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MOLLUSCAN FAUNA OF THE UPPER VISTULIAN AND EARLY HOLOCENE SEDIMENTS OF SOUTH POLAND

Abstract

Rich molluscan assemblages occur in different sediments deposited in South Poland during the interval 20–8 thousand years BP. Successions of assemblages connected with shady and open habitats, swamps and marches as well as water basins can be distinguished. Each described succession comprises species of snails and bivalves characterizing changes of environment controlled mainly by climatic conditions. These species can be pointed out as important indicators of particular stages of the Upper Vistulian and Lower Holocene.

INTRODUCTION

The evolution of the molluscan fauna at the decline of the last glaciation and the beginning of the Holocene followed substantial changes in climate and environment. Different types of molluscan assemblages and successions of these assemblages occur in particular types of sediments deposited since the Pleniglacial of the Upper Vistulian till the Postglacial Climatic Optimum. They were described from many outcrops and profiles found in the whole area of South and Middle Poland, mainly in the Carpathians and their foothills as well as in the Polish Uplands (Fig. 1). Subfossil shells of snails, slugs and bivalves occur in such sediments as: loess and loess-like loams, lacustrine chalk and gyttja, calcareous tufa and travertines, sand and mud accumulated at the bottom of valleys, slope debris and soil enriched in calcium carbonate (rendsina). At many localities the age of mollusc-bearing deposits is established with the radiocarbon or TL dating. Sequences of molluscan assemblages from selected, most important profiles of the mentioned sediments characterize particular phases of the evolution of these fauna, inhabiting different biotops at the interval of 20–8 thousand years ago.

FAUNA OF MOLLUSC-BEARING DEPOSITS

Subfossil shells of molluscs occur frequently in the Upper Vistulian loess and loess-like loams. The most instructive profiles are known from

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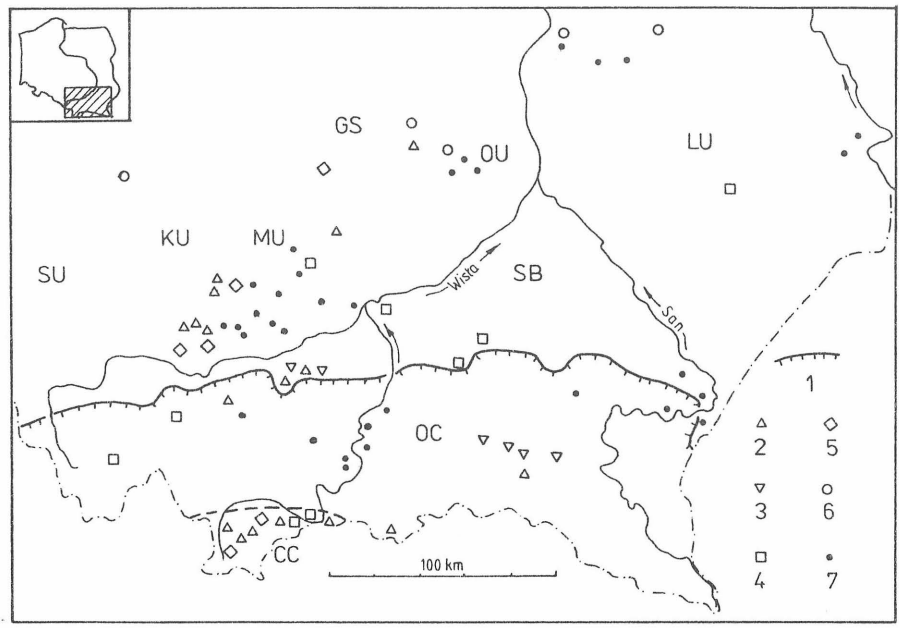

Fig. 1. Distribution of the Upper Vistulian and Lower Holocene mollusc-bearing sediments in South Poland

1. northern border of Carpathians; 2. calcareous tufa; 3. lacustrine chalk; 4. fluviatile sediments; 5. slope debris; 6. calcareous silts of dry valleys; 7. loess; CC – Central Carpathians; OC – Outer Carpathians; SU – Silesian Upland; KU – Cracow Upland; MU – Miechów Upland; SB – Sandomierz Basin; GS – Holy Cross Mountains; OU – Opatów–Sandomierz Upland; LU – Lublin Upland

the Cracow Upland and Carpathian Foothills (Fig. 2). The fauna of the loess deposited just before the last Pleniglacial, dated at 30–21 thousand years BP depends on local habitat conditions but may be relatively rich and contain usually 6–12 species, such as: *Trichia hispida*, *Arianta arbustorum*, *Pupilla muscorum*, *Clausilia dubia*, *Vallonia tenuilabris*, *V. pulchella*, *Columella columella* and *Vertigo parcedentata*, accompanied by snails connected with dry steppes (*Helicopsis striata*, *Pupilla sterri*) and numerous shells of snails most typical of loess (*Pupilla loessica*, *Succinea oblonga elongata*). A quite poor molluscan assemblage occurs in sediments of the last Pleniglacial. In a lot of samples only 1–4 species of snails can be found and the fauna is clearly dominated by *Pupilla loessica*. In the uppermost part of some profiles the last mentioned species is progressively replaced by *Succinea oblonga elongata* becoming the most important component of the fauna. The assemblage is usually more rich, enclosing *Vallonia tenuilabris*, *Pupilla muscorum*, *Columella columella*, *Semilimax kotulai* and a few other species (Fig. 2). Mesophile snails living in moderately humid and humid habitats prevail in sediments of the descending phase of the

