Ruins of medieval castles as refuges of interesting land snails in the landscape

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The ruins of castles have become very specific habitats. They have locally enriched substratum by lime, and their disintegrated walls have changed into artificial screes. The site of the ruins thus constitutes a very diverse habitat. Data from 114 Czech castles were processed in the programs STATISTICA and CANOCO. The model shows especially the influence of phytogeographical areas (Central European zonal vegetation, mountain vegetation, thermophilous vegetation), the stage of the ruin, the century of desolation and the degree of isolation on species variability. The snail communities inhabiting the ruins of castles reached the highest species richness. The ruins offer favourable habitat conditions for rare species of snails. Ruins of castles are not only an important dominant features of a landscape, but often islands of species diversity and refuges of rare species, especially in the landscapes poor in calcium-rich substratum.

Keywords: Mollusca, Gastropoda, human impact, castle ruins.

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Introduction

Castles were built mainly in the Middle Ages as fortified seats to watch over particular dominions. In the Czech lands only few of them have been preserved in good state to present times. Most of them fell into disrepair and turned into ruins, overgrew with forests and bushes or remained as open spaces and were incorporated into the natural surroundings. The ruins of castles have become very specific habitats, because they have locally enriched the substratum in lime, the disintegrated walls have changed into artificial screes and the area of the ruins constitutes a very diverse mosaic of habitats.

Ložek and Skalický (1983) and Alexandrowicz (1995) pointed out the importance of castle ruins not only as historical monuments, but also as refuges of plant and animal species.

This detailed survey, based on a representative sample of mollusc fauna of the Czech Republic's castle ruins, should shed light on the influence of these habitats on the mollusc fauna of particular landscapes and should provide an opportunity for generalization.

Material and methods

The material was collected at 98 castles in 1993-1999 using standard methods (Kerney et al., 1983). Data from 16 castles were taken over from other authors (Hlaváč, 1998a,b,c; Ložek, 1994; Pfleger, 1997; Horsák unpublished).

Data on numbers of species were transformed (natural logarithm) and altitude values were divided by 100 to obtain identical units of variables and their variance for further non-parametric tests of analysis of variance in the program STATISTICA.

The following data were recorded:

Ordinal: Size of castle (size): 1. Fortress (e.g. Malešov), 2. Small castle (e.g. Jinčov, Břečštejn), 3. Medium sized castle (e.g. Hláska, Radyně), 4. Big castle (e.g. Bezděz, Kunětická hora); Isolation of castle (isolatio): 1. Island – castles on isolated hills (e.g. Kunětická Hora, Andělská hora), 2. Spit – castles on rocky spits above the river, higher that surrounding terrain (Loket, Oheb), 3. Rise – castles at the same altitude or lower than surrounding terrain (Kokořín, Kynžvart), 4. Castles in lowland – called water castles (Mydlovar, Borotín); Century of destruction (cen-des): 1. Preserved castle, 2. Destructed in 18. – 19. century, 3. Destructed in 16. – 17. century, 4. Destructed in 14. – 15. century; Stage of destruction (st -des): 1. Preserved castle, 2. Ruin of the whole castle (high walls and towers, preserved interior spaces, 3. Ruin partly disintegrated, only parts of the walls without interior space, 4. Remains of the ruin integrated to the natural surroundings; Attendance (attend): 1. Very high, 2.

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High - ruderal habitats, 3. Medium - mosaic of ruderal and natural habitats, 4. Low – natural habitats.
Categorial: Vegetation (habit): open habitats – shrubs – forest (close); surrounding vegetation: 1. spruce, 2. pine, 3. larch, 4. beech, 5. oak, 6. hornbeam, 7. sycamore maple, 8. Norway maple, 9. ash, 10. lime; phytogeographic zones (zone) - oreophyticum (oreo) (mountain vegetation), mesophyticum (Central European zonal vegetation), thermophyticum (thermophilous vegetation); geological background: 10 categories were chosen and arranged according to suitability for molluscs (from extremely suitable to extremely unsuitable) - 1. limestone (limeston), 2. calcareous lime-rocks (marlstones, marls, calcareous sandstones), 3. basalts, 4. basic crystalinicum (gabbro, amphibolites, calcareous gneisses), 5. trachytic rocks, 6. shales, 7. sandstones, 8. Cambrian conglomerates, quartzites, silicates, 9. granites, 10. acidic crystalinicum (aci-cry).
Numeric: altitude (alt) (m), number of species.

Exploration of species data

Indirect gradient analysis was used to explore multidimensional data sets of species and environmental variables (Jongman et al., 1995; Lepš and Šmilauer, 1999) in the program CANOCO for Windows, v. 4.0 (ter Braak and Šmilauer, 1998). The values of species data were transformed with the log-transformation Y = log (Y + 1), which increased the relative rate of rare species that are mostly good indicators. The categorical data on geological substrate and prevailing woods were nominal "dummy" variables.

