Late Pleistocene and Holocene molluscan succession from Vrutice in the north Bohemian chernozem area

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Abstract. A detailed molluscan succession from a 3 m thick talus deposit at Vrutice near Litoměřice (NW Bohemia) provides a record from the chernozem area of NW Bohemia. The sedimentary and faunal sequences have been divided into two sections corresponding to the Weichselian Late Glacial and Holocene. Both sections are dominated by steppe assemblages with minor admixture of a few woodland elements in the Holocene, which documents the persistence of the early Holocene steppes up to the Neolithic landnam. *Oxychilus inopinatus* and *Cepaea vindobonensis* are index fossils of the Middle and Late Holocene in the Bohemian xerothermic area where fully developed woodland malacocoenoses of the Postglacial Climatic Optimum are lacking.

Kurzfassung. Die spätpleistozäne und holozäne Molluskenabfolge von Vrutice im nordböhmischen Tschernosemgebiet. – Die feingegliederte Molluskenabfolge aus 3 m mächtigen Hangfußsedimenten in Vrutice bei Leitmeritz dokumentiert die nacheiszeitliche Entwicklung der Schneckenbestände in der nordwestböhmischen Tschernosemzone. Die Ablagerungs- und Faunenfolge gliedert sich in zwei Einheiten, die dem Weichsel Spätglazial bzw. dem Holozän entsprechen und von Steppenarten mit geringer Beimischung von Waldelementen im Holozän beherrscht werden, was das Überdauern von frühholozänen Steppen bis zur Zeit der neolithischen Landnahme belegt. *Oxychilus inopinatus* and *Cepaea vindobonensis* sind mittel- und jungholozäne Leitfossilien im innerböhmischen Trockengebiet, in dem voll ausgebildete Waldschneckenbestände des nacheiszeitlichen Klimaoptimums fehlen.

Key words. Bohemia, molluscan succession, Weichselian Late Pleistocene, Holocene.

Introduction

The main purpose of this study is to report the results of malacostratigraphic and paleoenvironmental investigation of a molluscan succession from the time-span Late Weichselian-Holocene within the northwest Bohemian chernozem area, a territory which may correspond to the Early Holocene forest steppe belt. Particular emphasis is placed on the continuous occurrence of open-country species, indicating the persistence of open steppe habitats during the Postglacial Climatic Optimum, as well as on the absence of most indicators of woodland environments.

Site description

The fossiliferous deposit is situated at the foot of a southfacing slope in the shallow valley of the Úštěcký potok brook close to the eastern margin of Vrutice, a village situated 12 km ESE of the town of Litoměřice (Leitmeritz) near the boundary between the north Bohemian Cretaceous tableland and the foothills of the Bohemian Middle Mountains (České Středohoří, Böhmisches Mittelgebirge). Its surroundings are dominated by fields with patches of xerothermic grassland on slopes and lynchets. Basic topographic and climatic data are given in figure 1 (map) and in the following review:

Latitude:	50°30′14″	Mean annual temperature:	8.5°C
Longitude:	14°17′55″	Mean July temperature:	18.3°C
Altitude:	165 m	Mean January temperature:	-1.6°C
Mean annual rainfall:	472 mm	Vegetational period m.t.:	14.8°C

