

ISSN 0375 - 7633

Bollettino

della

Società Paleontologica Italiana

Pubblicato sotto gli auspici e col contributo
del Consiglio Nazionale delle Ricerche

Volume 41, n. 1, 2002

MUCCHI - MODENA

The Turolian Megafauna of West Bulgaria and the character of the Late Miocene "Pikermian biome"

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KEY WORDS – Large mammals, Palaeoenvironment, Late Miocene, Bulgaria.

ABSTRACT – Most of the localities of Miocene vertebrate fauna in Bulgaria are of Turolian age. The fossilization happened mostly in river and lake coastal sediments. The disposition of the localities shows that the recent hydrological system of Bulgaria already basically existed. The largest fossil faunal complexes in West Bulgaria are in the regions of Hadjidimovo, Kalimantsi, Kromidovo, Gorna Sushitsa and Hrabarsko. The age of the fossils from the last mentioned locality seems to be heterogeneous. The lower horizons seem to be Maeotian, while the upper one has a Pontian (Late Turolian) to Early Ruscinian age (most probably MN13). The fossiliferous sediments in the area of Kalimantsi (Kalimantsi Formation) includes a number of exact localities. The age of the oldest one in the section of the formation could be Late Sarmatian (Vallesian). The rest of the localities, stemming from the upper levels, are of Maeotian (Early-Middle Turolian) age - MN11-12. The richest - for the time being - Late Miocene mammal fauna is the one from Hadjidimovo-1 (Mesta basin). The accumulation of the fossils could be a result of periodical floods. The preliminary investigation shows the presence of 29 mammal species in the taphocenosis of the locality. The taphonomical and palaeontological analysis show a prevalence of the species inhabiting open, to one or other extent, spaces. There are indications for a relatively arid environment with the appearance of a forest savanna. Such should be the main appearance of the so called "Pikermian" biome. The origin of its zoocenosis should be looked for as early as in the thin arid forests from the Late Paleogene of Central Asia.

RIASSUNTO – [Caratteristiche "Pikermiane" nella fauna a grandi mammiferi del Turoliano (Miocene superiore) in Bulgaria occidentale] – La maggior parte delle località a vertebrati del Miocene superiore della Bulgaria è di età Turoliana e proviene da contesti sedimentari di ambiente lacustre o fluviale. La distribuzione areale dei siti fossiliferi dimostra come l'attuale sistema idrologico fosse, nel Miocene superiore, già definito nelle sue linee principali. I più importanti complessi faunistici in Bulgaria occidentale sono situati nelle provincie di Hadjidimovo, Kalimantsi, Kromidovo, Gorna Sushitsa e Hrabarsko. Le età rappresentate in queste località abbracciano intervalli di tempo diversi. Si inizia con un livello probabilmente Meotico, arrivando ai livelli più recenti del Pontico (Turoliano superiore) o del Rusciniano basale (probabilmente ancora MN 13). I sedimenti affioranti nell'area di Kalimantsi (Formazione Kalimantsi) sono caratterizzati dalla presenza di numerose associazioni fossili, la più antica delle quali potrebbe essere del Vallesiano, mentre le più recenti sono del Turoliano inferiore-medio (MN 11 – 12). Allo stato attuale, la più ricca associazione faunistica nota è quella di Hadjidimovo-1 (bacino di Mesta). Da un punto di vista tafonomico è il risultato di una successione di eventi di esondazione di canale, e dallo studio preliminare emerge una tafocenosi costituita da 29 specie di mammiferi. L'analisi tafonomica e paleoecologica evidenzia la prevalenza di taxa caratteristici di spazi più o meno aperti, con indizi della presenza di ambienti aridi, tipici di una savana forestata. Per questi caratteri, l'associazione di Hadjidimovo-1 può essere considerata la prima evidenza di una fauna di tipo "Pikermiano". L'origine di una tale zoocenosi può essere individuata nelle aree aride a scarsa copertura vegetale del Paleogene superiore dell'Asia centrale.

THE LATE MIOCENE LOCALITIES IN BULGARIA

The abundant data available up till now show the presence of a large number of Miocene localities of vertebrate fauna in Bulgaria (see: Bakalov & Nikolov, 1962; Nikolov, 1985; new localities are being found even now - Text-fig. 1). The map of the Neogene localities in Bulgaria clearly indicates that those from the Late Miocene, especially Turolian, strongly prevail (Tab. 1). Those of Vallesian age are relatively few. Of the Vallesian localities especially interesting are Nessebar and Kalimantsi-1 in SW Bulgaria (see below), because of their fauna. The fauna from Nessebar - old Turkish cemeteries (South Black Sea coast of the country) includes: *Schizochœrus vallesiensis* (cf. Nikolov & Thenius, 1967), *Prodeinotherium bavaricum* (cf. Nikolov, 1985), *Hipparion* aff. *H. primigenium*, *Dinocrocuta gigantea*, *Machairodus aphanistus*. (Spassov, N. & Koufos, G. in preparation). This fauna gives reason to the latter authors to

refer it to the zones MN 9-10. The rich Turolian (Maeotian-Pontian) fauna gives a rather good idea of the zoocenosis and the natural environment of this time. The latest summary of the Late Miocene localities of hipparion fauna is presented on Text-fig. 1 and Tab. 1. The Turolian localities are concentrated in several regions – Sofia area, the area of NW Bulgaria near the Danube, the basins of Maritza and Tundja and especially the basins of Struma and Mesta in SW Bulgaria. Obviously this is an indication that by this time the main hydrological net of the region already existed. This also supports the suggestion of an active transportation of destructed rock material and its accumulation by the Turolian rivers in the region, related to the planation processes. The concentration of fossiliferous sites in the fluvial and lake sediments is not accidental. Favourable taphonomic conditions in this mainly arid environment were present exactly in the river dales where the embedding (mostly seasonal) of the organisms took place.

About the Maeotian-Pontian (Turolian) fauna of the mammals of W Bulgaria one could judge not only after separate finds but in many cases after whole fossil faunal complexes. Such are represented mostly by:

- Hadjidimovo from the basin of Mesta river.
- Some localities from the Struma basin as Gorna Sushitsa, Kromidovo and especially Kalimantsi
- Hrabarsko (Sofia region).

The faunal check-lists of the Turolian localities mentioned (except Hadjidimovo and Kalimantsi - Pehtsata) are given below after Nikolov (1985) with nomenclature or taxonomic corrections and some additions. (A number of taxa need revision and are therefore noted with: ?, aff., cf. as consecutive degrees of resemblance to the relevant species or generic taxon).

