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On the Morphological Changes during Ontogenesis of Some Hungarian Molluscs

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Abstract — The increase of the whorls in the species of *Planorbarius corneus* L. and *Anisus septemgyratus* ROSSM. is roughly exponential. The growth of *P. corneus* comprises one phase only, that of *A. septemgyratus* can be divided into a rapid and a slow period. In the species of *Chondrula tridens* O. F. MÜLLER the tooth variation of strong H_3, G_3 and weak B is quite frequently found. There is almost a direct ratio between the shell elongation and height. In studying the changes of form of *Unio* shells the functionality established between the elongation and the length can be applied. With 17 figures.

Introduction — Most malacologists do not collect juvenile specimens, or rather do not insist on the juvenile, living specimens or their empty shells found in leaf-litter or alluvium samples.

In studying the dynamics of the population it is important to analyse the proportions of individual specimens in different states of development. The quantitative sequence of whichever parameter, although obtained from individual specimens of different age and in different states of development, gives valuable information on the situation of the species within the biota as well as on the species itself. In Figs. 1 and 2 some characteristic and informative linear diagrams are presented:

1. The high total percentage, the spread of the individual specimens growing old, rsp. perished in biota 1 show that the species lives in a favourable ecosystem, the shells are not carried away and they perish very slowly. — 2. The collection was of representative nature and did not cover living specimens, or no such were found in the examined area. The species perished, or it momentarily left the examined district. — 3. Our collection was made on a spot where the studied species is "conquering". The species migrated through a district where no other individual perished, or if it did, it had already been assimilated by the stratum. — 4. We endeavoured to collect only dead specimens and from different biotas. Modus γ is the most frequent value of single specimens living in a less favourable ecosystem. The diagram can be interpreted, of course, also as two populations following each other in time. The keeping of the shells decides in this case. — 5. The given number of samples is not sufficient for statistic studies.

A right, reliable analysis demands very great circumspection and a time-consuming work. Repeated collections in the same biota should be performed. After measuring the living specimens must be returned to the ground. Without a good working knowledge of population dynamics, the analysis of the parameters cannot be completed. Studying population dynamics is also useful for when the characteristics of molluscs in different states of development are systematized, one can conceive the development trend of the species without having effectively followed the development of the given specimens. Studies of this type constitute the subject of this paper. (I omit the demonstration of the measuring methods and the expounding of the evaluation; thereof I have already spoken in my previous papers.) In my paper I study the development of the morphological characters of four species. Three of the four species are *Gastropoda* (as regards form, according to the nomenclature of MOSLEY 1838, two species are discoid and one is turbinal) and one is bivalve. In other words, I tried to choose species representing the molluscs living in Hungary.

Results

Discoid forms: *Planorbarius corneus* L. In studying the growth of the shell it is expedient to be performed in the plane perpendicular to the axis of the shell. The constants of the function describing a principally given logarithmic spiral should be determined.

Reality differs from the model in the following points: 1. In the plane of the axis, a dislocation of small extent and of varied dimensions have to be reckoned with. 2. Sections of the whorls are not circular but reniform. 3. The plane of the whorls diaphragm is not parallel to the axis.

The position, the form of the oral aperture reveals much on the shell-carrying, and, in an indirect way, on the habit of life of the animal (WAGNER 1928, GEYER 1929, ROTARIDES 1935–1936) (Fig. 3). In the case of the *Planorbidae* the plane of the oral aperture intersects the shell axis (the outer and the upper lips run forward). A comparative study of the two sides of the shell gives an interesting result. Fig. 4. shows the results derived after measuring both sides of the *Planorbarius corneus* in photographic way. The analysis was made with the assumption of a logarithmic spiral. The growth is in both cases logarithmic, as the functionality $\log r - K$ is linear. The rate of growth, however, is varying. At the top it is of a greater rate, although it starts from a lower value. This can be well seen also when studying the curve $r-K$ (Fig. 4). The angle of inclination (δ) of the diaphragm between the whorls can be determined by measuring $\overline{AB}$ and $\overline{AC}$ (Fig. 5). ($\overline{AC}$ by calculating the difference of values obtained photographically $\overline{AB}$ by direct measuring.) I have also studied how the rotundity index of the mouth increases during ontogenesis. The study was performed for ecological purposes. It is interesting that the index of the specimens collected in salt puddles

