FOLIA MALACOLOGICA
Folia Malacol. 4: 25–37
Cracow, 1990
http://dx.doi.org/10.12657/folmal.004.002

THE MALACOFAUNA OF DUMPS OF THE SODA FACTORY IN CRACOW

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: On the dumps of the Cracow Soda Factory there occur molluscan assemblages comprising 13 taxons. The assemblages display a succession connected with three phases in the development of vegetation, which occurred when the slopes of the dumps were getting overgrown. The succession phases correspond to the assemblage with *Helicella obvia*, the assemblage with *Pupilla muscorum*, and the assemblage with *Helicella incarnata*, respectively. A biometrical analysis of populations of 7 snail species has shown that the populations do not differ from those occurring in natural habitats. The diversity of the assemblages is very high: xerophilous and hygrophilous species can be found together in one assemblage.

KEY WORDS: snail assemblages, diversity, succession, environmental pollution

Folia Malacologica 4/1990 was originally published as No. 1276 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

ZESZYTY NAUKOWE
AKADEMII GÓRNICZO-HUTNICZEJ IM. STANISŁAWA STASZICA

Nr 1276 Folia Malacologica z. 4 Kraków 1990

STEFAN WITOLD ALEXANDROWICZ

The malacofauna of dumps of the soda factory in Cracow

ABSTRACT

On the dumps of the Cracow Soda Factory there occur molluscan assemblages comprising 13 taxons. The assemblages display a succession connected with three phases in the development of vegetation, which occurred when the slopes of the dumps were getting overgrown. The succession phases correspond to the assemblage with *Helicella obvia*, the assemblage with *Pupilla muscorum*, and the assemblage with *Helicella incarnata*, respectively. A biometrical analysis of populations of 7 snail species has shown that the populations do not differ from those occurring in natural habitats. The diversity of the assemblages is very high: xerophilous and hygrophilous species can be found together in one assemblage.

1. Introduction

In the southern part of the city, in the valley of the Wilga River, large dumps of the Cracow Soda Factory (the previous name: Solvay Factory) are situated. These are reservoirs covering at large an area of about 60 ha, bordered with high banks of slag and unburnt lime. The reservoirs are successively getting filled with sludge containing a suspension of $CaCO_3$ (postcaustic slurry) and with a solution of $CaCl_2$ (postdistil slurry). Both the components are mixed together in various proportions. The slopes of the banks are 10 – 15 m high and lie at an angle of about 40°. Water with calcium carbonate and calcium chloride percolates through the banks at some places and is then disposed to the Wilga River by a system of ditches and cuttings. On the slopes of the dumps, soils rich in calcium as well as in chlorine and sulphur compounds are formed. The soils are largely dry but in the zones where water exudes, very dump habitats appear to form a mosaic of much varied environmental conditions.

The dumps are partly covered with vegetation. On the old slopes, vegetation has lasted for 20, 30, or even 50 years, uninterruptedly, while in the places where the reservoirs are extended, vegetation has been completely devastated by getting bestrewn with limestone rubble and hot slag. Detailed floristic and phytosociological studies of the dumps in question were completed by TRZCIŃSKA-TACIK (1966). That author found 275 plant species to occur there and described their succession on the slopes and on sediments that filled the dried-out reservoirs. The

succession comprised three phases of an increasing degree of substrate covering. These were: I – the *Chamaenerion angustissimum–Caenorrhinum minus* phase of a great share of mosses and annual and biennial plants; II – the *Arrhenatheretum elatioris* phase of numerous meadow species and perennial plants; III – the phase with *Calamagrostis epigeios* of a full surface cover. As the succession were developing, scarce shrubs and trees appeared to form clumps and gatherings within which partly shaded habitats could develop, consequently. The most numerous plant species occurring in the habitats is *Betula verrucosa*, whereas *Populus tremula*, *Salix fragilis*, *Alnus tremula*, *Sambucus nigra*, and *Crategus monogyna* are somewhat less numerous.

The dumps are situated in a depression, on the flat bottom of a rather broad valley, at the altitude of 210 m a.s.l. The climatic conditions of the area correspond to the characters of the climate of Cracow that were described in detail by HESS (1967). The main climatic parameters assume the following values:

mean annual temperature	+8.1 °C;
mean temperature in January	–3.0 °C;
mean temperature in July	+18.5 °C;
total annual rainfall	650 mm;
length of vegetation period	215 days.