MAIN LOCALITIES FROM THE SOFIA REGION

HRABARSKO

Located in the Sofia district, it is an abandoned mine. At this site, the Balsha member of the Gnilyanska fnt. (Kamenov & Kojumdjieva, 1983) yielded fossil remains from three levels (here listed after Nikolov, 1985 with corrections and with addi-

tions from Spassov & Ginsburg, 1999). The oldest one includes: *Aceratherium* aff. *incisivum*, ?*Choerolophodon* sp., cf. *Hipparion mediterraneum*. The middle levels yielded: *Tetralophodon longirostris*, *Deinotherium giganteum*, *Mammot borsoni*. The uppermost one: *Anancus arvernensis*, *Mammot borsoni*, cf. *Dicerorhinus* sp. (*D. schleiermacheri* after I. Nikolov - but it seems this species has never been found in E. Europe), *Hipparion mediterraneum*, *Hipparion* sp., *Tapirus balkanicus*. The remains listed by Bakalov & Nikolov (1962) as "*Dipoides major*" and "*Lepus timidus*" need a revision, as well as the specimen referred to "*Vespertiliavus schlosseri*", actually belonging to a Desmaninae insectivore (B. Sige, S. Legendre, pers. comm.).

The sediments from Hrabarsko are referred to the Balsha member of the Gnilyanska formation (= Gnilyane formation). It occupies the upper parts of the formation. Basing upon the mollusk fauna and the flora found, Kamenov and Kojumdjieva (1983) suggest a Pontian - supposedly early Pontian - age (i.e. approx. the beginning of MN13) for the Gnilyanska formation, including the Balsha member.

The fauna of the lower and the middle layers of Hrabarsko should be most probably Maeotian after the composition.



Text-fig. 1 - Main Late Miocene localities of Vertebrate fauna from Bulgaria.

No	Localities in alphabetical order	Age	
		Main localities with most probable Vallesian age	Proposed biochronological position of the localities with Turolian age
1	Ahmatovo		from Early to Late Turolian
2	Aldomirovtsi		from ? Early to Late Turolian
3	Archar		Turolian
4	Baldevo		? Late Turolian
5	Batishnitsa		Early - Middle Turolian
6	Bogdanitsa		Late Turolian
7	Bogvovtsi		Early - Middle Turolian
8	Brezhane		Middle - Late Turolian
9	Brezmk		Turolian
10	Butan	? Early Vallesian	
11	Bvala Slatina		from ? Middle to Late Turolian
12	Cherkezitsa River, between Ahmatovo and Popovitsa		from Early to Late Turolian
13	Chirpan		from ? Middle to Late Turolian
14	Debar		cf. Late Turolian
15	Dimevo		cf. Late Turolian
16	Djigurovo		Turolian
17	Dolna Sushitsa		from Early to ? Middle Turolian
18	Dragovishtitsa		Late Turolian - Ruscian
19	Ezerovo		? from Middle to Late Turolian
20	Gaber		from Middle to Late Turolian/Ruscian
21	Giljene		Early - Middle Turolian
22	Goma Gradeshnitsa		Turolian
23	Goma Sushitsa		Early-Middle Turolian
24	Gomi Tsibar		Early-Middle Turolian
25	Hadjidimovo		Beginning of the Middle Turolian
26	Hairedin		Late Turolian - Ruscian
27	Hanovo		Middle Turolian - Ruscian
28	Haskovo		? Late Turolian
29	Hrabarsko		from Middle to Late Turolian/Ruscian
30	Ilindentsi		Early Turolian
31	Izgrez		Late Turolian-Ruscian
32	Kalimantsi*	see below*	see below*
33	Katina		Late Turolian
34	Kocherinovo	? Late Vallesian	
35	Koprivlen		Turolian
36	Kresna		Late Turolian
37	Kromidovo		Early or most probably Mid. Turolian
38	Kula		Turolian
39	Liubovishite		Middle-Late Turolian
40	Malorad		Late Turolian
41	Mandra		Late Turolian-Ruscian
42	Marino Pole		Turolian
43	Melmk		Late Turolian
44	Mihailovo		? Early Turolian
45	Mines Maritsa Iztok		from Middle to Late Turolian
46	Mursalevo		Early-Late Turolian
47	near Burgas (exact loc. Unknown)		from Early to Middle Turolian
48	Nessebar	Vallesian	
49	Noevtsi		Middle-Late Turolian
50	Ognyanovo		Late Turolian
51	Oryahovo		Late-Middle Turolian
52	Ostritsa		Late Turolian
53	Parvomay		Late Turolian (? Ruscian)
54	Petreluk		Early-Middle Turolian
55	Ploski		Early-Middle Turolian
56	Popitsa		Turolian
57	Ravda	Early Vallesian	
58	Rogozinovo		from E. Turolian to L. Turolian/Ruscian
59	Sandanski		Early-Middle Turolian
60	Seltsi		Early-Middle Turolian
61	Simitli - Oranovo (coal beds)	Late Vallesian	
62	Stanyantsi		Early-Middle Turolian
63	Temelkovo		Turolian
64	Tenevo		from ? Late Turolian to Villafranchian
65	Vama	? Early Vallesian	
66	Venets		Early-Middle Turolian
67	Vidin		Early-Middle Turolian
68	Vinogradi		Early-Middle Turolian
69	Vladichitsa		Turolian
70	Yambol (a factory yard)		Early-Middle Turolian

The localities are selected from Bakalov & Nikolov (1962) and Nikolov (1985) with changes and additions by the author.

The biochronology is after Nikolov (1985), revised by the author, (E. Turolian - MN11, Mid. Turolian - MN12, Late Turolian - MN13)

*Kalimantsi-I (the Kalimantsi river bank) - possible Late Vallesian (Vallesian/Turolian boundary); the rest localities (such as Kalimantsi - Bardoto, Kalimantsi - Bukovets, Kalimantsi - Pehtsata, Kalimantsi - Belovski pat, etc.) - Turolian (MN11 - 12, most probably MN12)

Legend: from ... to ... means a presence of more than one biochronological units.

... - ... means an undetermined age between two or more biochronological units.

Tab. 1 - Main Late Miocene localities of vertebrate fauna from Bulgaria in biochronological context.

The problem with the upper level of Hrabarsko where *Anancus* and part of the hipparions are found is not easy to solve. *Anancus* is mostly typical for the Pliocene.

Besides, the hipparion remains from the locality seem to be close to the Ruscinian form *Hipparion crassum* (Dr. A. Forsten, Helsinki – in lit.). At the same time, however, there are good reasons to suppose that those mammals penetrated SW Europe earlier. So, it would be useful to discuss the following problems:

1. The *Anancus* problem. Normally *Anancus* is known in Europe from the Ruscinian. It seems that in South Europe as Bulgaria and Spain and possibly in Central Europe – Dorn-Dürkheim *Anancus* exists as early as MN13 (Metz-Muller, 2000) (for Bulgaria see the faunal association of several localities as Ostritsa, Melnik, possibly Ahmatovo – II cycle etc. in Nikolov, 1985). These data need special attention and examination. Most of the finds of this genus, labeled in Bulgaria as “*A. arvernensis*”, are determined after separate teeth. Primitive dental morphs of *Anancus* could be in some cases mistaken with *Tetralophodon longirostris*.

2. The *Anancus* “*arvernensis*” – “*Zygalophodon borsoni*” association. In Bulgaria there is an archaic form of *Mammot* (= *Zygalophodon*) *borsoni* in MN13 (see the relatively “long” symphysis of the mandible from Ahmatovo in Nikolov & Kovachev, 1966), so the typical Ruscinian association *M. borsoni* – *A. arvernensis* probably exists here during the whole of MN13.

