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Middle Pleistocene small mammals (*Insectivora*, *Lagomorpha*, *Rodentia*) from Morovitsa Cave (North Bulgaria)

[With 11 text-figs]

Środkowoplejstoceńskie drobne ssaki (*Insectivora*, *Lagomorpha*, *Rodentia*) z jaskini Morowica (Bulgaria)

A b s t r a c t. The present paper is a study of small fossil mammals found in the matrix of multilayer deposits in the entrance chamber of Morovitsa Cave. The systematic part of study contains a review of 34 small mammal taxa. The characteristic feature of the Morovitsa local fauna is that it contains recent genera (except *Pliomys* in lower layers), but some of the species are somewhat more primitive than recent end-members of these phyletic lineages. The morphological evolution in some phyletic lineages is traced and discussed. The biostratigraphic zonation and correlations suggest that Morovitsa section represents the upermost part of Mauer and the lower part of Swanscombe phases of Steinheimian. The faunal change is not sharp and it is probably connected with progressive continentalisation of the climate during deposition of lower layers.

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I. INTRODUCTION

Morovitsa Cave is situated on the left slope of the Wit river valley, ca. 300 m above the river (about 800 m a.s.l.) near the village of Glogene, Lovec district.

The cave was known long time ago as an archeological and palaeontological

locality thanks to the investigations of R. POPOV (1913). The palaeozoological material elaborated in the present study comes from trench IV, which corresponds to R. POPOV's trench II. R. POPOV refers the "deluvial" sediments of the cave's entrance chamber to the "second interglacial" (POPOV 1913).

The sequence of the cave deposits in trench IV is presented in Fig. 1.

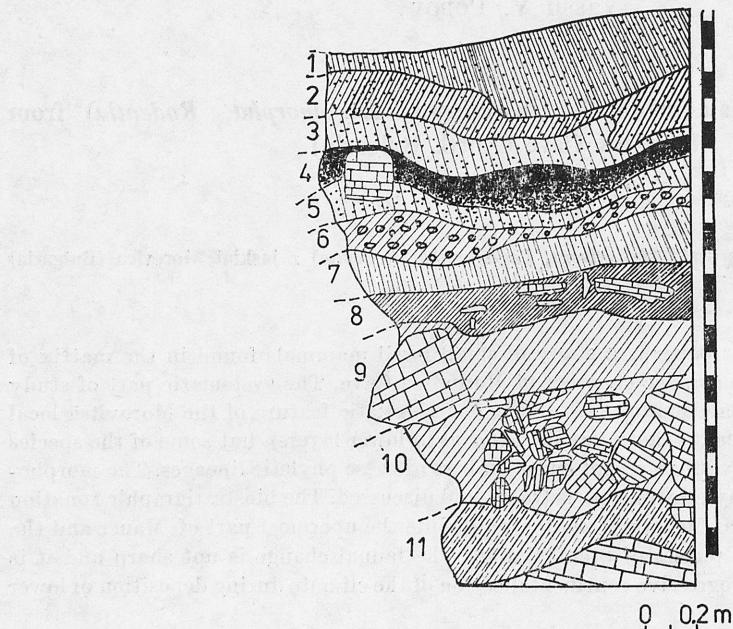


Fig. 1. The profile of the sediments in Trench IV, Morovitsa Cave. Layer 1: light brown loam with rounded rubble; Layer 2: dark brown loam with rounded fine rubble; Layer 3: reddish brown sandy clay with rounded fine limestone debris; Layer 4: black sandy clay with rounded rubble; Layer 5: yellowish sandy clay with fine rounded rubble; layer 6: dark brown clay with rubble consisting of slightly rounded and corroded fragments and carbonate-clay aggregates; Layer 7: whitish brown sandy clay poor in limestone debris; Layer 8: brownish clay with small amount of rounded fine rubble; large slab-stone fragments occur; Layer 9: yellowish sands, clay with substantial admixture of limestone debris; fine rubble particles are weathered, while the large ones are relatively angular; Layer 10: consists of large limestone blocks, large and middle-size angular limestone debris; the amount of the clay is only 1/3 of the sample volume; Layer 11: yellow brown clay with lenses and thin dark brown layers; fine rubble is rounded and corroded while large limestone fragments are angular-shaped; in some places carbonized rubble-bone aggregates occur

A systematic sampling at each layer was carried out. The number of individual samples (0.01 m^3 fine sediments each) per layer varied from 8 to 16 according to the concentration of the remains. Each individual sample was placed in a meshy bag (mesh size 1 mm) and washed. Small mammal remains were extracted from the residuum by picking under magnifying glass ($5\times$). The material from each individual sample was kept separately in order to estimate the minimal number of remains necessary to represent the "whole" small mammal

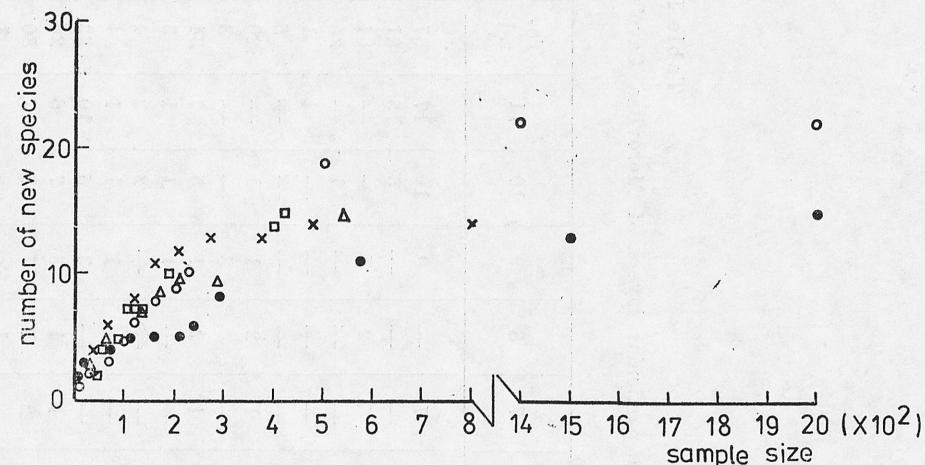


Fig. 2. The cumulative number of small mammal species plotted against the number of remains (teeth) collected. Data from: 1. layer 3 (the last two points represent the addition of the material from layers 4 and 5), (solid circles); 2. layer 6 (crosses); 3. layer 7 (white triangles); 4. layer 8 (white squares); 5. layer 9 (the last two points represent the material from layer 10 and 11), (white circles)

assemblage in a given layer (Fig. 2). It was concluded that at least 500 items should be reached per layer.

More than 8700 specimens of at least 34 species were collected (Tab. I). Moreover, the remains of fishes, amphibians, reptiles, birds and bats were yielded. This assemblage is probably due to the accumulation of owl pellets during the deposition of cave's sediments.

The details for the methods of elaborating the material (measurements, statistics, terminology etc.) can be found in our previous works (POPOV 1985, 1986, 1988).

The collection number of the material of each species is a combination of the running number of the species in Table I and the code of layer sample (Mor 1—11). Moreover, the index of Institute of Zoology, Sofia (IZ), where the material is stored, is added. For example the collection number of *Eolagurus luteus* material is 25-Mor 7, 8/IZ.

The number of remains determinable is presented in Tab. I. More details for the peculiarities of the material could be found in the tables of measurements (Tab. II—IV).

II. SYSTEMATIC REVIEW

1. Insectivores

Talpa cf. europaea LINNÆUS, 1758 (Tab. II). The material from Morovitsa Cave shows great resemblance to recent *T. europaea*, both in terms of morphology and measurements. On the other hand, some mandibular fragments, for

Table I
List of species (*Insectivora*, *Lagomorpha* and *Rodentia*) and number of remains* collected from particular layers of Morovitsa Cave's deposits (Trench IV)

Col. No:	Species	Layer	1	2	3	4	5	6	7	8	9	10	11	Total
1.	<i>Talpa</i> cf. <i>europea</i>	3	3	1	1	3	13	7	—	9	10	17	67	
2.	<i>Sorex subaraneus</i>	—	?1	—	—	—	—	—	—	—	—	5	21	
3.	<i>S. cf. araneus</i>	73	35	20	5	17	40	7	2	5	—	—	204	
4.	<i>S. minutus</i>	11	4	2	2	2	3	—	—	—	1	—	25	
5.	<i>S. minutissimus</i>	—	—	—	—	—	—	—	—	—	—	1	1	
6.	<i>Crocidura</i> cf. <i>zorzii</i>	4	1	—	—	—	—	—	—	—	—	—	5	
7.	<i>Ochotona</i> sp. (cf. <i>pussilla</i>)	8	2	—	—	1	4	1	2	1	1	—	20	
8.	<i>Lepus europeus</i>	—	—	—	—	—	—	—	—	3	—	—	3	
9.	<i>Spermophilus citellus</i>	8	2	2	3	6	1	1	2	1	5	3	34	
10.	<i>Muscardinus</i> cf. <i>avellanarius</i>	—	—	—	—	—	—	—	—	—	1	1	3	
11.	<i>Dryomys</i> cf. <i>nitedula</i>	1	—	—	—	—	—	—	—	—	1	1	4	
12.	<i>Glis</i> cf. <i>glis</i>	—	—	—	—	—	—	—	—	—	3	5	10	
13.	<i>Sicista subtilis</i>	2	—	—	—	—	—	2	—	—	1	1	22	
14.	<i>Nannospalax leucodon</i>	2	2	—	—	2	1	1	1	1	3	7	6	
15.	<i>Apodemus</i> ex gr. <i>sylvaticus</i> <i>flavocollis</i>	18	2	4	2	2	—	—	2	1	7	25	17	
16.	<i>Apodemus</i> sp.	—	—	—	—	—	—	—	—	1	—	—	1	
17.	<i>Alloricetetus bursae</i>	4	—	—	—	—	—	—	—	3	4	42	98	

* — „number of remains” means: for insectivores-number of molars and humeri/radi (*Talpa*); for lagomorphs and rodents except voles-number of molars; for voles-number of M₁. In all cases the number of teeth is counted regardless of state of preservation-in mandible/maxillae or isolated.

example from layer 6, fall at the top or above of modern *T. europaea* range. However they are smaller than *Talpa episcopalis* KORMOS, 1930 and differ from this species by its longer molar row, the absence of anterior cingulum of M_2 , and the situation of mental foramen.