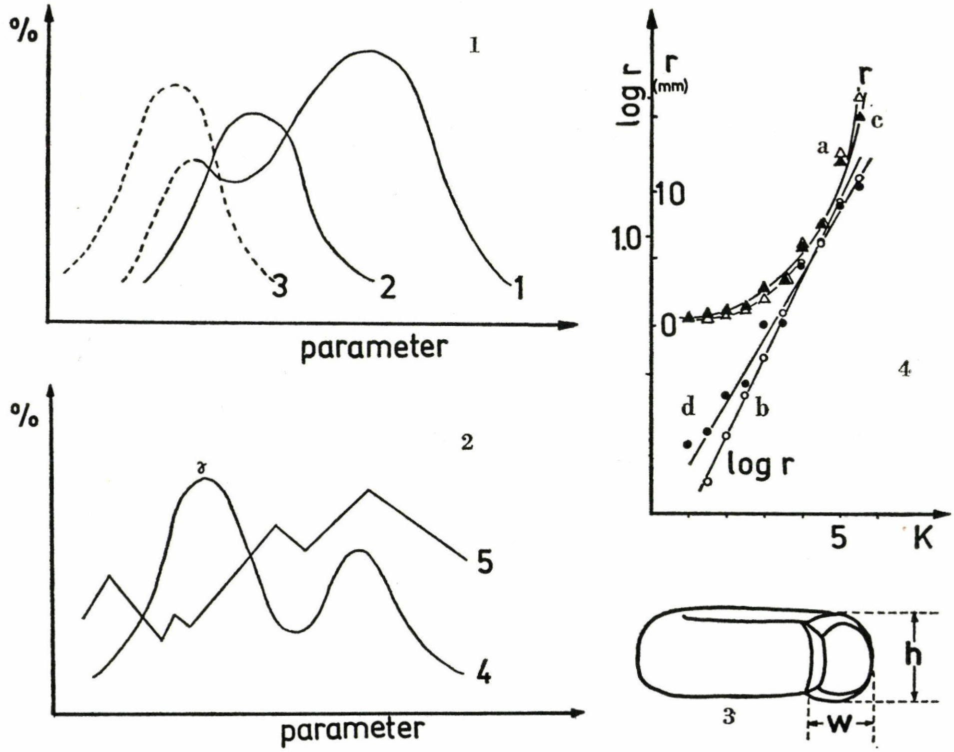
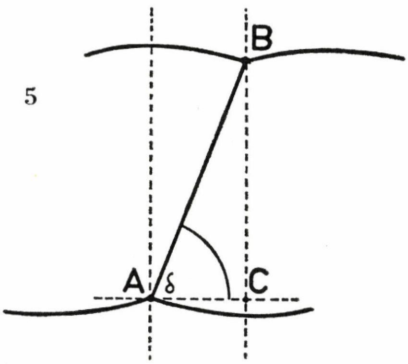


Fig. 1. Frequency curves: 1 = live and dead specimens (broken + continuous line), 2 = dead specimens, 3 = live specimens. — Fig. 2. Frequency curves of dead specimens. — Fig. 3. Characteristics of *Planorbidae:* w = breadth of mouth, h = height of mouth. — Fig. 4. Relationship between K (whorl number) and radius, $\log r$ of spiral *Planorbarius corneus:* at top "a" curve, "b" line; at bottom "c" curve, "d" line



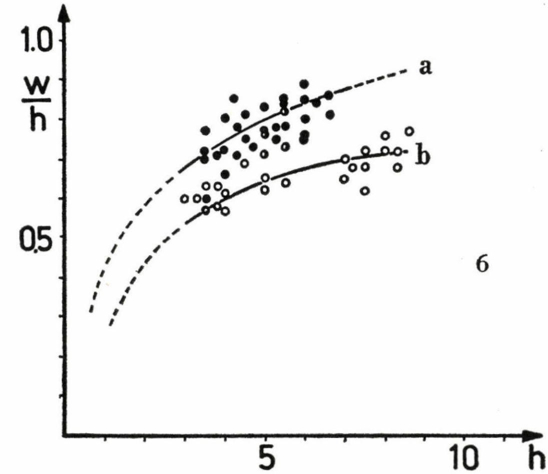
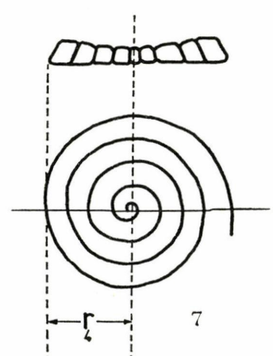


Fig. 5. Diving wall between neighbouring whorl of *Planorbidae*. — Fig. 6. a = The saline steppe around Szabadkígyós, 8 km from Békéscsaba; b = Ditch in the vicinity of Békéscsaba

is 20% greater on the average than that of the specimens of Békéscsaba (Fig. 6). Concerning the traced value, a significant, 25–30%, spread must be reckoned with in both biotas. It can also be seen that the increase of w results in the rounding of the mouth.