Similar chronostratigraphic position has the fauna from some other localities from the Sofia region as Katina, which is from the upper part of the Balsha member. There are two levels in Aldomirovtsi. The lower one yields fauna which is probably from MN11–12, but the upper one, where *Anancus* + *Hipparion* are found, could be MN13–14. For the time being the available data seem to indicate a Pontian s. str. – i.e. zone MN13 (probably mid/end of MN 13) rather than Ruscinian level for the upper layers of Hrabarsko.

MAIN LOCALITIES FROM THE STRUMA BASIN

GORNA SUSHITSA, Blagoevgrad district, Kalimantsi formation (“svita”), II cycle (for the lithostratigraphic units see Kojumdjieva *et al.*, 1982; Tenchov (ed.), 1993); Maeotian after mammals: *Ancylotherium pentelicum* Gaudry & Lartet, *Chalicotherium goldfussi* Kaup, *Hipparion* cf. *theobaldi* Lydekker, *Hipparion mediterraneum* Gervais, *Tragoportax amaltheus* Gaudry, *Mesopithecus* ?*pentelicus* Wagner, *Paleoreas lindermayeri* Gaudry.

KROMIDOVO, Blagoevgrad district, Sandanski formation (“svita”) II cycle:

Kromidovo 1 (in the village), Maeotian after mammals: *Aceratherium* sp., *Hipparion mediterraneum*

Gervais, *Hipparion* sp., ?*Chalicotherium goldfussi* Kaup; Kromidovo 2 (700 m east of the village): aff. *Bohlinia atica*, *Hipparion mediterraneum* Gervais, *Hipparion matthewi* Abel, *Adcrocuta eximia* Roth & Wagner, *Mesopithecus* cf. *pentelicus* Wagner.

KALIMANTSI, Blagoevgrad district, Kalimantsi Formation (“svita”), II sedimentation cycle after Kojumdjieva *et al.* (1982):

Kalimantsi 1 – (boundary I–II cycle). The locality is in the base of the Kalimantsi Formation s. str.: aff. *Acerorhinus zernowi* Borissjak, ?*Metaschizotherium fraasi* Koenigswald, *Hipparion* cf. *theobaldi* Lydekker, *Prodeinotherium bavaricum* (Meyer);

Kalimantsi 2: *Adcrocuta eximia* Roth & Wagner, *Paramachairodus* cf. *orientalis*, *Ancylotherium pentelicum* Gaudry & Lartet, *Hipparion mediterraneum* Gervais, *Microstonyx major* Gervais, *Tragoportax amalthea* Gaudry, *Mesopithecus* cf. *pentelicus* Wagner; Kalimantsi 3: *Dicerorhinus* sp., *Hipparion matthewi* Abel, *Helladotherium duvernoyi* Gaudry & Lartet, *Bohlinia atica*, *Gazella brevicornis* Gaudry, *Paleoreas lindermayeri* Gaudry;

Kalimantsi 4 (in the highest deposit levels, at about 100 m. above the level of site 1): *Ichthytherium* (?) *orbigny* Gaudry, *Dicerorhinus* sp. Kaup, *Hipparion* ?*crassum* Gervais, *Hipparion mediterraneum* Gervais, *Palaeoryx pallasii* Gaudry, *Palaeoryx majori* Schlosser.

The reference of I. Nikolov to “*H. cf. theobaldi*” (see also Gorna Sushitsa) needs a revision (Dr. A. Forsten, Helsinki – in lit.)

The fossiliferous site of Kalimantsi belongs, after the opinions expressed till now, to the Kalimantsi Formation, Sandanski Graben (Kojumdjieva *et al.*, 1982) [the concept of the Struma basin formations is recently under revision (T. Tzankov & N. Spassov, in preparation)]. The fossiliferous site of Kalimantsi spreads over a large area (ca. 8–10 km²) where a number of localities are known. The above-mentioned localities are officially known mainly from the works of Prof. P. Bakalov and I. Nikolov. Several new localities were found by D. Kovachev (Palaeontological Museum – Assenovgrad, branch of the NMNH – Bulg. Acad. Sci.) during the last decades as: Kalimantsi-Pehtsata, Kalimantsi – Bukovets, Kalimantsi – Bardovski pat, Kalimantsi – Bardoto, Kalimantsi – Prehvarloka (see Tab. 1). The unpublished materials in a process of research are kept in the Assenovgrad museum. Of special importance is the locality Kalimantsi-Pehtsata (Kovachev, 1988), situated in the middle/upper layers. The following taxa of Early/Middle Turolian age (MN12?) are found here: *Indarctos bakalovi* (Kovachev, 1988); aff. *Hyaenictitherium* sp.; *Helladotherium duvernoyi*; *Bohlinia attica*; *Gazella* sp.; *Kalimantsia bulgarica* gen. et sp. nov. (D. Geraads, N. Spassov & D. Kovachev, 2001). As it seems from the preliminary analysis of some finds – antelopes, rhinoceroses, chalicotheres, *Mesopithecus*, *Prodeinotherium*, *Deinotherium* etc. – the rich fossilif-

erous sediments from the different localities in the area of Kalimantsi (in deposits more than 100 m thick) represent a fauna that existed in a long period of time. The faunal remains in the base of the layers are probably of Late Vallesian age (the fauna of these layers – the river bank needs a revision: a very early Turolian age is not impossible). Most of the later faunal finds belong to the mammal zones MN11 or, more probably, MN12, possibly till the very end of the latter zone. So, we could suggest a Late Vallesian (Vallesian/Turolian boundary) age for Kalimantsi 1- (Kalimantsi, the river bank) and Maeotian [= Early-Middle Turolian age - (MN 11/12) of the western European biochronology]] for Kalimantsi 2-4 and Kalimantsi-Pehtsata and the rest localities known up till now.

MAIN LOCALITIES FROM THE MESTA BASIN: HADJIDIMOVO LOCALITY AND ITS SIGNIFICANCE

THE SITE

The richest among the Bulgarian localities of hipparion-fauna is the Hadjidimovo site. Hadjidimovo fossiliferous area is situated in the Mesta river valley near the Hadjidimovo town and the Bulgarian-Greek border and represents a Late Miocene fossil site with 4 localities of vertebrate fauna. The sediments (light clay sands) belong to the Nevrokop Formation (Vatsev, 1980). The site is first noted by I. Nikolov (1973) but its richness was evaluated after the excavations of D. Kovachev between 1985 – 1998.

THE FAUNA INVESTIGATIONS. MATERIAL, METHODS

More than 19,000 bone remains (D. Kovachev's collection) are presently stored in the Assenovgrad Museum - a palaeontological division of the National Museum of Natural History - Sofia. This vast material (mainly from Hadjidimovo-1) is still unpublished and is currently under investigation (by Spassov and others). The results presented here are preliminary. The estimation of the minimum number of individuals belonging to a species/genus in the ecological analysis is possible due to the very good preservation of the bones and is made after the dominating bones of each taxon in the taphocoenosis. For this purpose, the method of Bokonyi (1970) was used. The comparison of the locality taxa list with other known Late Miocene localities was made with the Poisson criterion for distances between samples after the method of Davis (1977) and programmed by O. Vitov (Inst. Applied Mineralogy, Sofia). By the reconstruction of the supposed ecological demands of the taxa, general observations on the dental and skeletal morphology are interpreted. In a number of cases analogies with Recent forms are given. This is possible in cases of relatively close taxonomical relationship, (the genera *Gazella*, *Hystrix*, *Ceratotherium*, *Tapirus*) or a

strong morphofunctional resemblance (*Adcrocuta* – *Crocota*, *Palaeoreas* – *Antilope*, etc.). As an additional method for the reconstruction of the landscape cenograms are used (Legendre, 1988). The estimation of the body mass of the species, needed for this method, is made by direct comparison of the size of the most informative bones and skeletal parts with those of morphofunctionally similar recent species.

