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MORPHOMETRIC STUDY OF THE UPPER PANNONIAN GASTROPOD *MELANOPSIS BOUEI STURI* FUCHS

A FELSŐ-PANNÓNIAI *MELANOPSIS STURI* FUCHS BIOMETRIAI VIZSGÁLATÁNAK KÖVETKEZTETÉSEI

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ABSTRACT

The small *Melanopsis* species, including *Melanopsis boueu sturi,* were common in the Upper Pannonian, and they displayed varied shell morphology. Independently from the quickly changing paleoenvironment, morphometric study of this species revealed its ontogenetic development, as reflected in shell size and ornamentation.

At the time of the deposition of the Pannonian sediments, i.e. 5.5 to 1.8 million years before present, the Bakony hills formed an island in the Pannonian lake system. The area of this study comprises the southeastern foreland of the Bakony hills, between Balatonfő and Csór. Here the Tihany Formation, belonging to the so-called „*Congeria balatonica beds*", is exposed. Its layers were deposited under varying conditions, mainly in shallower water, sometimes in paludal environment. Therefore, the area displays diversified sedimentological and petrological features. The small forms of *Melanopsis*, however, were found in layers representing four types of paleoenvironments:

1.) 65% of the specimens came from huminitic silt (lime mud), deposited in a several-metre deep, marsh-like environment, during subsidence of the area. Oligohaline, freswater, and terrestrial species of molluscs can be equally found in these lavers.

2.) 12% of the specimens was also found in huminitic lime mud (silt), deposited during uplift of the area. These layers also contain mixed molluscs fauna.

3.) 8% of the total specimens came from fine mud, deposited in an oligohaline, deeper water environment of moderate wave energy.

4.) Rest of the material (15%) was yielded by sandy, silty clay, deposited in oligohaline, even deeper water environment of low energy.

Small species of *Melanopsis* were found in outcrops and cores of the following localities: Balatonfűzfő (Gyártelep, János-hegy, Papvásár-hegy), Várpalota (Kálvária-domb, Kikeri-tó, Bántapuszta), and Csór. A highly varied species, *Melanopsis bouei sturi* FUCHS, made up 40% of the material. Morphometric study of this species involved 720 specimens. The most characteristic parameters of its shell (measurable and observable) are listed in Table 1.

A.) Height

Height of the shell is between 0.65 and 1.80 cm, with a mean of 1.10. The standard deviation is high (1.15). The highest values of standard deviation and height belong to the 1st environment (marsh formed during subsidence). Specimens from the 2nd environment (marsh formed during uplift) are the smallest with a mean of 1.07, and with a relatively high standard deviation (0.70–1.35; 0.65). Height data maintain bimodal distribution curves in all four environments.

B.) Width

Shell width is between 0.30 and 0.80 cm with a mean of 0.54 (0.50 standard deviation). Similarly to shell height, the highest standard deviation belongs to the 1st environment (0.30–0.80; 0.50), and specimens of the 2nd enviro-ment are the less wide ones (mean width: 0.48 cm). Width data maintain bimodal distribution curves in all four environments. However, the first peak of the curve, belonging to lower width values, is much more pronounced in each case than the second peak.

C.) Height/width ratio

The Height/width ratio is between 1.5 and 2.8 with a mean of 2.11 and standard deviation of 1.5. Distribution of standard deviation among the environments is the same as in case of height and width values.

The slimmest specimens came from the 2 nd environment (mean: 2.28), while specimens from the 4th environment are the squattest (mean: 2.05). All distribution curves are bimodal, but location of the two peaks and the distance between them is varied (Fig.4).

D.) Whorls

Number of whorls vary between 5 and 7 (mean: 6.63). Highest whorls belong to specimens from the 3rd environment, while lowest ones to the shells of the 2nd environment.

E.) Ornamentation

The shells of *Melanopsis bouei sturi* display varied morphological and colour ornamentation. Upon the ornamentation features, they can be grouped into 13 types:

1: no pigmentation, typical morphology (30.6 %);
2: orange speckles, typical morphology (11.7 %);
3: axial orange stripes, typical morphology (1.6 %);
4: axial orange zig-zag stripes, typical morphology (1.0 %);
5: no pigmentation, only last two whorls ornamented (2.5 %);
6: orange speckles, only last two whorls ornamented (5.4 %);
7: no pigmentation, last whorls with spines (17.5 %);
8: orange speckles, last whorls with spines (11.7 %);
9: no pigmentation, last whorls ribbed (7.8 %);
10: orange speckles, last whorls ribbed (3.8 %);
11: no pigmentation, last whorl smooth (4.6 %);
12: orange speckles, last whorl smooth (1.7 %);
13: axial orange stripes, alst whorl smooth (0.1 %).

The morphological ornamentation is typical in 44.9% of the specimens. The others either lack ornamentation (groups 11 to 13). or have different sculpture: spine-like nodes (groups 7 and 8), or axial ribs (groups 9 and 10). Some specimens display sculptural ornamentation only in the last two whorls (groups 5 and 6); it can be interpreted as result of either irregular growth or erosion.
It is noteworthy that specimens with typical sculpture are missing from the 4th environment, while they are abundant in the 1st one (more than 95%).