The characters of the macro- and mesoclimate are modified by local microclimatic conditions which have not been studied. It is probable that the temperature on the slopes of the heaps is heightened as compared with the temperature of air, which phenomenon can result in shortening the period of the snōw-cover lasting (TRZCIŃSKA-TACIK 1966). A similar phenomenon was observed in Upper Silesia. The pollution of the environment can be characterised by the value of mean concentration of SO_2 in air, which is 90 mg per cu. m, and that of mean fall of dust, which is 180 t per sq. km per year.

2. Material and methods

Snail shells were collected on three localities corresponding to the particular phases of the succession of plants on the heap slopes (Fig. 1):

Locality A – a heap situated on the right-hand side of the valley of the Wilga River, between the streets Jugowicka and Myślenicka. Only part of the southward slope is covered with vegetation (succession phase I).

Locality B – the eastward slope of the same heap, almost completely overgrown with plants (succession phase II). Locally, exudes of water are observed.

Locality C – a heap on the right-hand side of the valley, between the streets Jugowicka and Borowinowa. The northward slope is covered with a rich vegetation (succession phase III) with numerous clumps of small trees and shrubs. Some parts of the substrate are humid, which is chiefly observed within the lower part of the slope.

On each locality, three samples weighting 4 – 5 kg each were taken, so as to contain a material accumulated on the surface and the soil. The samples were desiccated and sieved with

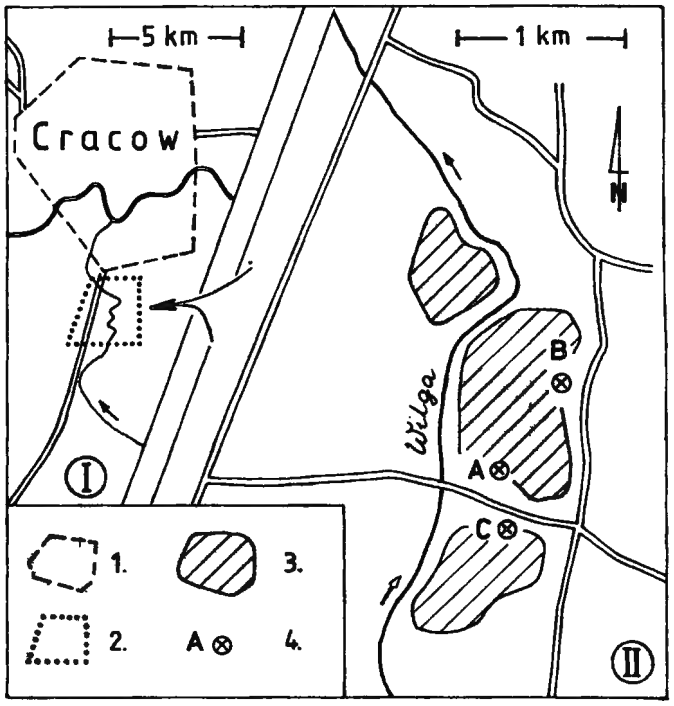

Fig.1. Situation of dumps of the Soda Factory of Cracow. I – draft plan, II – detailed plan, 1 – centre of the city, 2 – situation of the detailed plan area, 3 – dumps, 4 (A, B, C) – localities described in the text

several sieves to pick all mollusc shells and shell pieces that could be determined. The material was then cleansed by steeping in diluted Perhydrol. More than half the material were empty snail shells but all the species found were also represented by living individuals. The whole of the collection comprised nearly 1,500 specimens.

The number of the shells of each taxon has been presented on a logarithmic scale. To make a comparison between the assemblages, a quantitative taxonomical method with the use of Stalnhaus' d_{SA} index (ALEXANDROWICZ 1987) has been applied. Populations of several species selected have been characterised, the following characters beeing considered: shell height – h; shell width – w; degree of shell elongation – e = h/w; asymmetry index – a, measured as a proportion between the largest and the smallest diameter (width) of the shell; spire size index – s, calculated according to the formula s = (h – p)/h, where p is the mouth height. The accuracy of the measurements is 0.1 mm. Each assemblage analysed has been characterised by the following indices: n – number of specimens; x – arithmetic mean; se – standard error of arithmetic mean; sd – standard deviation; v – variability index; M – range of arithmetic mean; D – range of assemblage diversity. The intervals of M and D consider a confidence level of .05 (95%). The