PRELIMINARY TAXONOMIC RESULTS

The preliminary fauna list of the locality Hadjidimovo - 1 (Hadjidimovo-Girizite) includes at least 29 mammal species (det. N. Spassov, D. Kovachev; see also Geraads *et al.*, in press; Spassov & Ginsburg, 1999) (Tab. 2). Of special interest are: the large collection of hyaenictitheres with the mandible of cf. *Miohyaenotherium* (*Hyaenotheriini*); the rather complete skeleton of *Metailurus* cf. *major*; the coexistence of two chalicotheres genera (Geraads, Spassov & Kovachev, in press); the presence of *Tapirus* remains (Spassov & Ginsburg, 1999) - a single tooth – a very

No	Taxa
1	Mustelidae indet.
2	<i>Hyaenotherium</i> gr. <i>wongii</i>
3	<i>Hyaenictitheriini</i> indet.
4	cf. <i>Miohyaenotherium</i> <i>bessarabicum</i>
5	<i>Adcrocuta</i> <i>eximia</i>
6	<i>Paramachairodus</i> cf. <i>orientalis</i>
7	<i>Machairodus</i> <i>giganteus</i>
8	<i>Metailurus</i> cf. <i>major</i>
9	Gomphotheriidae indet.
10	<i>Mammot</i> gr. <i>borsoni</i>
11	<i>Ancylotherium</i> <i>pentelicum</i>
12	Chalicotheriinae indet.
13	? <i>Ceratotherium</i> <i>neumayri</i>
14	<i>Dicerorhinus</i> <i>pikermiensis</i>
15	<i>Tapirus</i> aff. <i>jeanpiveteaui</i>
16	<i>Hipparion</i> gr. <i>mediterraneum</i>
17	<i>Hipparion</i> cf. <i>brachypus</i>
18	<i>Hipparion</i> ? <i>platygenys</i>
19	<i>Microstonyx</i> sp.
20	Cervidae indet.
21	<i>Helladotherium</i> <i>duvernoyi</i>
22	<i>Palaeotragus</i> <i>rouenii</i>
23	<i>Gazella</i> (<i>Procapra</i>) sp.
24	<i>Palaeoryx</i> sp.
25	<i>Palaeoreas</i> <i>lindermayeri</i>
26	<i>Tragoportax</i> sp.1
27	<i>Tragoportax</i> sp.2
28	<i>Hystrix</i> <i>primigenia</i>
29	<i>Mesopithecus</i> cf. <i>delsoni</i>

Tab. 2 - Preliminary check-list of the taxa from Hadjidimovo-1.

rare animal for this time and landscape; the rich *Mesopithecus* skull and skeleton material, the large number of *Hipparion* and Bovidae skulls, mandibles and other remains etc.

Two undescribed mandibles in the Assenovgrad museum collections with different individual age (one from Hadjidimovo, and another from Kalimantsi show the main diagnostic features of the very rare till now *Miohyaenotherium* Semenov, 1989: they have clearly convex corpus mandibulae and entoconid of M1 stronger than the hypoconid. (For the diagnosis see Semenov, 1989 and also the discussion in Werdelin & Solunias, 1991). (It has to be noted, however, that some other hyaenictitheres also seem to have an entoconid higher than the hypoconid, a proportion changing with the wear of the tooth).

The first *Hipparion* remains collected from Hadjidimovo site were determined by Nikolov as *H. mediterraneum* (Nikolov, 1973), revised by Forsten as *H. primigenium* (Forsten, 1978) (it should be noted that in this case *sensu* Forsten this taxon seems also to comprise *H. brachypus* - see Forsten, 1968). The preliminary analysis of the rich *Hipparion* finds from Hadjidimovo-Girizite (materials collected by D. Kovachev in the Palaeontological branch of the NMNH in Assenovgrad) shows that there are at least two different species in this locality which in this preliminary analysis we could designate in the following way [This vast material is currently under investigation and a series of publications are in preparation (L. Ivanova, N. Spassov & D. Kovachev)].

1. *Hipparion* sp. I (robust form) - *Hipparion* cf. *H. brachypus* Hensel, 1862.

The main morphologic features, dimensions and proportions of the large species from this locality show affinities to morphotype I of Alberdi (1989) and the *H. primigenium* - *H. brachypus* line. The large form from Pikermi (*H. brachypus sensu* Koufos, 1987; "*Hippotherium*" *brachypus sensu* Bernor *et al.*, 1996b) probably evolved from large earlier forms as *Hipparion* gr. *primigenium* (see Koufos, 1987) (= *Hippotherium primigenium sensu* Bernor *et al.*, 1996b).

The dimensions of the teeth and the skull are large (LP2-M3 in 7 measured individuals is 154-167 mm). The plications of the cheek-teeth are relatively numerous and deep, often with 2 to 3 pli cabalin. The preorbital fossa is relatively small and elongated. The distance between the preorbital fossa and the orbit is large (about 40 mm or more). The incisor arcade is arcuate in the available specimens with preserved rostrums. Metapodials and phalanxes are robust and relatively short.

2. *Hipparion* sp. II ("gracile" form) - *Hipparion* gr. *H. mediterraneum* (Roth & Wagner, 1855).

The size of the teeth and the skull is smaller than in the previous species and not too large for a hippar-

ion (LP2-M3 in some measured individuals are 149-155 mm). Cheek-teeth with a small number of plications - 4-12 (L. Ivanova, N. Spassov & D. Kovachev, in prep.). (This number is less than in *Hipparion* sp. I as well as in "*H.*" *proboscideum* as a whole). The preorbital fossa is large, deep and high, with a distinct angle between the well-pronounced caudal and ventral surfaces. A weak intermediate fossa could be seen in some well preserved skulls between the preorbital fossa and the buccinator one. The distance between the preorbital fossa and the orbit is short, ca. 20-25 mm in the measured individuals. Metapodials and phalanxes are long but not wide.

Some of the features and proportions make the smaller (gracile) hipparion from the locality resembling *H. moldavicum* [the status of *H. moldavicum* is not quite clear. It is near to *H. mediterraneum* (Forsten, 1980)]. From this form the gracile hipparion from Hadjidimovo differs with larger dimensions, thus resembling mostly *H. mediterraneum* from Pikermi (see Koufos, 1987). [Most probably the hipparions of the taxa "*Hipparion*" *mediterraneum* and "*H.*" *moldavicum* must be referred to a genus separate from *Hipparion* - *Cremohipparion* (Bernor *et al.*, 1996b)].