To indicate degree of sculptural ornamentation, an ornamentation idex (I_D) was calculated as product of number of ornamentational elements in the last two whorls and their heights. Heights of ornamentational elements was determined in a 5-degree scale (0.05; 1.0; 1.5; 2.0).

The two domains, where the ornamentation index is 10 to 15 and 15 to 20, are characteristically distinet from the rest of the material. This phenomenon have two reasons. First, these two domains include 38.5% of the total specimens (I_D=10 to 15: 15.75%; I_D=15 to 20: 22.75%), while ratio of the other domains is significantly lower. Second, domains where I_D 10 and those where I_D 20 equally include specimens with increasing height and width (Table 3). That is, both height and vidth have two peaks: the main one in domain I_D 30, and the secondary one in I_D=0 to 5. It is in accordance with the bimodal distribution curves of shell height and vidth, discussed above.

As it was shown by the distribution curves, no relation can be established between height/width ratio and I_D.

Correlation between shell size and the paleoenvironments reveals that the bimodal distribution curves of shell height and width can not be an indicator of sexual dimorphism.

37% of the studied Melanopsis bouei sturi specimens are pigmented. Colour of pigmentation is always orange, but is pattern can be different. The most common pattern consists of irregularly distributed, though axially oriented, speckles (92%). These speckles are ordered into regular axial stripes in some specimens (groups 3 and 13), while others have axial zig-zag striped pattern (group 4).

In the 1st and 3rd paleoenvironments all these kinds of pigmentational patterns occur, while in the 4th environment only speckled specimens can be found (Table 4).

Analysing the relations between ornamentation and size, it turns out that the highest (1.16 cm mean) and widest (0.59 cm mean) specimens belong to group 10. If we separate the pigmented and non-pigmented groups, we find that size (both height and width) increases in the following order: groups 11, 1, 7, 9 in non-pigmented (Table 5), and groups 12, 13, 2, 3, 4, 8, 10 in pigmented specimens (Table 6, Fig. 5).

Apart from pigmentation, there is a spectacular relation between shell size and morphological ornamentation. The last whorl is not, or hardly, ornamented in the smallest specimens (groups 11 to 13), while shells, having measures close to the mean, display typical sculpture (groups 1 to 4). As shell size increases, the ornamentation becomes more and more pronounced; spines (groups 7 and 8), then, in the largest specimens, axial ribs appear (groups 9 and 10). This trend is well reflected by the ornamentation index I_D (Table 7).

How can we interpret these data?

Since these features show no relation to the quality of the embedding rocks, i.e. the paleoenvironment, they probably represent ontogenetic development. The age of the individuals show correlation with shell size, number of whorls, and, due to increasing carbonate secretion, the morphological ornamentation is more and more developed.

Colour ornamentation shows a different picture. Ratio of pigmented specimens is low in paludal, shallow-water environments, while it is above 80% under deeper water conditions. Therefore, different colour patterns should be interpreted separately.

The speckled specimens constitute the following ontogenetic line: group 12, 2, 8, 10. As the axially striped colour pattern is concerned, a trend from group 13 to 3 (and, perhaps, to 4) can be recognized. It seems that appearance of orange spots between the axial stripes leads to the formation of zig-zag stripes; but the sample, supporting this assumption, is rather small.

Table 1.: **Shell size of *Melanopsis bouei sturi* FUCHS in the Várpalota and Balatonfűzfő outcrops**
(MAKÁDI M., 1991)

	Paleoenvironments											
	1.			2.			3.			4.		
	F	V	mean	F	V	mean	F	V	mean	F	V	mean
height (cm)	1,20	1,17	1,19	1,06	1,08	1,07	1,15	1,14	1,15	1,15	1,08	1,12
width (cm)	0,54	0,56	0,55	0,47	0,48	0,48	0,53	0,56	0,54	0,55	0,53	0,54
height/width ratio	2,21	2,20	2,20	2,26	2,29	2,28	2,24	2,14	2,19	2,11	1,99	2,05
number of whorls	6,89	6,69	6,79	6,08	5,99	6,04	6,95	6,85	6,90	6,38	6,41	6,40
height of whorls (cm)	0,17	0,17	0,17	0,17	0,19	0,18	0,16	0,16	0,16		0,17	–
non pigmented (%)	60,6	68,6	64,6	52,9	71,8	62,4	18,2	12,9	15,6	6,9	10,5	8,7
smooth (%)	10,9	11,9	11,4	8,8	–	–	15,2	–	–	23,1	20,5	21,8