Table 1

The occurrence of mollusc species on dumps of the Cracow Soda Industry. A, B, C – localities described in the text, 1 – 9 – samples, I – IV – shell number on logarithmic scale: I – 1 – 3 specimens, II – 4 – 9 specimens, III – 10 – 31 specimens, IV – 32 – 99 specimens, V – 100 – 316 specimens

Taxon	A				B			C	
	1	2	3	4	5	6	7	8	9
Carychium minimum					I	IV			
Cochlicopa lubrica	I	II	I	IV	IV	III	IV	IV	IV
Pupilla muscorum				III	IV	II			
Vallonia costata	III	IV	IV	IV	IV	V	III	III	III
V. pulchella	I	I	II	IV	V	IV	IV	III	IV
Succinea putris				I		III	I	I	I
Vitrina pellucida	I	I	II	II	II	III	I	II	I
Zonitioides nitidus				I		II	III	III	III
Limacidae					II	I	I	I	
Helicella obvia	III	IV	II	I	I		I		
Monachoides incarnata							I	II	I
Cepaea nemoralis			I						I
Helix pomatia				I				I	II

A full list of the determined species is as follows (figures stand for specimen numbers):

Vallonia pulchella (O.F. MÜLLER, 1774)	524
Vallonia costata (O.F. MÜLLER, 1774)	344
Cochlicopa lubrica (O.F. MÜLLER, 1774)	288
Helicella obvia (MENKE, 1822)	118
Carychium minimum O.F. MÜLLER, 1774	101
Zonitioides nitidus (O.F. MÜLLER, 1774)	94
Pupilla muscorum (LINNAEUS, 1758)	74
Vitrina pellucida (O.F. MÜLLER, 1774)	50
Succinea putris (LINNAEUS, 1758)	24
Monachoides incarnata (O.F. MÜLLER, 1774)	12
Helix pomatia LINNAEUS, 1758	9
Cepaea nemoralis (LINNAEUS, 1758)	1
shells of slugs (*Limacidae* spp.)	8

differences between the statistical distributions of shell size and the corresponding normal distributions have been proved with the use of Kolmogorov's test. Similar statistical indices were applied by the author to a biometrical analysis of populations of four snail species of the Wawel Hill in Cracow (ALEXANDROWICZ 1988).

3. Molluscan assemblages

The mollusc fauna in question comprises 12 species of snails and shells of slugs conventionally referred to as *Limacidae*. The distribution of particular species and the number of specimens in samples representing the described localities are non-uniform. On each locality, a distinct molluscan assemblage occurs, corresponding to a particular phase of plant succession. The assemblages comprise different numbers of species and have distinct typical and predominant taxons (Tab. 1).

The molluscan assemblage connected with the first phase of the plant succession (locality A, samples 1–3) comprises 6 taxons. The character species of the assemblage is *Helicella obvia*. The shells of the snail are numerous on the locality in question, while in the remaining samples, if at all, there are only single specimens. Four other species of the assemblage show a high degree of constancy. Out of them, it is *Vallonia costata* that occurs in a considerable number, whereas the other three: *Cochlicopa lubrica*, *Vallonia pulchella*, and *Vitrina pellucida*, are subordinate components of the assemblage.

The molluscan assemblage connected with the second phase of the succession of plants (locality B, samples 4–6) is much richer in taxons and much more diversified. It consists of 11 taxons, 4 of them being represented by numerous shells. *Pupilla muscorum*, occurring only as an element of the said assemblage, can be considered the characteristic species. Shells of *Cochlicopa lubrica*, *Vallonia pulchella*, and *Vallonia costata* are numerous, while those of *Vitrina pellucida* are less numerous. All the taxons mentioned above show a high degree of constancy. The uneven humidity of the localities is marked by hygrophilous species, like *Carychium minimum*, *Succinea putris*, and *Zonitoides nitidus*, locally enriching the assemblage.