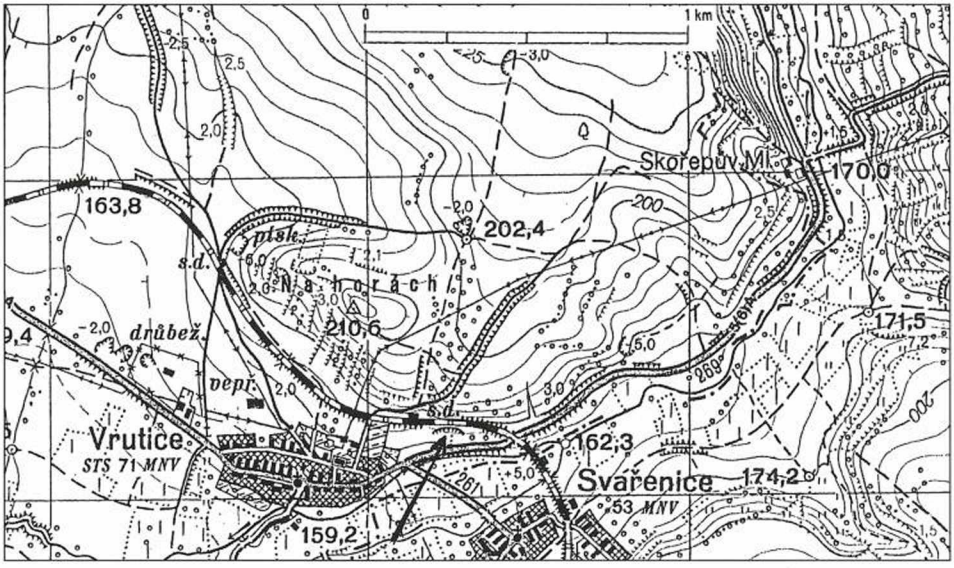

Fig. 1. Location of the site at Vrutice. The black arrow shows the position of the test trench.

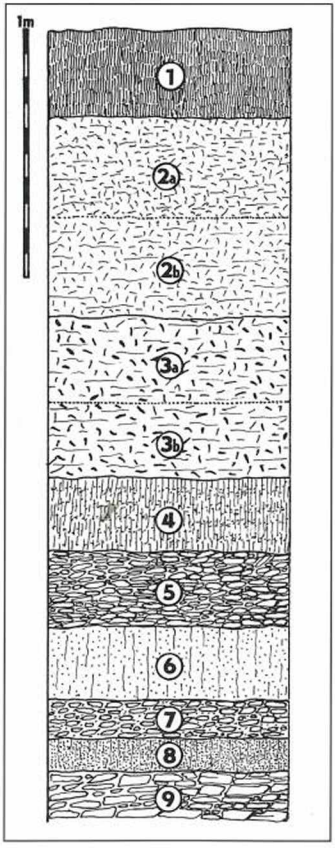

Fig. 2. Profile of the footslope deposit at Vrutice. 1 – Brownish grey humic topsoil (rendsina); 2 – Pale greyish brown slightly humic sandy loam, rich in fine rubble of sandy marlstones (size 1–2 cm); 3 – Brownish grey moderately humic sandy loam with coarser marlstone rubble (size 2-4 cm); 4 – Darker brownish grey humic loam with medium amount of finer marlstone fragments, numerous fine charcoals, burnt corn grains; 5 – Horizon of scree poor in sandy matrix. Consisting of 5–10 cm marlstone slabs, malacologically sterile; 6 – Pale greyish brown loess sand with scattered marlstone fragments; 7 – Scree of marlstone slabs with loessic-sandy matrix; 8 – Pale grey slightly humic loess sand, poor in fragments; 9 – Basal rather coarse scree of marlstones poor in sandy matrix (downslope redeposited weathered marlstone).

The Úštěcký potok Stream has incised an open valley in Turonian semi-solid marlstones that locally form low but rather steep slopes with patches of bare outcrops. The talus deposit grades by a gentle slope into the valley floodplain that is rather broad and swampy, however, mostly drained at present. The depositional sequence was exposed in a small loam pit in talus below the local railway. A test trench in its central part was thoroughly cleaned and described (Fig. 2).
The sedimentary section herein described consists of two different groups of strata: basal layers 8-6 are high in loess-like matrix, whereas the upper complex 5-1 is dominated by hillwash derived from weathering products of Cretaceous marlstones. Slightly humic horizons 8 and 4 resemble rendzina sediments, the latter being, however, tinted by numerous fine charcoals.