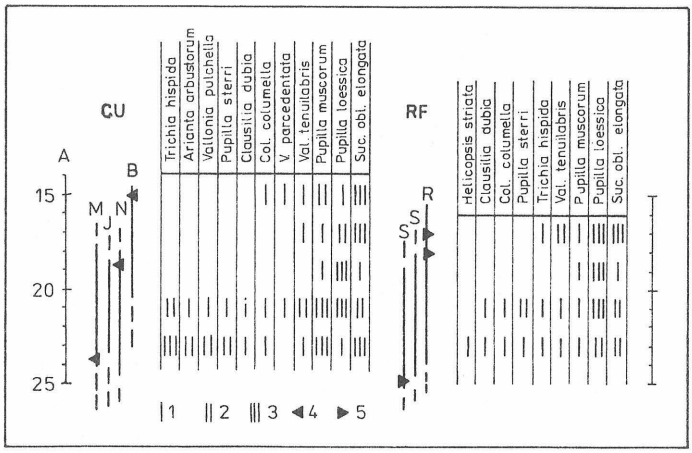

Fig. 2. Molluscan fauna of loess

A – age BP (in thousand years); KU – Cracow Upland; RF – Rożnów Foothill; M – Maszków; J – Januszowice; N – Niedźwiedź; B – Bibice; S – Sienna; R – Roztoka. Number of shells: 1. few; 2. common; 3. abundant; 4. datation – ^{14}C; 5. datation – TL

Pleniglacial. At three localities loess with numerous shells of water molluscs were noted, too (ALEXANDROWICZ, 1988, 1991a, b).

Lacustrine sediments developed as chalk, calcareous silt and gyttja were deposited during the Late Vistulian and Early Holocene in small, shallow lakes. In the Jasło–Sanok Depression (Carpathian Foothill) a lot of these water bodies had formed a lakeland completely declined before the Atlantic or even the Boreal Phase (WÓJCIK, 1987; GERLACH 1990). The molluscan fauna of the Late Glacial enclose the two main components: snails represented by *Gyraulus laevis* with an admixture of *Gyraulus acronicus*, and three taxa of bivalves (*Pisidium stewarti*, *P. obtusale lapponicum*, *P. lillieborgi*) accompanied by a few eurythermic species. The Holocene assemblage is characterized by a considerable content of shells and opercula of *Bithynia tentaculata* beside numerous species of snails (*Armiger crista*, *Anisus contortus*, *Physa fontinalis*) and bivalves (*Pisidium subtruncatum*, *P. nitidum*, *P. milium*). A fauna with *Lymnaea peregra* can be distinguished as a transitional assemblage separating the two previously mentioned (Fig. 3). The most representative profiles of the described mollusc-bearing lacustrine sediments are known in Roztoki near Jasło, Miejsce Piastowe near Krosno and Niepołomice near Cracow (ALEXANDROWICZ, 1981, 1987a, 1991c).

The silts and calcareous silts filling short, dry valleys are developed mainly in the Małopolska Upland. A rich and differentiated molluscan fauna can be found in these sediments. In the profile in Częstochowa the sequence begins at an assemblage with *Vertigo parcedentata*, *Succinea putris* and *Pupilla muscorum*. It corresponds with the swampy habitats of the de-

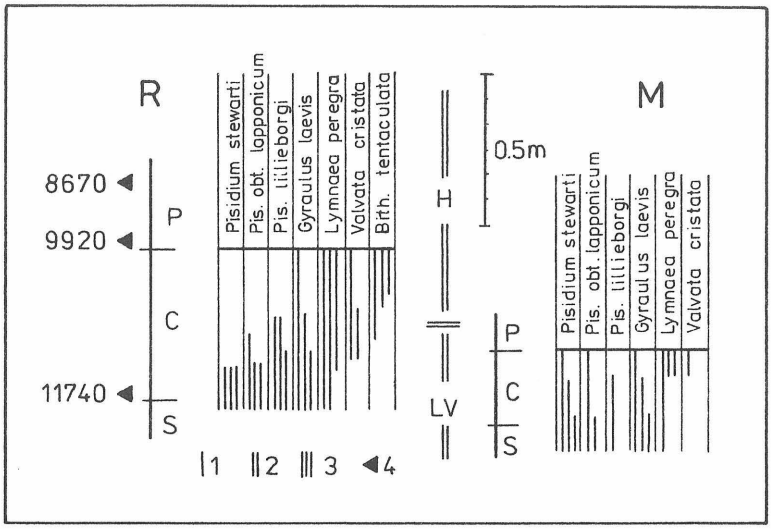

Fig. 3. Molluscan fauna of lacustrine chalk
R – Roztoki; M – Miejsce Piastowe; S – silt; C – chalk; P – peat; LV – Late Vistulian; H – Holocene. Remaining explanations as in Fig. 2