Anisus septemgyratus ROSSMÄSSLER. I studied the lines of growth of this species earlier (DOMOKOS 1976, 1977, 1978), and found that the whorls rise in the course of their growth step-like. With the growth of the whorls the side line of the mouth inclines more and more to the axis, and the rotundity of the initial whorls gradually decreases and becomes increasingly angular (Fig. 7). The analysis of the radial growth gave a surprising result. The growth can be divided into two phases: a rapid and a slow one (Fig. 8). The exact reason of this is unknown at the present time. Value K_f of the point of break varies from biota to biota. Factor $\overline{m_2}$ is normally in correlation with the final development of the single individual, quasi determining it (?) (Fig. 9).

T u r b i n a t e f o r m: *Chondrula tridens* O. F. MÜLLER. Statistics h and h/b of the fully developed specimens are found in Fig. 10. The most frequent value for $\underline{h}$ is 10 mm,



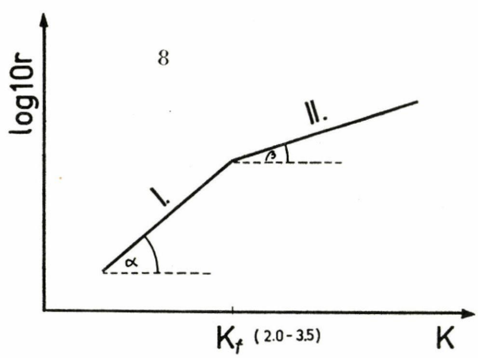
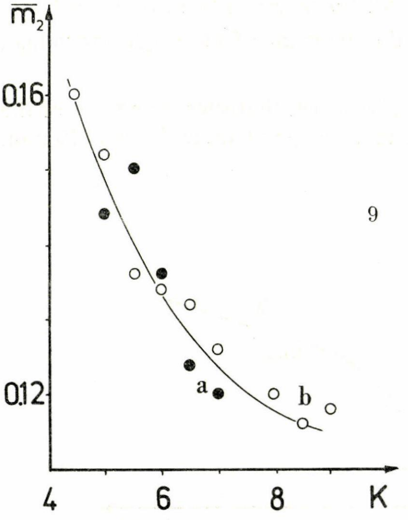


Fig. 7. Shell of *Anisus septemgyratus*, cross and sagittal section, r_4 = radius of fourth whorl. — Fig. 8. Relationship between K (whorl number) and log $10r$; I = primary phase, II = secondary phase. Characteristics: $m_1 = 0.366\ tg\alpha$, $m_2 = 0.366\ tg\beta$, K_t = whorl number of fracture of curve

value h/b is about 2.5. The data of the juvenile specimens (23 pieces) do not constitute a coherent picture if the study comprises the usual parameters. To absolutely ascertain the juvenile state is neither on the basis of size nor that of the set of teeth possible. Figs. 11 and 12 show clearly that even specimens of very big size can be edentate, or they have aborted teeth even if having strongly swollen lips. In the case of specimens having an abnormal set of teeth, the rudimentarity or the lack of a tooth on the pillar is most frequently the case. (In 97% of those with abnormal teeth.) The change of elongation, taking place in the course of the ontogenesis, can be illustrated by the functionality $h/b-h$ (Figs. 11 and 12). The correlation is nearly linear. The greatest divergence of 13% can be observed in the juv. specimens at the value $h = 4$ (Fig. 12). The direction tangent of the straight line is approximately 0.22. The result is similar also in the case of fully developed specimens having mostly 3 teeth (Fig. 11). Here the divergence is max. 11%. The 3 teeth of *Chondrula tridens* appear probably not at the same time, consequently grow not at the same rate. The oral aperture is being built in the direction *a*–3–2–*b* and thickens like an annual ring (Fig. 13). The tooth variations are given in Fig. 14.

Tooth 1 (H_3) is camel-hump-like on the vault. It always appears as the first one and is only in 2.6% weak. Tooth 2 (G_3) is L-shaped, its stem runs parallel to the edge of the oral aperture as far as the corner (*b*). Between the tooth and the corner, the oral aperture has a sharp edge and is slightly incised viewed from the side. It occurs that immediately below it the shell deepens to some millimetres. Tooth 3 (*B*) is hump-like at the bottom of the pillar. It is often lacking, it probably appears as the last one. The pillar itself cannot be regarded as a tooth. The order of tooth strength is: H_3-G_3-B.