Molluscan fauna

Except layer 5 all strata provided sufficient numbers of fossil snails, which enabled a reconstruction of past malacocoenoses to be made. Approximately 10 kg samples were taken from all macroscopically distinguishable layers. Since the upper strata 2 and 3 are too thick, they were subdivided into two sublayers (2ab, 3ab). After drying, each sample was disintegrated in water, wet-sieved and floating shells decanted into a 0.6 mm sieve. The residual sediment from the sieve was again dried and the incorporated shells and fragments extracted by picking, the shells were determined and counted after the standard quantitative treatment of fossil molluscan communities (Ložek 1964). Results are given in table 1 which also contains basic informations on the chronostratigraphic and paleoenvironmental significance of particular species.
A graphical presentation has been omitted since the molluscan succession is very monotonous and the difference between the upper and lower units is evident at first sight.

Malacostratigraphy

The sequence has been divided into two local molluscan zones corresponding to both groups of strata. Their characteristic features are given in table 1, chronostratigraphic interpretation is based on comparison with archeologically dated successions at a number of sites within the region in question (Fig. 3).
The lower complex 8-6 yielded a malacofauna which is rather poor both in species and individuals. It is dominated by *Pupilla*, mainly typical *P. muscorum*, associated with other loess species such as *Helicopsis striata, Vallonia tenuilabris* and *Succinella oblonga*. Of particular interest are *Vallonia pulchella* which is very rare in typical loess and a small fragment of *Discus* that might be attributed to *D. ruderatus*. *Cecilioides acicula* in 7 and *Oxychilus inopinatus* in 6 are subterranean burrowing species that burrow to considerable depths and thus are out of context with associated fauna, which is particularly true of *Cecilioides*. This assemblage closely approaches the fauna of pleniglacial loess steppe and corresponds to Late (Weichselian) Glacial communities of xerothermic environments in NW Bohemia (Ložek & Šibrava 1982).
The upper complex 4-1 is dominated by assemblages that are much richer in numbers and species, and are characteristic of warm-dry grassland habitats on Cretaceous marls and their derivates. *Vallonia tenuilabris* and *Pupilla sterri* disappeared and were replaced by a number of warm-dry grassland species such as *Granaria frumentum, Chondrula tridens, Cepaea vindobonensis, Oxychilus inopinatus, Truncatellina cylindrica* and *Vallonia costata*. This fauna is thus similar to present-day malacocoenoses of such habitats in the adjacent landscape, with except of *Xerolenta obvia* that occurs only in the surface soils and dominates the local malacocoenoses at present. Other ecological groups were represented only by a few elements in low amounts. Of particular interest is the low number of woodland snails, altogether of euryoecic character. *Fruticicola fruticum* and *Helix pomatia* often live in semi-open habitats, *Monachoides incarnatus* occurs in mesic tall-herb vegetation. Indicators of closed forests are absent. Wetland species (*Vertigo antivertigo, Carychium minimum*) and *Galba truncatula* came obviously from the adjacent floodplain of the Úštěcký potok Stream.

Tab. 1. Late Glacial and Holocene malacofauna from Vrutice.