scending phase of the Pleniglacial. The next one is dominated by *Vertigo genesii*, accompanied by *Semilimax kotulai*, *Euconulus fulvus*, *Nesovitrea hammonis* and a few other eurythermic species. This fauna is typical of the Late Vistulian therefore the presence of *Discus ruderatus* is noteworthy here. The increasing content of shadow-loving snails such as: *Acicula polita*, *Acanthinula aculeata*, *Vitrea crystallina* and *Discus rotundatus* indicates the early phase of the Holocene while the advanced amelioration of the climate is marked by the occurrence of *Cochlodina orthostoma*, *Isognomostoma isognomostoma* and *Helicigona lapicida* (Fig. 4).

A similar sequence of molluscan assemblages was described by PIECHOCKI (1977) from Kunów in the Kamienna river valley. In the Late Vistulian sediments filling a side valley open-country and eurythermic species dominated. Snails connected with the cold climate (*Columella columella*, *Vertigo parcedentata*, *Vallonia tenuilabris*) were accompanied by *Nesovitrea hammonis, Euconulus fulvus*, *Vallonia pulchella*, *Vertigo genesii and Succinea putris.* Since the beginning of the Holocene the content of woodland snails had been increasing markedly. These were at first: *Acicula polita, Acanthinula aculeata, Aegopinella pura* and *Discus ruderatus* followed with a fauna with *Clausilia cruciata, Macrogastra latestriata, M. ventricosa, Discus perspectivus* and *Perforatella vicina.* The last mentioned assemblage corresponded with the climatic optimum and according the radiocarbon dating it fell into the interval 8,620–6,160 years BP (JERSAK, 1977).

The richest molluscan fauna occurs in calcareous tufa and travertines in the Carpathians, Carpathian Foothill, Cracow Upland and Kielce–Sandomierz Upland. The mentioned sediments are connected with the Holocene but in a few profiles they are preceded by mollusc-bearing silts of the Late Vistulian. The assemblage with *Vertigo genesii* accompanied by *Columella columella*, *Succinea oblonga*, *Semilimax kotulai*, *Vertigo geyeri*, *V. substriata*, *Nesovitrea hammonis*, *Vallonia pulchella*, *V. costata* and *Pupilla muscorum* was found in the lowermost part of the profile near Gdów (Fig. 5). Similar assemblages occur in Late Vistulian tufa in the Central Carpathians (Gliczarów, Ostrysz) and in Sieradowice near Bodzentyn (Fig. 6). The age of this type of fauna is confirmed by the radiocarbon dating.

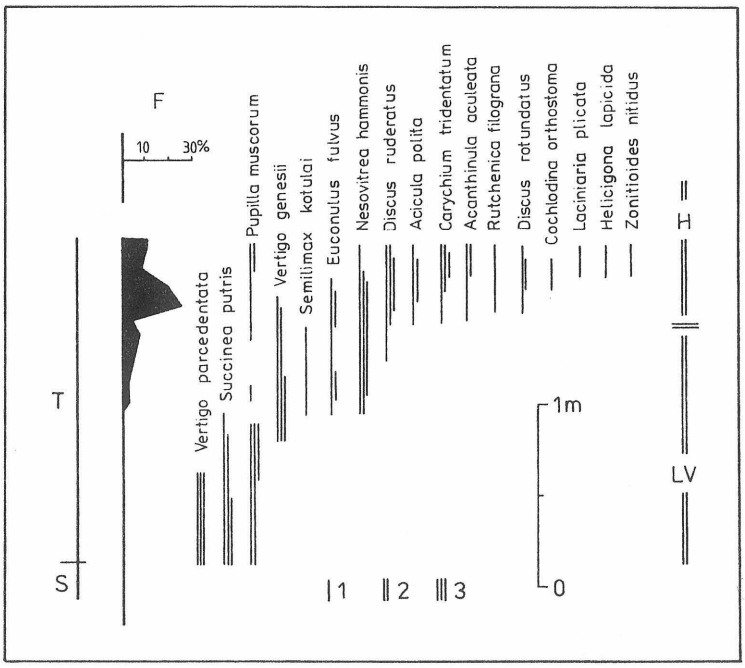

Fig. 4. Molluscan fauna of calcareous silt filling dry valleys (Częstochowa)
S – silt and sandy silt; T – calcareous silt and tufa; F – content of woodland snails. Remaining explanations as in Fig. 2

