FOLIA MALACOLOGICA
Folia Malacol. 5: 97–107
Cracow, 1993
http://dx.doi.org/10.12657/folmal.005.004

BIOMETRICAL STUDY OF *CHOANOMPHALUS MAACKI* GERSFELDT, 1859 FROM THE BAIKAL LAKE

STEFAN WITOLD ALEXANDROWICZ[1, 2]

[1]Institute of Geology and Mineral Deposits, S. Staszic Academy of Mining and Metallurgy, Al. Mickiewicza 30, 30-059 Cracow, Poland
[2]Polish Academy of Arts and Sciences, Sławkowska 17, 31-016 Cracow, Poland

ABSTRACT: The population of *Choanomphalus maacki* Gersfeldt, 1859 that represents the thanatocoenosis of the eastern part of the Baikal Lake covers shells that are various shapes and sizes. Based upon biometrical and taxonomic analysis, four morphologic types of the species are distinguished. They correspond to the varieties described upon a basis of characters of individual, big specimens, the dimensions of which have been two times bigger than the mean values. The distinction of the morphologic types is due to particular environmental conditions.

KEY WORDS: Gastropoda, Pulmonata, Planorbidae, freshwater, Baikal, shell, morphometry

Folia Malacologica 5/1993 was originally published as No. 1462 of Scientific Bulletins of University of Mining and Metallurgy, Cracow. This digitalised version was prepared by the Association of Polish Malacologists and first published on-line on December 30th, 2016.

Ministry of Science and Higher Education
Republic of Poland

This digitalised version of Folia Malacologica is funded by the Ministry of Science and Higher Education, Republic of Poland under the agreement no. 646/P-DUN/2016 allocated to the activities of disseminating science and by the courtesy of the Rector of the AGH University of Science and Technology, Cracow

STEFAN WITOLD ALEXANDROWICZ *

Biometrical Study of *Choanomphalus maacki* GERSFELDT, 1859 from the Baikal Lake

1. Introduction

The fauna of the Baikal Lake is very rich and comprises many endemic elements. On of them is the snail *Choanomphalus maacki* GERSFELDT, 1859, described in the initial phase of studying the molluscs of the lake. The main phases of the studies correspond to the papers by DYBOWSKI (1875, 1901), LINDHOLM (1909), and KOZOV (1939), and descriptions of all the taxons known so far are published in ZADIN's (1952) monograph. The species in question is very variable, so that besides the nominal form, three morphologic varieties are distinguished: *Ch. maacki var. andrussovianus, Ch. maacki var. elatior, Ch. maacki var. korotnievi* (LINDHOLM 1909). They differ from each other in size as well as in the shape of their shells including the diameter of the umbilicus, the height of the spire, and the rounding of the peripheral part of the last whorl. The differences are well visible in single, big shells, the diameter of which is more than 8 mm. In populations consisted of numerous smaller and bigger specimens the differences are less conspicuous, and determining the character of population variation needs biometrical studies.

2. Material and methods

The shells of *Choanomphalus maacki* were collected by the author in July, 1980, on the north shore of the east part of the lake, near the outflow of the Angara River, at the village of Listvennicne. They had been accumulated as a line thanatocoenosis created at a slight, temporary decrease in water level. The *Choanomphalus* specimens were the main component of the thanatocoenosis, occurring along with scarce shells and shell fragments of *Valvata piligera* LINDHOLM, *Baicalia herderiana* LINDHOLM, and *Benedicta sp.*

Out of the population of *Choanomphalus maacki*, 60 specimens were analysed, which were all the specimens of the taxon that had been found well preserved. Shell measurements were done by means of a measurement eyepiece, magnification 20 x, accuracy 0.05 mm. The following characters were considered (Fig. 1):

* University of Mining and Metallurgy, Kraków

Ministry of Science and Higher Education
Republic of Poland

This digitalised version of Folia Malacologica is funded by the Ministry of Science and Higher Education, Republic of Poland under the agreement no. 646/P-DUN/2016 allocated to the activities of disseminating science and by the courtesy of the Rector of the AGH University of Science and Technology, Cracow