Ecological and biostratigraphical characteristics				List of species	Layer								
					8	7	6	4	3b	3a	2b	2a	1
A	1		(G)	*Discus sp. (?ruderatus)*	-	1	-	-	-	-	-	-	-
			!	*Monachoides incarnatus* (Müller)	-	-	-	-	2	1	1	-	-
	2	W(M)	!	cf. *Alinda biplicata* (Montagu)	-	-	-	-	-	-	1?	-	-
		W(S)	(!)	*Fruticicola fruticum* (Müller)	-	-	-	-	2	4	3	3	1
			!	*Helix pomatia* Linnaeus	-	-	-	-	1	1?	1	2	-
B	4	S	M	*Cecilioides acicula* (Müller)*	-	(9)	-	29	170	292	274	184	126
			(+)	*Granaria frumentum* (Draparnaud)	-	-	-	4	98	107	64	16	8
			+	*Helicopsis striata* (Müller)	1	1	1	9	41	53	32	44	8
			(+)	*Chondrula tridens* (Müller)	-	-	-	-	11	15	11	8	1
			M	*Oxychilus inopinatus* (Uličný)*	-	-	1	1	3	2	2	1	1
			+	*Pupilla sterri* (Voith)	4	2	4	-	-	-	-	-	-
			M	*Xerolenta obvia* (Menke)	-	-	-	-	-	-	1	1?	68
		S(W)	!!	*Cepaea vindobonensis* (Férussac)	-	-	-	-	6	6	4	2	2
	5	O	+	*Pupilla muscorum* (Linnaeus)	41	9	6	14	11	9	5	2	3
			(!)	*Truncatellina cylindrica* (Férussac)	-	-	-	4	54	57	12	21	20
			(+)	*Vallonia costata* (Müller)	-	-	-	3	72	30	13	7	9
				Vallonia excentrica Sterki	-	-	-	-	1	-	-	-	-
			G	*Vallonia pulchella* (Müller)	1	4	1	188	549	325	412	317	300
			++	*Vallonia tenuilabris* (A. Braun)	1	3	1	-	-	-	-	-	-
			(G)	*Vertigo pygmaea* (Draparnaud)	-	-	-	1	-	-	3	-	-
C	6		(!)	*Cochlicopa lubricella* (Porro)	-	-	-	1	1	1	-	-	-
			(!)	*Euomphalia strigella* (Draparnaud)	.	.	.	.	1?	1?	1	1?	1?
	7	Me	(+)	*Limacidae/Agriolimacidae*	-	-	-	-	2	4	2	8	1
			(G)	*Vitrina pellucida* (Müller)	-	-	-	-	8	11	1	2	-
	8		+	*Succinella oblonga* (Draparnaud)	2	1	-	-	10	3	-	3	-
D	9		G	*Carychium minimum* Müller	-	-	-	-	-	-	-	-	1
			(+)	*Succinea putris* (Linnaeus)	-	-	-	-	-	-	-	-	1
			(G)	*Vertigo antivertigo* (Draparnaud)	-	-	-	-	-	-	-	1	-
	10		(+)	*Galba truncatula* (Müller)	-	-	-	1	-	-	-	-	-
Number of species					6	7	6	11	19	18	19	18	16

Ecological characteristic

Main ecologic groups:
A – woodland, B – open country, C – indifferent, D – wetlands, water;

Ecologic groups:
1 – closed forest; 2 – predominantly woodland (and open habitats: W(M) – mesic, W(S) – xeric); 4-S: steppes, xerothermic rocks; S(W): and open woodland; 5 – open habitats in general; woodland and open country: 6 – dry, 7 – Me: predominantly mesic, 8 – damp; 9 – wetlands; 10 – aquatic habitats

Biostratigraphic characteristic:
+ loess species, ++ – index loess species, (+) – local or accidental loess species, G – surviving the glacial out of the loess steppe, (G) – dtto, as relics, ! – warm-phases species, !! interglacial index species, (!) – eurythermic warm-phases species, M – modern elements (known only from the Holocene)

1? – determination approximate only, * – subterranean species.

