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The description of Talpa romana ehiki n. subsp., and the biometrical analysis of skull measurements

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ABSTRACT: (The description of Talpa romana ehiki n. subsp., and the biometrical analysis of skull measurements. - Dr. Lajos VÉGHELYI's collection III.) - The new subspecies is described on the basis of specimens collected by István VÁSÁRHELYI at Pusztapó in 1929. A comparative biometrical analysis of the populations of Talpa europaea and Talpa romana is presented. A biogeographically and geologically based proposal to the taxonomy of Talpa romana populations is also given.

Working on Dr. Lajos VÉGJELYI's mammal collection I recognized, that the measurements of Talpa skulls collocted at Pusztapó were different from those of Talpa europaea given in Fauna Hungariae. So, those skulls were examined in more detail.

It was a great surprise, that the teeth of these specimens were quite different from that of Talpa europaea, according to the description of S. G. MILLER (1912), G. H. V. STEIN (1951), E. SCHWARZ (1948), C. G. OVENDEN (1982). The following characteristics referred to the teeth of Talpa romana, according to the description of E. SCHWARZ (1948), S. G. MILLER (1912), C. G. OVENDEN (1982), G. H. W. STEIN (1951), E. CAPANNA (1981) and B. M. PETROV (1971):

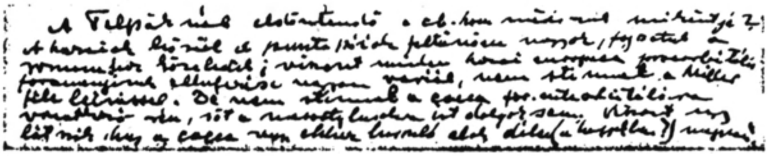
- maximal diameter (3,8 - 4,0 mm) of maxillar M_1
- developed cingulum of maxillar M_1
- detached bifid mesostyle of maxillar M_{1-3}
- developed cingulum of maxillar P_4
- wide parastyle.

All the authors mentioned above agree in that Talpa romana differs from Talpa europaea in the detached bifid mesostyle of maxillar M_1 and in having bigger teeth.

Revising the Talpa specimens from Pusztapó of the mammal collection of the Museum of Natural History, I found a new interesting fact, concerning the history of science. Dr. Gyula ÉHIK recognized and described this difference in the late 1920-s. He wrote on the identity paper of Mus. Nat.-His. No. 3524/1: "It may be Talpa hungarica -Éhik-", and on the back of the paper: "The moles at Pusztapó are all bigger, than normal.". On the leg-paper of this specimen he wrote: "It may be Talpa hungarica", whereas in the carton of the specimen he wrote: "The mode of measuring CB should be defined in Talpa. From the Hungarian specimens, those of from Pusztapó are considerably big, and the teeth of them are like those of Talpa romana; the position of preorbital foramen varies gretly in all Talpa europaea, it is not in harmony with MILLER' s description . And neither the for. suborbitalis, nor the mesostyle satisfy MILLER' s description of Talpa caeca. On the other hand it seems, that the caeca or a similar form exists in the south (in the mountains)."(Fig. 1).

It is difficult to judge, whether the last sentence refers to Talpa romana stankovici MARTINO and MARTINO (1931) having been described later. Nevertheless one can see, that ÉHIK had really sharp eyes.

At the time of ÉHIK's notes besides the species description (THOMAS, 1902) only MILLER's (1912) data were available concerning Talpa romana terra typica, which were based on very few specimens. This is why ÉHIK was not able to classify the Talpa population of Pusztapó on the basis of similarities in the teeth. Even more, the two specimens that he studied had relatively narrow rostrum comparing with the others from Pusztapó (c. f. Table 1.) THOMAS and MILLER regarded wide rostrum as distinctive characteristic. Both specimens are very old with threadbare teeth, so it was difficult to recognize their distinctive characteristics. Perhaps that is why ÉHIK thought of a new species, Talpa hungarica.



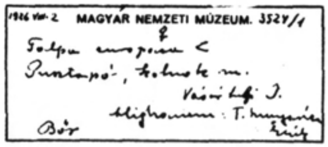


Figure 1. A- Note written by Gyula ÉHIK (1926) about the Talpa population at Pusztapó. B- The identinfying paper of Talpa specimens at the Natural History Museum with ÉHIK's handwriting (for text see page)

The intense study of Talpa romana was started by the works of SCHWARZ (1984) and STEIN (1950, 1959, 1960, 1963).
The debates concerning this species have continued since that time. Originally THOMAS (1902) introduced this name to describe the mole population around Rome, since it was different from Talpa europaea in some important measuements, especially in its bigger body size. MILLER accepted that, moreover he stressed a characteristic feature of this species, the detached bifid mesostyle of the upper three molars. In Talpa europaea they are simple. SCHWARZ (1948), STEIN (1950) and TOSCHI (1954) agree with MILLER and THOMAS in this taxonomic interpretation.

ELLERMANN and MORRISON-SCOTT (1951) had important objection to the validity of this species, namely, these species have allopatric distribution. So it ~~is~~ not sure, whether the morphological difference between the two species (Talpa romana and Talpa europaea) would remain if they occured in the same area. SAINT-GIRONS (1973) had the same opinion, and suggested, that these two taxa should be classified as subspecies.

In a less known study on the mammal fauna of Apulia by PASA (1951) the occurrence of these two species is mentioned in that part of Italy. Talpa romana occurs in the mountains (700 - 1000 m), whereas Talpa europaea at less than 100 meters above sealevel. So ELLERMANN's and MORRISON-SCOTT's objection has not any sound basis. Especially if one regards the common occurrence of Talpa romana stankovici and Talpa europaea in Macedonia (STEIN, 1960, 1963, FELTER and STROCH, 1965, TODOROVIC, 1960, GURLICH, 1971, PETROV, 1971, 1974, 1979). To judge this dilemma E. CAPANNA (1981) studied the karyotypes of Talpa europaea and Talpa romana terra typica from Italy, then compared them with those of Talpa romana stankovici, Talpa caeca caeca and Talpa caeca hercegovinensis. The conclusion was, that there are two possible solutions:

1. "All the populations mentioned above are regarded as separate species accepting the differences in their karyotypes, or"
2. "Formation of two superspecies, namely Talpa europaea including Talpa europaea europaea, Talpa europaea romana and Talpa europaea stankovici, and Talpa caeca including Talpa caeca caeca and Talpa caeca hercegovinensis as subspecies. The difference in chromosome number of Talpa europaea stankovici and Talpa europaea romana, and their big teeth contradict the existence of these superspecies.".

M. CORTI et al. (1985) studied the Talpa populations of Italy using multivariate analysis. According to their results Talpa romana terra typica and Talpa romana from Southern Italy are both distinct from either the northern, or the southern populations of Talpa europaea at the species level. And both species are distinct from the populations of Talpa caeca at Abruzzo, Piedmont and Aosta. Regarding the high values of discriminant functions (DF I. = 8,92425, DF II. = 3,12768), it is plain that Talpa europaea, Talpa romana and Talpa caeca are three distinct species.

During the course of this debate much data have come out concerning different populations of Talpa romana. This makes much easier to judge the taxonomic position of the Talpa population at Pusztapó.

In this paper the Pusztapó population is described as a new subspecies of Talpa romana (THOMAS, 1902) - Talpa romana ehiki n. subsp. -. First the description of the new subspecies is presented, which is based on 1 holotype, 4 paratypes and 7 other specimens. Then a mathematical comparision of Talpa romana ehiki and the Hungarian population of Talpa europaea is given:

a) analysis of the means of some distinctive skull measurements,
b) analysis of the same measurements of Talpa romana terra typica, Southern Italian Talpa romana, Talpa romana ehiki and the Italian, Macedonian, Hungarian populations of Talpa europaea, using linear regression,
c) analysis of the frequency distributions of the three most important measurements in Talpa romana stankovici, Talpa romana ehiki and in the Macedonian, Hungarian populations of Talpa europaea. Finally a taxonomic-biogeographic conception, concerning Talpa romana, is outlined, incorporating the findings of Dénes JÁNOSSY's and Zoltán VARGA's recent studies.

TALPA ROMANA EHIKI N. SUBSP.

The holotype and the paratypes were collected by István VÁSÁRHELYI near Pusztapó (new name Kétpó), Szolnok County, Hungary, in 1925-26. The average elevation of the area is 88 meters above sealevel. To characterize the climate of the area Figure 2. shows the climate diagram of Pusztapó. The climate diagrams of other localities, where Talpa romana occurs are also given after WALTER (1960 -1966).