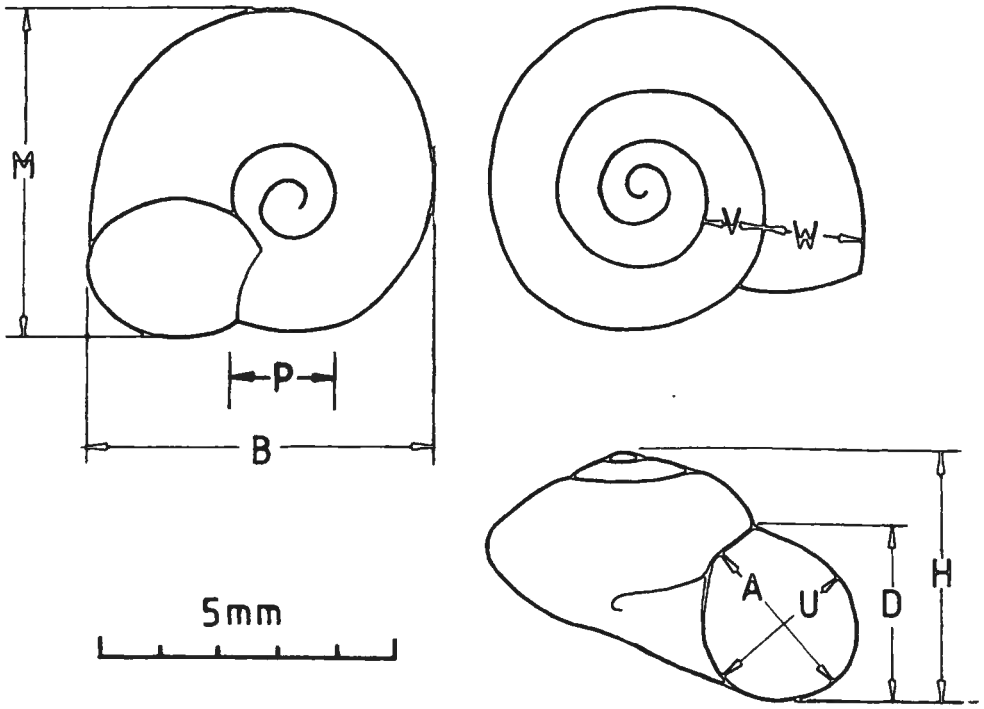

Fig. 1. The shell of *Choanomphalus maacki* GERSFELDT and its biometrical characters. H - shell height, aperture height, B - large diameter of shell, M - small diameter of shell, A - aperture length, U - aperture width, W - ultimate whorl width, V - penultimate whorl width, P - umbilicus diameter

shell height H, aperture height D, shell large diameter B, shell small diameter M, aperture length A, aperture width U, ultimate whorl width W, penultimate whorl width V, umbilicus diameter P, whorl number S. Relations between selected characters, regarded as shell shape indices, were calculated, as follows: height index HB = H/B, spire height index HR = (H - D)/H, asymmetry index BM = B/M, aperture shape index AU = A/U, whorl growth index WV = W/V, umbilicus size index PB = P/B, ultimate whorl width index WB = W/B. Whorls were counted beginning at the apex of the protoconch, with an accuracy of 1/4 of a whorl. Six classes of shell size were distinguished, marked S1 to S6, according to whorl number: S1 - 2.00, S2 - 2.25, S3 - 2.50, S4 - 2.75, S5 - 3.00, S6 - 3.25. Calculations of statistical characters of the set, correlation and regression coefficients, and Perkal indices, as well as taxonomical analysis and distribution normality tests, were done by means of an Amstrad-Schneider 6128 computer, using programs written by Dr. A. Krawczyk and the author.

3. Shell description

The shell is small, discoid, consisted of 2.5...4.5 slowly widening whorls, with a flat or slightly risen spire; the umbilicus open, more or less wide, the aperture oval, slanting to the shall axis. The peripheral side of the ultimate whorl is rounded or bears a keel, another keel may surround the umbilicus. The small specimens with two keels, a flat spire, and a wide umbilicus represent *Ch. maacki var. korotnievi*. The nominal taxon has a low spire, a rounded side edge, a narrower umbilicus, and a big shell, which has up to 10 mm in diameter. The shell of *Ch. maacki var. andrussovianus* is also big, its spire more risen, and bears a keel around the narrow umbilicus, while that of *Ch. maacki var. elatior* is flat, with an open, rather wide umbilicus. There are intermediates between the described morphologic types, which may be regarded as intrapopulation variation. This variation may be controlled by environmental conditions, as the *andrussovianus* variety, for instance, is connected with the littoral or even with the surf zone of the shore of the lake, whereas the *korotnievi* type is associated with a calmer aquatic environment (KOZOV 1936).

4. Biometrical characteristics of the population

The analysed set of shells is characterised by simple statistical indices, calculated for all the characters, which are as follows: arithmetic mean - x, standard error - bs, standard deviation - s, variability index - v, arithmetic mean interval at a confidence level of .05 (95%) - $x \pm t.b$, character variability interval at the same level of confidence - $x \pm t.s$ (FREUND 1968, SACHS 1972). The extremes of each character - x_{max} and x_{min} - are also presented (Fig. 2). To test the normality of distributions chi-square test has been applied, the confidence levels being .10, .05 and .01 (Tab. 1).