? 3. *Hipparion* sp. III (*H.* ? *platygenys* Gromova, 1952).

A skulls of adult individual (the snout part is broken) possibly represent another taxon related to the *Hipparion* s.s. group *sensu* Bernor *et al.* (1996b). It differs from the rest of the numerous cranial remains from Hadjidimovo in the virtually lacking fossa praeorbitalis (very slightly outlined). Such a feature strongly resembles *H. platygenys* described from Taraklia (Zhegallo, 1978; Krakhmalnaya, 1996-a) and to some extent *H. dietrichi*.

The measurements of the mandibles of *Mesopithecus* from Hadjidimovo collected by D. Kovachev indicate bigger size than these of *M. pentelicus* Wagner from Pikermi and similar to *M. delsoni* Bonis, Bouvraïn, Geraads, Koufos from Revin de Zouaves in Greece (RZO) and *M. aff. delsoni* from Maragha. The specific status of *M. "delsoni"* deserves a careful revision, as far as a number of the main diagnostic features are mostly gradual tendencies. Such are for example the size of lower M3's talonid, the extent of flattening of the mandibular symphysis (also depending on sex), the relative height of the mandible, etc. The differences in size and the morphological differences (mostly different morphological trends) could represent subspecific (populational) and not specific differences between *M. pentelicum* and *M. delsoni*. Despite the taxonomic dispute (Zapfe, 1991), the conclusion (Bonis *et al.*, 1990) that the size of *Mesopithecus* decreases during the time from RZO, Maragha (MN 11) and Hadjidimovo (beginning of MN12) through Pikermi (MN 12) to Diritko (MN 13) and Montpelier (MN 14) is correct and indicates that the size and some mandible and

teeth trends are related to the evolution of *Mesopithecus* in time. It seems that this observation has a stratigraphic significance.

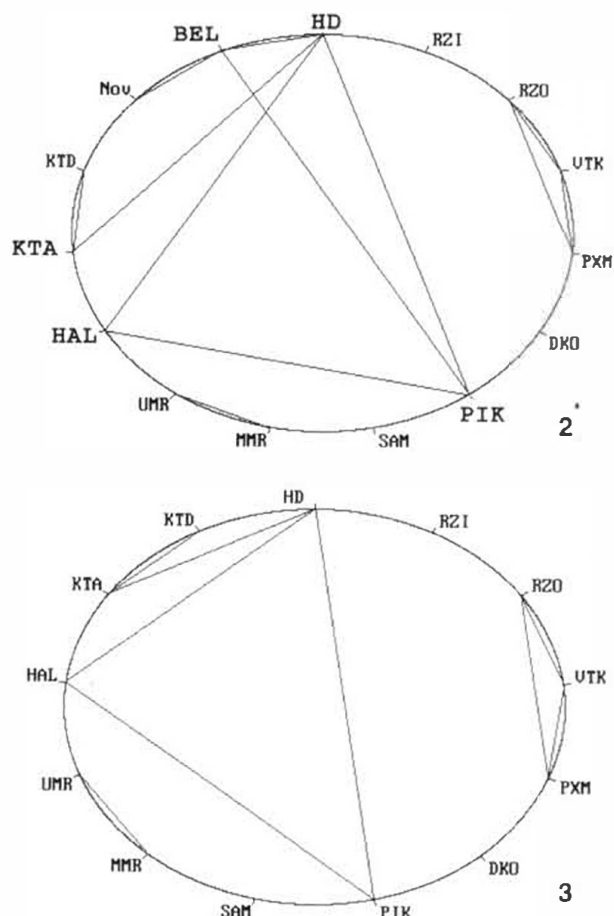
BIOCHRONOLOGICAL DATA

The faunal complex of Hadjidimovo (HD) shows similarities in taxonomic composition and faunal trends with the localities and faunal associations from the Balkans, Asia Minor and Ukraine indicating a Middle/ Late Maeotian age of the locality (most probably beginning-first half of MN12. The Belkian sub-complex in Ukraine (see Korotkevich, 1988), which is most probably from this time, characteristic feature is the domination of gazelles, *Tragoportax*, *Hipparion moldavicum* (i.e. *Hipparion* from the *H. "mediterraneum"* group). In Hadjidimovo *H. gr. mediterraneum*, *Tragoportax* and the gazelles are also among the dominant species after the number of bones and individuals. The mentioned conclusion on the biochronological and faunistic similarity of Hadjidimovo is tested also after the Poisson criterion of sample similarities by comparison of the faunal check-lists of diverse localities of hipparion fauna of the Balkan-Iranian region, incl. the territory North of the Black Sea (for the non-Bulgarian faunal check-lists see Bonis *et al.*, 1994; Korotkevich, 1976). It shows that Hadjidimovo-1 (HD-1) has greatest similarity to localities like Belka (Ukraine), Pikermi, Halmyropotamos (Greece) and the level of Kemiklitepe - KTA (Turkey) approximately corresponding to zone MN12 (see Bonis *et al.*, 1994; Bonis & Koufos, 1999). Because of the scarcer available data for the Ukrainian localities the comparison of the faunas including some of those localities is made at a generic level (Text-fig. 2). When comparing the faunal complexes at a specific level (and excluding the Ukrainian localities) the greatest similarity is still with the noted 3 Balkan - Asia Minor localities (Text-fig. 3).

We can accept the size similarity of the *Mesopithecus* population of HD-1 to these of Ravin des Zouaves (RZO) (MN11) and Maragha (MN11-base to basal MN12) (Steininger *et al.*, 1996) as another indication that HD is most probably something earlier than Pikermi. The chronological position of Pikermi is debatable. If the locality is at the boundary of MN11/12 (Bernor *et al.*, 1996a; Steininger *et al.*, 1996), than HD-1 should date from the end of MN11. Due to the strong faunistic similarity of the Pikermi complex with the fauna from the localities referred to MN12 unit, numerous authors put the locality positively in this zone (de Bruijn *et al.*, 1992; Bonis & Koufos, 1999). In such case HD should be placed at the very beginning of MN12 (Text-fig. 4).

PRELIMINARY TAPHONOMIC DATA

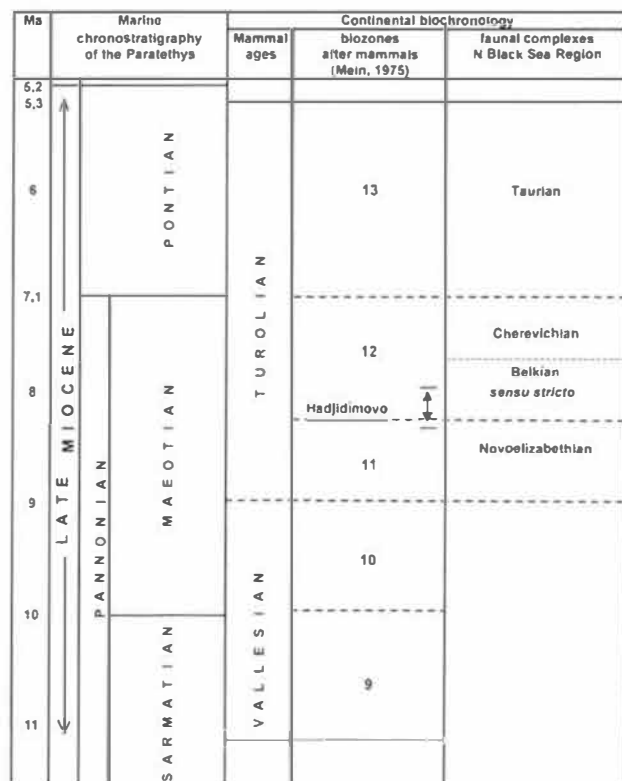
In the taphocoenosis the bones and the surfaces of the joints are very well preserved in the clay sands of



Text-figs 2-3 - Distance between samples with the Poisson criterion. Pcrit. area 0.01 [fig. 2 - including the Ukrainian (North Pontic) localities; fig. 3 - without the Ukrainian ones].