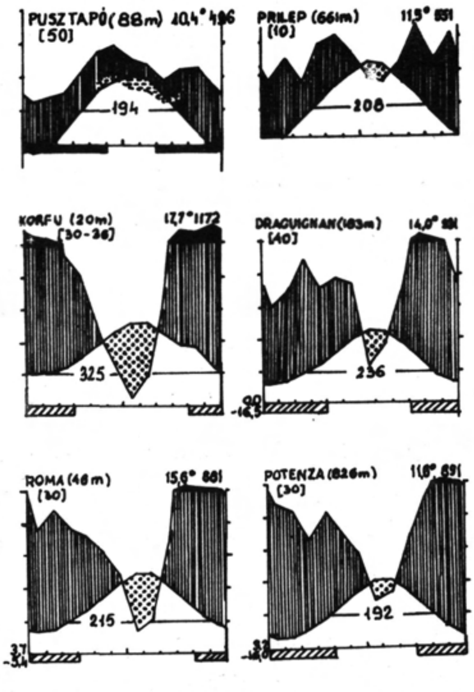


Figure 2. Climata diagrams os Talpa romana habitats (after WALTER, H 1960-66, and original for Pusztapó)

The skulls of 3 males and 5 females were found in Lajos VÉGHELYI's collection, which now belongs to the collection of the Mátra Museum.
The skulls of 3 males and 1 female, of wich 1 male and 1 female are with furs, were found in the collection of the Museum of Natural History. Two slightly injured skulls of the VÉGHELYI colloction were also classified as Talpa romana ehiki. To describe the new subspecies the 12 skulls and the 2 furs with their ori-

ginal measurements, taken by the collector, were only used. The measurements of the 12 skulls are given in Table 1.

Holotype: Mátra Museum No. 87. 2. 1. VÉGHELYI's collection in 84. 04. 02. 1926. Pusztapó leg.: VÁSÁRHELYI (skull)

Paratypes: Mus. Nat. Hist. No. 3524/1 - 02. 08. 1926. Pusztapó leg.: VÁSÁRHELYI (skull + fur); Mus. Nat. Hist. No. 3380/3 - 26. 01. 1925. Pusztapó leg.: VÁSÁRHELYI (skull + fur); Mátra Museum No. 87. 2. 2. VÉGHELYI's collection in 83. 08. 01. 1926. Pusztapó leg.: VÁSÁRHELYI (skull);Mátra Museum No. 87. 2. 3. VÉGHELYI's collection in 87. 01. 05. 1926. Pusztapó leg.: VÁSÁRHELYI (skull).

Description: The colour of the two furs is lighter, than that of *Talpa europaea*, it is dark brown, not black (VÁSÁRHELYI did not keep the material in alcohol, he stuffed the furs at once, so the colour can be regarded as original).

The rostrum of the new subspecies is a bit narrower (9,8 - 10,65 $\bar{x}$ = 10,02 mm), than that of the prototype (*Talpa romana* THOMAS, 1902 - terra typica). It must be noted that this tendency of rostrum narrowing from south to north is in good harmony with that of *Talpa europaea* (c. f. Italian, Macedonian, Hungarian material in Tables 1, 2 and 3). The rostrum of the new subspecies in much wider, than that of *Talpa europaea* from Hungary.

The posterior part of the rostrum is broadened expressly. The average width of the rostrum is 27,39 % of the length of the skull. The same ratio in *Talpa romana* terra typica is 28,1 %, and in *Talpa europaea* it is between 25,3 and 26,1 %, depending on body size (STEIN, 1951).

Maximal width of the skull is very much like that of the prototype (16,7 - 17,8 $\bar{x}$ = 17,4; c. f. Tab. 3).

Diagnostic characteristics: Maxillar M_1 with detached bifid mesostyle and well developed parastyle. The biggest diameter of M_1 (3,55 - 4,0 $\bar{x}$ = 3,69) is smaller, than that of *Talpa romana* terra typica, but is equal to that of *Talpa romana stankovici* (c. f. Tab. 2). Maxillar M_1 and M_2 with detached bifid mesostyle and parastyle.

P_4 is large and thick with developed parastyle and cingulum. P_1, P_2, P_3 are smaller, but P_2 is always smaller, than P_1 and P_3. The length of mandibular M_1 - M_3 is 7,5 - 8,2 mm $\bar{x}$ = 7,68 mm. In the lower jaw the canine is expanded, with a notch behind it, and larger, than incisors of hich I_3 is the smellest. The length of maxillar set of teeth is 13,2 - 14,6 mm $\bar{x}$ = 13.95mm.The length of palate is 15,5 - 16,9 mm $\bar{x}$ = 16,15 mm, ich is 44,01 % of skull length. This ratio is 45,1 % in *Talpa romana* terra typica, and depending on body size, 41,7 - 42,2 % in *Talpa europaea* (STEIN, 1951).

Body measurements of the to sexes:

Male: Mus. Nat. Hist. No. 3380/3 (26. 06. 1925. Pusztapó, leg.: VÁSÁRHELYI)

head and tail: 155 mm
tail : 30 mm
hind foot : 20 mm

Female: Mus. Nat. Hist. No. 3524/1 (02. 08. 1926. Pusztapó, leg.: VÁSÁRHELYI)

head and tail: 144 mm
tail : 30 mm
hind foot : 18 mm

Note: Measurements ere taken by VÁSÁRHELYI immediately after collecting the specimens.

A COMPARATIVE BIOMETRIC ANALYSIS OF THE SKULL MEASUREMENTS OF TALPA ROMANA EHIKI N. SUBSP.

In addition to my o n measurements, data on *Talpa romana stankovici* (PETROV, 1971) and Italian *Talpa romana* populations (CAPANNA, 1981) ere also used for the analysis.

1.00. Comparative study of *Talpa romana ehiki* n. subsp. and *Talpa europaea* (Hungary) on the basis of the means of skull measurements.

1.10. Standard deviation, mean and standard error of the data.

Table 1: **Skull measurements** of <u>Talpa romana eheki</u> (Hungary)

No.	C.B.	Zyg.brt.	Cran.brt.	Maxill. TWR:	Rostal width	M_1	Mandibula 1 - 3	M_1-M_1	length of Palat	M_1
In. 84. P. 926. 02. 04.	37,6	13,2	17,3	14,6	10,4	3,8	8,2	10,2	16,6	bifid
In. 83. P. 926. 01. 08.	37,6	13,3	17,8	14,6	10,4	4,0	8,0	10,3	16,9	bifid
In. 87. P. 926. 05. 01.	37,9	13,5	17,8	14,3	10,65	3,8	8,0	10,1	16,5	bifid
In. 86. P. 926. 04. 07.	37,2	13,2	17,8	14,2	10,35	3,7	7,8	9,9	16,6	bifid
In. 92. P. 926. 08. 19.	35,5	12,8	17,1	13,2	9,8	3,8	7,4	9,6	15,6	bifid
3524/2 926. 08. 03.	37,1	13,0	17,3	14,15	9,8	3,5	7,8	9,4	16,3	bifid
3376 926. 05. 20.	36,8	13,2	17,65	13,6	9,9	3,75	7,5	9,65	15,5	bifid
3521/1. 926. 08. 02.	37,5	13,2	17,8	14,2	9,9	3,55	7,55	9,6	16,4	bifid
3380/3. 925. 06. 26.	37,2	13,2	17,8	14,05	9,8	3,7	7,5	9,4	16,2	bifid
In. 82. P. 926. 01. 05.	35,3	12,5	17,0	13,4	9,85	3,8	7,5	9,5	15,6	bifid
In. 89. P. 926. 03. 17.	35,8	12,5	16,7	13,7	10,0	3,6	7,5	9,8	15,6	bifid
In. 93. P. 926. 08. 03.	34,8	12,5	16,8	13,4	9,8	3,5	7,45	9,4	15,7	bifid
Mean:	36.60	13,0	17,4	13,95	10,05	3,7	7,68	9,74	16,13	bifid

P: Pusztapó
In: Insectivora (N^o- Véghelyis catalogue)

Table 2: Skull measurements of <u>Talpa europaea</u> L. (Hungary)

No.	C.B.	Zyg.brt.	Cran.brt.	Maxill. TWR:	Rostral width	M_1	Mandibula 1 - 3	M_1-M_1	length of Palat	M^1
In. 104. Fm. 927. 08. 02.	34,7	12,8	17,1	12,8	9.55	3,35	7.05	8,0	14.8	no bifid
In. 112. Eszt. 928. 07. 10.	33,5	12,0	15,9	12,8	9.30	3,30	6,8	8.6	14.8	no bifid
In. 111. Tm. 927. 12. 30.	37,1	13,3	16.7	13.9	9.7	3.35	7.3	9.2	16.1	no bifid
In. 107. Fm. 927. 09. 08.	35,5	12,6	16.8	13.3	9.5	3.35	7.05	8.8	15.4	no bifid
In. 109. Fm. 927. 10. 28.	35,4	12,75	16,8	13,2	9,5	3,2	7,00	9.1	15,0	no bifid
In. 101. Fm. 927. 07. 23.	34,6	12,8	16.7	13.1	9.4	3.5	7.2	8.8	15.4	no bifid
In. 100. Fm. 927. 07. 20.	33,7	12,2	16.2	13.2	9.55	3,2	7,0	9.0	15.3	no bifid
In. 80. Eszt. 925. 09. 05.	33,6	12,5	16,5	12,6	8,9	3.2	7.0	8,55	14.7	no bifid
In. 91. Eszt. 926. 05. 21.	33,6	12,2	16.6	12.7	9,15	3,4	6,8	8,7	14.8	no bifid
In. 76. Eszt. 921. 05. 20.	32,1	11.4	15,9	12,2	9,3	3,1	6.4	8.3	14,2	no bifid
In. 75. Eszt.	33,2	11,5	15,6	13,1	9,0	3,4	6,7	8,2	14,6	no bifid
in. 78. Eszt. 924. 07. 16.	33,7	11.9	16.4	12.3	8,8	3.3	7.0	8,4	14,9	no bifid
Mean:	34,23	12,33	16.4	12.9	9.3	3.3	6.94	8.7	15	no bifid