In the first step we have decided to use an unimodal model (weighted averaging) of species response to the underlying environmental gradient, because the samples were widely scattered over the area of the Czech Republic. Concurrently we tested the lengths of gradient by DCA (see ter Braak and Šmilauer, 1998, p. 37).

From the explanatory variables we have selected a subset of the significant predictors with using the forward selection procedure (details see in ter Braak and Šmilauer, 1998, p. 98), because some of the explanatory variables were highly correlated. The limestone, oreophyticum, century of destruction, stage of destruction, beech, shrubs, pine, acidic crystalinicum and isolation were treated as factors, whilst the rest was treated as covariates.

Results

The molluscs were divided into 12 ecological groups on the basis of their ecological requirements (Ložek, 1964). The relations of particular groups in castle communities are very similar to the relations in mollusc communities of the whole Czech Republic (Juřičková et al., 2001). Naturally, in castles there are less moisture loving species (group 8), hygrophilous species (group 9) and species of group 2 (mostly forest species inhabiting also other shaded localities). Eurytopic species are more successful in castles than in the Czech Republic as a whole (Fig. 1).

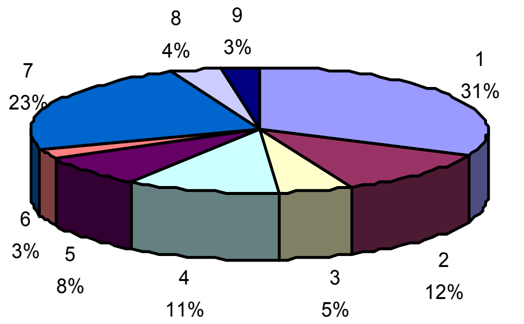

Fig. 1. The proportion of ecological groups (according to Ložek, 1964): 1 - closed forest, 2 - predominantly forest, 3 - humid forest, 4 - steppe – xerothermic habitats, 5 -open grounds in general, 6 - woodland and grassland, predominantly dry, 7 - woodland and grassland, mesic or variable, 8 - humid habitats 9 – wetlands.

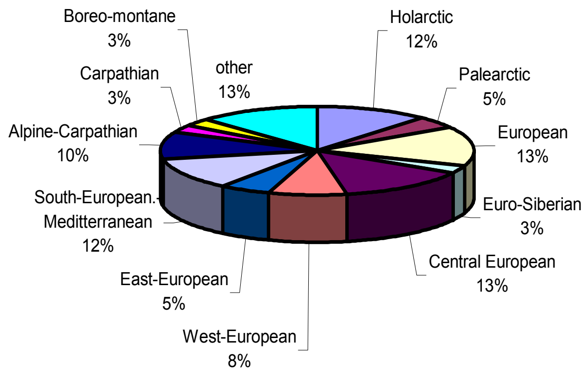

Fig. 2. The proportion of zoogeographical groups (according to Alexandrowicz, 1987 and Ložek, 1956).

The zoogeographical distribution of snails found on castle sites is also very similar to that found in the whole area of the Czech Republic. There are small differences in some groups (Fig. 2).

There is a group of „castle species“, which are more frequent or abundant in castles than in natural habitats. These are: *Balea perversa, Laciniaria plicata, Clausilia parvula, Clausilia dubia, Alinda biplicata, Pupilla muscorum, Vallonia costata*, and *Helicigona lapicida.*

The subterranean species *Cecilioides acicula* and thesemi-subterranean species *Vitrea contracta* are indicator species of soils with a thick humus layer – secondary rendzina in castles. They live especially in castles at lower elevations.

The group of species that survived the glacial periods in our area is composed of eurytopic species indicating initial stages of succession. These species are less frequent in castle communities than in natural communities. It can be concluded that castle communities are relatively stable.

Synanthropic and invasive species are not important components of castle communities.

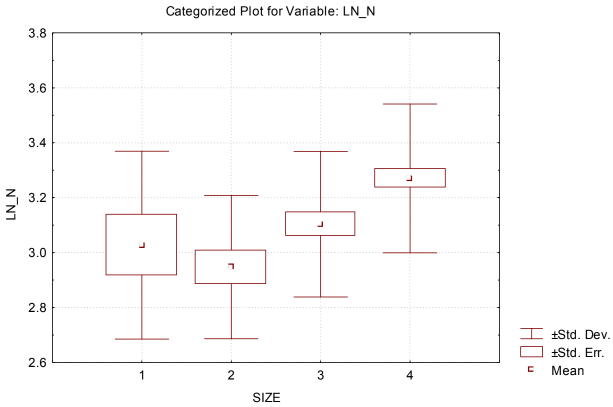

Fig. 3. Variability of species richness (LN-N) at the sites within the four different categories of ruin size. Abbreviations: 1. Fortress, 2. Small castle, 3. Medium-sized castle, 4. Big castle.