Having studied the parameters and the set of teeth, it is worth observing also the tendency of the shape of the oral aperture (Fig. 15). The angularity of the oral aperture of the young specimens is conspicuous. At the locus marked with an asterisk*, the oral aperture is nearly angular. Tooth 2 will eventually develop under this corner. At an older age, only a slight hollow in the shell and the depth of the previous seams might indicate this corner.



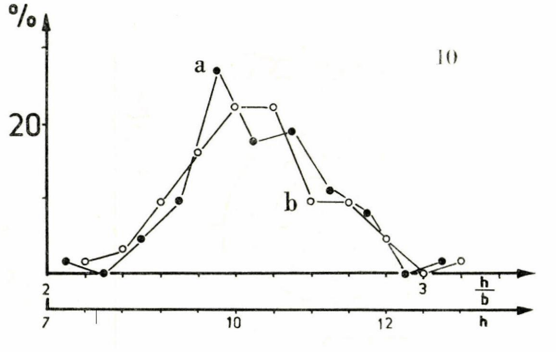


Fig. 9. Relationship between *K* (whorl number) and characteristic $\overline{m}_2$ (mean): a = Habitat Baja, b = Habitat Csurgó. — Fig. 10. a = *h* = Fully developed specimens of *Chondrula tridens* (Szabadkígyós), $b = \frac{h}{b}$ (*h* = height of shell, *b* = breadth)

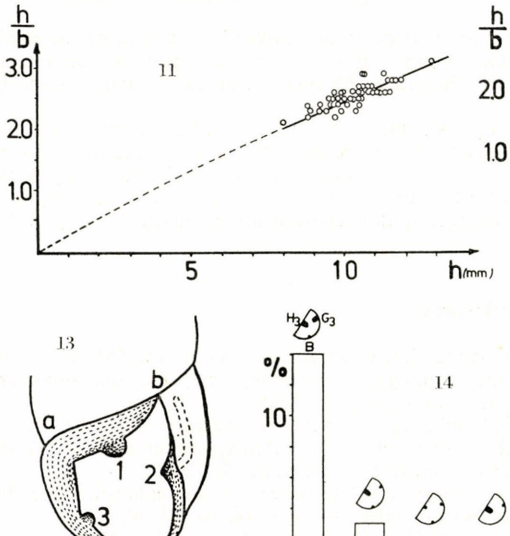
The more obtuse the corner marked* is, the deeper the seams will be. I presume that the rounding of the mouth is probably caused by the gradual growing of the body of the tensile force of the animal. The interrelation shell-body is constantly changing in the course of the ontogenesis.

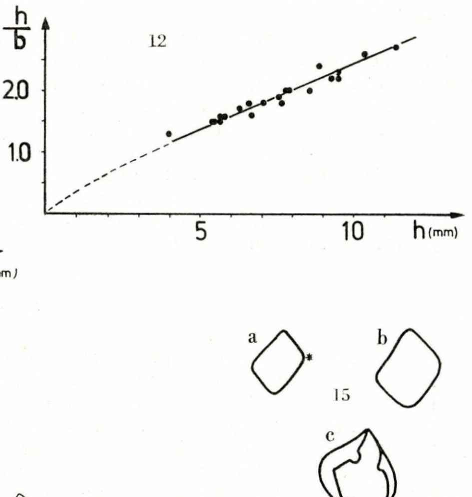
Bivalvia: *Unio* sp. I believe that an analysis of the functionality N–h should be applied in order to follow the form changes of the shells (Figs. 16–17) (DOMOKOS 1979). A great number of "annual rings" found on a single specimen offer a good possibility, even in spite of the errors resulting from h and from the difficult reproducibility of m to the cognition of the curve of the above functionality.

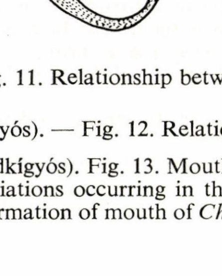
This paper demonstrates the essence of the analysis on the example of only some specimens taken at random. As it can be seen also in Fig. 17, the value N of the three *Unio* species found in the same biota increases considerably at the beginning, then, with the further increase of h its increase becomes slower. Studying the growth rate of the particular species, a considerable difference between the process of the elongation of *Unio pictorum* and that of *U. crassus* is experienced. When comparing specimens originating from various biotas, the interpretation is less ambiguous. In the course of the ontogenesis, simultaneously with the process of elongation a process of apiculation takes place (R increases). Studying the material of a biota of the Copper Age, I have succeeded in finding a correlation between R and N: $R = 2(N-c)$ where $c = 1.25$.