The third phase of the plant succession (locality C, samples 7–9) is connected with an assemblage of 11 taxons. An increase in the degree of shadow is reflected in the presence of *Monachoides incarnata* that can be regarded as the characteristic species of the assemblage. Its number in all the three samples was small, to be sure, but on the other localities the species was not found at all. Similarly as of locality B, the dominant species of this locality are: *Cochlicopa lubrica*, *Vallonia pulchella*, and *V. costata*, whereas *Vitrea pellucida* occurs with a high constancy. The presence of such species as *Succinea putris* and *Zonitoides nitidus* reflects a considerable humidity of the substrate in shady habitats. Locally, there were found single shells of the *Helicella obvia*, *Helix pomatia*, and *Cepaea nemoralis*.

The molluscan assemblages described are noticeably distinctive in character. A taxonomical analysis has shown that collections of samples of each locality are associated on a level of low values of taxonomical distance indices d_{SA} being 0.25 – 0.45. The assemblages of localities B and

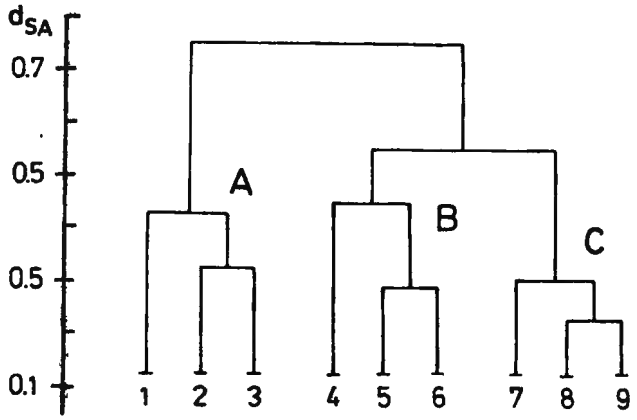

Fig. 2. Taxonomical dendrogram of the molluscan assemblages of a dump of the Soda Factory of Cracow. d_{SA} – taxonomical distances, A, B, C – localities of the fauna, 1–9 – samples

C are associated with each other on a level of 0.55, and the assemblage of locality A is the most distinct (Fig. 2). By studying the taxonomical dendrogram, one comes to the conclusion that a discernible change in the molluscan assemblage of the dump comes about at the transition from the first to the second phase of the plant succession. In the first phase, the most important role is played by species of modest needs as to habitat, which inhabit sunny ruderal habitats. The second phase is characterized by a larger number of mesophilous taxons and of those typical of open environment, and in the third phase an admixture of elements preferring shady habitats appears.

4. Biometrical analysis

The measurements of the shells of snails of the genera: *Carychium, Cochlicopa, Pupilla, Vallonia,* and *Zonitoides* have enabled the author to evaluate simple statistical indices and to draw diagrams characterizing the studied populations (Tab. 2, Fig. 3). Size-alterations in the shell of *Helicella obvia* in the successive growth-phases have also been determined.

Carychium minimum

The species is unevenly distributed on the heaps. It was found on locality B but only it was only in one sample (sample 6) its number was significant. The parietal lip having a simple and little

Table 2

Statistical indices to characterise biometric characters of populations of selected species

Taxon		L	n	x	b	s	v	X	D
	h			1.78	0.010	0.07	3.93	1.760–1.800	1.643–1.917
Carychium	w			0.95	0.004	0.03	3.16	0.942–0.958	0.891–1.009
minimum	e	B	49	1.86	0.009	0.06	3.23	1.843–1.877	1.742–1.987
	s			0.59	0.003	0.02	3.39	0.584–0.596	0.551–0.692
	h			5.69	0.038	0.23	4.04	5.616–5.764	5.239–6.141
	w	B	39	2.48	0.023	0.14	5.65	2.435–2.525	2.206–2.754
Cochlicopa	e			2.21	0.016	0.10	4.52	2.178–2.242	2.014–2.406
lubrica	h			5.69	0.049	0.32	5.62	5.594–5.786	5.063–6.317
	w	C	43	2.49	0.023	0.14	5.86	2.445–2.535	2.216–2.764
	e			2.27	0.015	0.10	4.41	2.241–2.299	2.074–2.466
Pupilla	h			3.35	0.042	0.27	8.06	3.268–3.432	2.821–3.879
muscorum	w	B	41	1.77	0.014	0.09	5.08	1.673–1.797	1.594–1.946
	e			1.86	0.014	0.09	4.84	1.833–1.887	1.684–2.036
	w			2.30	0.022	0.14	6.09	2.257–2.343	2.026–2.574
Vallonia	a	A	41	1.25	0.005	0.03	2.40	1.241–1.259	1.191–1.309
costata	w			2.49	0.013	0.13	5.22	2.464–2.516	2.235–2.745
	a	B	93	1.29	0.003	0.03	2.33	1.284–1.296	1.231–1.349
	w			2.40	0.016	0.14	5.83	2.370–2.430	2.126–2.674
Vallonia	a	B	81	1.25	0.003	0.03	2.40	1.243–1.257	1.191–1.309
pulchella	w			2.27	0.012	0.11	4.85	2.240–2.300	2.054–2.486
	a	C	91	1.23	0.004	0.04	3.25	1.222–1.234	1.152–1.308
Zonitoides	w			4.29	0.130	0.86	20.07	4.031–4–539	2.600–5.976
nitidus	h	C	44	2.76	0.066	0.44	15.95	2.631–2.889	1.898–3.622