Eszt: Esztergom
Fm: Felsőméra
In: Insectivora (N^{o}- Véghelyis catalogue)

Table 3. Mean standard deviation and standard error of skull measurements in Talpa europaea and Talpa romana populatios

Population	n	Cb. $\bar{X}$	Cb. S	Cb. Sm	Rostral width $\bar{X}$	Rostral width S	Rostral width Sm	Length of maxillar set of teeth $\bar{X}$	Length of maxillar set of teeth S	Length of maxillar set of teeth Sm	Maximal width of skull $\bar{X}$	Maximal width of skull S	Maximal width of skull Sm	Maximal diameter-M_1 $\bar{X}$
TALPA ROMANA:														
Terra typica	24	36.13	±0.93	±0.18	11.38	±0.26	±0.05	14.31	±0.51	±0.10	17.76	±0.56	±0.11	4.11
Pusztapó	14	36.55	±1.12	±0.29	10.02	±0.30	±0.08	13.95	±0.46	±0.12	17.44	±0.41	±0.11	3.69
S-Italy	18	34.35	±1.04	±0.24	10.91	±0.36	±0.08	13.92	±0.56	±0.13	16.9	±0.46	±0.11	4.07
Macedónia	34	32.29	±0.73	±0.13	10.38	±0.34	±0.06	13.44	±0.39	±0.07	-	-	-	3.7
TALPA EUROPAE:														
Italy	20	35.68	±1.03	±0.23	9.73	±0.41	±0.09	13.66	±0.40	±0.10	17.01	±0.44	±0.10	3.53
Hungary	18	34.22	±1.16	±0.27	9.27	±0.28	±0.07	12.91	±0.39	±0.09	16.5	±0.55	±0.13	3.3
Macedónia	31	33.85	±1.23	±0.22	9.45	±0.42	±0.08	12.74	±0.57	±0-09	-	-	-	3.3

Table 4. Mean, standard deviation and confidence intervals of the mean of rostal width data in the Hungarian populations of Talpa europaea and Talpa romana.

Population	$\bar{X}$	$S=\sqrt{\frac{SQ}{n-1}}$	$S_x=\frac{S}{\sqrt{n}}$	P 1% h_1	P 1% h_2	P 5% h_1	P 5% h_2	SQ	n
Talpa romana ehiki	10,018	±0,299	±0,0798	10,258	9,8	10,19	9,85	1,16	14
Talpa europae (Hung.)	9,270	±0,278	±0,0655	9,46	9,08	9,41	9,13	1,31	18

Comparision of the means.

$x_1 - x_2$	calculated t	table t (P.0,1%)	least significant difference SzD P1%	least significant difference SzD P5%	Standard deviation of diference Sd
0,748	7,262	3,65	0,28	0,208	0,102

Results of regression analysis (Y = rostál width X = Cb.)

Talpa romana ehikii: $Y = 4{,}608 + 0{,}148\,X$ $r = 0{,}555$ $r^2 = 0{,}309$

Talpa europaea: $Y = 3{,}71 + 0{,}163\,X$ $r = 0{,}678$ $r^2 = 0{,}459$

Table 5. Mean, standard devition and confidence intervals of the mean of maximal diameter of maxillar M_1 data in Hungarian populations of _Talpa europaea_ and _Talpa romana_.

Population	$\bar{X}$	$S=\sqrt{\frac{SQ}{n-1}}$	$S_x=\frac{S}{\sqrt{n}}$	P 1% h_1	P 1% h_2	P 5% h_1	P 5% h_2	SQ	n
Talpa romana éhiki	3,686	$\pm$0,15	$\pm$0,04	3,81	3,56	3,77	3,6	0,294	14
Talpa europae (Hung.)	3,294	$\pm$0,116	$\pm$0,027	3,37	3,22	3,35	3,2	0,23	18

Comparision of the means.

$X_1 - X_2$	calculated	table t (P.0,1%)	least significant difference SzD P 1%	least significant difference SzD P 5%	standard deviation of difference Sd
0,392	8,322	3,65	0,129	0,096	0,0471

Resulth of regression analysis (Y = Maxillar M_1 X = Cb.

Talpa romana ehiki: $Y = 2,26 + 0,039\ X$ $r^2 = 0,08$

Talpa europaea (Hung.): $Y = 2,3 + 0,028\ X$ $r^2 = 0,068$

Table 6. Mean standard deviation and confidence intervals of the mean of lenght of maxillar set of teeth data **in the Hungarian populations of** Talpa europaea **and** Talpa romana

Polulation	$\bar{X}$	$S=\sqrt{\frac{SQ}{n-1}}$	$S_x=\frac{S}{\sqrt{n}}$	P 1% h_1	P 1% h_2	P 5% h_1	P 5% h_2	SQ	n
Talpa romana ehiki	13,95	0,459	0,123	14,32	13,58	14,22	13,68	2,74	14
Talpa europae (M.o.)	12,91	3,385	0,091	13,17	12,65	13,10	12,72	2,52	18

Comparision of the means

$X_1 - X_2$	calculated t	table t (PQ,1%)	least significant difference SzD P 1%	least significant difference SzD P 5%	standard devition of Sd
1,04	6,979	3,65	0,409	0,303	0,149

Result of regression analysis (Y = length of maxillar set of teeth X= Cb.)

Population	Y a+bx	r	r^2	$\bar{X}$	$\bar{Y}$	h
Talpa romana ehiki	Y=1,09-0,35X	0,86	0,74	13,55	13,95	14
Talpa europaea (M.O.)	Y=12,91-0,031X	0,094	0,008	34,22	12,91	18

Table 7. Mean, standard deviation and confidence intervals of the mean of maximall widt of the skull data in the Hungarian populations of Talpa europaea and Talpa romana

Population	$\bar{x}$	$S = \sqrt{\frac{SQ}{n-1}}$	$S_x = \frac{S}{\sqrt{n}}$	P 1%		P 5%		SQ	n
				$+h_1$	$-h_2$	$+h_1$	$-h_2$		
Talpa romana ehiki	17,44	0,408	0,109	17,77	17,11	17,68	17,205	2,17	14
Talpa europaea (Hung.)	16,55	0,550	0,130	16,93	16,174	16,824	16,276	5,14	18

Table 8. Mean, standard deviation and confidence intervals of the mean of mandibular length ($M_1 - M_2$) data in the Hungarian populations of Talpa europaea and Talpa romana

Talpa romana eheki	7,66	0,269	0,071	7,88	7,44	7,81	7,51	0,94	14
Talpa europaea (Hung.)	6,98	0,21	0,049	7,12	6,84	7,08	6,88	0,74	18

E.CAPANNA (1981) presented the standard deviation, the mean and the standard error of distinctive skull and body measurements for Talpa romana terra typica, S. Italian Talpa romana, Talpa romana stankovici, using PETROV's (1971) data as well. These data were compared with those of the Macedonian and Italian populations of Talpa europaea. To fit the Hungarian Talpa europaea population and Talpa romana ehiki into this set of data, the respective values were calculated (c. f. Tab. 3). The table shows, that the Pusztapó population of Talpa romana ehiki n. subsp. corresponds to the other Talpa romana populations. Similarly, the values of the Hungarian Talpa europaea population can be fitted to those of other Talpa europaea populations. Table 3 also shows, that standard deviation (S) and standard error (S_m) values for the Pusztapó population (a random sample) are on the same order as those of CAPANNA's and PETROV's samples and the Hungarian Talpa europaea sample. This serves the basis for further biometric comparision of the populations studied.

1.20. Confidence intervals of the means

As second step, the confidence intervals of the means of skull measurements in Talpa romana ehiki (Pusztapó) and Talpa europaea (Hungary) were studied at confidence coefficients of 0,95 and 0,99 (c. f. Tables 4, 5, 6, 7, 8). The tables show that the confidence intervals of all distinctive skull measurements do not overlap at a confidence coefficient of 0,99. In other words the two samples were taken from different statistical populations, at a 1 % level of significance.

1.30. Comparision of means and testing the significance of their differences.

To answer the question, whether the samples were taken from the same statistical population, and to value the difference between the two populations, the means were compared, and the significance of their differences were tested.

In the second halves of Tables 4, 5, 6 the comparision of the means of rostral width, maximal diameter of maxillar M_1 and mean length of maxillar set of teeth in Talpa romana ehiki and Talpa europaea (Hungary) are presented. The data show, that the two populations are not from the same statistical population. The means of the three skull measurements are defferent at a 0,1 % level of significance.