Localities: *Bulgaria*: HD = Hadjidimovo-1; *Greece*: RZI = Ravin des Zouaves 1, RZO = Ravin des Zouaves -5, VTK = Vathyakkos, PXM = Prochoma, DKO = Dviko, PIK = Pikermi, SAM = Samos, HAL = Halmyropotamos; *Iran*: MMR = Mid. Maragha, UMR = Upper Maragha; *Turkey*: KTA = Late Turolian Kemiklitepe (cf. MN12), KTD = Early Turolian Kemiklitepe (cf. MN11); *Ukraine*: BEL = Belka (Late Maeotian), NOV = Novaya Fmetovka (Early/Middle Maeotian).

the locality. The bones are rather often articulated and only one bone (a giraffe femur) among thousands examined has obvious traces of gnawing. The preliminary taphonomic observations lead to the conclusion that the fossil locality is formed in a geologically rather short period with a mass accumulation and quick embedding of whole carcasses or large parts of them. It is an indication of probable periodic catastrophic causes for the death of the largest part of the animals. This idea suggests that the seasonal flooding of the periodically drying river is the cause of the piling of the bone remains in a comparatively short time period.



Text-fig. 4 - Biochronologic position of Hadjidimovo-1 and the Late Miocene chronology of the East Mediterranean-Pontic region (correlated by the author according to Rogl & Daxner-Höck, 1996; Rögl, 1996; Steininger *et al.*, 1996 and with data from Korotkevich, 1988).

BRIEF ANALYSIS OF THE NATURAL ENVIRONMENT OUTLOOK. THE "SAVANNA-LIKE" LANDSCAPE IN THE TUROLIAN OF E AND S-E EUROPE - IS IT A MYTH?

The mass accumulation of bone material of the same age in Hadjidimovo-Girizite (HD-1) excavated from a small, localized area gives the rare opportunity for a palaeoecological reconstruction of the natural environment and the palaeozoocenosis.

1. *Analysis of the taphocoenosis.* The concentration of the remains of hundreds individuals in isolated rock lenses with an area of tens of square meters and a maximum thickness less than 1 m virtually eliminates the origin of the taphocoenosis in the conditions of a forest landscape. This kind of "burial places" suggests an activity of inconstant, suddenly flooding and abundant water torrents. They drag large quantities of terrigenous sand and clay-sand deposits. The impetuous swelling of such inconstant (seasonal) water masses is typical for relatively open plains with a warm climate. The taphocoenosis indicates also the ungulates' large biomass and their high density in the palaeozoocenosis. Among the species, there are decidedly dominant forms (see below). The

presence of pronounced dominants in the ecosystem (Popov, 1997) and such a biomass are parameters confirming the suggestion that the landscape was open rather than forest.

2. *Analysis of the dominant species' ecological demands.* The dominant taxa in the taphocoenosis are *Palaeoreas lindermayeri* (min. 260 ind.) and *Hipparion* (min. 160 ind.) after the skull remains but at least 240 ind. after the metapodials for the three species as a whole. After the preliminary calculations, the first two species of the genus have an approximately similar numbers, while the third seems to be rare). The next abundant taxa are *Tragoportax* and after it *Gazella*. All the other taxa are represented much more poorly in the taphocoenosis.

Judging from the cervid-like degree of brachyodony of the teeth of *Palaeoreas lindermayeri* we could agree with Solounias *et al.* (1999) that this species was most probably a browser. That, however, does not automatically mean it inhabited a forest-like, tree-dense woodland. The horn cores of this species are similar to those of Recent *Antelope cervicapra*, a species where the horns are highly evolved and specialized, with an important social function (Geist, 1966). The development of such a socialization usually takes place with artiodactyls inhabiting spaces open enough, living in herds and having a high degree of visual communication. At the same time, a tournament and display function as with the *Antelope*-type horn is characteristic neither for the low-social inhabitants of dense woods, nor for the super-social artiodactyls of the fully open spaces (see Geist, 1974; Janis, 1986). *Antelope* is usually seen in herds of 20-30 to several hundreds. It lives in open plains covered with scrub and penetrates open forests, avoiding dense forests (Prater, 1971). Probably we should suggest a similar mode of life for the slightly larger *Palaeoreas*.

It is obvious that in the natural environment of Hadjidimovo both the robust (*H. cf. brachypus*) and the gracile (*H. gr. mediterraneum*) hipparions coexisted, occupying most probably different ecological niches (this is not unusual also for the later equids of Pleistocene-Holocene faunas): Gromova (1949) and many authors after her interpret the wide distal segments of the limbs and the numerous dental enamel plications in the equids as a specialization toward more humid biotopes, softer ground, more forest landscape and succulent vegetation. The narrower distal limb segments and, correspondingly, the small number of plications indicate a harder ground, more open and arid surroundings, with a more active utilization of hard (usually grass) vegetation. As for the lack of preorbital fossa in some late hipparions (*H. platygynys*), this is related to the reorganization of the buccal muscles, an elimination of the upper lip proboscis and an adaptation to a less differentiated food-catching, i.e. an adaptation toward grass vegetation.

The noted morphology should show an adaptation mostly towards grass vegetation and is an indication of mostly open landscape (Zhegallo, 1978). Thus, the broad-hoofed, robust form from Hadjidimovo 1 (*H. cf. brachypus*) with its arcuate incisor arcade, robust distal segments of the limbs and a relatively large number of teeth plications, was probably adapted to more humid environment with softer soil and woodland biotopes with stronger presence of arboreal and bush vegetation. The gracile form (*H. gr. mediterraneum*) was adapted to more arid conditions with scarcer tree vegetation and a more open landscape. This conclusion does not contradict the analyses of other authors on the hipparions of the gracile mediterraneum group but adds to them. The data on the tooth microwear of *H. mediterraneum* from Pikerim indicate a mixed nutrition – browser to grazer (Solounias *et al.*, 1999), and the morphofunctional analysis of the related *H. moldavicum* from the Moldavia and Ukraine (Zhegallo, 1978; Krakhmalnaya, 1996-b) shows a similar way of feeding and an inhabitation in partially forested glades.