The size of the shells (big diameter - B) ranges from 2.70 mm to 6.15 mm. These are specimens of 2.0 to 3.5 whorls, more than half of them having 2.75 to 3.00 whorls. The specimens are smaller than the ones described by KOZOV (1936) and by other authors, according to whom the whorl number and the diameter of the biggest shells were 4.0...4.5 and 8 mm...10 mm, respectively.

The majority of the characters have a normal distribution proved at a high confidence level of chi-square test (.10). Only two characters, penultimate whorl width (V) and shell height index (HB) have distributions that are similar to a normal distribution, which is proved at a confidence level of .01 (Tab. 1). Hence, the analysed set of specimens has all the measured and calculated characters of shell size and shape distributed normally (Fig. 3). The distributions have either

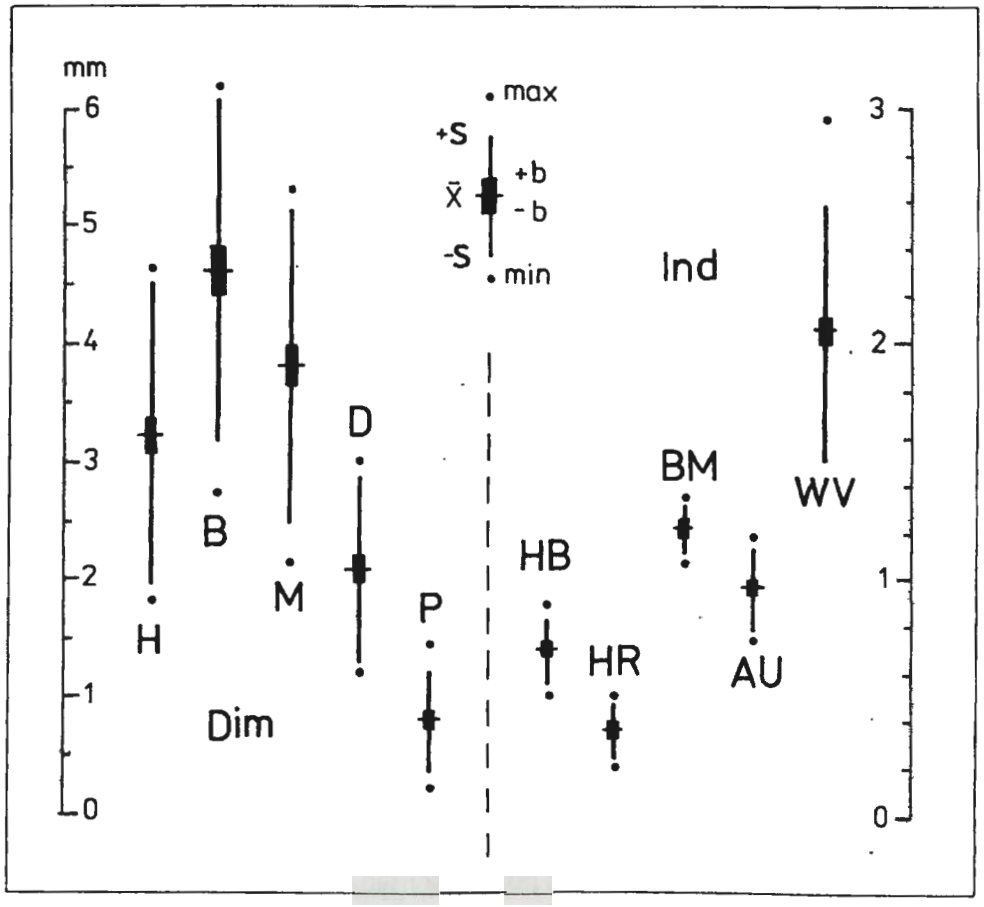

Fig. 2. The variability of selected biometrical characters of the shell of *Choanomphalus maacki*. Dim - measured characters: H - shell height, B - large diameter of shell, M - small diameter of shell, D - aperture height, P - umbilicus diameter; Ind - shape indices: HB - shell height index, HR - spire height index, BM - asymmetry index, AU - aperture shape index, WV - whorl growth index; statistical indices: x - arithmetic mean, ±b - confidence interval of arithmetic mean (x ± t.b), ±s - variability range of set (x ± t.s), max - maximum value, min - minimum value

a slight negative asymmetry (13 characters), max. - 0.441, or a slight positive asymmetry (3 characters), max. + 0.396. The values are smaller than the critical value 0.492, which means that the analysed distributions are not asymmetrical. None of them shows a curtosis absolute value higher than the respective critical value (0.843).