Since the beginning of the Holocene the content of shadow-loving snails has been increasing markedly. Besides a typical species – *Discus ruderatus*, a lot of such taxa as: *Acicula polita*, *Vitrea crystallina*, *Aegopinella pura* and *Bradybaena fruticum* are found in several outcrops. The most instructive profile characterizing the whole postglacial sequence of molluscan assemblages is known in the Racławka stream valley (Fig. 6). Species of shady habitats (*Discus rotundatus*, *Perforatella incarnata*, *Ena*

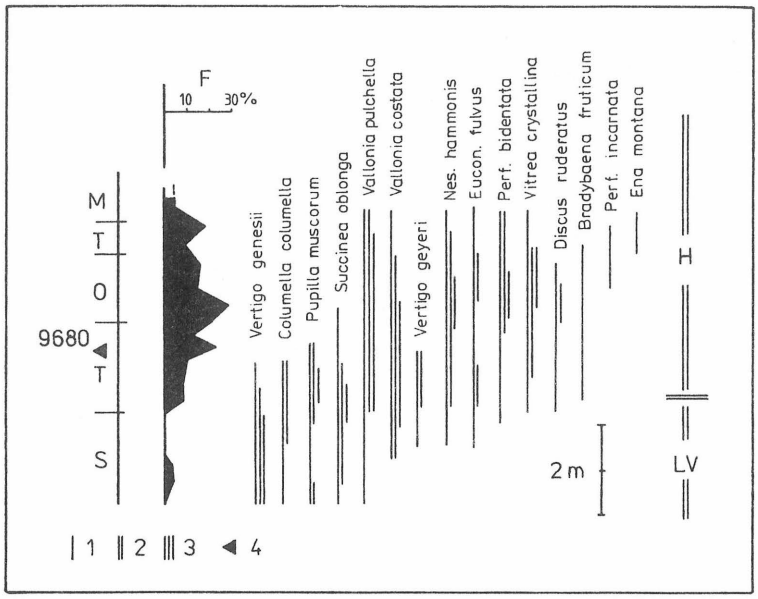

Fig. 5. Molluscan fauna of silt and calcareous tufa from Carpathian Foothill (Gdów–Zabłocie)

S – silt; T – calcareous tufa; O – organic mud; M – mud. Remaining explanations as in Fig. 2

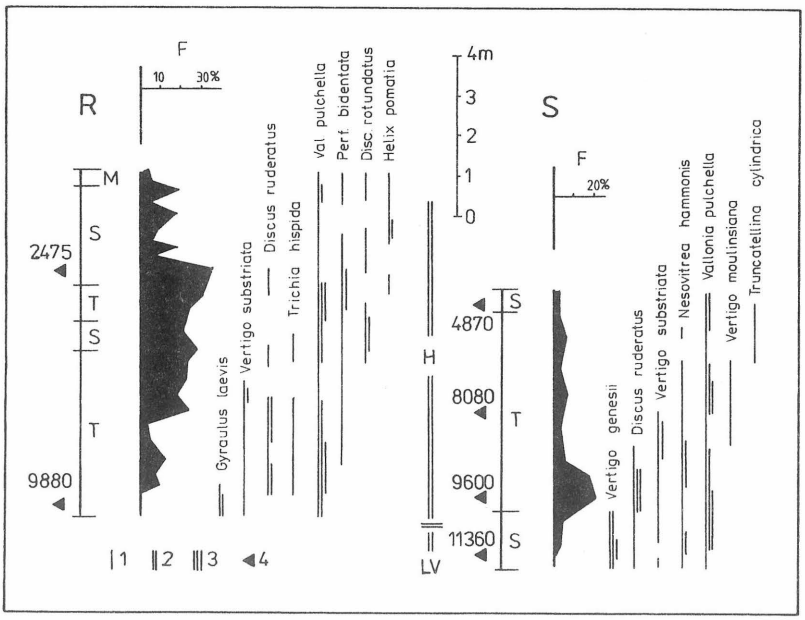

Fig. 6. Molluscan fauna of calcareous tufa in the Małopolska Upland

R – Racławka near Cracow; S – Sieradowice near Bodzentyn. Explanations as in Fig. 2

montana) prevail in the tufa of the climatic optimum while in the younger sediments open-country and catholic snails are the most important components of the fauna. In particular profiles of the Holocene tufa relations between the main ecological groups of molluscs are quite variable. Four types of molluscan successions can be distinguished (ALEXANDROWICZ 1983, 1987b; ALEXANDROWICZ, CHMIELOWIEC, 1992; ALEXANDROWICZ *et al.*, 1992):

– assemblages with woodland snails, characterized by a sequence: *Discus ruderatus–Discus rotundatus–Discus perspectivus*;
– assemblages dominated by open-country and mesophile snails;
– assemblages of march species: *Vertigo antivertigo–Vertigo angustior–Vertigo moulinsiana*;
– assemblages of water molluscs containing taxa living mainly in streams or temporary water bodies.