The two skulls we note as ?*H. platygenys* let us presume that this form, although scarcely represented in the taphocoenosis, is an indicator for the presence of rather extensive, open grass biotopes. So, the landscape of Hadjidimovo has both forest and steppe habitats, judging from the adaptive specializations of the hipparions. This could be interpreted as a presence of mosaic/mixed distribution of the biotopes or the so-called “park type landscape”, typical for the physiognomy of the forest savanna.

Tragoportax seems to be represented by two forms (Geraads, D., N. Spassov, D. Kovachev – in preparation). Much more abundant is the larger form (min. 87 individuals against min. 25 for the smaller) which is hypsodont and presumably utilizes grass vegetation to a great extent.

Gazella (Procapra) sp. The gazelles' remains (min. 50 ind.) should be referred most probably to the subgenus *Procapra* following the diagnosis of Korotkevich (1976). The morpho-functional skull analysis shows an adaptation of this form toward relatively large open spaces and hard grass vegetation (Korotkevich, 1976; 1988; Krakhmalnaya, 1996-b).

3. *Analysis of the ecological niches of the species from the zoocoenosis as a whole.* The analysis of the ecological demands of the species as a whole shows a domination of biotopes that could be related to landscapes, physiognomically similar to a forest savanna. At the same time, this could be a mosaic landscape of open spaces and forest spots (Text-fig. 5). Besides *Gazella (Procapra)*, *Hipparion ?platygenys* and partially *H. gr. mediterraneum*, the presence of non-forest and rather open biotopes is indicated by species as: *Ceratotherium neumayri* (well present in the taphocoenosis), *Hystrix primigenia*, *Adcrocuta eximia* and possibly the abundant hyaenictitheres (on the ecolo-

gy of the latter see Semenov, 1989; Werdelin & Solounias, 1991). *Adcrocuta* seems to be the most abundant carnivore in the zoocoenosis. An analogue of Recent *Crocuta*, it is presumably typical for relatively open landscapes, which is also supported by its frequent presence in the taphocoenosis.

Species demanding humid, typically forest biotopes or river bank thickets are rare to extremely rare. Such are *Mammuth borsoni*, *Palaeotragus rouenii*, the tapir and *Microstonyx* (1 bone from the tapir and 2 bones from the suid species among many thousands of determined bones). Such is also the singular find of *Deinotherium*, which was found near the locality HD-1. Here could be included the cervids, whose remains are rare too. At the same time, the biotope of Late Miocene cervids could be a non-forest, open bush.

The presence of real wood vegetation is also indicated by the rather abundant finds of *Mesopithecus* and *Helladotherium*. Both the giraffe and the primate, however, should be inhabitants of sparse, “open forest” habitats. *Mesopithecus* is not an exclusively arboreal genus, it shows an adaptation toward a semiterrestrial mode of life (Delson, 1973; Yulatos, 1999; Koufos, G., N. Spassov & D. Kovachev, in preparation).

4. *Analysis of the fauna cenogram.* The curve of the cenogram of the mammal megafauna from the taphocoenosis of the locality (Text-fig. 6) shows a relative continuity. In this it is similar to the cenograms of zoocoenoses from the Recent forest tropical habitats, and also to those of mosaic habitats (a mixing of open savannas with tropical forests: see Legendre, 1988, fig. 28: Cote d'Ivoire). At the same time, interruption of the curve in the portion corresponding to the of small macromammals (in the Recent forms this is usually between 0.5-8 kg, and in this case between approx. 1-15 (18) kg) is a peculiarity typical for open habitats (Montuire, 1994). The plateau-like form of the curve in its middle part reflects the specific Late Miocene zoocoenosis which was especially rich in species. We could suggest that the abundance of ecological niches for a large number of species with similar body mass in this case is due to the mixed presence of species both of more open and of woody habitats, suggesting an open forest - tree-savanna-like landscape. As a whole, the analysis of the cenogram indicates the forest-savanna / mosaic landscape of Hadjidimovo-1, similarly to the other analyses given above.

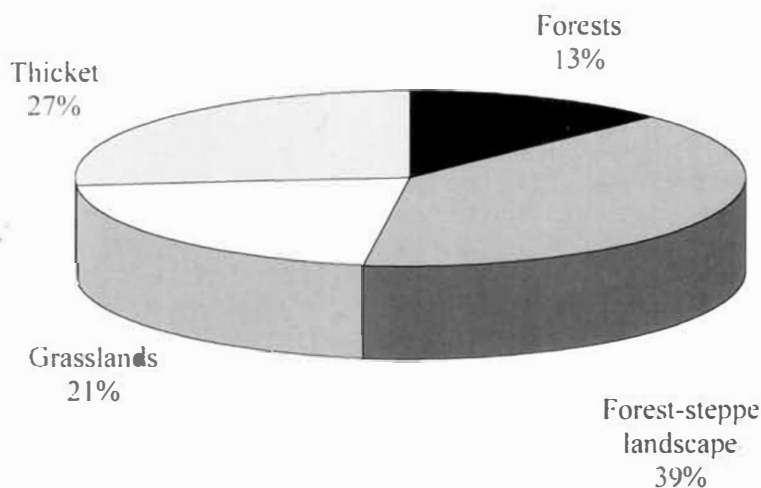
The summary of all the analyses establishes the idea of a relatively arid, physiognomically forest-savanna-like landscape prevailing in Hadjidimovo-1.

Similar conclusions on the strong enough presence of spaces open to one or other extent, were made by Krakhmalnaya (1996-b) for the environment of the North-Circumpontic locality Novaya Emetovka-2. This Turolian locality is close to or some earlier than Hadjidimovo.

The idea of the existence of so-called “Pikerian hipparion fauna” in “savanna” landscapes is not new

Taxa	Biomes			
	Forests	Forest-steppe landscapes	Thicket	Grasslands
Mustelidae indet.	?	?	?	?
<i>Hyacotherium</i> gr. <i>wongii</i>	-	+	+	+
<i>Hyacotherium</i> indet.	-	+	?	+
<i>Miohyacotherium bessarabicum</i>	-	+	+	+
<i>Adcrocuta eximia</i>	-	+	-	+
<i>Paramachairodus orientalis</i>	+	+	+	-
<i>Machairodus giganteus</i>	-	+	?	+
<i>Metailurus</i> cf. <i>major</i>	?	+	+	+
Gomphotheriidae indet.	?	+	+	?
<i>Mammuth borsoni</i>	+	+	-	-
<i>Ancylotherium pentelicum</i>	-	+	-	-
<i>Chalicotherium</i> sp.	+	+	+	-
? <i>Ceratotherium neumayri</i>	-	+	?	+
<i>Dicerorhinus pikermiensis</i>	-	+	+	-
<i>Tapirus</i> aff. <i>jeanpiveteaui</i>	+	-	?	-
<i>Hipparion</i> gr. <i>mediterraneum</i>	-	+	?	+
<i>Hipparion</i> cf. <i>brachypus</i>	-	+	+	?
<i>Hipparion</i> ? <i>platygens</i>	-	+	-	+
<i>Microstonyx major</i>	+	+	+	-
Cervidae indet.	+	?	+	-
<i>Helladotherium duvernoyi</i>	-	+	?	-
<i>Palaeotragus rouemii</i>	?	+	+	-
<i>Gazella</i> (<i>Procapra</i>) sp.	-	+	-	+
<i>Palaeorx</i> sp.	-	+	?	+
<i>Palaeoreas lindermayeri</i>	-	+	?	?
<i>Tragoportax</i> sp. 1 & 2	-	+	+	-
<i>Hystrix pringenia</i>	-	+	+	-
<i>Mesopithecus</i> cf. " <i>M. dalsoni</i> "	?	+	-	-