Table 2.: Ratio of ornamentational groups in the different paleoenvironments

/MAKÁDI M, 1992/

ornamentational groups	Paleoenvironments 1. Vpt.			2. Vpt.			3. Vpt.			4. Vpt.			mean
	Vpt.	Fűzfő	mean	Vpt.	Fűzfő	mean	Vpt.	Fűzfő	mean	Vpt.	Fűzfő	mean	
1.	34,5	66,8	50,6	19,3	60,4	39,9	9,1	54,3	31,7	-	-	-	30,6
2.x	16,9	21,8	19,4	19,3	22,9	21,1	6,1	6,7	6,3	-	-	-	11,7
3.x	2,0	4,7	3,4	3,8	-	1,8	-	2,9	1,4	-	-	-	1,6
4.x	1,4	0,8	1,1	-	-	-	-	5,6	2,8	-	-	-	1,0
5.	-	0,8	0,4	-	5,2	2,6	-	14,3	7,1	-	-	-	2,5
6.x	-	1,1	0,6	-	3,1	1,6	24,2	2,9	13,5	-	11,6	5,8	5,4
7.	19,8	2,2	11,0	26,9	3,1	15,0	12,1	14,3	13,2	30,8	29,9	30,6	17,5
8.x	8,6	0,8	4,7	19,2	1,1	10,2	33,3	-	16,5	15,4	15,6	15,5	11,7
9.	4,0	0,8	2,4	7,7	-	3,8	-	-	-	23,0	27,3	25,1	7,8
10.x	3,7	0,2	1,9	-	4,2	2,1	-	-	-	7,7	15,6	11,5	3,8
11.	2,9	-	1,4	3,8	-	1,9	15,2	-	7,5	15,4	-	7,7	4,6
12.x	5,8	-	2,9	-	-	-	-	-	-	7,7	-	3,8	1,7
13.x	0,4	-	0,2	-	-	-	-	-	-	-	-	-	0,1
	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
pigmented /x/			34,2			36,8			40,5			36,6	37,0
non pigmented			65,8			63,2			59,2			63,4	63,0

Table 3.: Relation between ornamentational index (I_D) of Melanopsis bouei sturi and its shell size (MAKÁDI M, 1992)

I_D	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	30<
height /cm/	1,27	1,11	1,15	1,13	1,18	1,24	1,39
width /cm/	0,56	0,51	0,55	0,50	0,58	0,60	0,62
height/ width	2,22	2,15	2,19	2,14	2,06	2,00	2,02

Table 4.: Ratio of the ornamentational groups in the different paleoenvironments of Melanopsis bouei sturi (percent) (MAKÁDI M, 1992)

I. non-pigmented specimens (63 %)

		ornamentational groups				ratio
		11.	1.	7.	9.	
environments	1.	1,4	50,6	11,0	2,4	16,4
	2.	1,9	39,9	15,0	3,8	15,2
	3.	7,5	31,7	13,2	-	13,1
	4.	7,7,	-	30,6	25,1	15,9

II. pigmented speciements (37 %)

		ornamentational groups				ratio	ornamentational			ratio
		12.	2.	8.	10.		13.	3.	4.	
environments	1.	2,9	19,4	4,7	1,9	7,2	0,2	3,4	1,1	1,6
	2.	-	21,1	10,2	2,1	8,3	-	1,8	-	0,6
	3.	-	6,3	16,5	-	5,7	-	1,4	2,8	1,4
	4.	3,8	-	15,5	11,5	8,6	-	-	-	-

Table 5.: Relation between size and ornamentation in non pigmented specimens - *Melanopsis bouei sturi* FUCHS /MAKÁDI M, 1992/

ornamentational groups	height (cm)				width (cm)				height/width ratio			
	Vpt.	Fűzfő	others	mean	Vpt.	Fűzfő	others	mean	Vpt.	Fűzfő	others	mean
1.	1,04	1,14	1,09	1,09	0,51	0,55	0,52	0,53	2,25	2,14	2,20	2,20
5.	-	0,85	0,87	0,86	-	0,50	0,45	0,47	-	1,80	1,95	1,87
7.	1,15	1,03	1,11	1,10	0,53	0,58	0,53	0,57	2,18	1,81	2,11	2,03
9.	1,17	1,09	1,14	1,13	0,53	0,53	0,58	0,57	2,17	2,08	1,75	2,00
11.	1,08	-	1,06	1,07	0,44	-	0,50	0,47	2,43	-	2,43	2,43
mean				1,05				0,52				2,11

Vpt.= Várpalota

Table 6.: Relation between size and ornamentation in pigmented specimens - Melanopsis bouei sturi FUCHS /MAKÁDI M, 1992/

ornamentational groups	height /cm/				width /cm/				height/width ratio			
	Vpt.	Fűzfő	others	mean	Vpt.	Fűzfő	others	mean	Vpt.	Fűzfő	others	mean
2.	1,10	1,12	1,08	1,10	0,50	0,55	0,54	0,53	2,11	2,21	2,33	2,22
3.	1,04	1,24	1,12	1,13	0,53	0,55	0,52	0,53	2,00	2,33	2,35	2,23
4.	1,08	1,22	1,12	1,14	0,42	0,59	0,60	0,54	2,20	2,21	2,27	2,23
6.	1,19	1,08	0,95	1,05	0,53	0,53	0,41	0,49	2,24	1,55	1,96	1,91
8.	1,11	1,28	1,09	1,15	0,49	0,60	0,65	0,58	2,28	2,06	2,06	2,13
10.	1,22	1,02	1,26	1,16	0,57	0,57	0,60	0,59	2,14	2,06	1,85	2,01
12.	1,10	-	1,04	1,06	0,52	-	0,43	0,47	2,41	-	2,46	2,44
13.	1,10	-	1,05	1,07	0,55	-	0,42	0,48	2,00	-	2,52	2,26
mean				1,11				0,53				2,18

Table 7.: Relation between ornamentational index (I_D) and orna-ornamentational groups of Melanopsis bouei sturi (MAKÁDI M. 1992)

		ornamentational groups						
non-pigmented speciemens		11.	1.	7.	9.			
	I_D	3,66 →	7,37 →	15,36 →	17,96			
pigmented specimens		12.	2.	8.	10.	13.	3.	4.
	I_D	3,69 →	8,39 →	15,62 →	16,97	3,72 →	5,93 →	12,91

Fig.1.