Sorex subaraneus HELLER, 1958 (Tab. II). The size of the remains from lower layers of Morovitsa Cave is intermediate between *Sorex runtonensis* HINTON, 1911 and *Sorex araneus* LINNAEUS, 1758 and differ from these two species in having a relatively high and narrow condyle. In this respect they show similarity with *S. subaraneus*. The specimens under study are larger than *S. subaraneus* from Varbeshnitsa (POPOV 1987) and attain size similar to this species from La Fage (JAMMOT 1973).

Sorex cf. araneus LINNAEUS, 1758 (Tab. II). The material under study, though generally similar to that of recent *S. araneus* differs by its larger size. The size

Table II

Selected postcranial mandibular and teeth measurements (mm) of some insectivores from Morovitsa Cave's deposits (Trench IV). Abbreviations. Measurements: cL-coronar length, H-height, L-length, w-width; anatomical elements: r-radius, h-humerus, pc-proc. *coronoides*, mr/ M_2 -mandibular ramus below M_2 , M-molar, P-praeomolar, I-incisive; statistics: N-sample size, O.R.-observed range, X-mean, SD-standart deviation, CV-coefficent of variability (in %)

Species	Character	N	O. R.	X	SD	CV
1	2	3	4	5	6	7
<i>Talpa cf. europaea</i> (all layers)	L(r)	13	11.80—13.90	12.87	0.50	3.88
	L(h)	5	14.00—15.60	14.88	0.61	4.13
	max W(h)	3	9.30—11.40	10.66	—	—
	min W(h)	11	3.70—4.90	4.44	0.31	7.07
	H (mr/ M_2)	20	2.24—3.25	2.72	0.32	11.84
	cL($M_1—M_3$)	2	7.19—7.62	—	—	—
<i>Sorex subaraneus</i> (layers 11—10)	H (pc)	7	4.09—4.52	4.31	0.16	3.64
	H (mr/ M_2)	16	0.99—1.38	1.19	0.05	4.03
	cL($M_1—M_3$)	4	3.57—3.95	3.75	0.16	4.18
<i>Sorex cf. araneus</i> (layers 9—1)	H (pc)	83	4.52—5.24	4.88	0.15	2.99
	H (mr/ M_2)	148	1.24—1.62	1.47	0.09	6.39
	cL($M_1—M_3$)	72	3.76—4.33	4.03	0.12	2.95
	cL(P ₃ —M ₃)	25	5.23—5.95	5.57	0.20	3.55
	cL(I ₁ —M ₃)	19	7.62—8.33	8.06	0.20	2.48
<i>Sorex minutus</i> all layers	H (pc)	20	3.09—3.33	3.19	0.07	2.19
	H (mr/ M_2)	31	0.67—0.99	0.86	0.07	8.32
	cL($M_1—M_3$)	10	3.19—3.47	3.34	0.09	2.69
<i>Crocidura cf. zorpii</i>	H (pc)	3	5.28—5.45	5.36	—	—
	H (mr/ M_2)	4	1.62—1.99	1.76	—	—
	cL($M_1—M_3$)	2	4.47—4.62	—	—	—
	cL(P ₃ —M ₃)	2	6.19—6.42	—	—	—
	cL(I ₁ —M ₃)	2	8.24—8.66	—	—	—

of Morovitsa form is identical with Middle Pleistocene *S. a. macrognathus* JÁNOSSY, 1965.

Sorex minutus LINNAEUS, 1758 (Tab. II). The material from the whole sequence is homogeneous. The comparison of the Morovitsa sample with recent species from Bulgaria does not show any clearcut differences in pattern and size.

Sorex minutissimus ZIMMERMANN, 1870. The tips of the teeth are pigmented darkcherred. The mental foramen is under the first half of the M_1 . The measurements of the single mandible available are as follows: height of the horizontal ramus under M_2 — 0.62 mm; length of the molar row ($M_1—M_3$) — 2.99 mm. The size of this specimen is smaller than those of recent *S. minutus* and about equal to those of *S. cf. minutissimus* (RZEBIK 1968).

Crocidura cf. zorzii PASA, 1943 (Tab. II). The Morovitsa specimens strongly resemble the recent *Crocidura leucodon* HERMANN, 1780 but are distinctly larger. The material available agrees well with the description of *C. zorzii* (PASA 1949) and with the specimens from Gössweinstein (BRUNNER 1957). The specimens from La Fage referred to this species (JAMMOT 1973) are larger than our material

2. Lagomorphs

Ochotona sp. (cf. *pusilla* PALLAS, 1768). The scarce material from Morovitsa cave comes nearest to *O. pusilla* as far as the morphology and size of molars are concerned. The absence of the diagnostic P_3 does not permit a conclusive determination.

Lepus europaeus PALLAS, 1778. Only isolated upper incisive and one P_3 were found. They are identical with these in recent comparative material of *L. europaeus*.

3. Rodents

Spermophilus citellus (LINNAEUS, 1776), (Fig. 3 : 9, 10, Tab. III). The material from Morovitsa cave can not be distinguished from the recent *S. citellus* by means of dental pattern and measurements.

Muscardinus cf. avellanarius (LINNAEUS, 1758), (Fig. 3 : 1—3). The scarce material from Morovitsa cave is difficult to determine conclusively. Although there is similarity in size with recent species from Bulgaria, morphological differences such as additional ridge on M^1 differentiate the specimen from the recent species.

Measurements (length \times width) in mm: $M_1 = 1.66 \times 1.24$; 1.62×1.19 ; $M^1 = 1.99 \times 1.28$.

Dryomys nitedula (PALLAS, 1778), (Fig. 3 : 11, 12). The size of specimens under consideration is larger than the size of both recent species — *D. nitedula* (STORCH 1978, author's data) and *D. laniger* FELTEN et STORCH, 1968 (FELTEN et al. 1973). The Middle Pleistocene *D. nitedula* from the isle of Chios (STORCH 1975) is also smaller. The scarce material available as well as the lack of complete

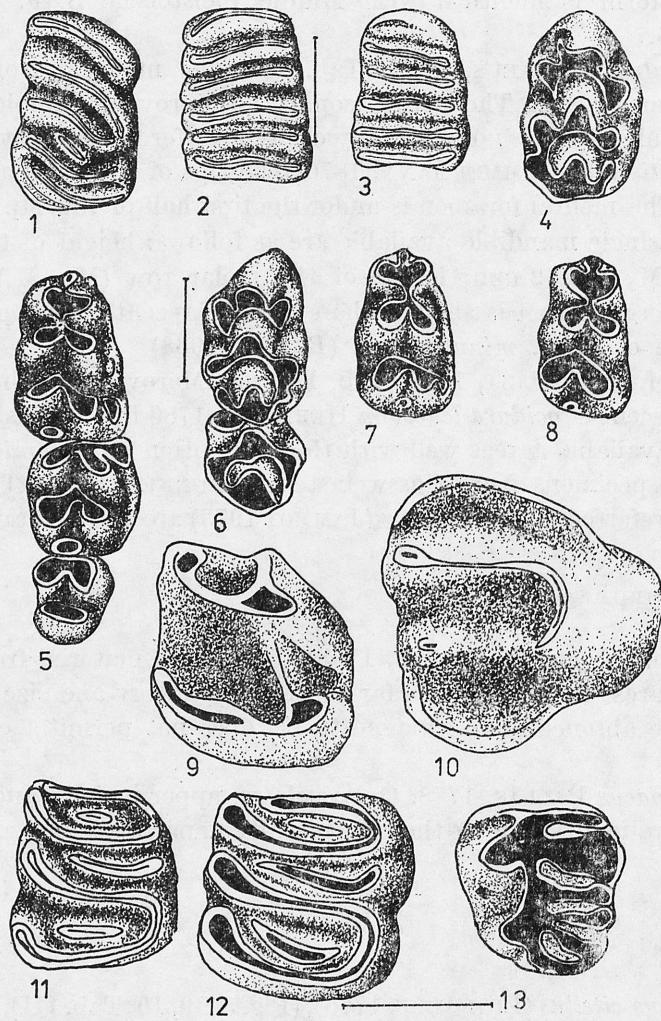


Fig. 3. 1—3. *Muscardinus* cf. *avanlanarius*. 1. — right M^1 (No: 10-Mor 9/IZ), 2. — left M_1 (No: 10-Mor 9/IZ), 3. — right M_1 (No: 10-Mor 11/IZ); 4.—7. *Apodemus* ex gr. *sylvaticus-flavicolpis*. 4. — right M^1 (No: 15-Mor 10/IZ), 5. — right M_1 — M_2 (No: 15-Mor 3/IZ), 6. — left M^1 — M_2 (No: 15-Mor 10/IZ), 7. — right M_1 (No: 15-Mor 6/IZ); 8. cf. *Apodemus* sp., right M_1 (No: 16-Mor 8/IZ); 9, 10. *Spermophilus citellus*. 9. — right $M_{1/2}$ (No: 9-Mor 11/IZ), 10. — right M^3 (No: 9-Mor 11/IZ); 11, 12. *Dryomys* cf. *nitedula*, 11. — left M_1 (No: 11-Mor 11/IZ), 12. — right M_2 (No: 11-Mor 11/IZ); 13. *Sicista subtilis*, left M^2 (No: 13-Mor 11/IZ). Scales represent 1 mm

data on Pleistocene *Dryomys*-species do not permit to ascertain whether these differences are of systematic value.