Table 1

Biometrical characters of *Choanomphalus maccki* population. Fr - symbols of characters (as in Figs 1 and 2), x - arithmetic mean, x_{min} - minimum value, x_{max} - maximum value, b_s - standart error, s - standart deviation, v - variability factor, $x \pm tb$ - confidence interval of arithmetic mean, $x \pm ts$ - variability range of set, norm - confidence level describing normality of statistical distribution

Fr	x	x_{min}	x_{max}	b_s	s	v	x-tb	x+tb	x-ts	x+ts	norm
H	3.22	1.80	4.60	0.08	0.66	20.43	3.05	3.38	1.93	4.50	0.10
B	4.64	2.70	6.15	0.10	0.74	16.04	4.41	4.79	3.16	6.05	0.10
M	3.81	2.15	5.30	0.09	0.68	17.77	3.64	3.98	2.48	5.14	0.10
D	2.07	1.20	3.00	0.05	0.41	19.37	1.97	2.17	1.28	2.86	0.10
A	2.11	1.10	2.90	0.05	0.038	18.04	2.01	2.20	1.36	2.85	0.10
U	2.20	1.15	3.10	0.05	0.39	17.85	2.10	2.30	1.43	2.97	0.05
W	1.46	0.85	1.95	0.03	0.24	16.62	1.40	1.52	0.99	1.94	0.05
V	0.73	0.40	1.10	0.02	0.16	21.48	0.69	0.77	0.42	1.03	0.01
P	0.80	0.20	1.45	0.03	0.22	27.23	0.74	0.85	0.37	1.22	0.10
HB	0.70	0.50	0.89	0.01	0.07	10.62	0.68	0.72	0.55	0.84	0.01
HR	0.35	0.22	0.49	0.01	0.06	15.72	0.34	0.37	0.24	0.46	0.10
BM	1.21	1.08	1.33	0.01	0.05	4.29	1.20	1.23	1.11	1.31	0.10
AU	0.96	0.80	1.20	0.01	0.09	8.96	0.94	0.98	0.79	1.13	0.10
WV	2.05	1.50	3.00	0.04	0.29	14.01	1.98	2.12	1.49	2.61	0.10
PB	0.17	0.07	0.24	0.01	0.03	18.94	0.16	0.18	0.11	0.24	0.05
WB	0.32	0.26	0.37	0.01	0.03	8.34	0.31	0.33	0.27	0.37	0.10

Relations between individual characters have been determined using correlation and linear regression coefficients. Almost all the correlation coefficients calculated are significant at various levels of confidence, and the minimum critical values for a set of n = 60 are 0.211, 0.250, 0.325, and 0.443, for confidence levels of .10, .05, .01, and .001, respectively. The majority of the coefficients acquire values that are higher than one of the said critical values, and relations between the main characters that determine the size and shape of the shells are as follows (Fig. 3):

1. H - B r = + 0.859
2. H - HR r = + 0.352
3. B - M r = + 0.971
4. B - W r = + 0.860
5. HB - HR r = + 0.494
6. H - AU r = + 0.152
7. B - P r = + 0.753
8. H - BM r = - 0.581
9. HB - BM r = - 0.631
10. B - WV r = - 0.273