The fauna of fluviatile sediments deposited on alluvial plains and filling ox-bows was described from several localities in the Carpathians and Carpathian Foreland. In the profile in Łężkowice near Wieliczka the succession begins with an assemblage with *Succinea oblonga* and *Trichia hispida* passing upward into a fauna dominated by open-country snails (*Vallonia pulchella, V. costata*), accompanied by *Vertigo geyeri*, *Nesovitrea hammonis* and *Perforatella bidentata* found in the sand and silt of the Late Vistulian (Fig. 7). The main components of this assemblage pass to the fauna of the Holocene sediments which is enriched in several mesophile and

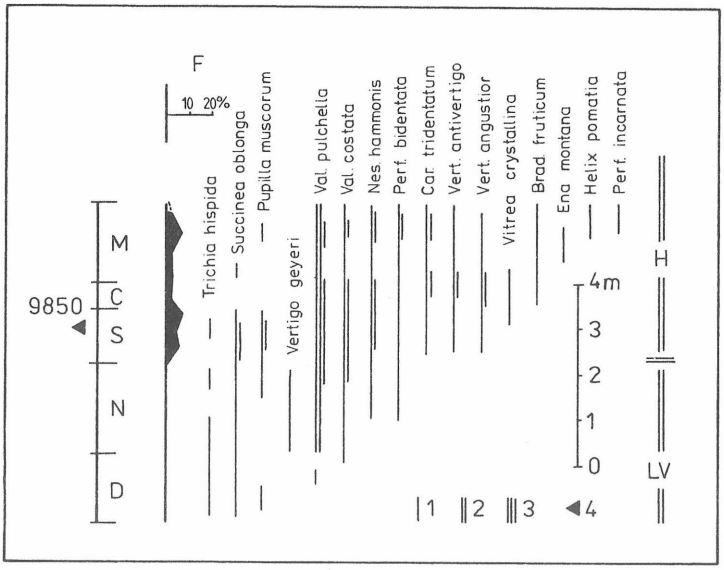

Fig. 7. Molluscan fauna of fluviatile sediments from the Carpathian Foothill (Łężkowice)
D – sand; N – sandy silt; S – silt; C – clay; M – mud. Remaining explanations as in Fig. 2

shadow-loving snails, such as *Carychium tridentatum*, *Vertigo antivertigo*, *Vitrea crystallina* and *Perforatella incarnata* (ALEXANDROWICZ, WYŻGA, 1992).

The succession of assemblages found in the sediments filling ox-bows and other water basins developed on the alluvial plains of several river valleys are distinctly differentiated and controlled mainly by local conditions. Water molluscs, march snails and catholic species are the main components of these assemblages. Instructive examples of such successions are described from the Wisłoka river valley and Sancygniówka river valley (ALEXANDROWICZ, 1987b). In both valleys the fauna dominated by water molluscs passes upward into an assemblage containing an admixture of species living in swamps or marches and into a fauna with a considerable content of march and mesophile snails. The changes of molluscan assemblages reflect particular phases of the transformation and declining of the mentioned water basins during the Lower Holocene. Similar molluscan assemblages were found in sediments filling dam-lakes connected with landslides or small water bodies developed on slided colluvial masses (ALEXANDROWICZ, 1987, 1993).

Shells of land snails are fairly common in slope debris, in loams with limestone lumps deposited in caves and fissures as well as in some soil profiles. A sequence of four assemblages corresponding to the interval 20–6 thousand years BP is known from the Zawalona Cave in the southern part of the Cracow Upland. It begins with a fauna with *Pupilla loessica* and *Succinea oblonga elongata* accompanied by *Trichia hispida*, *Semilimax kotulai* and *Clausilia dubia*, attributed to the descending phase of the Pleniglacial. The next fauna is enriched in open-country and catholic snails of a wide climatic tolerance. The occurrence of *Discus ruderatus* and *Vertigo geyeri* beside *Semilimax kotulai* and *Vallonia tenuilabris* is noteworthy and indicates the Late Vistulian age. The Early Holocene fauna is dominated by *Vallonia pulchella* and *V. costata* with a considerable admixture of *Discus ruderatus*, *Vitrea crystallina*, *Bradybaena fruticum* and *Nesovitrea hammonis*. A rich molluscan assemblage with a lot of woodland snails indicating the climatic optimum can be distinguished as the next component of the said sequence.

Another profile of the mollusc-bearing slope sediments was found close to the outlet of a small cave in the Sobczański Gully (Pieniny Mts). A fauna with *Discus ruderatus*, *Vallonia costata*, *Arianta arbustorum* and *Semilimax kotulai* attributed to the lowermost part of the Holocene is the oldest component of the sequence. It passes upward into a fauna with *Discus ruderatus, Vitrea crystallina*, *Bradybaena fruticum*, *Vallonia costata* and *Clausilia dubia*, characterizing the Boreal Phase of the Holocene. The assemblage with numerous species of woodland snails such as *Vitrea diaphana*, *Isognomostoma isognomostoma*, *Ruthenica filograna* and *Helicigo-*

na faustina corresponds to the Atlantic Phase while in the upper part of this sequence traces of the deforestation attributed to the Upper Holocene are clearly expressed (ALEXANDROWICZ, 1987b). Similar successions of Holocene molluscan assemblages were noted in both the Pieniny Mts and Cracow Upland as well as in the Tatra Mts.