Measurements (length \times width) in mm: $M_1 = 1.19 \times 1.09$; $M_2 = 1.38 \times 1.43$; 1.24×1.24 ; 1.24×1.33 .

Glis cf. *glis* (LINNAEUS, 1766). The material under study falls to the lower part (or below it) of the modern *G. glis* size-range, while in the same time it

Table III

Molar measurements (mm) for some rodents from Morovitsa Cave's deposits. For abbreviations see Tab. II

Species	Character	N	O. R.	X	SD	CV
1	2	3	4	5	6	7
<i>Spermophilus citellus</i> (all layers)	LP ₄	2	1.95—2.14	—	—	—
	WP ₄	2	2.19—2.23	—	—	—
	LM _{1/2}	10	1.99—2.70	2.24	0.217	9.70
	WM _{1/2}	10	2.62—3.33	2.99	0.222	7.44
	LM ₃	3	2.81—3.05	2.95	—	—
	WM ₃	3	2.57—2.90	2.70	—	—
	LP ⁴	1	2.05	—	—	—
	WP ⁴	1	2.28	—	—	—
	LM ^{1/2}	10	1.90—2.28	2.08	0.119	5.71
	WM ^{1/2}	10	2.17—3.05	2.66	0.281	10.57
<i>Sicista subtilis</i> (all layers)	LM ³	5	2.43—2.95	2.70	0.205	7.61
	WM ³	5	2.17—2.82	2.55	0.257	10.07
	LM ₁	9	1.24—1.38	1.27	0.045	3.62
	WM ₁	9	0.85—0.95	0.92	0.046	4.08
	LM ₂	5	1.09—1.24	1.17	0.057	4.87
	WM ₂	5	0.85—1.09	0.97	0.086	8.92
	LM ₃	2	0.86—0.86	—	—	—
	WM ₃	2	0.76—0.81	—	—	—
	cL(M ₁ —M ₃)	1	3.33	—	—	—
	LM ¹	4	1.14—1.19	1.15	—	—
<i>Apodemus ex gr.</i> <i>sylvaticus-flavicollis</i> (all layers)	WM ¹	4	1.14—1.19	1.17	—	—
	LM ²	3	1.05—1.14	1.11	—	—
	WM ²	3	1.05—1.09	1.06	—	—
	LM ₁	30	1.62—1.95	1.76	0.113	6.41
	WM ₁	3	0.95—1.19	1.08	0.055	5.11
	LM ₂	13	1.05—1.43	1.21	0.116	9.57
	WM ₂	13	0.99—1.19	1.09	0.069	6.33
	LM ₃	2	0.90—0.95	—	—	—
	WM ₃	2	0.81—0.86	—	—	—
	LM ¹	14	1.66—2.05	1.88	0.135	7.18
<i>Allocricetus bursae</i> (all layers)	WM ¹	14	1.14—1.43	1.25	0.082	6.64
	LM ²	8	1.19—1.33	1.25	0.048	3.85
	WM ²	8	1.09—1.25	1.18	0.069	5.88
	LM ³	1	0.87	—	—	—
	WM ³	1	0.93	—	—	—
	LM ₁	21	1.62—1.90	1.78	0.079	4.47
	WM ₁	21	1.05—1.24	1.11	0.048	4.36
	LM ₂	21	1.38—1.52	1.45	0.056	3.38

Table III cont.

1	2	3	4	5	6	7
	LM ²	14	1.19—1.47	1.37	0.078	5.69
	WM ²	14	1.09—1.43	1.23	0.086	6.99
	LM ³	3	1.09—1.14	1.12	—	—
	WM ³	3	1.05—1.19	1.11	—	—
	cL(M ¹ —M ³)	1	4.43	—	—	—
cf. <i>Oricetulus migratorius</i>	LM ₁	5	1.47—1.71	1.62	0.090	5.57
	WM ₁	5	0.99—1.12	1.03	0.058	5.59
	LM ₂	4	1.19—1.42	1.28	—	—
	WM ₂	4	0.95—1.19	1.09	—	—
	LM ₃	3	1.14—1.40	1.24	—	—
	WM ₃	3	0.90—1.10	1.02	—	—
	cL(M ₁ —M ₃)	3	3.86—4.19	3.95	—	—
	LM ¹	3	1.76—1.81	1.78	—	—
	WM ¹	3	1.14—1.16	1.15	—	—
	LM ²	2	1.24—1.33	—	—	—
	WM ²	2	1.09—1.19	—	—	—
	LM ³	2	1.05—1.14	—	—	—
	WM ³	2	0.99—1.09	—	—	—
	cL(M ¹ —M ³)	2	4.05—4.09	—	—	—
<i>Mesocricetus newtoni</i> (all layers)	LM ₁	25	2.14—2.57	2.35	0.111	4.74
	WM ₁	25	1.05—1.43	1.24	0.088	7.15
	LM ₂	24	1.90—2.38	2.16	0.127	5.88
	WM ₂	24	1.38—1.76	1.55	0.099	6.37
	LM ₃	19	2.14—2.80	2.45	0.201	8.20
	WM ₃	19	1.43—2.05	1.63	0.169	10.38
	cL(M ₁ —M ₃)	7	6.47—7.10	6.79	0.268	3.95
	LM ¹	26	2.38—2.81	2.57	0.100	3.88
	WM ¹	26	1.33—1.81	1.63	1.120	7.39
	LM ²	16	1.90—2.38	2.11	1.125	5.91
	WM ²	16	1.43—1.81	1.64	0.114	6.97
	LM ³	19	1.71—2.28	2.02	0.165	8.17
	WM ³	19	1.33—1.76	1.55	0.119	7.68
	cL(M ¹ —M ³)	1	7.30	—	—	—

falls towards the top of the Middle Pleistocene *G. cf. sackdillingensis* (HELLER, 1930)-range from Varbeshnitsa (POPOV 1988).

Measurements (length × width) in mm : M₂ = 1.95 × 2.05; 2.05 × 1.90; M₃ = 1.90 × 1.62.

Sicista subtilis (PALLAS, 1773), (Fig. 3 : 13, Tab. III) The simple structure of the occlusal surface and large size of the molars available differentiate them from recent *S. betulina* (PALLAS, 1778) and falls in the upper part or above the range of variability of recent *S. subtilis* from Roumania (PUCEK 1982). In this respect the remains show a similarity with Upper Pleistocene materials referred to *S. subtilis* (TERZEA 1971, 1974, MAYHEW 1978, POPOV 1985).

Apodemus ex gr. sylvaticus (LINNAEUS, 1758) — *flavicollis* (MELCHIOR,

1834), Fig. 3 : 4—7, Tab. III) The major dental features are largely the same in both *A. sylvaticus* and *A. flavigollis*, which renders doubtful the evaluation of the differences between small samples.

In general the size of the molars available is smaller than in the recent *A. flavigollis* from cave's surroundings.

cf. *Apodemus* sp. (Fig. 3 : 8). Among the *Apodemus* material from layer 8 a small M_1 (1.62×0.99) without supplementary labial tubercles was found. The overall pattern of this molar is reminiscent of *Micromys minutus* (PALLAS, 1771) but it is considerably larger. On the other hand, such morphotypes can be found in recent *Apodemus microps* KRATOCHVIL et ROSICKY, 1953. Thus, we consider this molar as belonging to genus *Apodemus* KAUP, 1829 rather than to *Micromys* DEHNE, 1841.

Nannospalax leucodon (NORDMANN, 1840). The dental pattern and measurements show that the material is indistinguishable from recent *N. leucodon*.

Measurements (length \times width) in mm: $M_1 = 2.66 \times 2.24$; $M_2 = 2.28 \times 1.85$; 2.14×1.90 ; 2.28×2.28 ; $M_3 = 1.66 \times 1.62$; 1.76×1.71 ; $M^1 = 2.62 \times 1.99$; 2.66×1.95 ; LM^2 (min.-mean-max.) = $1.81—2.23—2.52$ ($N = 7$); $WM^2 = 1.81—2.05—2.47$ ($N = 7$); $M^3 = 1.57 \times 1.66$; 1.76×1.62 ; $L(M^1—M^3) = 8.70$; 8.50 .