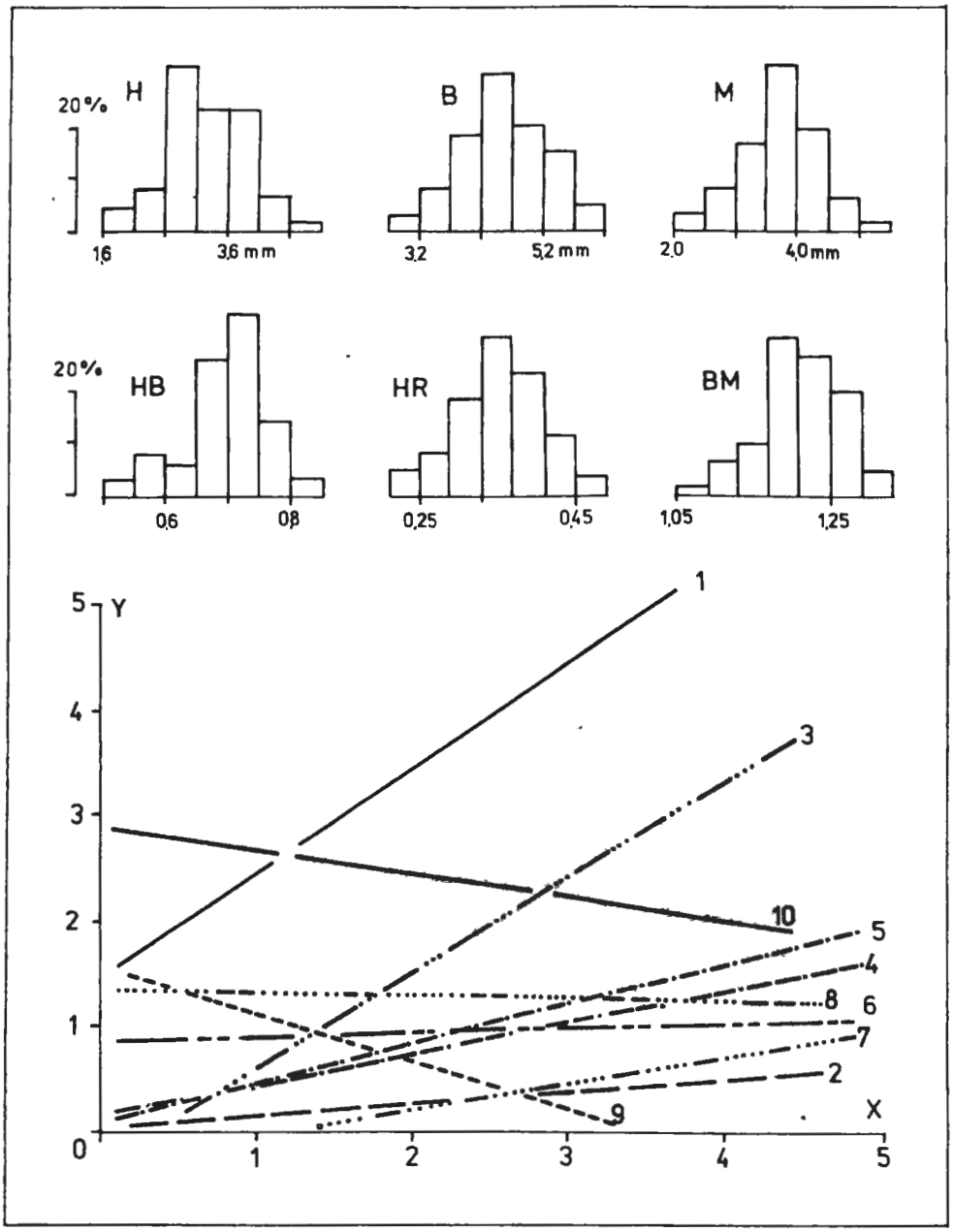

Fig. 3. Histograms of the distributions of selected characters (explanations of symbols as to Fig. 2) and regression lines corresponding to selected pairs of characters (for explanations of symbols, see next page)

The relations reflect changes in the morphology of the shells, which are due to growth. The main characters that determine the size of the specimens, which are H, B, M, W, and P, are very closely correlated with each other, which is expressed by the values of the r coefficient being higher than + 0.750. The shell shape characters are much more variable between individuals and depend on each other less, and some of them are negatively correlated with the others. Very distinct relations are those indicating that as the shell height (H) or the shell height index (HB) increase, the shell asymmetry (BM) decreases.

The allopatric changes of the species in question can be presented by the statistical indices (x, s) calculated for specimens grouped according to their whorl number. The basic characters that reflect shell size (B and M) indicate a very rapid and regular size growth, whereas the ones that reflect shape little change with age. As to the changes, two different tendencies are observed. One of them is represented by the asymmetry index (BM), which gradually decreases, and the other by the height index (HB) and the spire height index (HR), which slightly increase (Fig. 4).