curved profile – a typical character of the species – was observed in many specimens. To determine statistical indices characterizing the shell dimensions, a population of n = 49 specimens was used (Tab. 2). Biometrical characters of the population correspond to data given by several authors for various countries of Europe (SOOS 1943, LOŽEK 1956, URBAŃSKI 1957, LIKHAREV & RAMMELMEIER 1962, KERNEY & CAMERON 1979). It is worth of attention that the present biometrical data fully correspond to the respective measurements of specimens collected from all over Poland, which were published by BERGER (1963). This correspondence can be illustrated by drawing a comparison between the mean values and variability ranges of three shell conchological characters of the population coming from Cracow (data given as x_K) and those of the collection described by BERGER (given as x_P): h_K = 1.78 mm (1.64 – 1.92), h_P = 1.78 mm (1.57 – 2.05); w_K = 0.95 mm (0.89 – 1.01), w_P = 0.95 mm (0.85 – 1.08); e_K = 1.86 (1.74 – 1.98), e_P = 1. 87 (1.67 – 2.10), where h is shell height, w is shell width, and e is shell elongation degree. The variability ranges of the characters, given by BERGER (1963) are wider than the ones determined for shells coming from the heap. This is due to the fact that in the former case these are differences between the extreme values (the biggest and the smallest shells of the set) whereas in the latter they were calculated on a basis of the value of standard deviation, considering a confidence level of .05, hence the latter represent 95% of the set. The present measurement results indicate that as concerns the basic biometrical characters, specimens of *Carychium minimum* that occur on the heap in Cracow do not differ from those which can be found in natural habitats.

Cochlicopa lubrica

This is a species which was found in all samples, being numerously represented on localities B and C. Both the analysed populations comprised specimens of one size (h = 5.69 mm ± 0.04...0.05). The shells from locality C are somewhat more elongated than those from locality B, but the difference is not significant on a confidence level of .05. The dimensions of the shells, the elongation, and the height of the spire are contained within variability ranges of the discussed species that were given by various authors. The size of the measured shells usually corresponds to the lower parts of the ranges. This is due to the lack of biometrical studies on populations of this species, that it is impossible to make true comparisons and to evaluate the significance of the differences. The populations of *Cochlicopa lubrica* of the Wawel Hill in Cracow, described by the author (ALEXANDROWICZ 1988) comprise shells of a varied size. On the westward hillsides there were found specimens that had the same characters as those found on the heap, while the populations that occurred on the northward and eastward hillsides comprised bigger shells.

Pupilla muscorum

Shells of this species have been found in all samples of locality B. They have one easily discernible parietal tooth. The biometrical characters of a population of 41 specimens correspond to the respective dimensions of the species given by several authors (LOŽEK 1956, URBAŃSKI