Allocricetus bursae SCHAUB, 1930 (Fig. 4 : 10, 11, Tab. III). The comparison of the Morovitsa sample with extant *Cricetulus migratorius* (PALLAS, 1773) and Pleistocene *Allocricetus bursae* SCHAUB, 1930 shows that there are not any clear-cut differences in pattern. According to the literature, the main difference between these species concerns only the size. On the other hand, the overlap in measurements between the species is such that individual specimens are often indeterminable. Although there seems to be little reason to doubt that *C. migratorius* and *A. bursae* are closely related, the nature of this relationship remains as yet obscure.

As follows from the measurements, the range of Morovitsa sample falls within the range of *A. bursae* from the type-locality Brassö (SCHAUB 1930). When examined against the background of the range of recent *C. migratorius* from Moldavia (POPOV 1988), the Morovitsa specimens are definitively larger and the most logical interpretation would appear to be specific differences.

cf. *Cricetulus migratorius* (PALLAS, 1773), (Tab. III). Some specimens from Morovitsa Cave fall below the range of *A. bursae*. The geographical situation of the locality allows to suppose that these remains belong to *C. migratorius*. Poor reason given above the classification of such a small sample with this species is rather arbitrary. On the other hand, the comparison with other Pleistocene records from adjoining areas, referred to *C. migratorius* (VAN DER VEERD 1973, STORCH 1975, MAYHEW 1978) show similarity both in size and morphology.

Mesocricetus newtoni (NEHRING, 1898), (Fig. 4 : 6,7, Tab. III) The data concerning the size of recent and fossil representatives of genus *Mesocricetus* NEHRING, 1898 (BATE 1943, TCHERNOV 1968, SAMSON, RADULESCO 1972, STORCH 1975, MAYHEW 1978, BARISHNIKOV, BARANOVA 1983 etc.) show that during the Pleistocene as well as at present, the species can be arranged into two size groups.

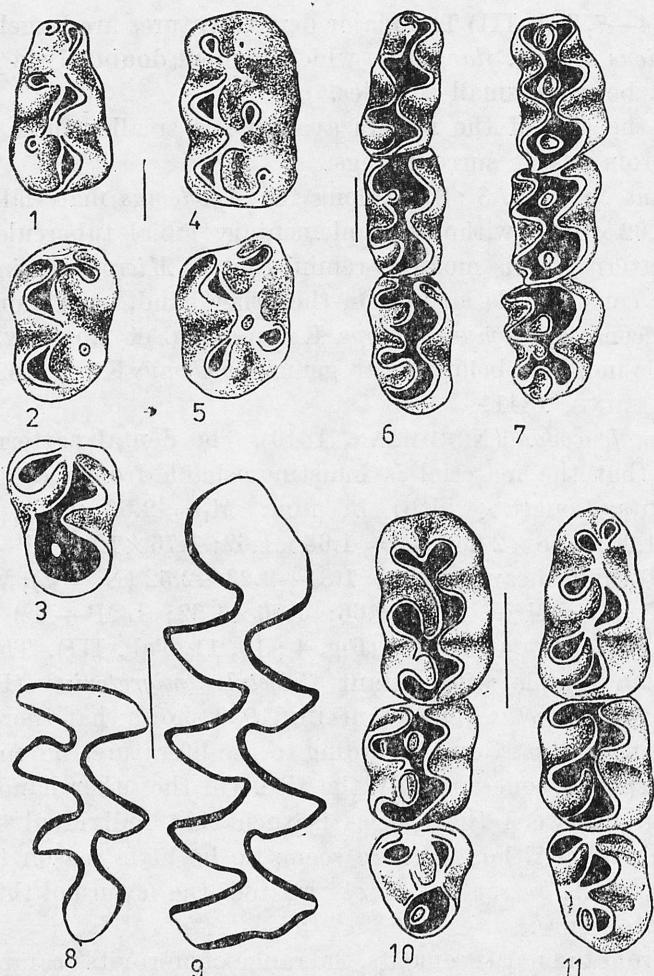


Fig. 4. 1—5. *Cricetus cricetus*, 1. right M_1 — (No: 20-Mor 10/IZ), 2, 5—left M_2 's (No: 20-Mor 11/IZ), 3. — left M_3 (No: 20-Mor 10/IZ), 4. — left M^1 (No: 20-Mor 11/IZ); 6, 7. *Mesocricetus newtoni*, 6. — right M_1 — M_3 (No: 19-Mor 8/IZ), 7. — right M^1 — M^3 (No: 19-Mor 2/IZ); 8, 9. *Eolagurus luteus*, 8. — right M^3 , 9. — right M_1 (No: 25-Mor 8/IZ); 10, 11. *Allocricetus bursae*, 10. — right M^1 — M^3 (No: 17-Mor 1/IZ), 11. — left M_1 — M_3 (No: 17-Mor 2/IZ). Scales represent 1 mm

ups: 1. large-sized ("northern") species — *M. raddei* NEHRING, 1894 (the Pre-caucasus region) and *M. newtoni* (Balkan peninsula); 2. small-sized ("southern") species — *M. brandti* NEHRING, 1898, *M. auratus* WATERHOUSE, 1839, *M. arameus* BATE, 1943. The size of Morovitsa remains agrees well with the first group. Although similar in size to Middle Pleistocene *M. raddei planicola* ARGYROPULO, 1941 (BARISHNIKOV, BARANOVA 1983) our material differs in the relative length of molars. According to this criterion the Morovitsa specimens are more similar to Upper Pleistocene and recent *M. newtoni*.

Cricetus cricetus (LINNAEUS, 1758), (Fig. 4 : 1—5). Both the dental pattern

and the size of the big hamster found in the Morovitsa deposits are nearly identical with that of recent and Upper Pleistocene *C. cricetus* (PRADEL 1981, 1985, BARISHNIKOV, BARANOVA 1983, RADULESCO 1972).

Measurements (length \times width) in mm: $M^1 = 3.33 \times 2.24$; $M^2 = 2.38 \times 2.24$; 2.85×2.33 ; $M_1 = 2.95 \times 1.81$; $M_2 = 2.62 \times 2.19$; 2.57×2.09 ; $M_3 = 2.57 \times 2.05$; 2.80×1.99 ; 2.90×1.99 ; 2.86×1.99 ; $L(M_1 - M_3) = 8.10$.

Pliomys lenki (HELLER, 1930), (Fig. 5 : 13—15, Tab. IV). The very high dentine tracks show that we deal with an advanced form. This assumption is confirmed by the large size of M_1 as well as by M_1/M^3 dental pattern. In these respects the

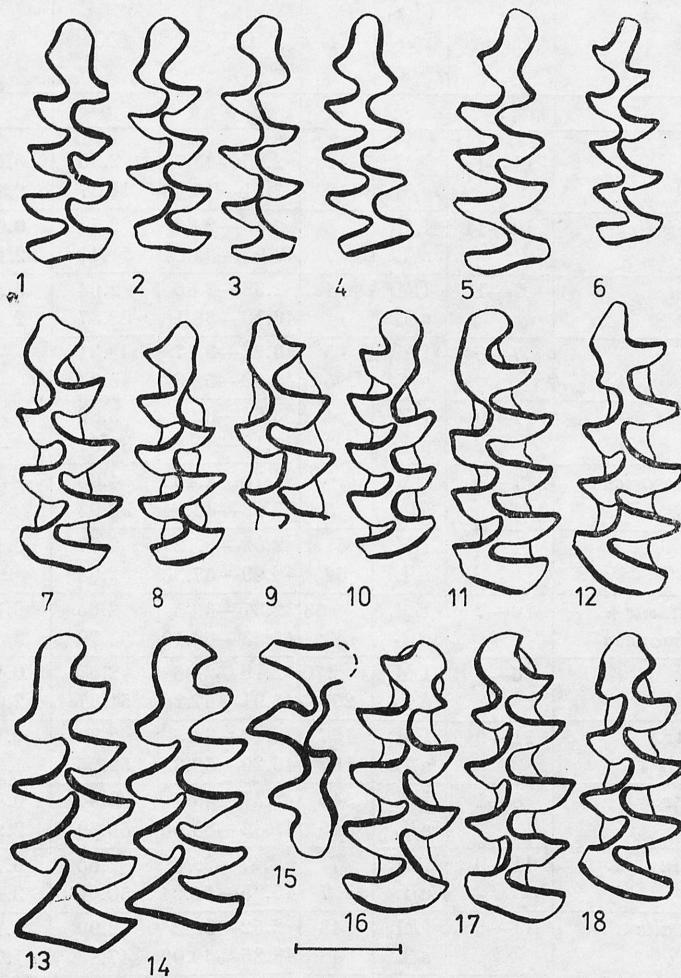


Fig. 5. 1—5. *Lagurus* cf. *transiens*, 1, 3, 4, 5. — right M_1 's, 2. — left M_1 (No: 23-Mor 11/IZ); 6. *Lagurus lagurus*, right M_1 (No: 24-Mor 2/IZ); 7—12. *M. (Stenocranius)* cf. *gregalis*, 7. — left M_1 , 8, 10. — right M_1 's (No: 33-Mor 11/IZ), 9. — left M_2 (No: 33-Mor 10/IZ), 11, 12. — left M_1 's (No: 33-Mor 9/IZ); 13—15. *Pliomys lenki*, 13, 14. — left M_1 's, 15. — left M^2 (No: 21-Mor 11/IZ); 16, 17. *Microtus* (s. str.) ex gr. *arvalinus-arvalis*, 16. — right M_1 , 17. — left M_1 (No: 31-Mor 10/IZ); 18. *Chionomys nivalis*, left M_1 (No: 34-Mor 2/IZ). Scale represents 1 mm

material under study shows the highest resemblance to some progressive chrono-subspecies such as *P. l. ultimus* FEJFAR, 1975 and *P. l. relictus* CHALINE, 1975. However these forms can be distinguished only on the basis of large samples. Hence it is difficult to assign our scarce material to one of these subspecies conclusively.