SUCCESSIONS OF MOLLUSCAN ASSEMBLAGES

Particular molluscan assemblages are connected with ancient habitats changing subsequently to the evolution of climate. A fauna living in stable habitats is modified mainly by climatic conditions forming a simple succession developed in a specific type of environment. Relations between ecological groups of molluscs remain almost unchanged for a long time while species of different climatic tolerance follow one another. A combined type of succession occurs in changing habitats. It contains assemblages characterized by a different content of particular ecological types of snails and bivalves and reflects the transformation of environment documented in one sequence of deposits and molluscan fauna. Quaternary molluscan successions were described from different regions by LOŽEK (1976, 1982), ALEXANDROWICZ (1983, 1987b), LIMONDINE, ROUSSEAU (1991) and other authors as important indicators of evolution of the climate and environment.

Four types of simple successions can be distinguished in the Upper Vistulian and Lower Holocene of South/Middle Poland (Fig. 8):

S – succession: assemblages of snails living in shady or partly shady habitats (mainly the woodland fauna);

O – succession: assemblages of open-country snails connected with dry and moderately humid habitats;

M – succession: assemblages of march species living in humid habitats, mainly in wet meadows, damps and marches;

W – succession: assemblages of water molluscs.

Changes of the molluscan fauna can be attributed to the following time intervals corresponding with the main climatic phases (Fig. 8):

Ps-1 – the Late Interpleniglacial just before the last cold period (23,000–21,000 BP);

Ps-2 – the last Pleniglacial (20,000–18,000 BP);

Ps-3 – the descending phase of the Pleniglacial (16,500–14,500 BP);

Ps-4 – the Late Vistulian (12,000–10,500);

Ps-5 – the Preboreal and Boreal Phases of the Lower Holocene (10,000–8,500 BP);

Ps-6 – the climatic optimum of the Holocene (8,000–6,000 BP).

The molluscan fauna typical of shady habitats developed subsequently to the afforestation, mainly since the beginning of the Holocene but ini-

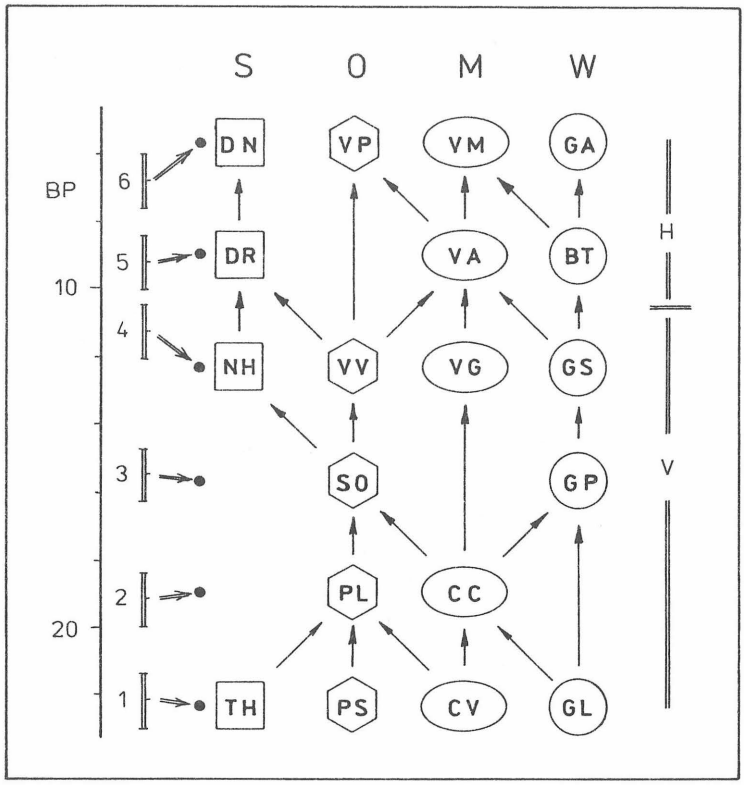

Fig. 8. Molluscan successions of the Upper Vistulian and Lower Holocene sediments of South Poland

BP – age in thousand years; 1–6. intervals connected with climatic phases (described in the text); S, O, M, W – types of successions of molluscan assemblages (described in the text); DN–GL – particular molluscan assemblages (described in the text)

tially also during the warm episodes of the Late Vistulian. Shells of mesophile snails connected with both open and shady environments, accompanied by a few species living in bushes and on skirts of forest occur in sediments of the Interpleniglacial as components of the first assemblage of the S–succession (*Trichia hispida* fauna, Fig. 8, TH). This assemblage contains snails typical of loess with an admixture of *Trichia hispida*, *Arianta arbustorum*, *Semilimax kotulai*, *Clausilia dubia*, *Nesovitrea hammonis*, *Euconulus fulvus* and shells of slugs. It is the richest fauna of the Interpleniglacial. The lack of this type of assemblage in the following two phases (Fig. 8, Ps-2, -3) is responsible for a break in the described S–succession. Its next element is represented by the *Nesovitrea hammonis* fauna developed in Late Vistulian sediments (Fig. 8, NH). It is a fauna with snails of a wide climatic tolerance such as: *Nesovitrea hammonis*, *Euconu-*

lus fulvus, Punctum pygmaeum, Trichia hispida, Arianta arbustorum and Bradybaena fruticum. The occurrence of *Discus ruderatus, Vitrea crystallina* and *Vertigo substriata* is noteworthy.

