New mathematical-statistical methods in small mammal taphonomy

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The studied bones were yielded to us by Dr. Gábor Csorba (Hungarian Natural History Museum, Department of Zoology, Mammalia Collection). 7980 limb bones of 70 specimens of 10 small mammal species had been measured. The diagrams of size frequency distribution of the bones of some frequent Pleistocene small mammals were made from these measurements for each studied species. Every distribution was made from three selected specimens (average adult size, below the average and over the average). The fact of filtration can be proved with mathematical-statistical methods. The size frequency distribution of the limb bones in the fossil sample was set against a theoretical distribution. It was calculated from the diagrams in fig. 1 and fig. 2. The

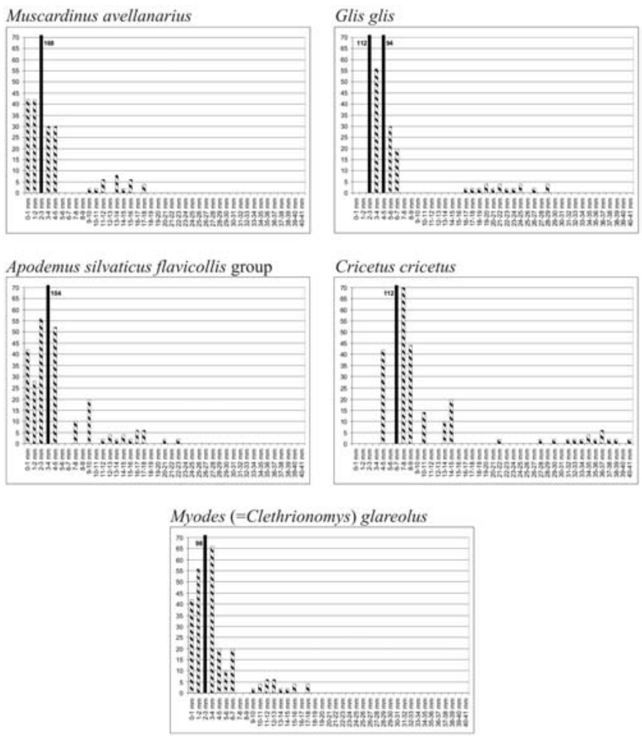

Fig. 1 — Size frequency distributions of some Pleistocene small mammals I. The black columns are higher then 70

percental distribution of the species (it comes from the cranial elements) were considered when the comparative diagram was made. The investigation of filtration is applied χ^2 (Chi-square) test. This is a statistics by what it can be decided that an F distribution of ξ variates can be a distribution characterized by an F_0 distribution function.

$$\chi^2 = n_1 \times n_2 \times \sum_{i=1}^{n} \frac{\left(\frac{\nu_i}{n_1} - \frac{\mu_i}{n_2}\right)^2}{\nu_i + \mu_i}$$

where n_1, n_2 are the numbers of studied bones in the two distributions; υ_i, μ_i are the numbers of samples which pertain to category i in the distribution. There is a critical rate $\chi^2_{n-1}(\alpha)$ ($\alpha > 0$ significance level). If the result is more than a definite value, then the null assumption is false at $1-\alpha$ level. The critical rate can found in the χ^2 distribution table. The result can be interpreted together with taphonomical investigations and can be compared with other ones from other fossil deposits.

The application of the new method is demonstrated on the Late Pleistocene small mammal fauna of Vaskapu II. Rock-Shelter. The deposit is situated about 5 km NE of Felsőtárkány village (Heves County,

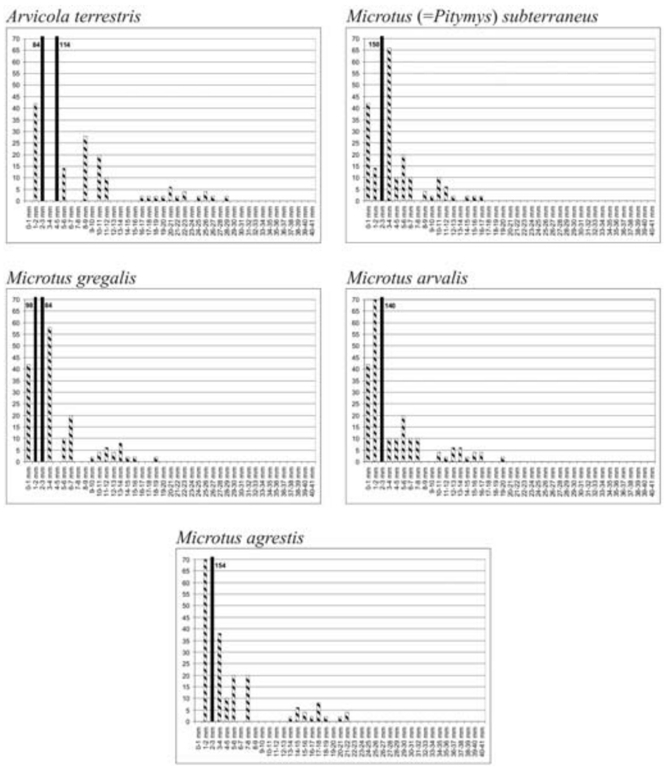

Fig. 2 — Size frequency distributions of some Pleistocene small mammals II. The black columns are higher then 70

North-Hungary), 350 m above sea level (fig. 3). MÉSZÁROS (1999) correlated the deposit of the cave with the Upper Pleistocene, Upper Würm, Pilisszántó Horizon, about 15,000 years B.P. by the occurrence of *Sorex alpinus*. It was detected with taphonomical investigations that the fossil sample got into its recent place through 15 m high rift system which can be found above the Vaskapu II. Rock-Shelter. The filtration of the fossil sample has been concluded by the measure of the bones. The rate of the filtration can be quantified.