1.40. Differences in maximal diameter of maxillar M_1

Since MILLER (1912), SCHWARZ (1948) and CAPANNA (1981) regarded maximal diameter of maxillar M_1 as distinctive characteristic between Talpa romana populations, the differences in this data were studied in more detail. The resulte show, that Talpa romana ehiki is different from the two Italian Talpa romana populations at 1 % level of significance, whereas it is not defferent significantly from Talpa romana stankovici. Similarly, the two Italian Talpa romana populations are different from the Macedonian population at 1 % level of significance. The resulte imply, that Talpa romana stankovici and Talpa romana ehiki are closer relatives with each other, than with the two Italian populations, and vice versa.

2.00. Regression analysis

To select the least climate dependent diagnostic specific characteristics, and to study the behaviour of certain skull measurements is Talpa romana and Talpa europaea populations, simple- and multiple linear regression analyses were carried out.

Methods: For the calculations Commodore 64 computer and TI-57 TEXAS programmable calculator were used. Simple- and multiple linear regression equations were computed using the MLINREG program.

It fits a $y = a_o + a_1 + . . . a_m x_m$ curve (here $1 \leqslant m \leqslant 12$) to N points using the minimum SO method. The program enables us to eliminate a_o. This makes possible the solution of linear equations with "m" unknowns. the $y = ax$ linear equation is solved by $\underline{a} = (\underline{x}^T \underline{x})^{-1} x^T$ matrix equation. Inversion is carried out by using Gauss-Jordan method. To reach the desired precision, the program can also change the rows and columns. If $N \geqslant m + 2$ the program carries out regression analysis. Correlation coefficient (r), r^2, the value of F test and the standard error of curve fitting are calculated.

2.10. Multiple analyses

2.11. Searching for the most distinctive characteristic among the measurements used (i. e. wich has the highest coefficient, which gives the biggest distance between Talpa romana ehiki and Talpa europaea /Hungary/), a 4-variable analysis was carried out. In this way previous distinctive characteristics were also checked. Variables used: b_1 = skull width, b_2 = rostral width, b_3 = maximal diameter of maxillar M_1, b_4 = longest distance between the two maxillar M_1 (rostral width after STEIN), y = CB (length of skull base).
The equations obtained:

Talpa romana ehiki n. subsp.:

$$y = -5{,}07a + 2{,}001b_1 - 0{,}45b_2 - 2{,}66b_3 + 2{,}19b_4$$

Talpa europaea (Hungary):

$$y = -9{,}17a + 0{,}51b_1 + 0{,}097b_2 + 2{,}978b_3 + 2{,}79b_4.$$

The biggest differences obtained are $b_{r3} - b_{e3}$ = 5,638 (maximal diameter of maxillar M_1 (and $b_{r1} - b_{el}$ = 1,491 (skull width). The coefficients are real, since the results of regression analysis are as follows:

Talpa romana ehiki: r = 0,931, r^2 = 0,866, F = 11,40,
Talpa europaea (Hungary): r = 0,868, r^2 = 0,754, F = 5,369.

In both cases the correlation is significant at level of 0 0,1% (n = 12-12).

2.12. To check these results a 5-variable analysis was carried out, where a_0 was eliminated. The variebles used were:
b_1 = rostrlal width, b_2 = maximal diameter of maxiller M_1,
b_3 = mesostyle of maxillar M_1 (if bifid +1, if not -1),
b_4 = distance between the two maxillar M_1, b_5 = skull width.
The equations obtained were as follows:

Talpa romana ehiki n. subsp.:

$$y = -0{,}45b_1 - 2{,}67b_2 - 5{,}07b_3 + 2{,}19b_4 + 2{,}001b_5$$

Talpa europaea (Hungary):

$$y = 0{,}096b_1 + 2{,}97b_2 + 9{,}17b_3 + 2{,}79b_4 + 0{,}509b_5.$$

The order of differences has not changed. However the absolute difference in the mesostyle of maxillar M_1 (bifid or not) $b_{e3} - b_{r3}$ = 14,77 serves as reference to judge the differences in other measurements. On this basis I propose to regard the maximal diameter of maxillar M_1 ($b_{e4} - b_{r4}$ = 5,64) as distinctive characteristic at the species level, whereas skull width, rotsral width, together with the distance between the two maxillar M_1 used formely, as only so-called subspecies characteristics ($b_{e5} - b_{r5}$ = 1,492; $b_{el} - b_{rl}$ = 0,456; $b_{e4} - b_{r4}$ = 0,6).

2.20. Regression of M_1 on CB

2.21. As the third step, maximal diameter of maxillar M_1 was plotted against CB in Talpa romana terra typica, Talpa romana (S-Italy), Talpa romana stankovici, Talpa romana ehiki and Talpa europaea (Hungary) (Fig. 4). In Figure 5 the same is shown for the Hungarian, Macedonian an Italian populations of Talpa europaea. In thisway the relation of the populations mentioned could be studied on the basis of important distinctive characteristic. A relation between the geographical location (altitude and 1 latitude) of the respective populations and the centroids of their M_1 (CB sets can be recognized in the diagram of Talpa romana (Fig. 4). Concerning the distribution of the four Talpa romana populations the following can be stated:

- the more southern the location, the bigger the diameter of maxillar M_1.
- the higher the altitude of the location, the smaller the body size (CB).

As an illustration of this the average elevation of the locations and the mean body size (CB) of the four Talpa romana populations are presented:

Talpa romana (Macedonia)	1,125 m	32,29 mm
Talpa romana (S-Italy)	850 m	34,35 mm
Talpa romana terra typica	100 m	36,13 mm
Talpa romana ehiki	88 m	36,55 mm

The two sets of numbers are highly correlated: r = -0,97, r^2 = 0,94, t_2 (P = 0,1 % in table) = 31,6 t = 31,82. This means, that there is a strong (the level of significance is 0,1 %) negative correlation between the elevation of the habitat and body size (CB) in Talpa romana.

The distribution of individual specimens of each of the four populations in the diagram suggests, that these populations are genetically isolated. On the other hand the individuals of the three Talpa europaea populations are distributed along a common line in the diagram. This suggests a strong genetic relation between them, although there is a slight geographic variaiton, as wel.

2.22. The lack of significant (or any) correlation beween the diameter of maxillar M_1 and body size (CB) is one more reason for regarding the former as distinctive specific characteristic. Body size, wich is dependent on elevation, does not alter the diameter of M_1. The correlation coefficient for Talpa romana ehiki and Talpa europaea (Hungary) are r = 0,29 and r = 0,26 (c. f. Tab. 5), whereas in Talpa romana stankovici r = 0,1156, in Talpa romana terra typica r = 0,66 (a slight correlation P = 1 %).

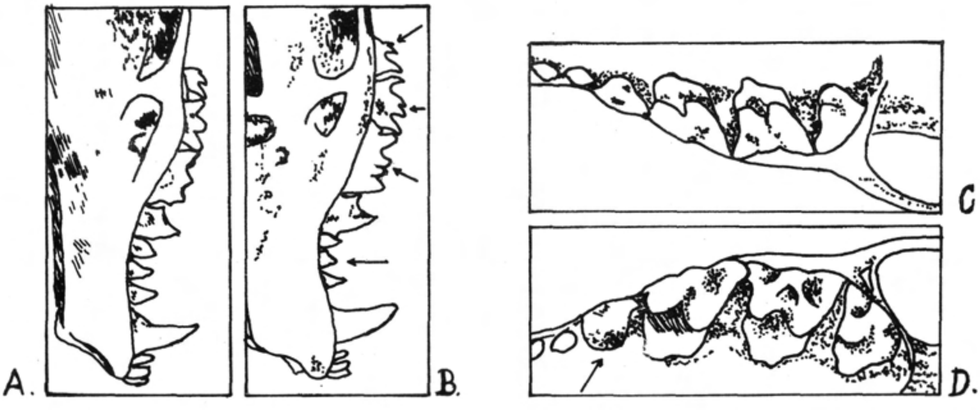


Figure 3. A - Lateral view of the upperset of teeth of Talpa europaea L. (Hungary). B - Lateral view of the upper set of teeth of Talpa romana eheki, arrows: M_1-M_3 bifid mesostyle, P_2 is the smallest. - C. - Bottom view of the upper set of teeth of Talpa europae L. (Hungary). - D - Bottom view of the upper set of teeth of Talpa romana eheki, arrow: wide cingulum of P_4

2.30. Regression of rostral width on CB

2.31. As the fourth step the rostral width was plotted against CB for the populations mentioned in 2.21. (Figs. 6,7). Linear regression equations were calculated. Concerning rostral width, wich used to be regarded as distinctive specific characteristic the following can be stated:

In the case of all the four Talpa romana populations it has much higher correlation with CB, than the diameter of maxillar M_1 has. In the case of three of the four populations this relation is significant at a level of 0,1 %, and r^2 varies between 0,31 and 0,62. This proves indirectly, that habitat factors have strong (30 - 60 %) effect on restral width.