The assemblage with component of the S–succession is typical of the Lower Holocene (Fig. 8, DR). It is a rich fauna with a considerable number of woodland and mesophile snails such as: *Discus ruderatus, Acicula polita, Vertigo pusilla, V. substriata, Acanthinula aculeata, Aegopinella pura, Cochlodina laminata, Vitrea crystallina, Cochlicopa lubrica* and *Punctum pygmaeum.* Similar molluscan assemblages described as *Ruderatus* fauna are known from many profiles of the Lower Holocene deposits in the whole Europe (LOŽEK, 1964, 1970, 1982; DEHM, 1967; FUHRMANN, 1973; ALEXANDROWICZ, 1987b). The youngest element of the mentioned succession is represented by a fauna with *Discus rotundatus* (Fig. 8, DN). It contains a lot of species of woodland snails including taxa migrating from West and South Europe subsequently to the amelioration of the climate. The main components of this fauna are species of the preceding assemblage completed by: *Discus rotundatus, D. perspectivus, Ena montana, Cochlodina orthostoma, Ruthenica filograna, Macrogastra plicatula, Vitrea diaphana, Carychium tridentatum, Perforatella incarnata, Isognomostoma isognomostoma* and many others. This is the richest and most differentiated fauna of the described sequence, widely distributed (LOŽEK, 1964, 1982; FUHRMANN, 1973; ALEXANDROWICZ, 1987b; DEHM, 1987).

The succession of molluscan assemblages typical of open environments begins with a fauna with *Pupilla sterri* and *Helicopsis striata* (Fig. 8, PS). Besides the nominal species it contains numerous shells of *Pupilla loessica, P. muscorum, Succinea oblonga elongata* and *Vallonia tenuilabris* with an admixture of *Vallonia pulchella, V. costata* and occasionally – *Chondrula tridens.* Shells of other species typical of loess can be found, too. The mentioned assemblage is connected with the Interpleniglacial. Subsequently to the deterioration of climatic conditions it passes into a poor and less differentiated fauna with *Pupilla loessica*, typical of the last cold period (Fig. 8, PL). The nominal species clearly dominates or is even the sole component of the assemblage. It can be accompanied by shells of *Succinea oblonga elongata, Vallonia tenuilabris, Columella columella* and a few other snails. In a lot of samples the mentioned fauna encloses only one species represented by a different number of specimens. During the descending phase of the Pleniglacial in open environments *Pupilla loessica* was gradually replaced by *Succinea oblonga elongata* – the nominal species of the next assemblage (WIKTOR, 1960; ALEXANDROWICZ, 1987b, 1991b). The number of species increased slightly. Such taxa as *Pupilla muscorum, P. loessica, Trichia hispida, Vallonia tenuilabris* and *Columella columella* occur besides numerous shells of *Succinea oblonga elongata* but in many places the fauna encloses only one – the last mentioned taxon (Fig. 8, SO).

A quite another assemblage characterizes the open environments of the Late Vistulian. This is a fauna dominated by the two species: *Vallonia pulchella* and *V. costata* (the *Vallonia* fauna, Fig. 8, VV), known also from the West Europe (LOŽEK, THOSTE, 1972). A few other species can be found additionally in this assemblage: *Vallonia tenuilabris*, *Pupilla muscorum*, *Cochlicopa lubrica* and *Nesovitrea hammonis*. The mentioned fauna continues throughout the Lower Holocene but it is enriched in such components as: *Cochlicopa lubricella, Euomphalia strigella*, *Vitrea contracta* and *Vitrina pellucida* instead of *Vallonia tenuilabris* and other taxa connected with the cold climate. The next assemblage of open-country snails is characterized by the same species with a domination of *Vallonia pulchella* and *V. costata*. It also contains species found occasionally in older deposits: *Vertigo pygmaea*, *Truncatellina cylindrica*, *Chondrula tridens* and a few others. The assemblage with *Vertigo pygmaea* closes the O–succession as its youngest element (Fig. 8, VP). This type of fauna is wide-spread in the Upper Holocene sediments and indicates human impact, particularly the progressing deforestation of large areas. Assemblages of snails inhabiting humid and wet habitats form the M-succession characterized by a fairly rich and differentiated fauna. It begins at an assemblage with *Columella columella* and *Vertigo parcedentata*, typical of the Upper Vistulian (Fig. 8, CV). In the Interpleniglacial deposits besides the two nominal species shells of *Succinea oblonga elongata*, *S. putris*, *Lymnaea truncatula* and a few other eurythermic snails can be found but only the first mentioned reach a considerable number of specimens. The second assemblage characterized by *Columella columella* is quite poor. It occurs in deposits of the Pleniglacial and its descending phase (Fig. 8, CC). An increasing number of *Succinea oblonga elongata* characterizes the transition of the CC–assemblage to the SO–assemblage, noted frequently in deposits of the Late Pleniglacial.