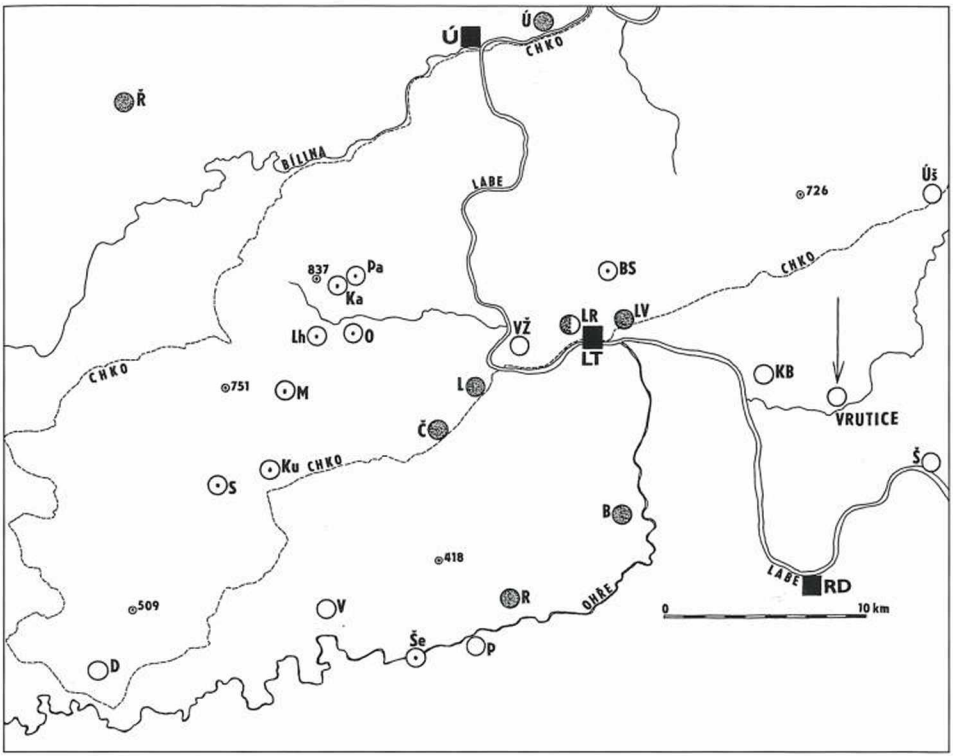

Fig. 3. Malacostratigraphically treated Quarternary sites at the southern foot of the Bohemian Middle Mts. (České Středohoří). Holocene successions without woodland malacocoenoses: D – Dobroměřice, V – Vojnice, P – Poplze, VŽ – Velké Žernoseky, KB – Křešice (fenland), Úš – Úštěk (fen), LR – Litoměřice, Richard, Š – Štětí. Holocene successions with woodland malacocoenoses: S – Řisuty, Ku – pod Kuzovem, Lh – Lhota, O – Ostrý, Ka – pod Kamýčkem, Pa – pod Paškapolem, BS – Bílá stráň, Še – Šebín. Sites with fully developed woodland malacocoenoses from various interglacials: Ř – Řetenice, Ú – Ústí-Krásné Březno, LR – Litoměřice, Richard, R – Radovesice, B – Brozany; LV – Litoměřice East-early Vistulian interstadial faunas. 509 – summits of volcanic hills. Black squares – towns: Ú – Ústí nad Labem, LT – Litoměřice, RD – Roudnice. CHKO – boundary of the Protected Landscape Area České Středohoří (Bohemian Middle Mts.).

As a whole, the fauna suggests an open warm-dry landscape with fields, pastures and relics of early Holocene steppes, which corresponds to the younger half of the Holocene (Epiatlantic, Subboreal and Subatlantic) periods in mid-European chernozem areas (Ložek 1982).

Species of special biostratigraphical interest

Steppe assemblages with index species *Helicopsis striata* and *Chondrula tridens* represent relics from the Late Glacial and Holocene. During the Holocene, they were enriched by immigrants of southern or southeastern provenance that entered Central Europe in different Holocene phases. For this reason, they may represent important index fossils in areas where classical index species confined to woodland are lacking.

At Vrutice the following species should be mentioned:

Oxychilus inopinatus is a modern subterranean species which has colonized the warm-driest areas of Central Europe since Neolithic times, but never was recorded in the Pleistocene (Ložek 1982). In contrast to *Cecilioides*, it burrows in minor depths, exceptionally up to

60–80 cm only, so that its frequent occurrences in Neolithic horizons date back its arrival to the early Epiatlantic or final Atlantic. It is widespread throughout the Pannonian Region, in Bohemia it occurs in the surroundings of Kolín (Central Bohemia) as well as in a wider area at the southern foot of the Middle Mountains (České středohoří) in NW Bohemia.
Cepaea vindobonensis has an isolated range in inner Bohemia where it has been recorded since Neolithic times so that it may be considered here modern immigrant, although it occurred in several interglacials in Moravia and Slovakia.
In contrast to these "old" immigrants, *Xerolenta obvia* invaded Bohemia much later, probably only in protohistoric times, since its first seriously dated records are not prior to the Slavonic colonization during the 5th and 6th centuries.
Cecilioides acicula – dating of its arrival to Central Europe is problematic, since this snail occurs living at depths up to 2 m. Nevertheless, the occurrences of its replaced shells in sites where it does not live, particularly in cave fills indicate that its appearance was earlier than that of *Xerolenta obvia*, probably during the Iron Ages.
As concerns *Granaria frumentum*, a xerothermophilous snail of southern provenance, recorded at a number of sites in warmer glacial phases, its arrival to inner Bohemia falls into the Early Holocene (Preboreal–Boreal).