2.32. In the rostral width (CB diagram the isolation of Talpa romana populations can be recognized (c. f. Figs. 6,7). Studying the distance between Talpa romana ehiki and the other three populations it seems to be possible, that Southern French population of Talpa romana could fit into this gap (?). Talpa europaea populations are groupped along a common line. Rostral width of Talpa romana ehiki is somewhat similar to that of S-Italian Talpa europaea population, which can be explained by differences in the habitats, as it was discussed above.

2.40. Regression of the diameter of maxillar M_1 rostral width

2.41. As the fifth step the diameter of maxillar M_1 of Talpa romana populations were plotted against rostral width (Fig. 8.). The same was done for Talpa europaea populations (Fig. 9). The behaviour of these two variables was quite different in the case of the two species. Talpa europaea populations are dist distributed arount a common centre. It is worth mentioning, that the southern the location of the population, the higher the standard deviation around the common centre.

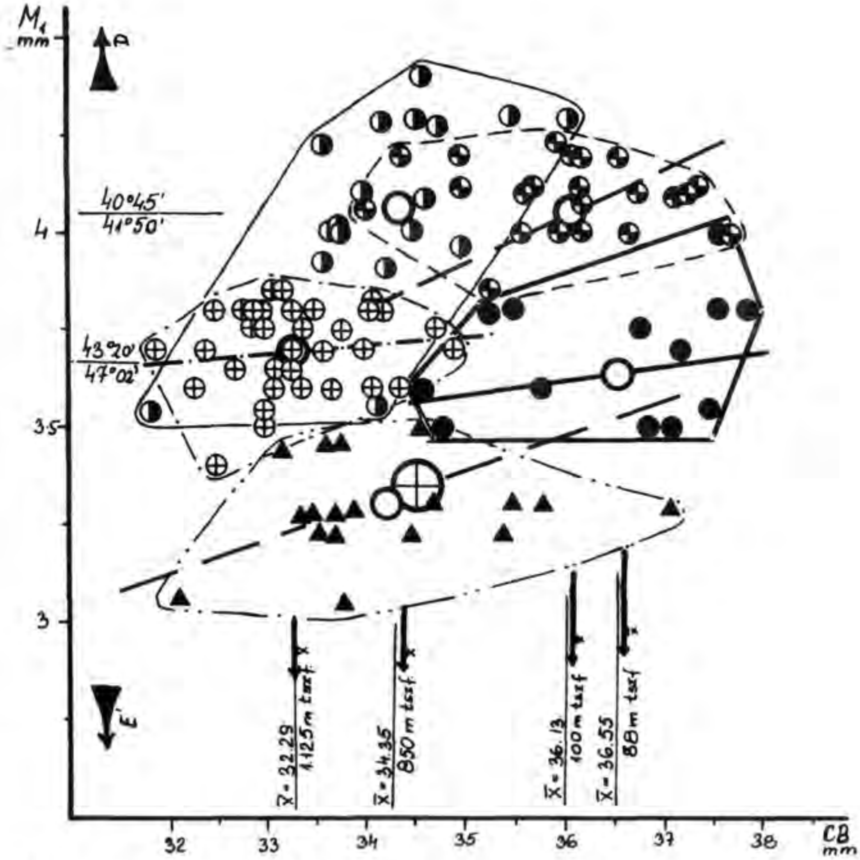


Figure 4. M_1/Cb functions of Talpa romana populations. Legend: cross in ring - T. r. Macedonean, half-black circle - T. r. Southern Italy, Two quaters-black circle - T. r. terra typica, full-blac circle - T. r. ehiki, full-black triangle - T. europaea (Hungary)

In my opinion this proves, that the longer growing season and higher annual insolation and consequently better food supply cause greater variability of the populations. On the other hand a strong genetic relation can be seen among the populations, which is reflected in the common centre. The populations of Talpa romana are distributed along a common regression line, but with different centroids, which is caused by genetic isolation of the populations of common origin.

2.42. According to the results of regression analysis there is a strong correlation (P = 0,1 %) between maximal diameter of maxillar M_1 and rostral width, in the case of all the four Talpa romana populations. Equation of common regression line.

$y = 0,136 + 0,305x$

Equation of the regression line of Talpa romana ehiki

$y = 0,63 + 0,305x$

This latter refers to correlation at 5 % level of significance.

2.43. The coordinates of the centroids of Talpa romana populations in Figure 8 can be substituted for geographical location and climate goodness.

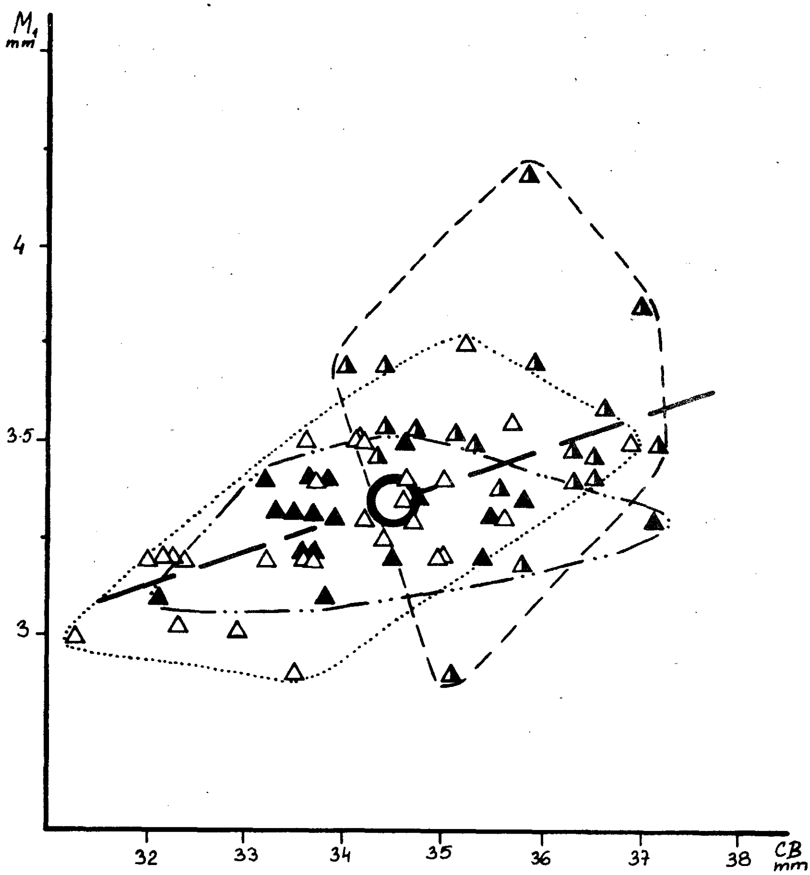


Figure 5. M_1/Cb functios of Talpa europaea populations. Legend: full-black triangle - T. e. Hungary, empty triangle - T. e. Macedonia, half-black triangle- T. e. Italy

2.44. To study the relationship between the mean rostral width, as so-called subspecific characteristic and habitat factors, the term - climate goodness - was introduced. This expression characterizes the macroclimatic conditions of the habitat.

Climate goodness =

$$= \frac{\text{long term mean annual precipitation} \times \text{mean annual temperature}}{100}$$

Since genetic isolation affects on a long time scale, the long term means of climatic factors were used. Precipitation and temperature were chosen, because these two have the most direct effect on food supply and the animals themselves. WALTER (1968, 1970) also regarded them as best characteristics of habitats. To make the calculation easier the values are divided by 100. Climate goodness and rostral width data for Talpa romana populations:

Talpa romana terra typica	137,43	11,38 mm
Talpa romana (S-Italy)	103,35	10,91 mm
Talpa romana stankovici	63,36	10,38 mm
Talpa romana ehiki	51,18	10,02 mm

There is a strong (0,1 % level of significance) positive correlation between the two sets of data, which indicates a strong connection between macroclimatic