Forests	12.88
Forest-steppe	39.4
Grasslands	21.21
Thicket	26.52

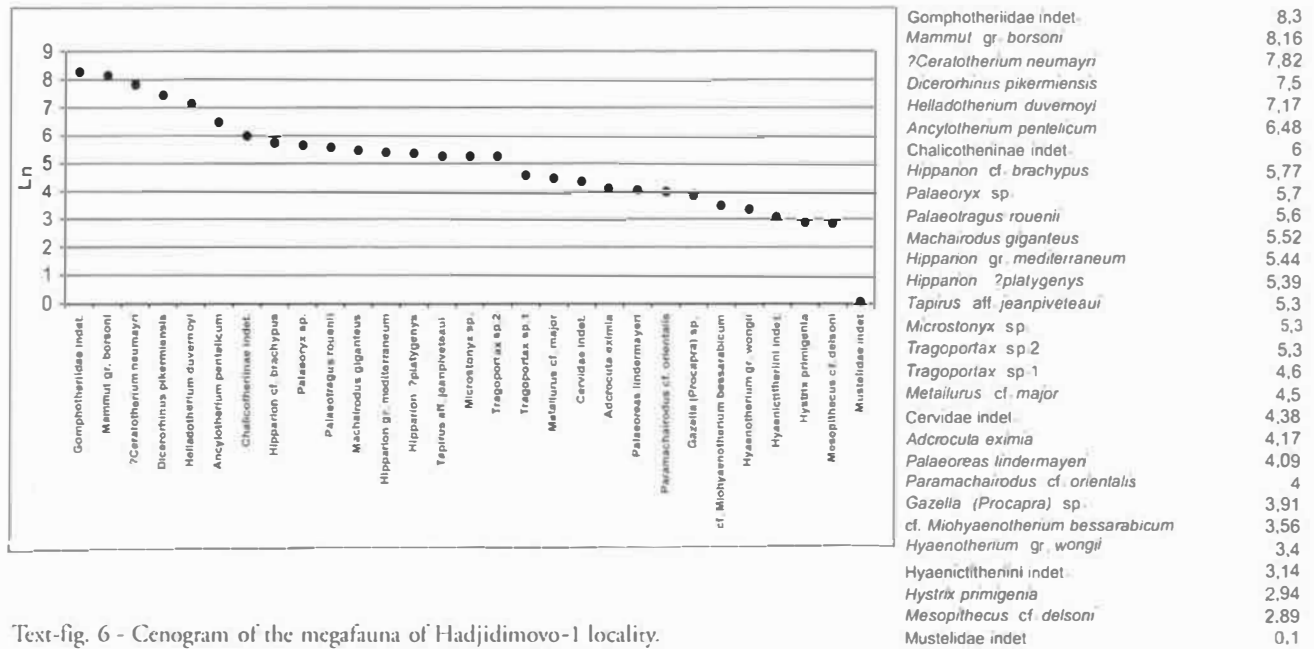


Text-fig. 5 - Distribution of the biomes from Hadjidi-movo after the ecological requirements of the species.

(see the retrospection in Solounias *et al.*, 1999). It should be noted, however, that the savannas are a biome associated with certain vegetation species and the tropic latitudes. So, the name "savannas" is not fully correct. More correct is to speak about savanna-like landscapes.

Recently Solounias *et al.* (1999) criticized the concept of "open", "savanna" landscapes determining the Pikermian biome. The authors claim that the palaeobotanic data, the isotope, the tooth microwear and the masticatory analysis of the herbivores show a strong presence of tree/thicket vegetation (sclerophyllous evergreen woodland) in this palaeobiome and the adaptation of ungulates toward it. We should

note, however, that a savanna landscape does not obligatorily mean open grasslands. Savannas are typical for a warm, relatively arid climate with seasonal dry periods. The prevailing types of savannas represent dry open forests (so called tree savannas), with a strongly developed grass store, with low and relatively scarce tree vegetation (park-type landscapes), often turning into bush-grass communities (Hopkins, 1977; Fukarek *et al.*, 1979; Gruev, 1988). The tree and bush vegetation in this case, however, is represented well enough - that's why the abundance of leaf-eating browsers with brachyodont teeth as *Palaeoreas* and *Palaeotragus*, or grazers to possible browsers as *Cremhipparion mediterraneum* is not



Text-fig. 6 - Cenogram of the megafauna of Hadjidimovo-1 locality.

astonishing. At the same time, the large part of those animals would not live in dense thickets or woods for numerous reasons, as we noted above. As we also noted above the analysis of the taphocoenosis of Hadjidimovo shows a predominance of forest-steppe s. l. species and biotopes. That is why we could accept the term "woodland" *sensu* Solounias *et al.* (1999) for the typical physiognomy of the "Pikermian biome" only if this term means a forest-steppe landscape, physiognomically resembling a forest savanna (so-called park type), and not hardly penetrable dense thickets and woods.

Eventually, the so-called Pikermian biome (*sensu* Solounias *et al.*, 1999) and especially the landscape from Hadjidimovo were rather represented by forest-savanna-like (in terms of physiognomy of the landscape) biotopes. Such was most probably the prevailing environment in the Turolian of Southeast Europe, the region north of recent Black Sea and the hinterland.

Solounias *et al.* (1999) note that the origins of the Recent African savanna fauna are related to the Pikermian non-African biome. This is an opinion we generally support. We could look for the origin of this fauna in the areas of dispersal of vegetal communities physiognomically close to a forest savanna: there are numerous data that out of Africa, on large areas northeast of the continent, the forest-savanna-like woodlands (we mean open forests of "park" type) and their faunal complexes, already existed for a long time. The spreading of more or less open spaces is seen in Eurasia as early as the Late Eocene and Oligocene, during the gradual aridification in Central Asia (Flerov & Yanovskaya, 1974). This process continues in time and space. The late Miocene fauna complexes linked to forest-savanna-like landscapes

are probably related in their origin to the area including vast territories of West Central Asia, Asia Minor, the Circumpontic regions and the East Mediterranean (including the Balkans and possibly parts of N. Africa) – so called Southeast European – Southwest Asian "superprovince" *sensu* Bernor *et al.*, (1996a) (cf. Balkan-Kaukasian subprovince *sensu* Flerov & Yanovskaya, 1974; cf. Greco-Iranian province *sensu* Bonis *et al.*, 1994). This is where the origins of the Recent savanna fauna complex of the Old world should be looked for.

ACKNOWLEDGMENTS

I would like to express my gratitude for the help to Prof. I. Rook (Univ. of Firenze) as well as to Prof. R. Bernor (Howard Univ., Washington D.C.) for his greatly useful comments as a reviewer. Paper published with the support of CNR grant (Lorenzo Rook).

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(manuscript received June 26, 2001
accepted December 18, 2001)

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