<u>Southeastern foreland of</u>
<u>Bakony hills</u>

1-2. level line (m)
3. distribution of Pannonian formations
4. roads
5. railways
6. studied outgroups
7. borings

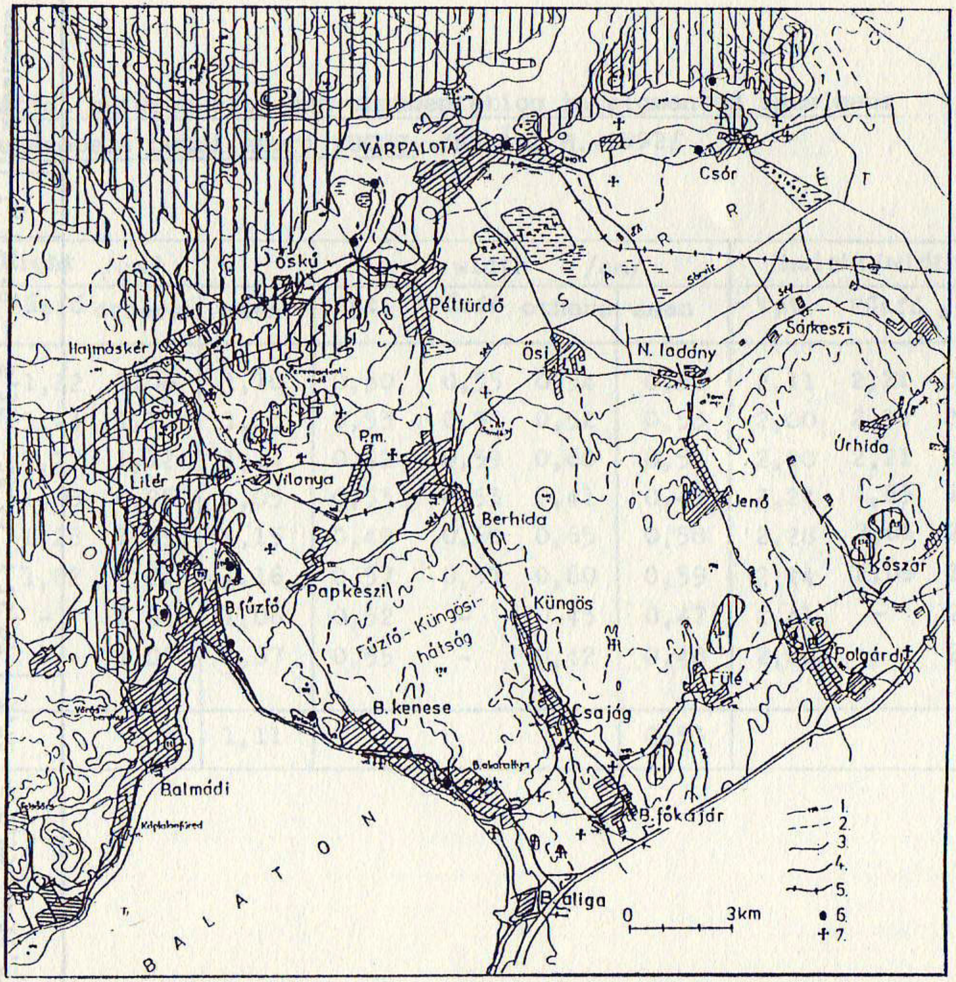
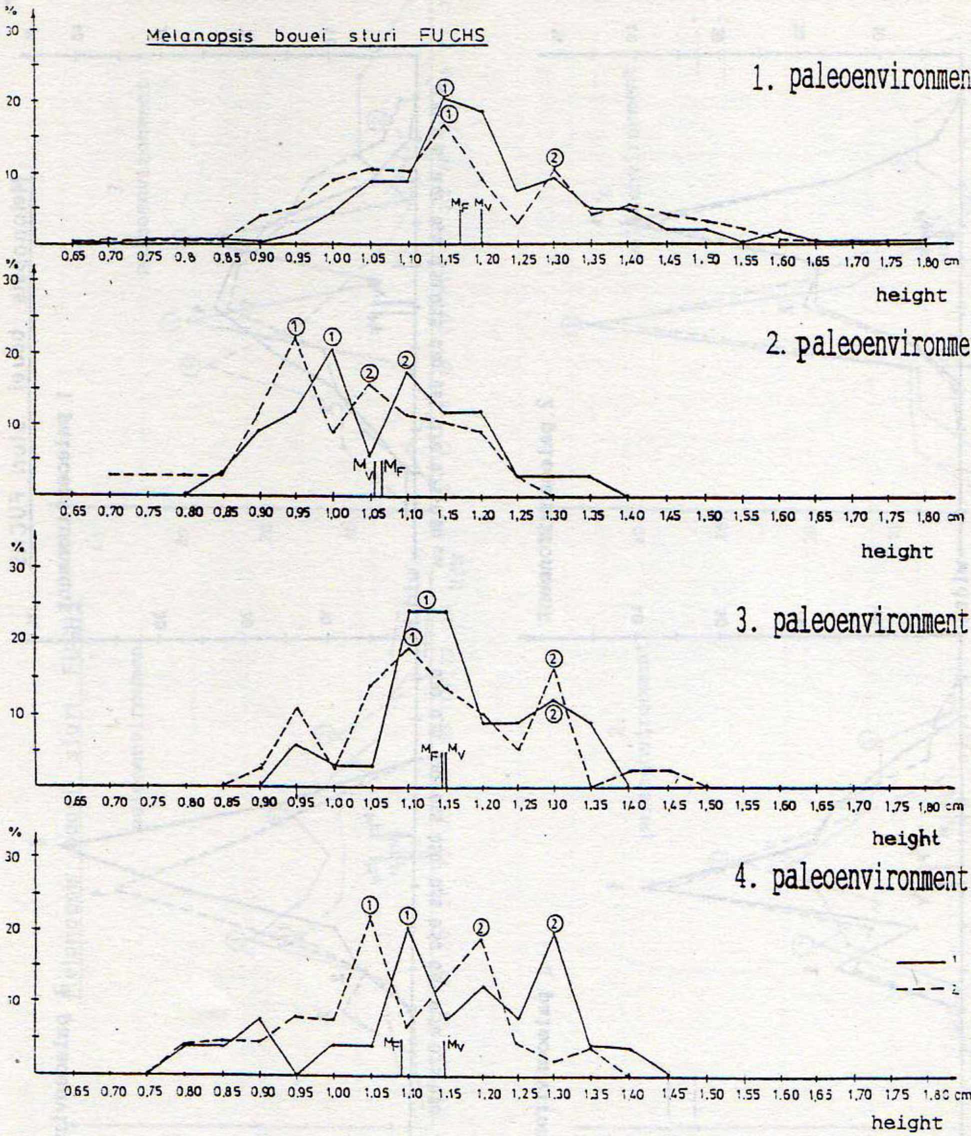