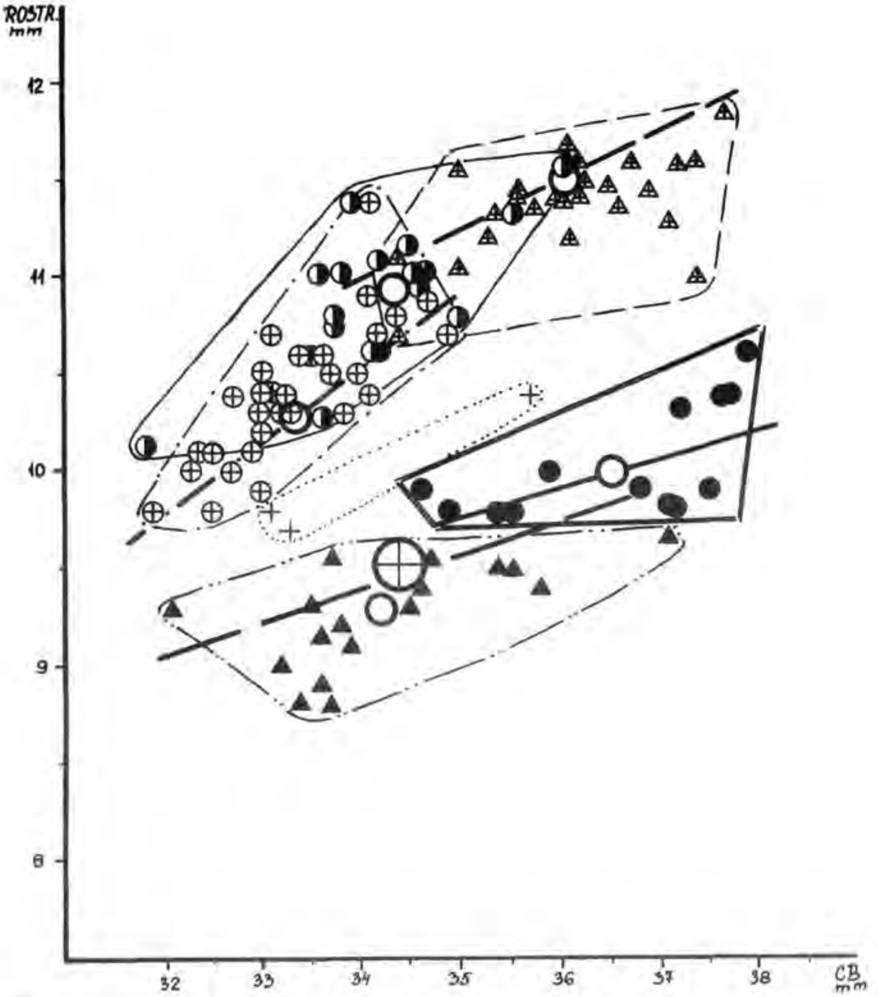


Figure 6. Rostral width/Cb functions of Talpa romana populations. Legend: cross in ring - T. r. Macedinia, half-black circle - T. r. Southern Italy, cross in triangle - T. r. terra typica, full-black circle - T. r. ehiki, full-black triangle - T. europaea (Hungary), cross - T. r. Southern France

characteristics of the habitat and rostral width. It also proves, that differences between subspecies evolved in geographical isolation, are affected by long-term and still effective climatic conditions.

2.45. The relationship between maximal diameter of maxillar M_1, as distinctive specific characteristic, and cliamate goodness was also stüdied. Only a loose correlation (P = 5 %) was obtained. This implies, that in creating this older specific characteristic climatic conditions had less effect. I think, that the diameter of maxillar M_1 is determined by the age of isolation. There are two isolating groups (northern = Talpa romana stankovici and Talpa romana ehiki, southern=Talpa romana terra typica and Talpa romana /S-Italy/), that were isolated much earlier, than the members within both groups. Each isolatum evolved in genetic connection with the other member of its group. the groups diverged from

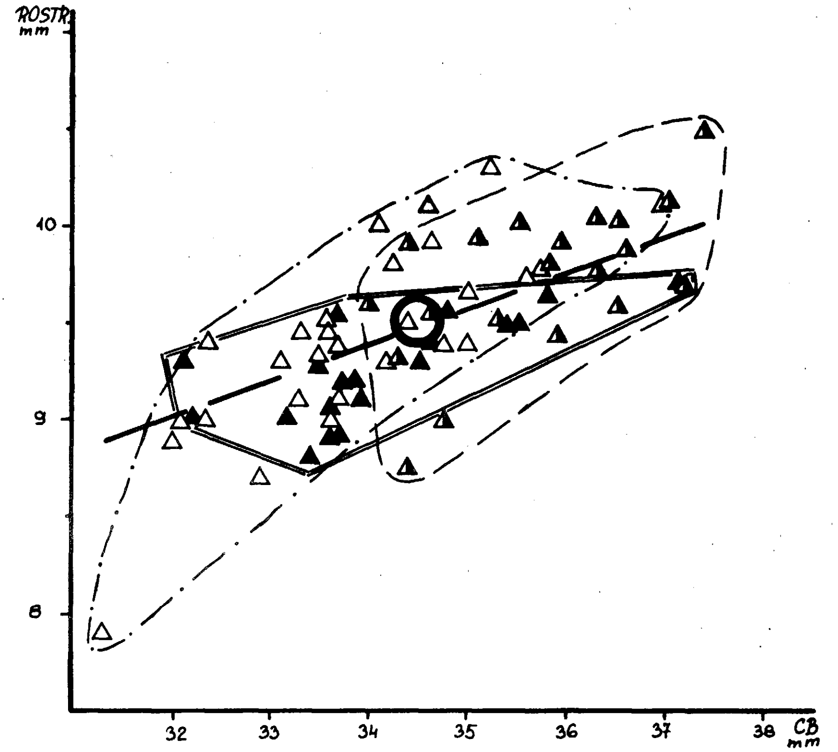


Figure 7. Rostal width/Cb functions of Talpa europaea populations. Legend: as in Fig. 5

each other in genetic isolation having been governed by differences in environmental factors. This view is corroborated by E. CAPANNA (1981), who showed, that the karyotype of Talpa romana stankovici differs from that of Talpa romana terra typica and Talpa romana (S-Italy). The evolution of subspecies took place much later. This is why a strong connection exist between present-day climatic conditions and subspecies characteristics.

3.00. Frequency distribution of skull measurements in Talpa romana ehiki, Talpa romana stankovici and the Macedonian and Hungarian population of Talpa europaea.

According to the results of regression analyses and the comparision of means it can be concluded - in agreement with CAPANNA (1981) -, that Talpa romana stankovici is in a closer relation with Talpa romana ehiki, than with the other two Italian Talpa romana populations. The aim of this paper is the comparision of Talpa romana ehiki and the Hungarian population of Talpa europaea. This is why in further comparisions only the populations that are close to them, are included.

3.10. Frequency distribution and test of homogeneity

3.11. Frequency distribution

First the frequency distribution of certain skull measurements was studied. Figure 10 shows the frequency distribution of maximal diameter of maxillar M_1, the lenght of maxillar set of teeth and rostral width in the four populations. The data indicate, that skull measurements of Talpa romana ehiki and Talpa romana stankovici are distributed in similar interval, and are separated from those

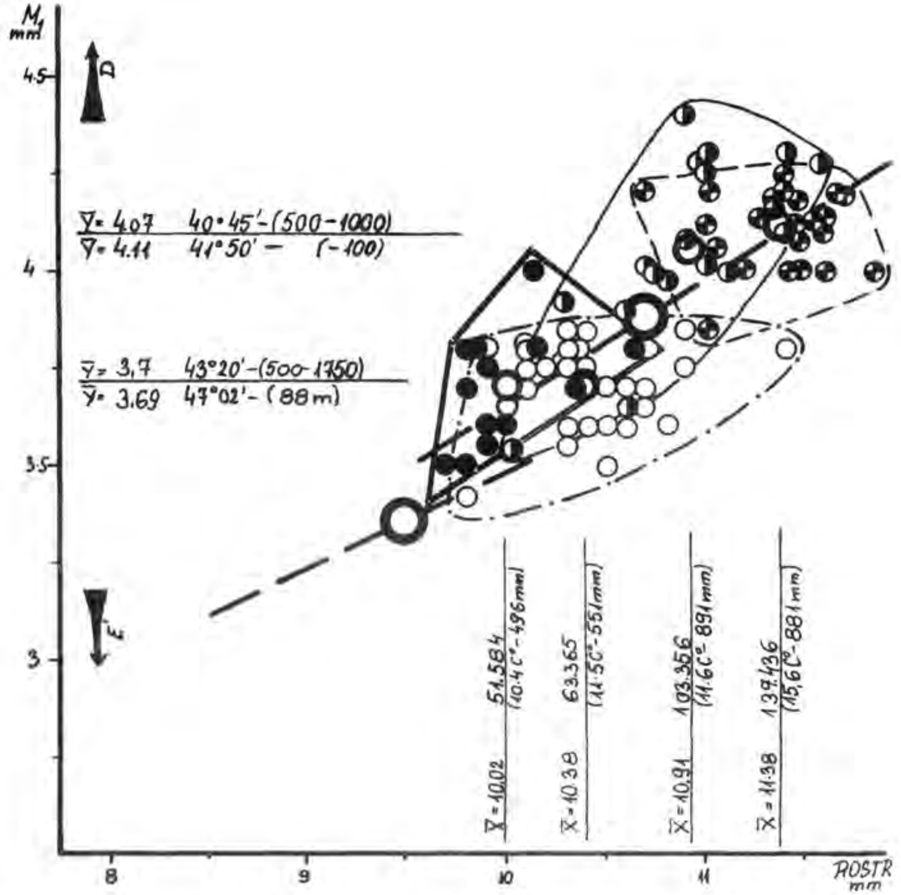


Figure 8. M_1 / Rostal width functions of Talpa romana populations. Legend: empty circle - T. r. Macedonia, full- black circle - T. r. eheki, two quaters- black cicrle T. r. terra typica, half-black circle - T. r. Southern Italy

of Talpa europaea populations. It is worth mentioning, that the maxima of rostral width - the so-called subspecific characteristic - are different in the two Talpa romana populations. This difference is in harmony with the results of regression analyses and comparision of the means (c.f. Tab. 3 and Fig. 8).