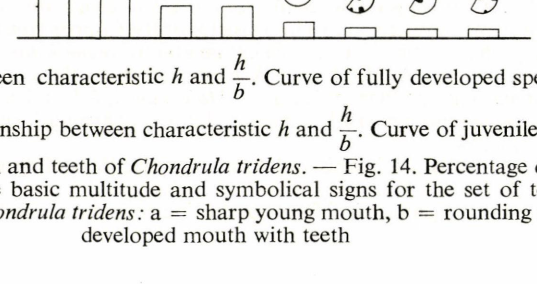
Summary — When collecting molluscs it is important to study the composition of the population. In addition to information on the biota, the particular phases of the species development can be cognized as well.

The logarithmic spiral can be used in the analysis of discoid *Planorbidae*. In an interesting way, the growth of *Anisus septemgyratus* can be divided into two phases (Fig. 8), and the final number









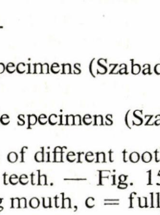
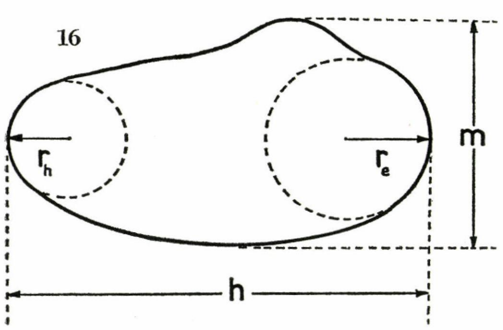


Fig. 11. Relationship between characteristic h and $\frac{h}{b}$. Curve of fully developed specimens (Szabadkígyós). — Fig. 12. Relationship between characteristic h and $\frac{h}{b}$. Curve of juvenile specimens (Szabadkígyós). Fig. 13. Mouth and teeth of *Chondrula tridens*. — Fig. 14. Percentage of different tooth variations occurring in the basic multitude and symbolical signs for the set of teeth. — Fig. 15. Formation of mouth of *Chondrula tridens:* a = sharp young mouth, b = rounding mouth, c = fully developed mouth with teeth



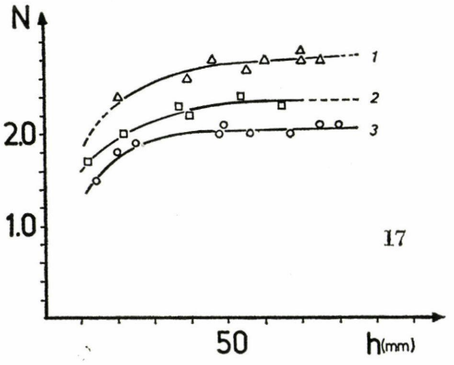


Fig. 16. Characteristics of *Bivalvia:* $\frac{h}{m} = N$, $r_e/r_h = R$. — Fig. 17. Relationship between h (length) and N (elongation). 1 = *Unio pictorum*, 2 = *U. tumidus*, 3 = *U. crassus* (Békéscsaba, Körös-ditch)

of whorls is dependent of the growth rate of the second phase (Fig. 9). A comparison of the logarithmic spirals assumed on the two sides of the disk-shaped shell yields information not only on the radial growth of the shell but on its slight coning as well. (The radial growth of the spiral is different on the two sides of the shell, Fig. 4). The rotundity index of the cross-section of the whorls (Fig. 6) gradually increases with the growth of the shell in the case of *Planorbarius corneus*. In the course of growth, the oral aperture becomes angular in *Anisus septemgyratus* (Fig. 7) and round in *Chondrula tridens* (Fig. 15).

In *Unio* species, the character role of the oral aperture is taken over by the edge of the shell. Its formal change can be characterized by the elongation (Fig. 17). During ontogenesis, the elongation increases according to a saturation curve. In *Chondrula tridens* (Figs. 11–12) the curve is nearly linear in the course of ontogenesis.

Using mathematical formalism in malacology is somewhat out of date. Since, among others, also MOSLEY (1838), THOMPSON (1942), H. WAGNER (1929) and recently HUBENDICK (1951), FRANK & MEYLING (1966) have dealt with conchometry. Few are however, the works which, having some significance beyond mathematicizing may establish a relationship of the mathematical, physico-chemical and biological parameters. Without establishing this relationship, a conscious study of the ecosystems cannot be envisaged.

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