Discussion

Comparison of the fossil assemblages at Vrutice with standard developmental pattern of the mid-European Holocene malacofauna based in numerous sites on correlation with radiocarbon-dated archeological cultures has revealed significant differences. The most striking feature is the total absence of forest optimum elements that generally played a very important role in the great majority of Postglacial molluscan successions in Central Europe. This peculiar situation is characteristic of mid-European chernozem areas where Late Glacial and Early Holocene steppe formations have continued up to the Neolithic landnam which hindered further expansion of woodland. Similar successions have also been recorded in other sites within the northwest Bohemian chernozem area, particularly at Poplze and Štětí (SMOLÍKOVÁ & LOŽEK 1978), whereas in the adjacent foothills of the České Středohoří Mts., for instance at Velký Hubenov (SMOLÍKOVÁ & LOŽEK 1973), Pokratice-Bílá stráň (LOŽEK 1982), at the foot of the Kuzov Hill (LOŽEK 1976) or at Řisuty (LOŽEK 2005), temporary expansions of more or less fragmentary woodland communities during the Climatic Optimum (Atlantic-Epiatlantic) have been recorded (Fig. 3). Unfortunately, the succession at Vrutice seems to be incomplete due to the hiatus in the sterile layer 5 which separates the lower section (8-6) with late Pleistocene fauna from the upper one (4-1) whose snail assemblages are obviously Middle to Late Holocene in age, as documented by the occurrence of *Cepaea vindobonensis* and *Oxychilus inopinatus* which entered Bohemia only at Neolithic times, i.e. in the Atlantic.
The absence of Early Holocene assemblages, dominated by aboriginal steppe species such as *Helicopsis striata*, *Chondrula tridens* and *Vallonia costata* might be due either to the sterility of layer 5 or to the erosional event in the final Boreal that has been observed at a number of mid-European Postglacial sites (JÄGER & LOŽEK 1983). Character of layer 5, consisting of a comparatively coarse scree of marlstone slabs, may support this opinion.

Conclusions

As for stratigraphic subdivision of the Holocene group of strata 4-1, it is unfortunate that almost all our knowledge of Holocene malacostratigraphy comes from woodland assemblages in view of their greater sensitivity to climatic and vegetational changes. Anyone attempting to interpret in detail the Holocene periods reflected by open-ground snail species finds abruptly how little is known of their chronological successions. In the area of Vrutice this steppe faunas have survived up to the present, being enriched by *Xerolenta obvia* at protohistoric times and

recently endangered by various kinds of pollution. Nevertheless, on the basis of malaco- and lithostratigraphic analyses of the investigated test trench at Vrutice, the following conclusions can be drawn:

The column of the trench is apparently divisible into two main sections separated by a malacologically sterile scree interlayer (5).

The lower section (8-6) is rich in loess-like material and includes a tolerant steppe fauna indicating its Late Glacial age.

The upper section (4-1) consists of hillwash sediments, includes a well developed steppe fauna with xerothermophilous (*Granaria frumentum*) and modern elements such as *Oxychilus inopinatus* and *Cepaea vindobonensis* that did not occur in Bohemia at pre-Neolithic times. The whole complex is dominated by a uniform steppe assemblage, except of the surface soil with high amounts of *Xerolenta obvia*, a protohistoric immigrant.

The most appropriate explanation of the sterile interlayer 5 is that its formation was linked to the erosional event at the Boreal-Atlantic boundary (JÄGER & LOŽEK 1983) that might destroy the horizon with Early Holocene fauna.

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