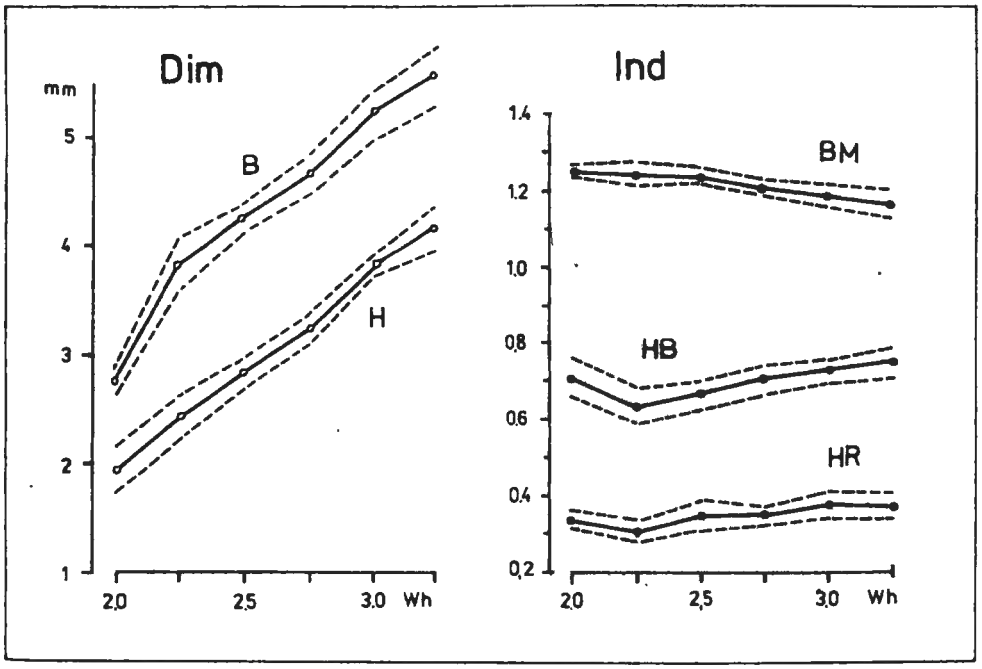

Fig. 4. Shell growth changes in the value of selected characters. Wh - number of whorls, explanations of the other symbols as to Fig. 2

5. Taxonomical analysis

The analysed set has been divided to distinguish morphologic types within the population of *Choanomphalus maacki*. In the taxonomical analysis only the characters that correspond to the shell shape are considered, as follows: HB, HR, BM, AU, PB, VW. On the contrary, all the characters that have been directly measured to describe the size of the shells are neglected. The dSA taxonomical distances are calculated according to STEINHAUS' formula (ALEXANDROWICZ 1987) and the result is presented in the form of a dendrogram (Fig. 5).

All the set of 60 specimens has been divided into 4 subsets: I, IA, IIB, III, only one specimen being left outside the sets. Subsets IIA and IIB are connected with each other at a low level of taxonomical distances, and then they join subset I. The most individual morphologic type is that of subset III. The specimen numbers of the subsets are as follows: I: 23, IIA: 18, IIB: 11, III: 7 (Fig. 5).

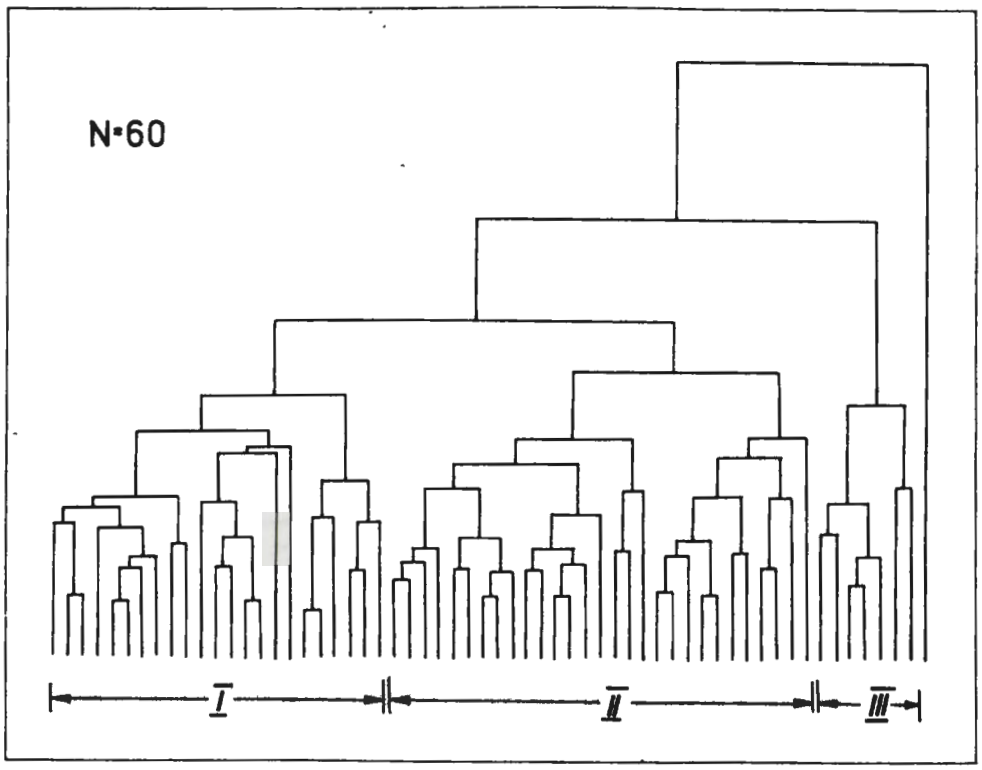

Fig. 5. Taxonomical dendrogram of 60 speciments of *Choanomphalus maccki*. I, IIA, III - subsets representing morphologic types of the species