The fauna with *Vertigo genesii* and *V. geyeri* is the most typical assemblage of the Late Vistulian (Fig. 8, VG). It is fairly rich and contain species living in swamps and marches in both cold and temperate climate. These are: *Succinea putris*, *S. oblonga*, *Lymnaea truncatula*, *Vertigo substriata* and *Zonitioides nitidus* as well as a glacial relic – *Columella columella*. The next assemblage with *Vertigo antivertigo*, (Fig. 8, VA) is more rich and contains such species as: *Vertigo substriata*, *V. angustior*, *Succinea putris, Carychium minimum* and *Perforatella rubiginosa* with an admixture of *Vertigo geyeri* and occasionally – *Vertigo genesii*. The youngest fauna of the mentioned succession encloses all species known from the previously described one, completed by *Vertigo moulinsiana, Vallonia enniensis* and a few other taxa (Fig. 8, VM). Transitions to assemblages of water molluscs or shadow-loving snails are noted in profiles of different sediments.

The succession of water fauna (W–succession) is composed by a few assemblages connected with the sediments of particular types of water basins inhabited by snails and bivalves. The oldest assemblage is known

mainly in loess deposited just before the last Pleniglacial. It is a fauna with *Gyraulus laevis* accompanied occasionally by *Aplexa hypnorum* and *Pisidium obtusale lapponicum*. The same assemblage can be found in sediments of the last cold period (Fig. 8, GL). During the descending phase of the Pleniglacial the fauna was enriched in a few species (*Gyraulus acronicus*, *Pisidium stewarti*, *P. lillieborgi*). It is distinguished as the Gyraulus–Pisidium fauna (Fig. 8, GP). The next assemblage is more rich again and occurs mainly in lacustrine chalk, lacustrine silt and calcareous gyttja. It is composed of species known from the previously described fauna and additionally of: *Valvata piscinalis*, *Lymnaea ovata*, *Gyraulus rossmaessleri*, *Anisus leucostomus*, *Armiger crista*, *Pisidium milium* and *P. nitidum* (Gyraulus–Valvata fauna, Fig. 8, GV).

The fauna of the Lower Holocene deposits is characterized by *Bithynia tentaculata* (Fig. 8, BT). Beside numerous shells and opercula of this species a lot of other taxa occur in the mentioned assemblage: *Gyraulus laevis*, *G. riparius*, *Armiger crista*, *Hippeutis complanatus*, *Anisus contortus*, *Valvata cristata*, *Sphaerium corneum*, *Pisidium nitidum*, *P. casertanum* and *P. subtruncatum*. Subsequently to the warming of climate the Bithynia fauna (BT) passes into the assemblage with *Gyraulus albus* and *Pisidium moitessierianum* (Fig. 8, GA). The nominal species is connected mainly with the sediments of lakes and rivers while in the deposits of small and temporary water bodies the fauna with *Lymnaea truncatula*, *L. palustris*, *Planorbis planorbis*, *Planorbarius conreus*, *Anisus leucostomus* and many other species can be found.

CONCLUSIONS

Substantial changes in molluscan fauna followed the evolution of climate since the last Interpleniglacial till the Atlantic Phase of the Holocene (Ložek, 1970, 1976, 1982; Alexandrowicz, 1987b; Limondine, Rousseau, 1991). The fauna connected with particular types of habitat developed subsequently to changes of climatic conditions from a few simple and combined successions of molluscan assemblages, found in different sediments. The assemblages typical of loess can be successively related to the Late Interpleniglacial (the fauna with *Trichia, Arianta* and *Pupilla*), the Pleniglacial (the fauna with *Pupilla loessica*) and its descending phase (the fauna dominated by *Succinea oblonga elongata*). The assemblages of the Late Vistulian enclose species climatically very tolerant, including the most typical taxon – *Vertigo genesii*, living in marches and swampy habitats subsequently to the deglaciation. The woodland snail *Discus ruderatus* is typical of this interval while a few other taxa characterize open and swampy habitats. The water snail *Bithynia tentaculata*, living now in temperate zone within areas covered with mixed or deciduous forests with *Corylus*,

indicates the beginning of the Holocene in profile of sediments of different water basins. During the climatic optimum the molluscan fauna remained distinctly differentiated. Particular assemblages enclose species typical of the humid, temperate climate, which migrated at that time from western and southern Europe.

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