Table IV

Selected M_1 measurements (mm) and ratios (%) for some voles from Morovitsa Cave's deposits (Trench IV). For abbreviations see Table II. a-length of anteroconid complex (ACC), a/L-relative length of ACC

Species	Layer	Char- acter	N	O.R.	X	SD	CV
1	2	3	4	5	6	7	8
<i>Clethrionomys glareolus</i>	11—1	LM ₁ a/L	12 12	2.05—2.57 37.71—45.45	2.35 41.37	0.187 2.43	7.85 5.88
<i>Lagurus cf. transiens</i>	10—11	LM ₁ a/L	8 7	2.38—2.66 48.97—55.64	2.54 51.40	0.099 2.12	3.91 4.12
<i>Lagurus lagurus</i>	7—1	LM ₁ a/L	14 14	2.38—2.86 46.18—56.10	2.64 52.57	0.137 2.36	5.21 4.49
<i>Eolagurus luteus</i>	7—8	LM ₁ a/L	5 5	3.22—3.47 42.59—53.31	3.31 49.34	— —	— —
<i>Arvicola cf. kalmakensis</i>	11—9	LM ₁ a/L	4 3	3.62—3.99 37.18—41.60	3.82 39.87	— —	— —
<i>Arvicola cf. chosaricus</i>	7—1	LM ₁ a/L	5 5	3.76—4.43 37.53—42.04	4.03 38.93	— —	— —
<i>M. (Pitymys) arvalidens</i>	11	LM ₁ a/L	51 52	2.52—3.12 46.69—57.33	2.77 52.08	0.154 2.59	5.57 4.98
<i>M. (P.) arvalidens+</i> <i>M. (P.) subterraneus</i>	10—7	LM ₁ a/L	63 63	2.37—3.05 45.23—56.19	2.65 51.79	0.195 2.66	7.28 5.14
<i>M. (Pitymys) subterraneus</i>	6—1	LM ₁ a/L	270 270	2.19—2.86 46.91—57.26	2.57 51.87	0.110 2.04	4.28 3.93
<i>Microlus (s. str.) arvalinus-arvalis</i>	11—9	LM ₁ a/L	157 157	2.42—3.15 46.29—58.33	2.79 52.25	0.176 1.91	6.45 3.65
<i>Microtus (s. str.) arvalis-agrestis</i>	8—1	LM ₁ a/L	545 545	2.37—3.57 41.52—58.96	2.94 52.59	0.196 2.24	6.66 4.26
<i>M. (Stenocranius) cf. gregalis</i>	11—9	LM ₁ a/L	7 7	2.47—2.76 45.75—54.24	2.65 50.04	0.117 3.17	4.40 6.33
<i>Chionomys nivalis</i>	11—3	LM ₁ a/L	48 48	2.52—3.42 43.25—50.00	2.99 47.13	0.168 1.76	5.62 3.74
	2	LM ₁ a/L	12 12	2.71—3.38 37.87—50.78	3.11 46.77	0.196 3.44	6.31 7.43
	1	LM ₁ a/L	21 21	2.52—2.99 44.73—49.31	2.82 46.46	0.139 1.55	4.94 3.32
<i>Pliomys lenki</i>	11—9	LM ₁ a/L	3 3	3.14—3.33 47.15—51.59	3.22 49.84	— —	— —

Clethrionomys glareolus (SCHREBER, 1780), (Tab. IV). The M_1-M^3 sample does not differ from the Upper Pleistocene (NADACHOWSKI 1984, POPOV 1985) and recent *C. glareolus* from Bulgaria.

Lagurus cf. *transiens* JÁNOSSY, 1962 (Fig. 5 : 1—5, Tab. IV). *L. transiens* is an intermediate chronospecies between *Prolagurus pannonicus* (KORMOS, 1930) and *L. lagurus* (PALLAS, 1773). These three species differ from each other in the relative abundance of particular M_1 morphotypes, i. e. they could be distinguished only on the basis of large samples. All available M_1 's from lower layers belong to the morphotype "transiens". So, in spite of the small sample, it can be assumed that this morphotype dominated the population during the deposition of these layers (11—10) and the material could be referred to *L. transiens*. This assumption is confirmed by the lower values of a/L ratio and the small size in comparison to these of *L. lagurus* from upper layers.

Lagurus lagurus (PALLAS, 1773), (Fig. 5 : 6, Tab. IV). The morphology of ACC of M_1 is similar to Upper Pleistocene and recent *L. lagurus*. In the other hand it differs by lower values of a/L:

Morovitsa (layers 7—1) = 52.57

Temnata dupka (N. Bulgaria, Upper Pleistocene) = 53.97 (N = 41)

Gortalovo I (N. Bulgaria, Holocene) = 54.58 (N = 8)

These comparisons allow the conclusion that the material from Morovitsa represents a primitive form of *L. lagurus*.

Eolagurus luteus (EVERSMANN, 1840), (Fig. 4 : 8,9, Tab. IV). The morphology of M_1 from Morovitsa Cave is closest to *E. luteus* from the late Upper Pleistocene of Dobrudja. On the other hand the a/L values are even lower than these of the both Middle Pleistocene forms *E. gromovi* TOPACHEVSKY, 1963 and *E. g. vistorensis* RADULESCO, SAMSON, 1976. Taking into account the small sample, it can only be assumed that this material represents an early form of *E. luteus*.

Arvicola cf. *kalmankensis* ZAZHIGIN, 1980 (Fig. 6 : 1—3; Tab. IV). The material from the lower layers of Morovitsa Cave differs from the recent species by the pattern of enamel differentiation which is of *Mimomys*-type and size, smaller than *Arvicola terrestris* (LINNAEUS, 1758). The evolutionary level of *Arvicola* from Morovitsa Cave is comparable with that of *A. cantiana* (HINTON, 1910) but it is clearly different because of its larger size. In this respect our material is nearly identical with *A. kalmankensis*, described from Western Siberia (ZAZHIGIN 1980).

Arvicola cf. *chosaricus* ALEXANDROVA, 1976 (Fig. 6 : 4—8, Tab. IV). The form from the upper layers of Morovitsa section differs from the former (*A. cf. kalmankensis*) by the enamel differentiation and by its having a larger size. The level of specialization is similar to that of recent species, however the differences in some characters of the dental pattern (unstable enamel differentiation, smaller size, lower values of a/L ratio etc.) do not make it very probable that the Morovitsa form is conspecific with *A. terrestris*. The overall impression is that in this case we deal with an intermediate form which corresponds to *A. ex gr. cantiana-terrestris* from Central and Western Europe, but differs by its larger

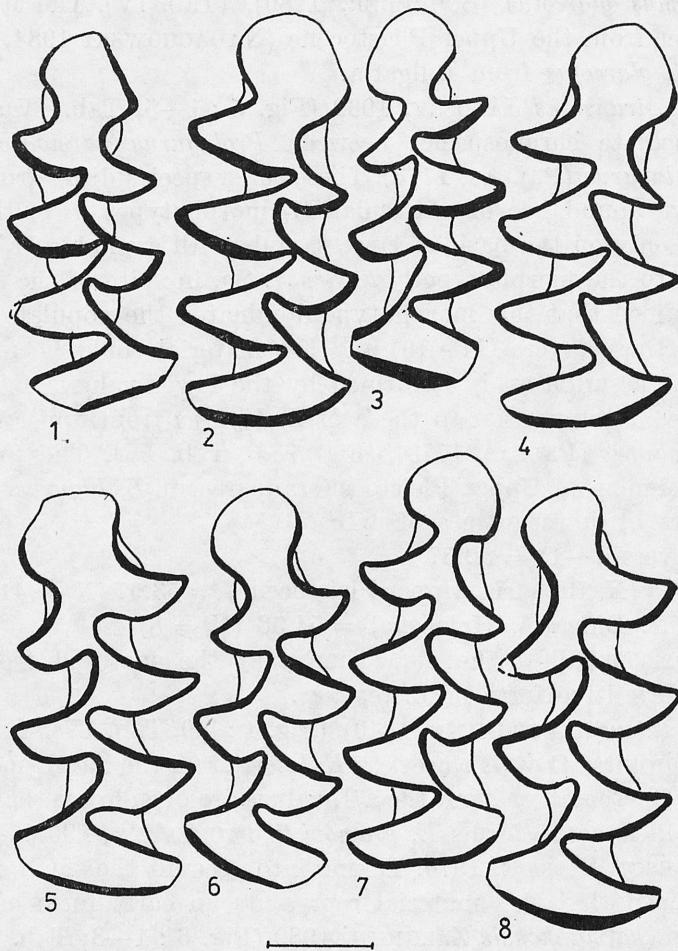


Fig. 6. 1—3. *Arricola* cf. *kalmankensis*, 1, 2. — right M_1 's (No: 26-Mor 11/IZ), 2. — left M_1 (No: 26-Mor 10/IZ); 4—8. *Arricola* cf. *chosaricus*, 4. — right M_1 (No: 27-Mor 7/IZ), 5. — left M_1 (No: 27-Mor 6/IZ), 6. — left M_1 (No: 27-Mor 5/IZ), 7. — right M_1 (No: 27-Mor 1/IZ), 8. — left M_1 (No: 27-Mor 2/IZ). Scale represents 1 mm

size. Such a form is known from Cherniy Jar, Middle Pleistocene (ALEXANDROVA 1976) under the name *A. chosaricus*.