The interpretation of results of taxonomical analysis consists in determining characters of the specimens that are representative of each subset and expressing the characters in values normalized in relation to the x and s of the whole set. In the diagrams, 8 characters are considered: H, B, M, HB, HR, BM, WV, PB (Fig. 6).

The shells grouped in subset I in the dendrogram have small dimensions and low values of height index and spire height index. The corresponding normalized values are lower than zero, and some of them are even lower than -1. On the other hand, the specimens are conspicuously asymmetric, showing a considerable gain in the width of the ultimate whorl, and having a wide umbilicus (characters of positive normalized values). Compared with the morphologic types described by KOZOV (1936) the specimens closely correspond to *Choanomphalus maacki var. korotnievi*.

The shells grouped in subset IIA are big, as their normalized values of H, B and M are positive, approximating to +1. The specimens are high, their HB and HR values positive, and the normalized values of their BM asymmetry index, WV spire growth index, and PB umbilicus size index are negative. Therefore, they are big specimens with a high spire, slowly widening ultimate whorl, and narrow umbilicus. They correspond to the nominal form of *Choanomphalus maacki*.

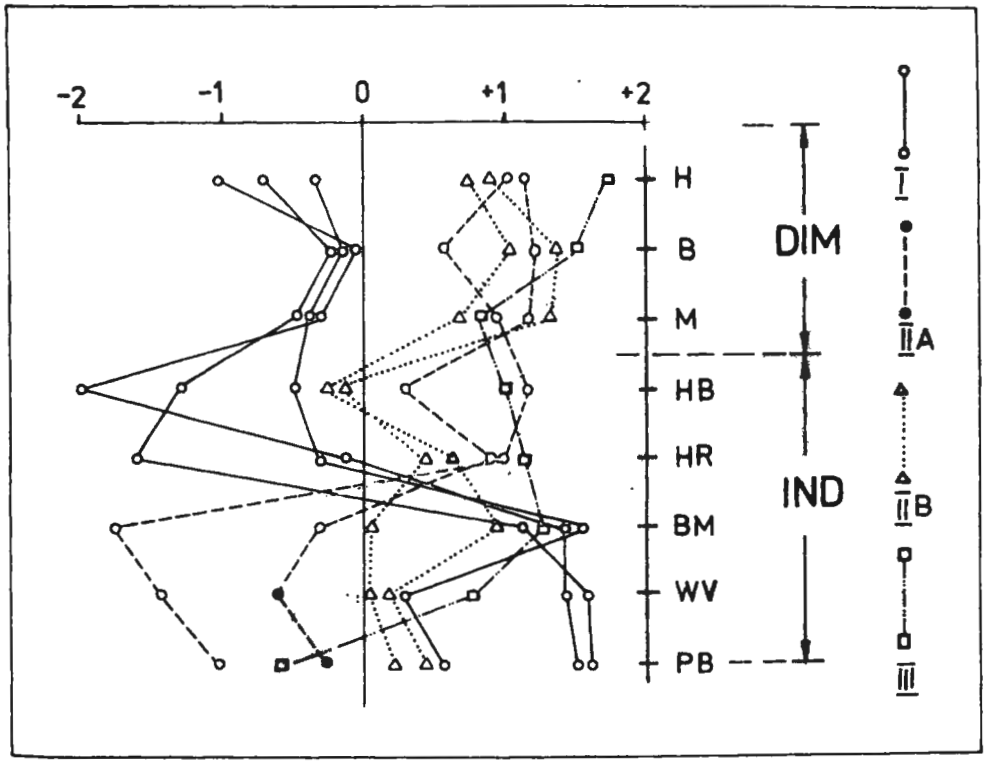

Fig. 6. Diagram of normalized values of selected characters of specimens representing morphologic types of *Choanomphalus maccki*. I, IIA, III - morphologic types of species, -2-+2 - range of normalized values, other symbols as in Fig. 2

The shells of subset IIB are characterized by positive normalized values of H, B and M, the values of the other characters approximating to 0, thus being close to the arithmetic means of the characters. Therefore, they are quite big specimens, discoid in shape, with a low spire, weakly marked asymmetry and moderately wide umbilicus. They are comparable to *Choanomphalus maacki var. elatior.*