Fig.2.



Melanopsis bouei sturi FUCHS
1. paleoenvironment
2. paleoenvironment
3. paleoenvironment
4. paleoenvironment
height
%

Fig.3.

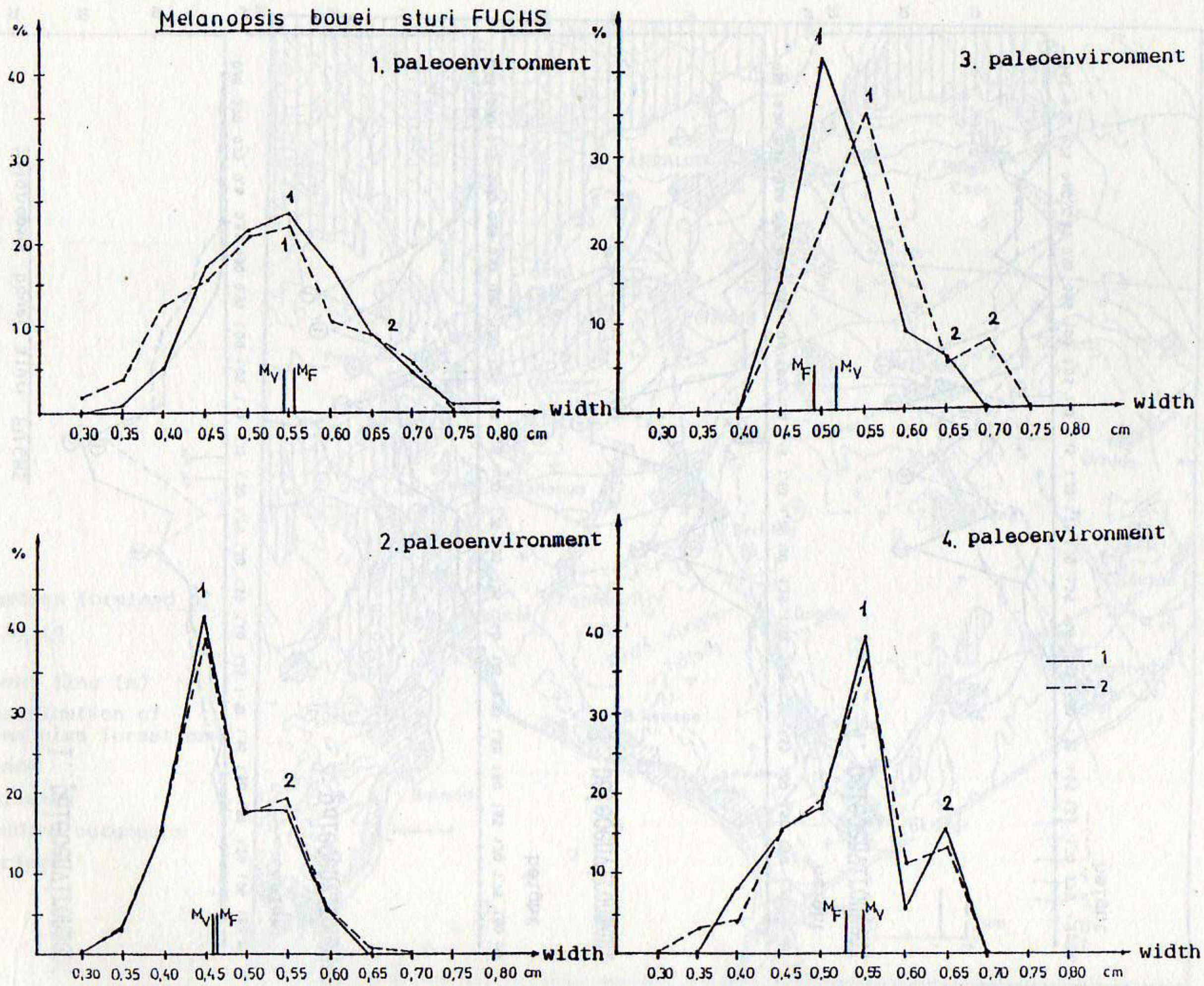
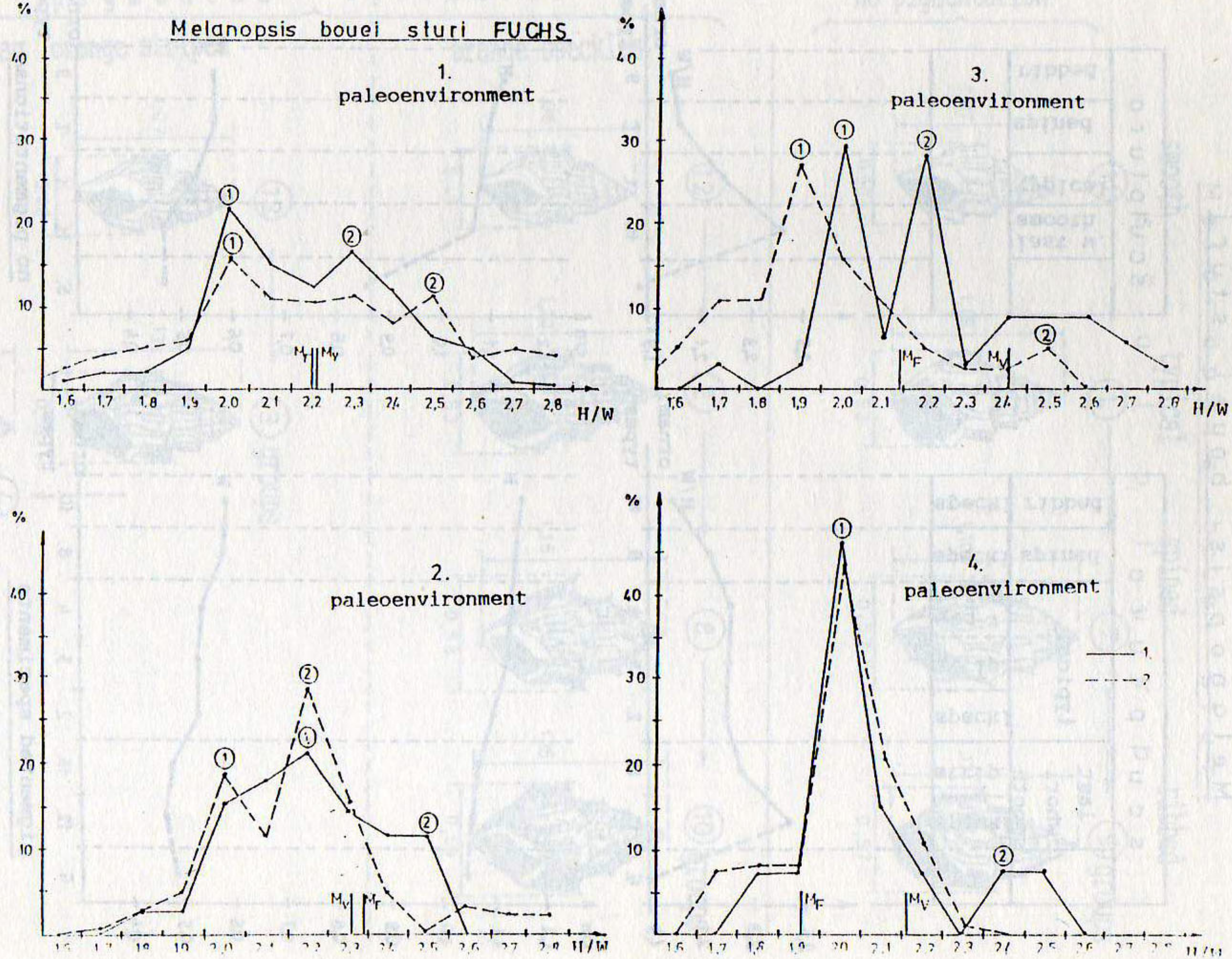
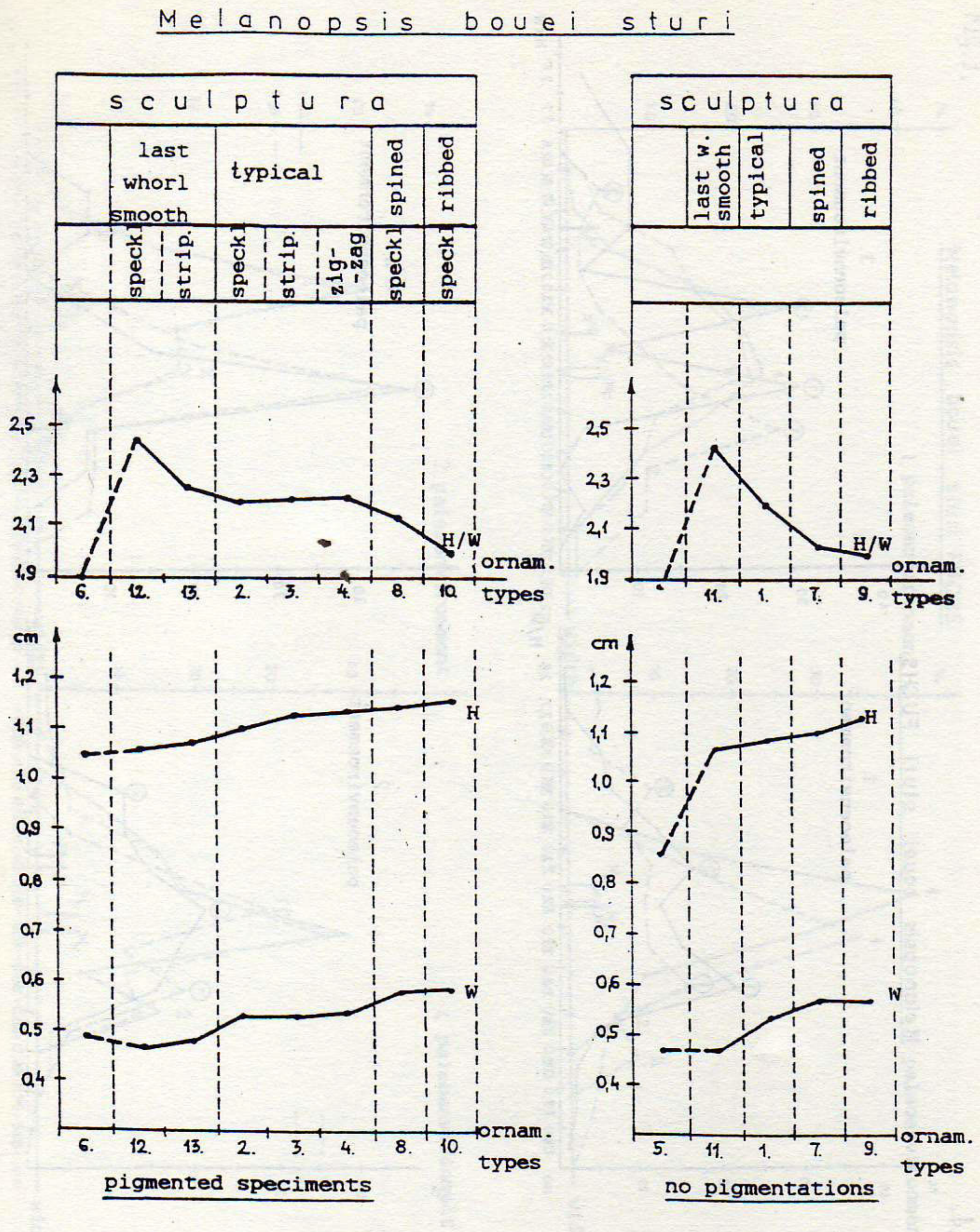