Genus *Microtus* SCHRANK, 1798

Based on the shape of the ACC on M_1 we venture to identify the following subgenera: *Microtus* (s. str.), *Pitymys* McMURTRIE, 1831 and *Stenocranius* KASTCHENKO, 1901. It was difficult to distinguish the first two subgenera in lower layers because of the occurrence of numerous intermediate specimens (M_1) between the two extremes: with T4 and T5 separated (*Microtus*, s. str.) and with large confluence between these triangles (*Pitymys*). Moreover the size of these extreme variants is nearly equal (Tab. IV). The distribution of c/W values (VAN DER MEULEN 1973) for the material from layer 11 shows a clear-cut

bimodality (Fig. 7). This result is considered as a proof that the material consists of two forms. In spite of overlapping c/W distributions, only six from 143 specimens cannot be surely assigned to one of the two groups, namely *Microtus* (s. str.) and *Pitymys*.

Subgenus *Microtus* SCHRANK, 1798

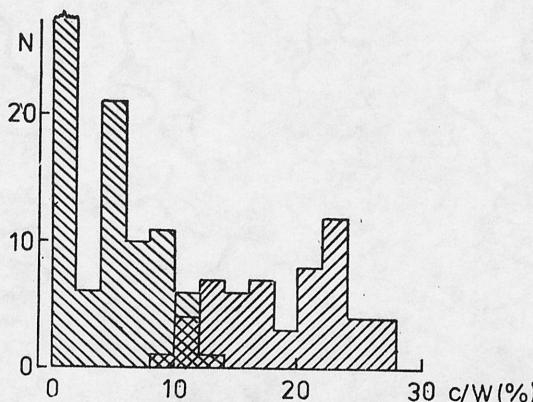


Fig. 7. Frequency histograms of distribution for the c/W values in M_1 -sample of *Microtus* (s. str.) from layer 11. Identification of distribution modes: left part—*Microtus* (s. str.), right part—*M. (Pitymys)*, double hatched part-area of overlapping between the two distributions

Morphology. The nomenclature and description of the variants of ACC (M_1) are the same as in POPOV (1988), (see also Figs. 5: 16, 17 and 8 in the present paper). The characteristic feature of *Microtus* (s. str.) from layer 11 is the imperfect separation of T4 and T5 (M_1), in contrast to the situation seen in the above-laying layers. In this respect this material (layer 11) shows similarity with upper Biharian *M. (M.) arvalinus* HINTON, 1923 from Varbeshnitsa (POPOV 1988). The same is true as far as the morphology of the whole ACC is concerned, but the relative proportion of the "agrestoid" morphotypes (variants F—I) is lower. The variability of the ACC in the material from layers 9—8 is not great and is similar to the one in recent *M. arvalis*-group (POPOV 1988) with a slight difference in the somewhat higher frequency of variant C. The relative proportion of "agrestoid" variants increases in the upper layers. The overall appearance of population is typical for mixed material of *M. arvalis* (PALLAS, 1779) and *M. agrestis* (LINNAEUS, 1761).

Biometrical analysis (Tab. IV). On the basis of statistical comparisons between particular layer samples, by using STUDENT t-test, the *Microtus* (s. str.) material from Morovitsa deposits could be divided in two size groups: 1. small sized—the size of M_1 from layers 11—9 is similar to the recent *M. arvalis*-group (POPOV 1988) but it differs significantly in the lower values of the relative length of ACC ($t = 3.85$); on the other hand the a/L values are higher than in *M. arvalinus* from Varbeshnitsa ($t = 2.74$). 2. the above-laying layers (8—1)

contain large-sized M_1 and this fact is interpreted as the appearance of *M. agrestis* (NADACHOWSKI 1984).

Discussion. On the basis of analyses presented above, the *Microtus* (s. str.) material from Morovitsa Cave could be determined as follows.

The material from layers 11—9 may be considered as belonging to an inter-

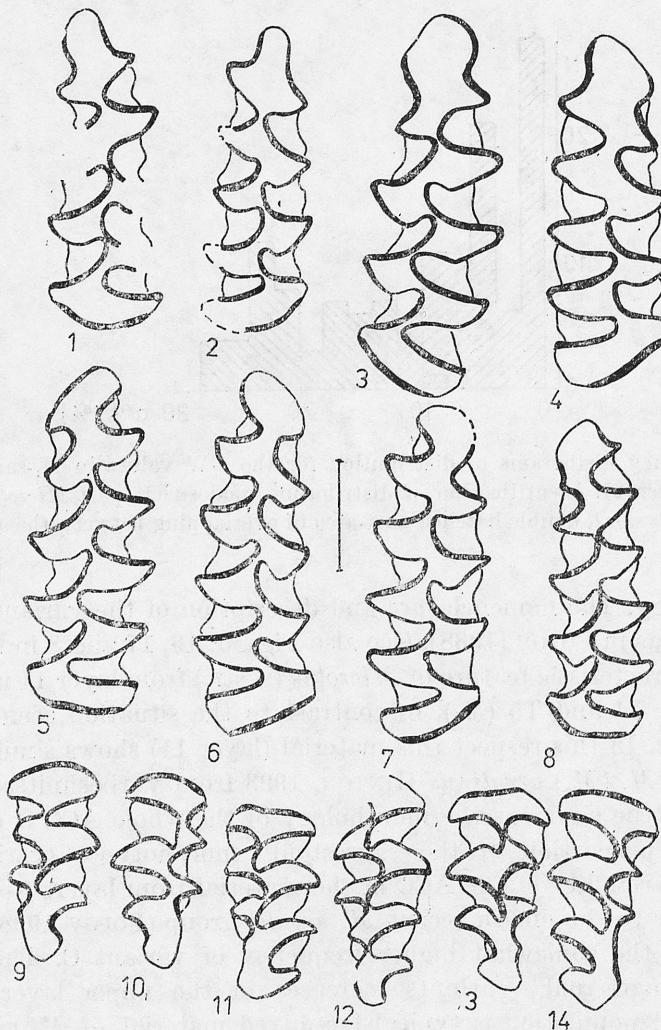


Fig. 8. 1—7 *M. (Pitymys) ex gr. arvalidens-subterraneus*, M_1 's, 1. — left, variant A, 2. — right, variant A, 3. — left, variant B (No: 29—Mor 10/IZ), 4. — right, variant B, 5. — left, variant C (No: 29-Mor 9/IZ); 6. — right, variant C (No: 29-Mor 8/IZ), 7. — right, variant D (No: 29-Mor 9/IZ); 8. — *M. (Pitymys) subterraneus*, left M_1 , variant F (No: 30-Mor 4/IZ); 9, 10. — *M. (Pitymys) arvalidens*, right and left M^3 's, 9. — morphotype I—B, 10. — morphotype II—B (No: 28-Mor 11/IZ); 11—14. *M. (Pitymys) ex gr. arvalidens-subterraneus*, M^3 , 11, 12. — right, morphotype II—C, 13, 14. — left, morphotype I—C (No: 29-Mor 10/IZ). Scale represents 1 mm

mediate form between *M. arvalinus* and *M. arvalis* (Tab. IV). The other layers probably contain mixed material of *M. arvalis* and *M. agrestis* (Tab. IV).

Subgenus *Pitymys* McMURTRIE, 1831

Morphology. The nomenclature and description of the variants of ACC (M_1) are the same as in POPOV (1988) (see also Fig. 8 in present paper). The morphological structure of M_1 in *Pitymys* assemblage changes considerably during the deposition of Morovitsa sequence. The main direction is expressed by the increase of the "*Pitymys*" morphotypes (variant C, Fig. 8: 5, 6) and by the decrease of "arvalid" morphotypes (variant D, Fig. 8: 7) and some primitive variants (var. A and B, Figs. 8: 1—4). The morphological variability of M_1 in the upper layers is nearly the same as in the Holocene and present day populations of *M. (P.) subterraneus* (DE SELYS-LONGCHAMPS, 1836) (Fig. 9).