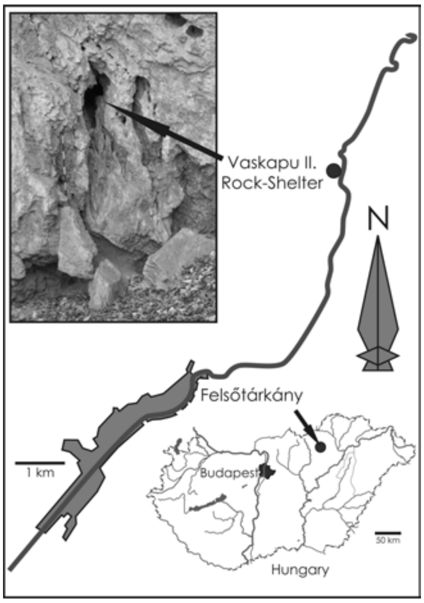

Fig. 3 — Location of the Vaskapu II. Rock-Shelter. Photo: Ádám Csorba (2005)

The comparative diagram can be produced with this formula:

$$X_i = \sum_{s=1}^{n} (p_s \times r_i)$$

where X_i is the number of the limb bones in the theoretical distribution in measure category i, p_s is the percental abundance of the given species in proportion to all identified species and r_i is the number of the limb bones in the measure category i of the given species.

1109 limb bones from the Vaskapu II. Rock-Shelter were measured (fig. 4 and diagram 2). The distribution of species (by cranial elements) amongst all identified taxa were 7,87% *Apodemus silvaticus-flavicollis* group, 1,12% *Cricetus cricetus*, 5,62% *Myodes* (=*Clethrionomys*) *glareolus*, 68,54% *Microtus gregalis*, 15,73% *Microtus arvalis*, 1,12% *Microtus agrestis*. The theoretical distribution was produced with the aforementioned formula. This diagram contains all the limb bones of all specimens in proportion of the given percental distribution of the identified taxa. Because of the operability the comparative diagram were reduced to 1109 bones (like measured fossil bones from the cave). The shape of the diagram was not changed during the mathematical distortion. Diagram 1 on fig. 4 is the final theoretical distribution. The first top (white) on the theoretical diagram includes the small bones (metacarpi, metatarsi, carpi, tarsi, phalanges), the second one (black) includes the long limb bones (humeri, radii, ulnae, femora, tibiae, fibulae). In the case of Vaskapu II. Rock-Shelter there are fewer long bones (over 12 mm) because of the cracking during the filtration. The bone fragments are added to the increase of mean measure categories (3-12 mm). There are more fragments of more specimens in the Vaskapu II. Rock-Shelter in spite of that the two diagrams have the same number of bones. The decrease of the number of short bones (0-3 mm) is explicable with destruction and wash-out.

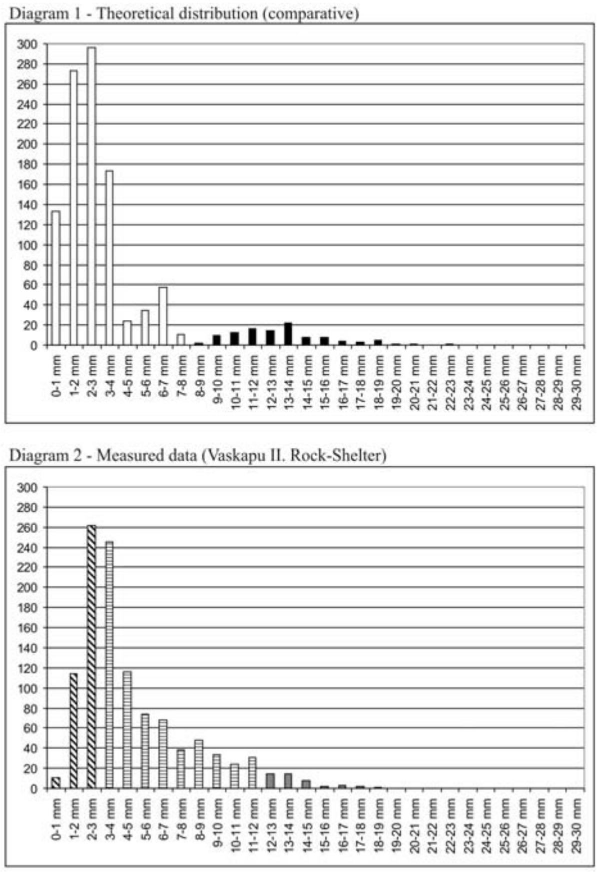

Fig. 4 — Diagrams for the χ^2 test.

The comparison of the diagrams was made with χ^2 test. The result was 345.6301469, which shows huge difference between the two diagrams. The reason of the difference is filtration. It was proved that there are a taphocoenosis in this deposit which do not correspond to the original biocoenosis. The possibility of drawing palaeoecological cosequences is limited.

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