3.12. Test of homogeneity by x^2- test

To judge which sample of the four could be originated from the same statistical population, x^2- test of homogeneity was carried out for all the possible pairs and for Talpa romana and Talpa europaea joint samples. For all the three skull measurements x^2- test shows no significant difference (P = 0,1-5%) between the two Talpa romana populations. The same results were obtained for Talpa europaea populations. On the other hand there was significant difference (P = 0,1%) between Talpa europaea and Talpa romana populations. The same was obtained for Talpa europaea (Hungary) - Talpa romana ehiki and Talpa europaea (Macedonia) - Talpa romana stankovici. It can be concluded that these four populations belong to two distinct species.

3.20. Fitting of normal distribution to the frequency polygons

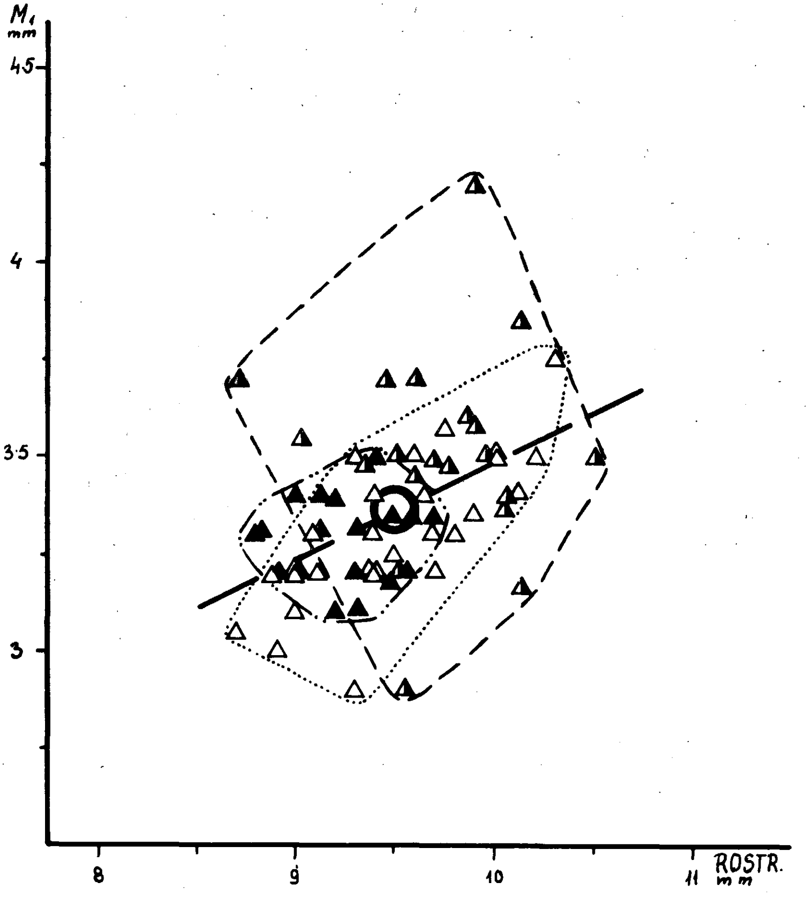


Figure 9. M_1 / Rostral width functions of Talpa europaea populations. Legend: as in Fig. 5

Finally the theoretical normal distribution of skull measurements of the two distinct species was studied. Skull measurements were treated as continous variables, and the normal distribution curves of the two pairs of populations were drawn (Fig. 11). Original frequency polygons are also illustrated in the figure. In the case of maximal diameter of maxillar M_1 and rostral width the distinction between the two species is obvious. So it is one more reason for regarding them as distinvtive specific and so-called subspecific characteristics.

The samples used are relatively small (n_r = 46, n_e = 43). This is why some more relevant analyses (e.g. discriminant analysis) were not carried out. In spite of that, the analyses used proved, that the Talpa populations at Pusztapó belongs to Talpa romana and not to Talpa europaea It forms a distinct subspecies.

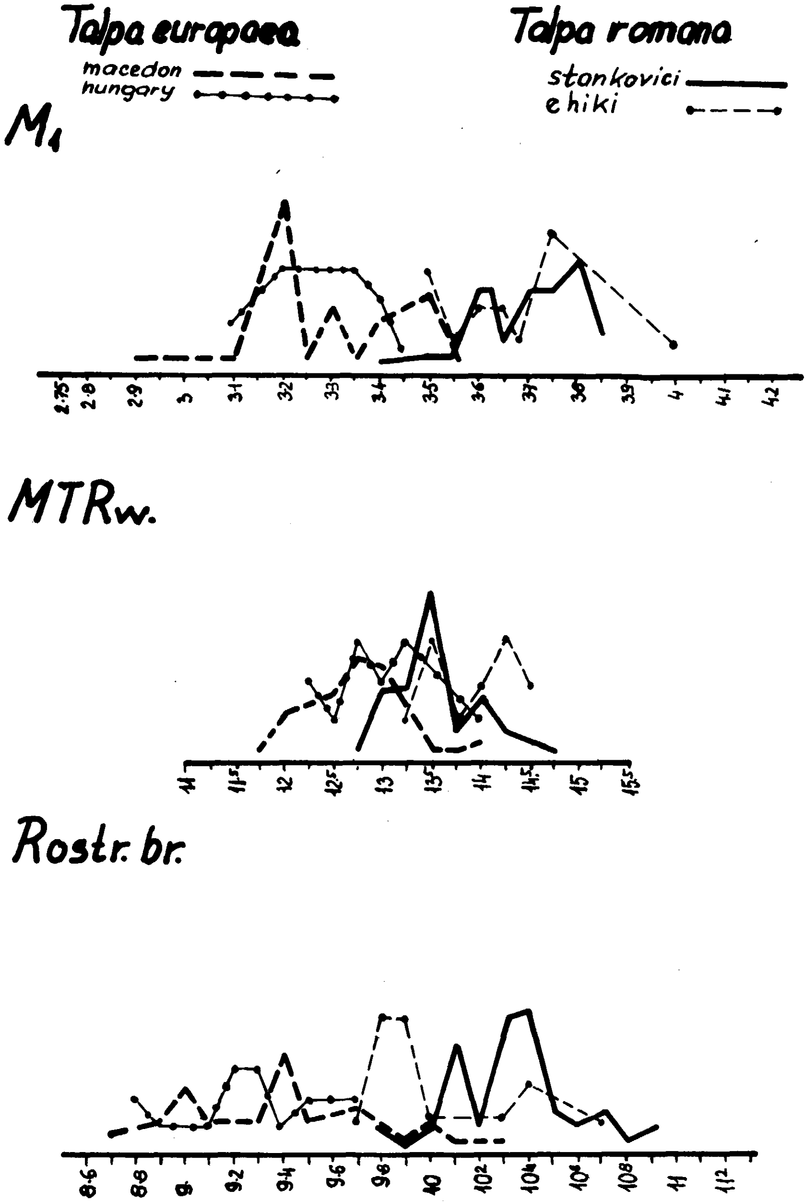


Figure 10. Frequency distribution of M_1 size, length of maxillar set of teeth and rostral width in Talpa romana eheki, Talpa romana stankovici and Talpa europaea (Hungary)