The analysis of M^3 *Microtus* (s. l.) sample from layer 11 reveals the occurrence of some primitive morphotypes (Fig. 8: 9, 10) characteristic for *M. (Pitymys) arvalidens* KRETZOI, 1958 from Varbeshnitsa (POPOV 1988), but the Morovitsa specimens are less numerous. In the above-laying layers of the sequence these primitive morphotypes disappeared completely.

Biometrical analysis (Tab. IV). The main trend is characterized by a decrease of the mean length of M_1 . The values of a/L ratio follow the same tendency, with an exception in layer 8. The STUDENT t-test reveals significant differences between layers 11/10; 9/8 (only a/L) and 7/6. On the basis of these observations the *Pitymys* material from Morovitsa section may be classified into three biometrical groups replacing one another in the time: I group — layer 11; II group — layers 9—7; III group — layers 6—1 (Tab. IV). These groups correspond to the changes of the ACC shape (Fig. 9).

Discussion. The material from layer 11 (first biometrical group, see above) is similar to *M. (P.) arvalidens* from Varbeshnitsa in terms of variability of ACC. This is confirmed by the presence of some primitive M^3 morphotypes in this layer. On the other hand, the whole variability of M^3 assemblage, the somewhat higher values of a/L ratio of M_1 in comparison with *M. (P.) arvalidens* from Varbeshnitsa etc., show that in this case we deal with a more advanced form (Tab. IV).

The material from layers 10—7 (second biometrical group) can be considered as an intermediate one between *M. (P.) arvalidens* and *M. (P.) subterraneus*. It is difficult to say on the basis of available morphological evidence whether this transition is due to the gradual evolution in situ or to the immigration of a new form. The sharp biometrical differences confirm rather the second assumption (see below). Moreover, the gradual evolution towards shorter ACC (lower values of a/L) seems unlikely in a single evolutionary lineage, taking into account that the main tendency in all voles is towards an increase of relative ACC length. Hence, the sharp biometrical change between layers 11/10 is an evidence of migration of a new form with relatively short ACC: *M. (P.) subterraneus*, which lived together with *M. (P.) arvalidens* up to layer 7. Thus,

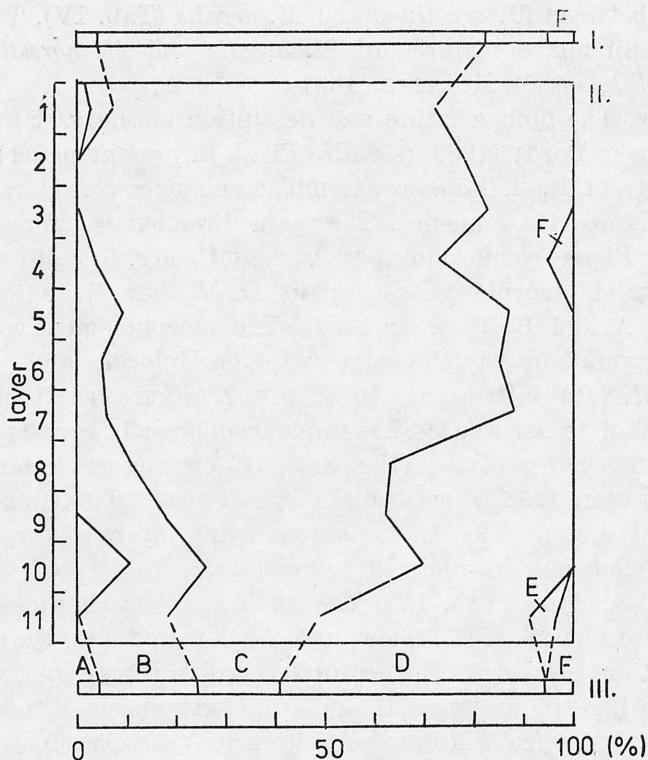


Fig. 9. Changes in relative abundance (in percentages) of ACC-variants in M_1 -samples of *M. (Pitymys)*-lineage throughout Morovitsa sequence (II) in comparison with the spectra of ACC-variants in the Holocene *M. (P.) subterraneus* from the Rhodopes (I) and *M. (P.) arvalidens* from Varbeshnitsa (III), upper Biarian

the *Pitymys* material from layers 10—7 represents a mixed sample of *M. (P.) arvalidens* and primitive form of *M. (P.) subterraneus* (Tab. IV).

The *Pitymus* material from layers 6—1 (third biometrical group) is nearly identical with Upper Pleistocene *M. (P.) subterraneus* from Bulgaria (NADACHOWSKI 1984) but it is smaller than the recent form and has shorter ACC (Tab. IV).

Microtus (Stenocranius) cf. gregalis (PALLAS, 1779), (Fig. 5: 7—12, Tab. IV). Part of the material referred to this species (mainly from layer 9) fits the characteristics of *M. (St.) gregalis*: the T4 and T5 are separated, the LSA5 is well developed, followed by a deep LRA5; BSA4 is week. On the other hand the specimens from the lowermost layers (11—10) differ from these from layer 9 in the less elaborated ACC, similar to *Pitymys hintoni* KRETZOI, 1941. In general, the more primitive appearance of the Morovitsa material is confirmed by the lower a/L values in comparison with the Upper Pleistocene *M. (St.) gregalis* from Brizeni (Moldavia): LM₁ (min.-mean max.) = 2.37—2.65—2.97, N = 24, SD = 0.160, CV = 6.06; a/L (min.-mean-max.) = 45.29—53.38—56.92,

$N = 24$, $SD = 2.370$, $CV = 4.44$, (author's measurements of material obtained from Dr. DAVID, Kischinev).

Chionomys nivalis (MARTINS, 1842) (Fig. 5: 18, Tab. IV). The overall features of M_1 -sample from Morovitsa agree well with the Upper Pleistocene (NADACHOWSKI 1984, POPOV 1985) and recent *Ch. nivalis* from Bulgaria. On the other hand, the material under study shows some biometrical peculiarities — the M_1 specimens from layer 2 are significantly larger than in both below- and above-laying layers; the M_1 samples from layers 2 and 1 show significantly lower values of a/L ratio.

III. GENERAL REMARKS AND DISCUSSION

1. Remarks on morphological evolution in some phyletic lineages

The morphological and taxonomical analyses presented above show a progressive evolution in some phyletic lineages towards the recent end-members. In this respect the Morovitsa section provides a good opportunity to examine the biostratigraphic pattern in terms of rate-related concepts of morphological change like punctualism or gradualism.

The phyletic lineages under consideration are: 1. "*S. subaraneus-S. araneus*"; 2. "*L. transiens-L. lagurus*"; 3. "*A. kalmankensis-A. chosaricus*"; 4. "*M. (P.) arvalidens-M. (P.) subterraneus*"; 5. "*M. arvalinus-arvalis* — *M. arvalis-agrestis*".

There is no gradual transition from one form (species) to another within the scope of these phyletic lineages. In all cases we deal with abrupt transitions localized between different layers in the lower half of the sequence (Tab. I and tables of measurements). It is possible to consider these abrupt transitions as a result of imperfections of either biostratigraphic or lithostratigraphic records. We cannot reject the first assumption only in two cases because of poor documentation of *Lagurus* — and *Arvicola*-lineages (see Tab. I). The lithostratigraphic imperfection relates to the possible existence of gaps (lack of deposition and/or erosion) during accumulation of the sequence. However, if it is true, one can expect that in all phyletic lineages the abrupt transitions would be localized at one and the same place(s) of the sequence. In fact, they are evenly dispersed between particular layers. In this respect the second assumption seems unlikely.

The assessment of biostratigraphic records from this point of view might allow us to state that the most likely interpretation of morphological changes observed in Morovitsa section is that they represent immigration events. All these immigrations are probably connected with the gradual changes of palaeo-environments (see below).

2. Palaeoecology

The palaeoecological interpretation is given on the basis of quantitative relationships between species. In order to reduce the data into comprehensive units and to delineate patterns of change between layers the principal component analysis was applied (POPOV, GERASIMOV in press). Five factors have been extracted from the matrix of correlations among species. These factors combined the small mammal species into groups and reflect a general pattern that are meaningful in relation to the ecological characteristics of the various species

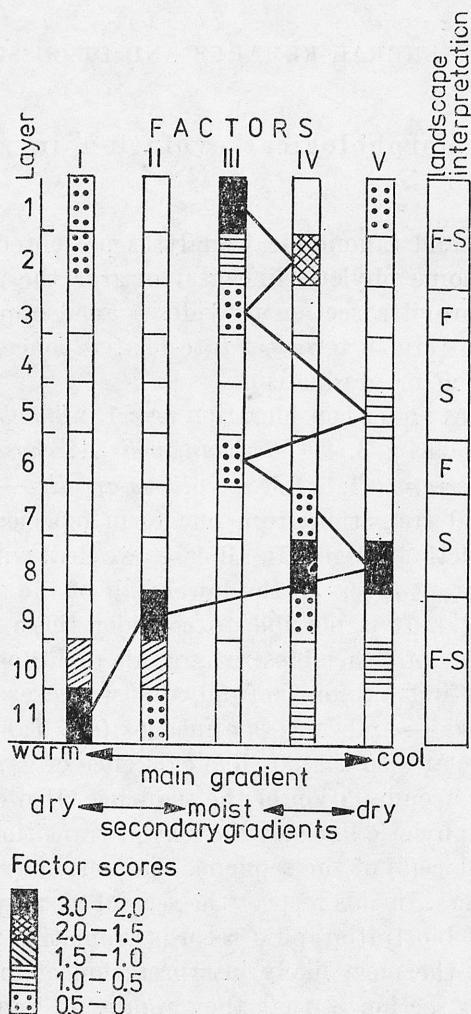


Fig. 10. Stratigraphic plotting of factor scores. The highest scores at each layer are connected; the resulting curve represents palaeoenvironmental changes. F-forests, S-steppes, F-S — forest-steppes

included. In our previous work the factors were arranged in order of the amount of total variance they explained. In the present study they are rearranged according to their ecological interpretation (Fig. 10). On the basis of the factor loadings of each species, the extracted factors could be interpreted as follows: Factor I — forest-steppe association of small mammals, Factor II — forest-meadow and forest-steppe association of small mammals, Factor III — forest and forest-meadow small mammal association, Factor IV — forest-steppe and steppe small mammal association, Factor V — steppe small mammal association. Stratigraphic plotting of factor scores results in the ecological curve presented in Fig. 10. It can be seen that the probable main gradient of climatic change is from relatively warm and/or temperate climate to relatively cool and continental climate. The main ecological boundary lies between layers 9/8. The secondary gradients probably reflect changes in the humidity.