The distinguishing features of the shells of subset III are considerable height and diameter and positive normalized values of shape characters, except for the negative value of umbilicus size index. These are big, high and asymmetric shells, the ultimate whorl growing rapidly, but their umbilicus being very narrow. They correspond to *Choanomphalus maacki var. andrussovianus.*

The diagnostical importance of each character can be determined by using PERKAL's indices (PERKAL 1967). They are differences between the values of each normalized character and the arithmetic means of the normalized characters of a given taxon or morphologic type. If we assume ± 0.50 and ± 1.00 to be the boundary values of the indices, the specimens that represent the four sets described will be described as follows (Tab. 2). The shells that correspond to group I distinguish themselves by having all the five selected characters. The shells of the other three groups are less individualized and have one or two specific characters as, for instance, high spire (IIA), rather well marked asymmetry (IIB, III), or very small umbilicus. For each pair of morphologic types, values of the divfferences between particular characters and the arithmetic means of the values can be calculated (Tab. 2 - diff.). They express the degree of similarity (difference) between the types, which is determined numerically. In the studied material, morphologic type I (*Choanomphalus maacki var. korotnievi*) is markedly different from the other three.

Table 2

Values of Perkal's index for representatives of morphologic types of *Choanomphalus maacki* and differences calculated for pairs of morphologic types. T - morphologic types of species; HB, HR, WV, PB - symbols of characters, see explanations to Fig. 2; diff - means of differences among representatives of morphologic types

T	HB	HR	BM	WV	PB	diff
I	-1.55	-1.88	+0.83	+1.28	+1.32	
IIA	+0.26	+0.89	-0.30	-0.58	-0.28	
IIB	-0.57	+0.24	+0.52	-0.22	-0.04	
III	+0.33	+0.42	+0.51	+0.02	-1.28	
I - IIA	1.81	0.99	0.53	1.86	1.60	1.36
I - IIB	0.98	2.12	0.31	1.50	1.36	1.25
I - III	1.88	2.30	0.32	1.26	2.60	1.67
IIA - IIB	0.83	0.65	0.82	0.36	0.24	0.58
IIA - III	0.07	0.47	0.81	0.60	1.00	0.59
IIB - III	0.90	0.20	0.01	0.24	1.24	0.52

6. Interpretation

Choanomphalus maacki GERSFELDT is a species, the shell shape and size of which are much varied. The morphologic types of the taxon, which are described by several authors, can be found within one population, a thanatocoenosis accumulated on the shore of a lake. Biometrical and taxonomical analysis prove that the variability is a characteristic feature of the species, which is observed even in a set, all the measured and calculated characters of which have normal distributions. The distinctness of each type and the dominance of one of them are due to particular characters of the environment, in which the *Ch. maacki* populations are developed. As the individuals grow, the characters that are specific to each morphologic type are developed, so that they are most conspicuous in big specimens. Such shells, very advanced in growth, reaching 8 to 10 mm in diameter, were a basis for definitions and descriptions of the said species (LINDHOLM 1909, KOZOV 1936).

REFERENCES

ALEXANDROWICZ S. W. 1987. Analiza malakologiczna w badaniach osadów czwartorzędowych. - *Kwartalniki AGH, Geologia*, **12**, 1 - 2: 1-240.

DYBOWSKI W. 1875. Die Gastropodenfauna des Bajkalsees. - *Mémoires Academie St-Petersburg*, **22**, 8: 1-73.

DYBOWSKI W. 1901. Diagnosen neuer *Choanomphalus*- Arten. - *Nachrichtsblätter der Deutsche Malakozoologische Gesellschaft*, **33**: 119-125.

FREUND J. E. 1968. Podstawy nowoczesnej statystyki. Państw. Wyd. Ekonom., Warszawa.

KOZOV M. M. 1936. Mollusques du Lac Bajkal. Trav. Stat. Limnol. du Lac Bajkal, 8: 1-352.

LINDHOLM W. A. 1909. Die Mollusken des Bajkalsees (*Gastropoda* und *Pelecypoda*). Ergebn. Zool. Exped. Bajkal., 4: 1-104.

PERKAL J. 1967. Matematyka dla przyrodników i rolników. Państw. Wyd. Nauk., Warszawa.

SACHS L. 1972. Statistische Auswertungsmethoden. Springer Verl., Berlin.

ZADIN B. I. 1952. Molljuski priesnych i solonowatych wod SSSR. Opried. fauny SSSR, 46: 1-376.

Reviewer: Prof. Jerzy Małecki D. Sc.