, before its extinction in this area before the end of the Turollian, but evidence for this is still wanting.

In Africa, sparse and incomplete remains dating from the late Miocene to the earliest Pleistocene have been referred to Ancylotherium. The talus from Laetoli (Guérin, 1987, fig. 9.1.B) looks lower than that of the Eastern Mediterranean form, and is not thicker medially than laterally, with a very narrow navicular facet. Relying on Guérin's figure, a specific difference is warranted. The Tanzanian form postdates the northern one by several million years, but according to Butler (1965), its metacarpal is less derived.

Much has been written on the ecology and mode of life of the chalicotheres. Ancylotherium is assumed to differ from the Chalicotheriinae by its very peculiar metacarpodigitogrady, the weight of the forequarters resting on a cushion pad under the distal end of the metacarpals, the proximal phalanges and the sesamoids. According to Zapfe (1979), Chalicotherium rested instead either on the lateral side of the hand or, more probably, on the dorsal part of the ungual phalanx. This latter position is, in our opinion, quite unlikely, first because the metacarpo-

phalangeal articulation would have been permanently prone to dislocation, and because the Hadjidimovo material has shown (Geraads et al., 2001) that the sesamoids are much larger than Zapfe (1979) thought, and are therefore more similar to those of Ancylotherium. We believe that both genera might have had a similar hand bearing on the ground but, in any case, since the hand was clearly not designed for walking, this is less important than its main function.

Ancylotherium is usually assumed to have been a browser feeding upon leaves, using its long arms and claws to bring branches to the mouth. We believe that this interpretation fails to account for the very peculiar set of adaptations of the fore-limb, which include radio-ulnar fusion, preventing hand rotation, but ability to extreme carpal flexion and extreme phalangeal extension, fused first and second phalanges of digit II, at least, and cleven third phalanges, presumably fitted with very powerful claws. Even if some of these adaptations were designed to keep the claws out of contact from the ground during walking, the whole set is ill-suited for branch grasping. Because of its lack of rotation ability, the forearm was certainly inefficient in bringing food to the mouth; it is so unlike that of, e.g., Primates, that a similar use of their arm and hand must be ruled out. On the other hand, it lacked fossorial adaptations (Coombs, 1983). Still, it is hard to imagine that the claws had no specific function. Being half bipedal, Ancylotherium must have stood more or less upright, using its long arms to collect food from the trees, but if standing against a tree or any tall plant, the hands could not have rested on the trunk in the way shown by Borissiak (1945, fig. 8). Instead, the hands had to lie on either side of the trunk with the claws directed inwards (medially). In this position, the most likely use of the strong, clawed fingers was ripping or peeling off the bark or the whole plant. Thus, we hypothesize that the food of Ancylotherium consisted basically of the bark of some tree, or of a plant stem itself. This kind of food would be tough but not very abrasive. This is in good agreement with their dentition, which includes a powerful sub-hypsodont shearing component and a crushing component that is large but low-crowned.

Plate I

Ancylotherium pentelicum

Fig.1: DP2-DP4 from Hadjidimovo, HD-634 (photo of cast).
Fig. 2-3: DP2-DP4 from Samos in MCGL for comparison. 2 : S-60 (reversed), 3 : S-64.
Fig. 4: Associated left McII-McIV and trapezoid from Hadjidimovo (HD-518, 527, 528). Anterior view.
Fig. 5: Left mandibular ramus from Hadjidimovo-Tumbichkite, HD-2-713. a : lateral view, b : detail of the anterior portion, c : occlusal view.
Fig. 6: Talus from Kalimantsi, K-708. a : anterior view, b : plantar view, c : distal view.
Scale = 10 cm for figs 1-3; 5 cm for figs 4, 5b, 5c, 6; 2.5 cm for fig. 5a.
Sub-family Chalicotheriinae Gill, 1872

No new material of this sub-family has come to light. *Kalimantsia bulgarica* is known from Kalimantsi-Pehtsata only. *Kalimantsia* is characterized by a high skull, very long cerebral (post-orbital) part and reduced facial part, upper teeth with a short protoloph as in other late Miocene forms ("Macrotherium" *macedonicum* and *Ch. goldfussi*), but unlike the middle Miocene "Chalicotherium" *brevirostris* and *Anisodon*. The molars are much longer than broad with long and less oblique distal half of the ectolophs, P3 is broad, with an isolated protocone. The "Macrotherium* macedonicum* skull from Dytiko in Greece could be a species of the genus *Kalimantsia*, but the muzzle is still shorter, and the molars are not long. A cf. *Chalicotherium* *goldfussi* is known from Hadjidimovo, Gorna Sushitsa and Kromidovo (all these localities are probably of early to middle Turolian age). A lower molar from Batishnitsa in the Ruse region was also figured by Nikолов (1975) under this name.

ACKNOWLEDGMENTS

We thank those people who gave us access to collections in their care: A. Currant (Natural History Museum, London), C. Doukas (University of Athens), M. Ivanov (University of Sofia), R. Marchant (Musée Cantonal de Géologie, Lausanne), C. Sagne and P. Tassy (Muséum National d’Histoire Naturelle, Paris). Research on Bulgarian late Miocene faunas has been greatly facilitated by a joint program Centre National de la Recherche Scientifique – Académie Bulgare des Sciences. Many thanks also to M. Coombs for her very helpful comments on the manuscript.

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