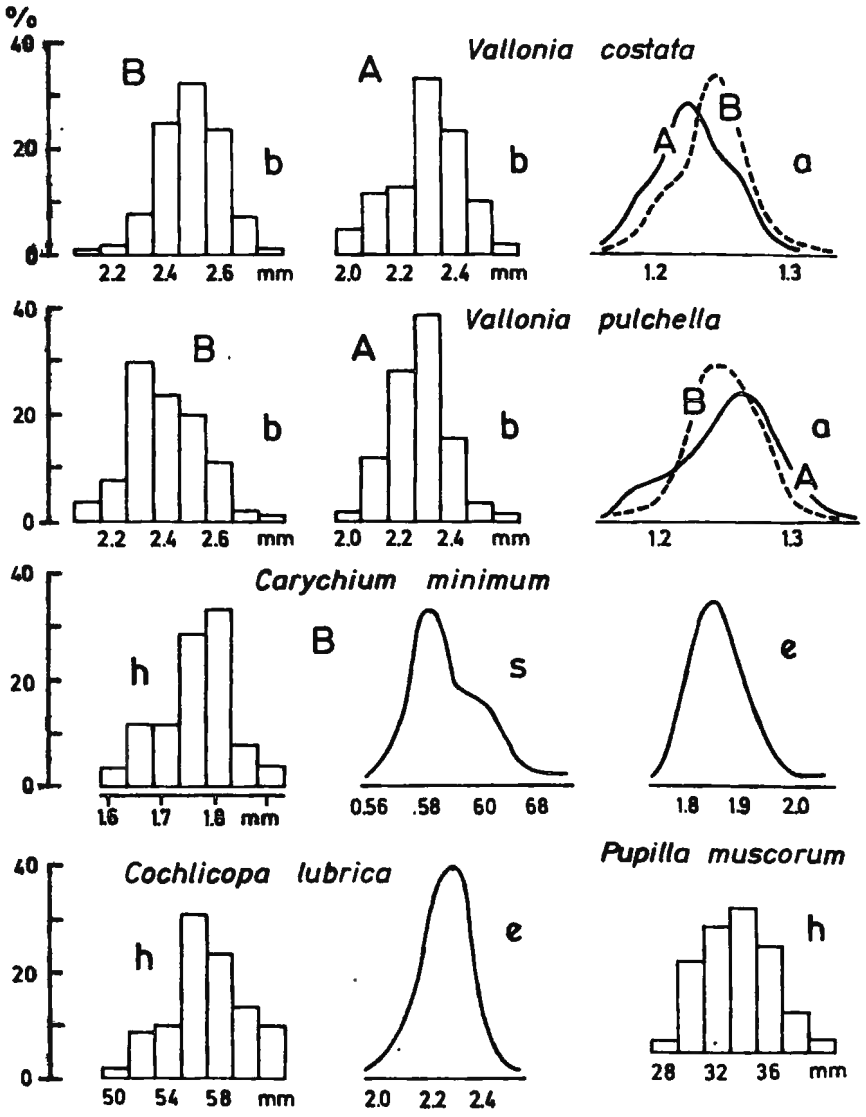

Fig. 3. Biometrical characteristics of selected snail species. A, B – localities of the fauna, a – asymmetry index, b – shell diameter (big diameter), h – shell height, s – spire size index, e – shell elongation degree

1957). The variability of size and shape of the *Pupilla muscorum* shell was studied in detail by ROUSSEAU (1985). That author has shown that West European populations of the species have

smaller shells than those inhabiting East Europe. It can be supposed that the specimens inhabiting the heap in Cracow do not differ in their characters from the ones of natural habitats.

Vallonia costata

The species have been found in all the analysed samples though numerous populations of it occur only on the localities that cprrespond to the first and second phases of plant succession. The size of the specimens, as determined by the larger diameter of the shells, shows a marked variation. On locality A, the specimens are smaller than on B. the difference between the arithmetic means of the character is significant on a confidence level of .05, though the variability ranges expressed by standard deviation on the same confidence level overlap each other. At the same time, the population from locality B shows a slightly larger shell asymmetry. Both the said populations are contained within the variability range of the species given by several authors (LOŽEK 1956, URBAŃSKI 1957). There are no biometrical data from other areas, hence it is impossible to draw comparisons.

Vallonia pulchella

This is a species found in all samples but numerous on localities B and C, the specimens of the previous locality being somewhat bigger. As in the case of the latter species described above, the difference expressed by the arithmetic means of the shells is significant on a confidence level of .05 but the variability ranges partly overlap each other. In spite of the lack of a quantitatively analysed material for comparison, it can be supposed that the size of the *Vallonia pulchella* shells coming from the heap in Cracow does not differ from the size of specimens of populations that live in natural habitats.