Melanopsis bouei sturi FUCHS
1. paleoenvironment
2. paleoenvironment
3. paleoenvironment
4. paleoenvironment
%
10
20
30
40
0,30 0,35 0,40 0,45 0,50 0,55 0,60 0,65 0,70 0,75 0,80 cm
width
M_V
M_F
1
2

Fig.4.


Melanopsis bouei sturi FUCHS
1.
paleoenvironment
2.
paleoenvironment
3.
paleoenvironment
4.
paleoenvironment
%
H/W
M_F
M_V
1.
2.


Melanopsis bouei sturi
sculptura
last whorl smooth
typical
spined
ribbed
speckl
strip.
speckl
strip.
zig--zag
speckl
speckl
H/W
ornam.
types
6.
12.
13.
2.
3.
4.
8.
10.
2,5
2,3
2,1
1,9
cm
1,2
1,1
1,0
0,9
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0,7
0,6
0,5
0,4
H
W
pigmented speciments
sculptura
last w. smooth
typical
spined
ribbed
11.
1.
7.
9.
5.
no pigmentations

Fig.5.

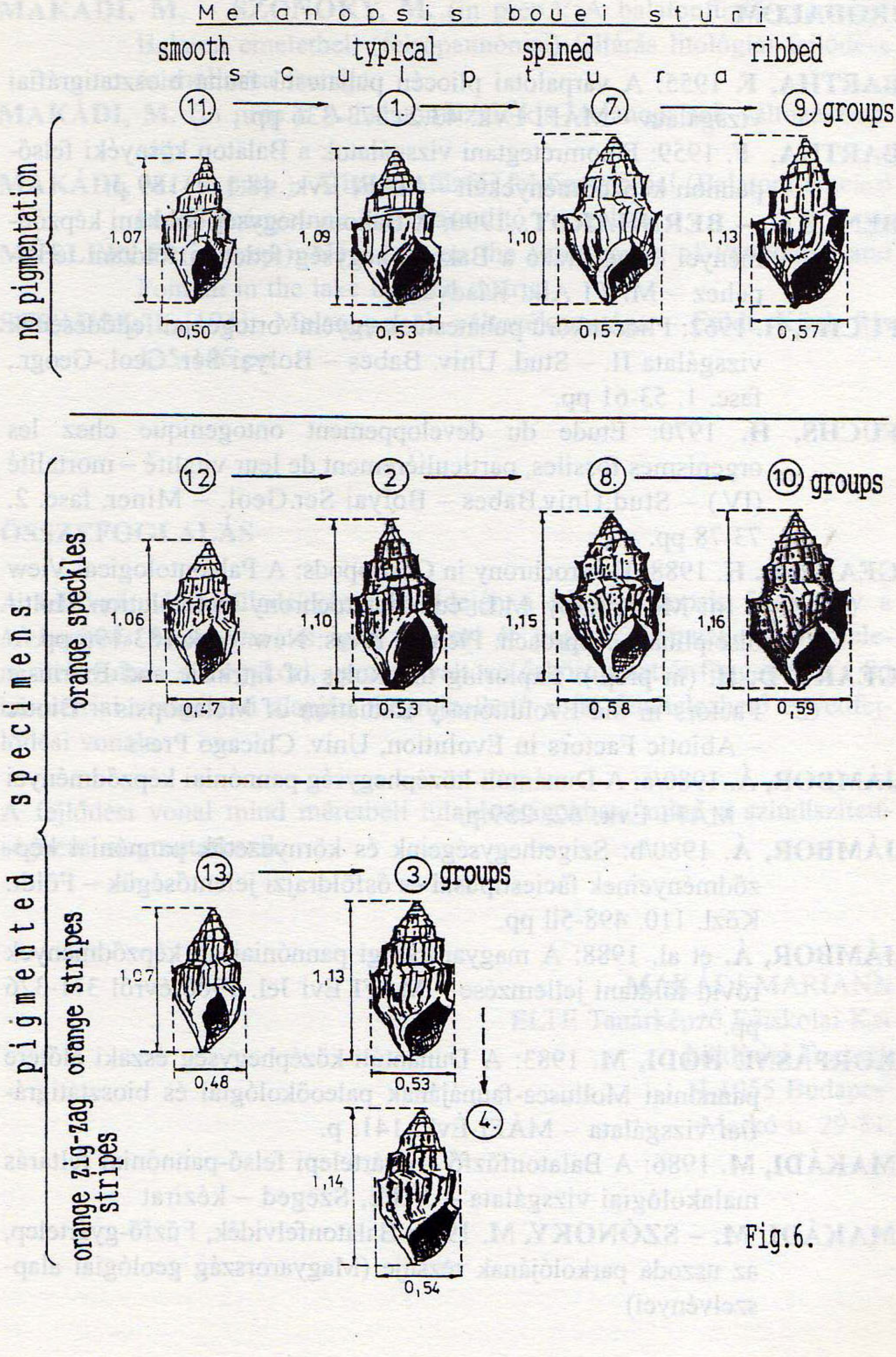
Melanopsis bouei sturi
smooth
typical
spined
ribbed
sculptura
11.
1.
7.
9. groups
no pigmentation
1,07
0,50
1,09
0,53
1,10
0,57
1,13
0,57
pigmented specimens
orange speckles
12
2
8.
10 groups
1,06
0,47
1,10
0,53
1,15
0,58
1,16
0,59
orange stripes
13
3. groups
1,07
0,48
1,13
0,53
orange zig-zag stripes
4.
1,14
0,54

Fig.6.

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ÖSSZEFOGLALÁS

A felső-pannóniai üledékképződés idején a kis-Melanopsis fajok, így a *Melanopsis bouei sturi* is igen gyakori és nagyon változékony megjelenésűek voltak. Az egykori, gyorsan változó őskörnyezettől függetlenül a faj biometriai vizsgálatai alapján megrajzolható a faj feltételezhető egyedfejlődési vonala.

A fejlődési vonal mind méretbeli tulajdonságokban, mind a színdíszítettségben megmutatkozik.

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