3. Biostratigraphy and correlations

On the basis of species composition of each layer (Tab. I), a matrix of faunistic similarity between the individual layers has been calculated using the JACCARD coefficient. This matrix has been analysed by means of cluster analysis (average linkage method). The level of 60—65 % is accepted as a cut-off point. In the recent biogeography this level of faunal similarity is recognized as corresponding to the boundary between particular mammalian provinces (HAGMEIER, STULTS 1964). In this way the dendrogram (Fig. 11) could be divided into the following clusters, interpreted here as subzones: Ia = layers 11—10; Ib = layer 9; IIa = layer 8—7; IIb = layer 6—1. These subzones correspond to the changes of morphology (resp. taxonomy) in some phyletic lineages (non recurrent features) as well as to gradual changes of ecological pattern of the fauna (recurrent features). The differences in both recurrent and non-recurrent features have the best expression between layers 9/8 (Fig. 11). This circumstance allows to divide the profile into two biozones: Morovitsa I (layers 11—9) and Morovitsa II (layers 8—1), (Fig. 11).

The characteristic species of Morovitsa I are: *S. subaraneus*, *P. lenki*, *L. transiens*, *A. cf. kalmankensis* (similar to *A. cantiana* but larger), *M. (P.) arvalidens* etc. The species spectrum of Morovitsa II mainly contains recent species, but some of them show a somewhat more primitive pattern (*L. lagurus* with low values of a/L ratio, *A. cf. chosaricus* — similar to *A. terrestris* but with imperfect enamel differentiation etc.). These peculiarities of the small mammal assemblages from Morovitsa Cave provide a basis for biostratigraphic correlations.

The Middle and Upper Pleistocene evolution of *Arvicola* provides some possibilities for biostratigraphic subdivision. Three stages could be distinguished: "Arvicola 1,2 and 3" (FEJFAR 1976). The biostratigraphic boundary expressed in Morovitsa deposits (boundary Morovitsa I/II) corresponds to the boundary

between "Arvicola 1/2". This boundary is thought to separate two of the Steinheimian's phases — Mauer and Swanscombe. Thus we may conclude that the Morovitsa I assemblage can be correlated with the upper part of Mauer and the Morovitsa II with the lower part of Swanscombe. Consequently, the Morovitsa

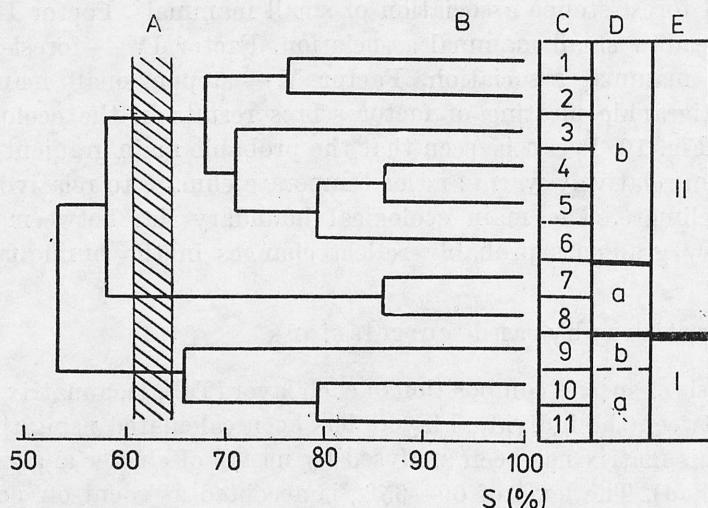


Fig. 11. Dendrogram showing the mean percent of similarity (B) for each pair of faunistically closest related small mammal layer assemblages from Morovitsa sequence (C). The level of 60—65% (A) is accepted as a base for delimiting of subzones (D). The main clusters, separable at level 53% are considered as biozones: Morovitsa I and II (E)

small mammal sequence marks one of the latest steps towards setting up the recent fauna.

The time range concerned contains two calibrate reference faunas from Central Europe — Vértezzöllös, ca. 350 t. y. B. P. (Mauer phase) and Weimar-Ehringsdorf, ca. 250 t. y. B. P. (Swanscombe), (FEJFAR, HEINRICH 1983). Thus, the boundary Morovitsa I/II lies between these two dates. Taking into account the ecological commitment of this boundary it may be assumed that it corresponds to the boundary between stages 9 and 8 (glacial cycle D) on the climatic curve from deep-sea cores. This time range (glacial cycle D) corresponds to the upper half of Lekanidis-complex from pollen curve in North Greece (VAN DER HAMMEN 1979). The climatic fluctuations identified on the basis of small mammals in Morovitsa sequence show a great similarity to the respective part of this pollen curve.

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STRESZCZENIE

Praca zawiera opis ponad 8700 szczątków ssaków z warstwowych osadów w jaskini Morovica w Bulgarii. W części systematycznej przedstawiono cechy morfologiczne uzębienia i pomiary 34 następujących taksonów drobnych ssaków: *Talpa* cf. *europaea*, *Sorex subaraneus*, *Sorex* cf. *araneus*, *Sorex minutus*, *Sorex minutissimus*, *Crocidura* cf. *zorzii*, *Ochotona* sp., *Lepus europaeus*, *Spermophilus citellus*, *Muscardinus* cf. *avellanarius*, *Dryomys nitedula*, *Glis* cf. *glis*, *Sicista subtilis*, *Apodemus* ex gr. *sylvaticus-flavicollis*, *Nannospalax leucodon*, *Allocricetus bursae*, cf. *Cricetulus migratorius*, *Mesocricetus newtoni*, *Cricetus cricetus*, *Pliomys lenki*, *Clethrionomys glareolus*, *Lagurus* cf. *transiens*, *Lagurus lagurus*, *Eolagurus luteus*, *Arvicola* cf. *kalmankensis*, *Arvicola* cf. *chosaricus*, *Microtus* (*Microtus*) *arvalinus-arvalis*, *Microtus* (*Microtus*) ex gr. *arvalis-agrestis*, *Microtus* (*Pitymys*) *arvalidens*, *Microtus* (*Pitymys*) ex gr. *arvalidens-subterraneus*, *Microtus* (*Pitymys*) *subterraneus*, *Microtus* (*Stenocranius*) cf. *gregalis*, *Chionomys nivalis*. Fauna ta zawiera współczesne rodzaje z wyjątkiem *Pliomys*, który występuje jedynie w dolnych warstwach. Większość gatunków wykazuje obecność prymitywnych cech w stosunku do współczesnych populacji. Jest to szczególnie dobrze widoczne w następujących liniach filetycznych: *Sorex subaraneus* —

Sorex araneus, *Lagurus transiens* — *Lagurus lagurus*, *Arvicola kalmankensis* — *Arvicola chosaricus*, *Microtus (Pitymys) arvalidens* — *Microtus (Pitymys) subterraneus*, *Microtus arvalinus* — *Microtus arvalis*. Fauna z jaskini Morowica wskazuje na zmiany klimatyczne zachodzące w trakcie tworzenia się kolejnych osadów, a polegające generalnie na oziębianiu i kontynentalizacji klimatu (ryc. 10). W oparciu o skład gatunkowy poszczególnych warstw utworzona została macierz podobieństw faunistycznych przy użyciu wzoru Jaccarda, która była następnie analizowana metodą "Complete linkage clustering". Skonstruowany dendrogram wskazuje, że badaną faunę można podzielić na dwie grupy: Morowica I (warstwy 11—9) i Morowica II (warstwy 8—1) (ryc. 11.). Przeprowadzone korelacje biostratygraficzne sugerują, że badaną faunę należy umieścić w najwyższej części fazy Mauer i dolnej części fazy Swanscombe Steinheimianu (środkowy plejstocen). Przemiany fauny mają charakter ciągły, co jest prawdopodobnie związane z postępującą kontynentalizacją klimatu podczas tworzenia się poszczególnych warstw.

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