Zonitoides nitidus

On locality C there has been found a population of the species that comprised more than 40 specimens. The shells have a varied size and whorl number, so there are both mature and juvenile specimens among them. The arithmetic mean of shell diameter, determined for such a population, does not extend 4.5 mm, but the said collection also contains individuals reaching 5...6 mm. The latter correspond in their size to the average size of the mature individuals occurring in natural habitats.

Helicella obvia

Numerous shells of the snail occured on locality A, to create local rich accumulations. In the populations of empty shells, as well as in those of living specimens, one could find individuals of a various size and a larger or smaller number of whorls that were in various growth phases. No character that would indicate that the individuals were mature or had finished their growth were

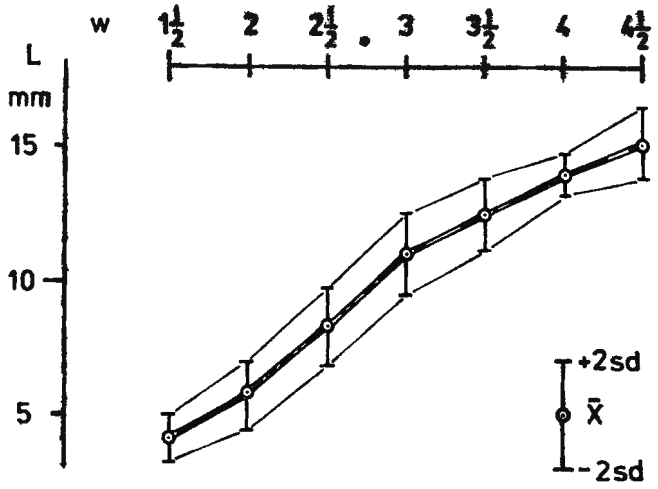

Fig. 4. Size changes in *Helicella obvia* with age. L – shell diameter, w – number of whorls, $\bar{x}$ 2 sd – variability range of shell size

discerned on the shells. Hence, it was difficult to obtain an appropriate set for a standard biometrical analysis, but it was possible to determine shell size alterations in the successive ontogenetic phases. For such reconstructions, it is convenient to use growth lines or rings that can be seen on the shell, which correspond to temporary decreases in growth, being connected for instance with the winter period. However, this method was not applied owing to the lack of data concerning the conditions under which the rings had been formed. A set of n = 116 shells was divided into subsets of a whorl number ranging from 1.5 to 4.5 (7 subsets). For every subset, the arithmetic mean and standard deviation of the largest diameter of the shell were determined (Fig. 4). The shell grew more rapidly in the earliest phase (from 1.5 to 3.0 whorls) than later on (from 3.0 to 4.5 whorls). The variability ranges of particular subsets, determined on a confidence level of .05 (95% probability) as the intervals: $\bar{x} \pm 1.96$ sd overlap each other, which indicates a considerable size variation in shells of a particular number of whorls (Fig. 4). In the studied material, the biggest specimens had 4.5 whorls and a diameter of 15.4...15.8 mm. Similar characters were displayed by specimens of the Wawel Hill in Cracow, collected on the southward localities (ALEXANDROWICZ 1988). Tentative data given by several authors indicate that the population of *Helicella obvia* occurring on the heaps of the Cracow Soda industry is not significantly different from populations inhabiting other localities.

5. Conclusions

The malacofauna inhabiting the heaps situated in the southern part of Cracow comprises 13 taxons. The described molluscan assemblages create a primitive succession of fauna, which is closely connected with the development of vegetation. The succession phases are as follows: an assemblage with *Helicella obvia*, an assemblage with *Pupilla muscorum*, and an assemblage with *Monachoides incarnata*. The succession reflects the evolution of the habitats from ruderal ones, through open habitats, to partly shady ones. The present biometrical analysis has pointed out that the studied populations of selected species that live on the heap do not differ from populations from natural habitats. On the contrary, the common occurrence of taxons having a different ecological valence (hygrophilous and xerophilous snails in particular) is worth of attention. This is due to the mosaic character of habitats of a varied humidity that are distributed on the slopes of the banks bordering the reservoirs of postcaustic and postdistil slurries. Such a diversification of both the habitat and fauna is rather not common in natural environment.