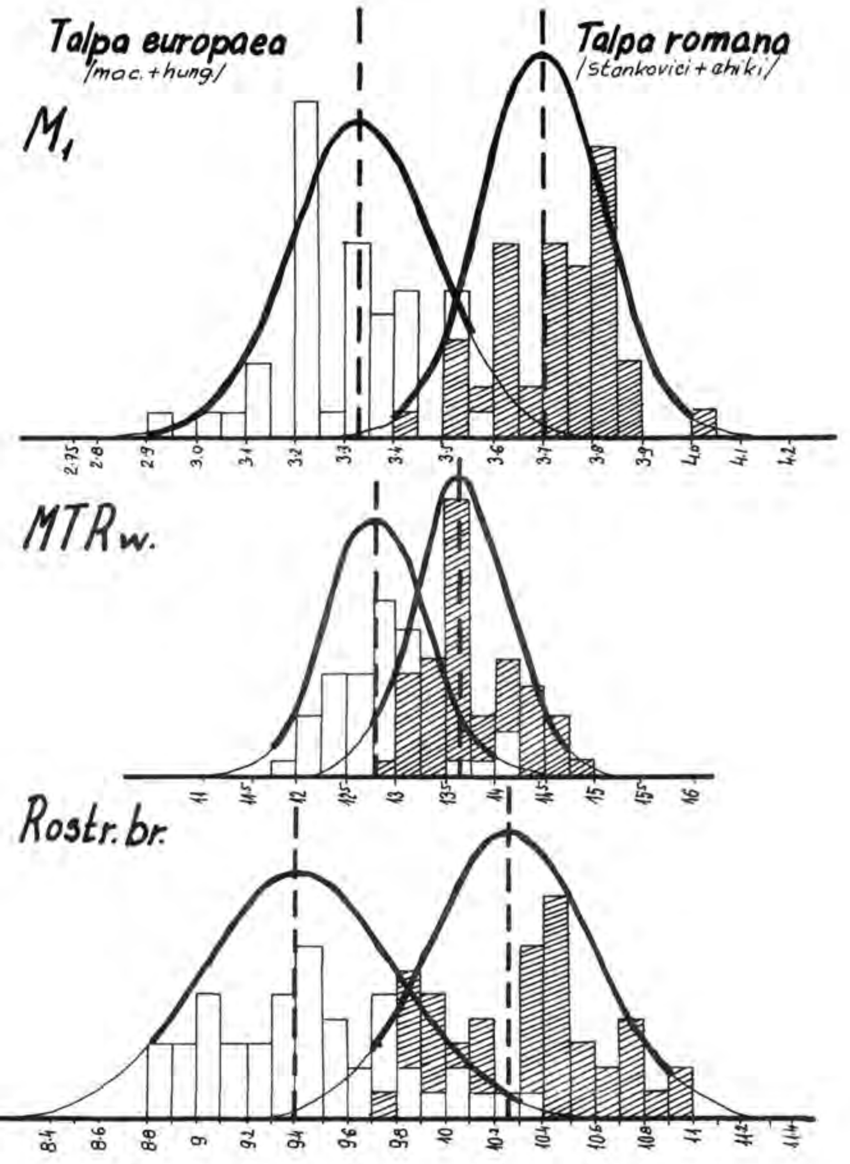


Figure 11. Calculated normal distribution curve of M_1 size, lenght of maxillar set of teeth and rostral width in Talpa romana ehiki, Talpa romana stankovici and Talpa europaea (joined Hungarian-Macedonian population)

A PROPOSAL FOR A NEW TAXONOMY OF TALPA ROMANA, USING BIOGEOGRAPHICAL ANALYSIS

Several authors have dealt with the evolution and taxonomy of Talpa romana (STEIN, 1963, U. ROESLER and G. R. WITTE, 1969, G. R. WITTE, 1965). An alaysis of Talpa romana is given below, using the results of biometrical studies given above, and some new biogeographical view-points. On this basis a new proposal for the taxonomy of Talpa romana is presented.

In addition to the results of biometrical analyses, there some more facts to be considered:

1. Talpa genus is not a young one in evolution, so changes might take places much slower, than in younger genera.

2. All the present-day habitats of Talpa romana can be characterized by firm deposit soils, or by redzinas. Near Rome: the alluvial deposit of the River Tevere, Macedonia Vardar region: Pontic marine deposit, Palegonean region: crystalline slate covered by Mesozoic limestone, Southern Italy: Campania:steep limestone slopes and firm slope-deposit soils, Kétpó-Pusztapó: firm marsh soils developed on the deposit of the River Kőrös.

3. The vicinity of every Talpa romana habitat served as refuge during the Pleistocene for the Mediterranean-like flora and fauna of the Pliocene (REINING, 1950, HASSLEIN, 1960, ANT, 1963, 1966, VARGA, 1971, 1976, 1981, BÁBA, 1982, 1986, POP, 1956). Paleobotanical evidences of refuges in the Bihar region and in the Southern Carpathean (Tusnádfürdő) were given by POP (1932, 1956). The assumed refuges at the time of the greatest glacier is given after B. FRENZEL's (1968) phytogeographical map.

According to the results of ROTARIDES (1944) and KROLOPP (1984), a great proportion of the recent Hungarian fauna existed in the Pliocene as well. These species are among the Holarctic species with wide distribution (SOÓS, 1926, VÁGVÖLGYI, 1954). They evolved to their recent forms in their Pleistocene refuges. "Stacioner Mediterranean oreal species ..... occured in the subalpine region, and they could be most abundant on steep slopes with no wind and high insolation ...... occasionally they occured at very low altitude under good edaphic conditions." (VARGA, 1981).

4.00. It is important, that Spalax leucodon occurs in the habitats of Talpa romana ehiki and Talpa romana stankovici, as well. This species is distributed in SE-Europe, and it requires firm soils. Its ancestor Prospalax priscus is documented from the Hungarian Pliocene and Lower Pleistocene fauna by JÁNOSSY (1979). But in the Bihar region early pleistocene layers contain Spalax, as well. Since that time Spalax has been a permanent member of the Hungarian fauna.

5.00. Talpa genus has been present in Hungary throughout the whole Pleistocene uptill now (JÁNOSSY, 1979). It is against STEIN's (1963) statement, that Middle European Talpa europaea populations survived the Pleistocene in refuges. The big Talpa fossilis and the small Talpa minor are characteristic of the Hungarian fauna from VILLAFRANKA (Villány 3. layer) to MINDEL II - III. (Vértesszőllős 1., Uppony I. 6 - 8 layers) (JÁNOSSY, 1979). Talpa romana seems to be geologically older species, than Talpa europaea. It has much more differentiated polyangular teeth with develoed cingulum. At the beginning of the RISS glacier (Hórvölgy cave): "The big red-toothed Sorex araneus, the medium size whitw-toothed Crocidura leucodon and the big homogeneous Talpa ct. europaea are the indicators of this layer" (JÁNOSSY, 1979). Tetrastes praebonasia is recorded for the first time from layers of the same age, whichmeans that the first invasion of the Siberian fauna reached Hungary in the Middle Pleistocene. It is possible, that Talpa europaea occured for the first time together with loess. This contradict VITTE's (1969) statement. At that time Talpa fossilis and Talpa minor disappeared. Or it might have survived in refuges in the Bihar region, in the Southern Carpathean and at other places. The recent form of Talpa romana ehiki might have evolved from one of these relic populations. Similar processes might have been characteristic of other parts of Europe. And this was the time, when the ancient (Pliocene) form of Talpa romana withdrew to certain refuges. Recent forms of Talpa romana might have evolved in the refuges, and during the time of expansion. It is possible, that the northern (Hungarian, Macedonian) and the southern (Italian) groups of Talpa romana were separated in the second half of the Pliocene, when the climate cooled slowly. As B. FRENZEL (1968) showed at the end of the Pliocene the shore of Ponti and Pannon seas was covered by forests containing Sequoia and other members of Taxodiaceae. These sea-shore habitats were separated from the Apennines by European spruce-fir forests. These forests were effective barriers for moles. In this way the ancestors of Talpa romana could differentiate into two groups. The same happened during the course of glacier - interglacier changes in the Pleistocene.

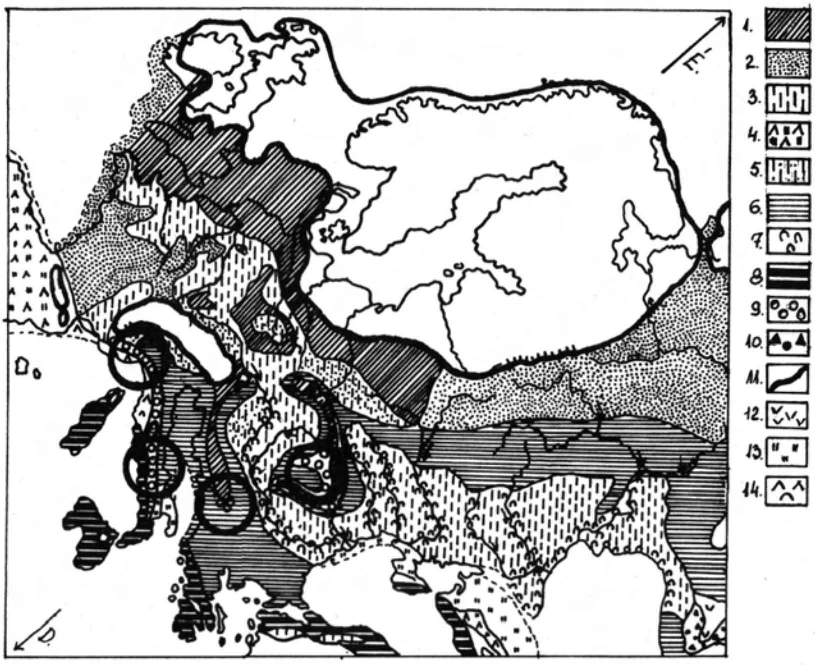


Figure 12. Vegetation map of Europe during the Weichsel glacier (FRENZEL, B., 1968). Big circles indicata the refugia of the 4 Talpa romana populations.Aquila glacier lies between the South and Nort- Italian populations. Legend: 1 - dwarf shrub vegetation with tundra and steppe species, 2 - subarctic cold steppe, withount loess, 3 - Loess steppe with montane vegation, 4 - steppe- woodland, 5 - loess steppe, 6 - forest-tundra and steppe-woodland on loess, 7 - galery forest, 8 - maritime mixed forest, 9 - forest-tundra with steppe mosaics, 10 continental mixed forest, 11 - the border of ice cover, 12 - steppe with cold winters, 13 - steppe without loess, 14 - steppe-woodland

Considering the statements in 3. and the reults of biometrical analyses and CAPANNA's (1981) karyotype analysis the folleings are proposed:

- Talpa romana - being a stacioner Miditerranean oreal animal - is regarded as Talpa romana superspecies.
- Talpa romana stankovici, Talpa romana terra typica, Talpa romana (S-Italy) and Talpa romana ehiki are regarded as individual subspecies
- it is noted that the northern and southern subspecies groups might be different even at the species level.

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