Molluscan assemblages of heaps has been very poorly known so far. Studies on such assemblages were undertaken by MATZKE (1969, 1976) who described the malacofauna of spoil banks of coal mines. A substrate of clays and clayey slates, lacking calcium carbonate, provides no favourable conditions for numerous snail species to develop on it, hence assemblages of such a habitat comprise only several taxons which mostly are slugs. The malacofauna of the heaps of limestone quarries in the region of Kielce was studied by BARGA-WIĘCŁAWSKA (1990: this volume) who distinguished only three species typical of dry habitats. Such a fauna corresponds to the first phase of succession.

Thorough studies on molluscan assemblages that occur on dumps may be of much importance to the determination of the conditions of natural and purposeful land reclamation. Such studies should cover dumps of various kinds of rock and waste that are situated in areas of a various degree of pollution, as well as older and younger dumps which are in a more or less advanced phase of plant succession.

REFERENCES

ALEXANDROWICZ S.W. 1987. Analiza malakologiczna w badaniach osadów czwartorzędowych. – *Zeszyty Naukowe AGH, Kwartalnik Geologia*, **12**, 1-2: 3-240.

ALEXANDROWICZ S.W. 1988. Malakofauna of the Wawel Hill in Cracow. – *Folia Malacologica*, **2**: 29-51.

BARGA-WIĘCŁAWSKA J. 1990 (this volume). The occurrence of snails *(Gastropoda)* on the dumps of the Ostrówka and Ołowianka quarries. – *Folia Malacologica*, **4**.

BERGER L. 1963. Polish species of the genus *Carychium* Müller *(Gastropoda, Ellobiidae)*. – *Acta Zoologica Cracoviensia*, **8**: 311–326.

HESS M. 1968. Klimat terytorium miasta Krakowa. – *Folia Geographica*, **1**: 35–97.

KERNEY M. P. & CAMERON R. A. D. 1979. A field guide to the land Snails of Britain and North-West Europe. Collins Publishers, London.

LIKHAREV I. M. & RAMMELMEIER E. S. 1962. Terrestrial Mollusks of the Fauna of the USSR. – Keys to the Fauna of the USSR, **43**: 1–574, Israel Program for Scientific Translations, Jerusalem.

LOŽEK V. 1956. Klič Československych mekkyšu. Vydalelstvo Slovenskej Akademie Vied, Bratislava.

MATZKE M. 1969. Zur Gastropodenfauna auf einigen alten Bergbauhalden im Gebiet von Brand-Erbisdorf bei Freiberg in Sachsen. – *Mitteilungen des deutschen Malakologischen Gesellschaft*, **2**, 15: 121–135.

MATZKE M. 1976. Die Gastropoden auf den Halden des Lugau-Delnitzer Steinkohlenreviers. – *Malakologische Abhandlungen Staatliches Museum für Tierkunde Dresden*, **5**: 1–19.

ROUSSEAU D. D. 1985. Structures des populations quaternaires de *Pupilla muscorum (Gastropoda)* –Univers. Dijon These, Dijon.

SOOS L. 1943. A Kárpát-Medence *Mollusca*-Faunája. Magyar Tudomanyos Akademia, Budapest.

TRZCIŃSKA-TACIK H. 1966. Flora i roślinnosc zwałów Krakowskich Zakładów Sodowych. – *Fragmenta Floristica et Geobotanica*, **12**, 3: 243–318.

URBAŃSKI J. 1957. Krajowe ślimaki i małże. Państwowe Zakłady Wydawnictw Szkolnych, Warszawa.

Akademia Górniczo-Hutnicza
Instytut Geologii i Surowców Mineralnych
Al. Mickiewicza 30, 30-059 Kraków, Poland

STRESZCZENIE

Malakofauna hałd fabryki sody w Krakowie

Na hałdach Krakowskich Zakładów Sodowych występują zespoły mięczaków, obejmujące 13 taksonów. Tworzą one sukcesję związaną z trzema fazami rozwoju roślinności, następującą w czasie zarastania zboczy hałd. Stadiom tej sukcesji odpowiadają kolejno: zespół z *Helicella obvia*, zespół z *Pupilla muscorum* i zespół z *Monachoides incarnata*. Badania biometryczne przeprowadzone na populacjach siedmiu gatunków ślimaków wykazały, że nie różnią się one od populacji występujących w środowiskach naturalnych. Bardzo duże zróżnicowanie powoduje, że w zespołach mięczaków obok gatunków kserotermicznych można znajdować gatunki higrofilne.