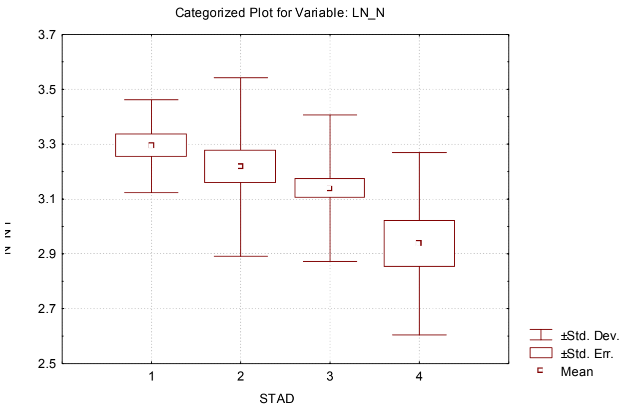

Fig. 4. Variability of species richness (LN-N) in the sites within the four different categories of destruction stage. Abbreviations: 1. Preserved castle, 2. Ruin of the whole castle, 3. Ruin partly disintegrated, 4. Remains of the ruin integrated to the natural surroundings.

Very rare species were found in the castles (*Bulgarica cana, Eucobresia nivalis, Daudebardia brevipes*) and 21 % of the species are among the first three IUCN categories of the Red List of the Czech Republic (Juřičková et al., 2001).

We tried to give some negative analysis of the castle species spectrum. We expected that some species, predictable in the studied types of habitats, would not be present in castles. However it has turned out that there are no predictable species, which would not be found in castles. Only some species occurred on these localities less often than we expected (*Vertigo pygmaea, Merdigera obscura, Oxychilus depressus*).

Some species have very isolated localities of their occurrence in castles. It is not only typical of some „castle species“ (*Laciniaria plicata, Clausilia parvula, Balea perversa*), but also of others (*Pupilla sterri* in the West-Bohemian castle Nečtiny, *Bulgarica cana* in the South-Bohemian castle Příběnice, *Daudebardia brevipes* in the Kumburk castle, *Vitrea subrimata* in Příběnice and Choustník, *Eucobresia nivalis* and *Chondrula tridens* in Rokštejn near Jihlava and so on). 26 % of the species, which have been found in castles, have here their isolated localities outside of their range.

The influence of the environmental variables on species diversity

For castles, like islands, it applies that the larger they are the more species inhabit them (Fig. 3). This is not valid for the smallest castles (SIZE 1). The fewest species occurred in the most destructed castles (STAD 4), where the habitat diversity has decreased (Fig. 4).

The influence of environmental variables on species variability

The constrained unimodal CCA method was used for the description of species response to environmental variables. From the 32 original variables 9 environmental variables were chosen in a regression analysis using the method of forward selection (Table 1). These variables explain conclusively 52 % of species variability.

As shown in Fig. 5 the *outliers* are the species that have strong ties to limestone. They skew the model, because the influence of limestone background on the mollusc communities is not the problem, which we were interested in.

A model without limestone (co-variable) was used to show the influence of the so-called castle phenomenon on species variability only. This model (Fig. 6) shows the influence of the stage of the ruin (st-ruin), the century of destruction (cen-des) and castle isolation (isol) on species variability much better. The first ordination axe distributes species with phytogeographical zones in the sense of Skalický (in Hejný and Slavík, 1988) (oreo) (*Discus ruderatus, Semilimax kotulae* and *Clausilia cruciata* are the leading species of the oreophyticum, *Causa holosericea*, a species of the higher parts of the meso- and oreophyticum). Some hygrophilous species (*Macrogastra ventricosa, Vertigo substriata, Succinea putris, Aegopinella nitens, Zonitoides nitidus*) and sensitive forest species (*Bulgarica cana, Petasina unidentata* and *Platyla polita*) are added to them. Some indicator species of thermophyticum (*Oxychilus draparnaudi, Cecilioides acicula* and *Xerolenta obvia*),

Table 1. Environmental variables explain higher proportion of species variability.

Variable	Var.N	LambdaA	P	F
limeston	14	0.13	0.015	5.08
oreo	3	0.07	0.012	2.60
cen-des	8	0.06	0.001	2.65
st-ruin	9	0.06	0.007	2.40
beech	27	0.05	0.001	2.06
Shrubs	12	0.04	0.001	1.75
pine	25	0.05	0.009	1.72
aci-cry	23	0.03	0.026	1.40
isolatio	7	0.03	0.040	1.39

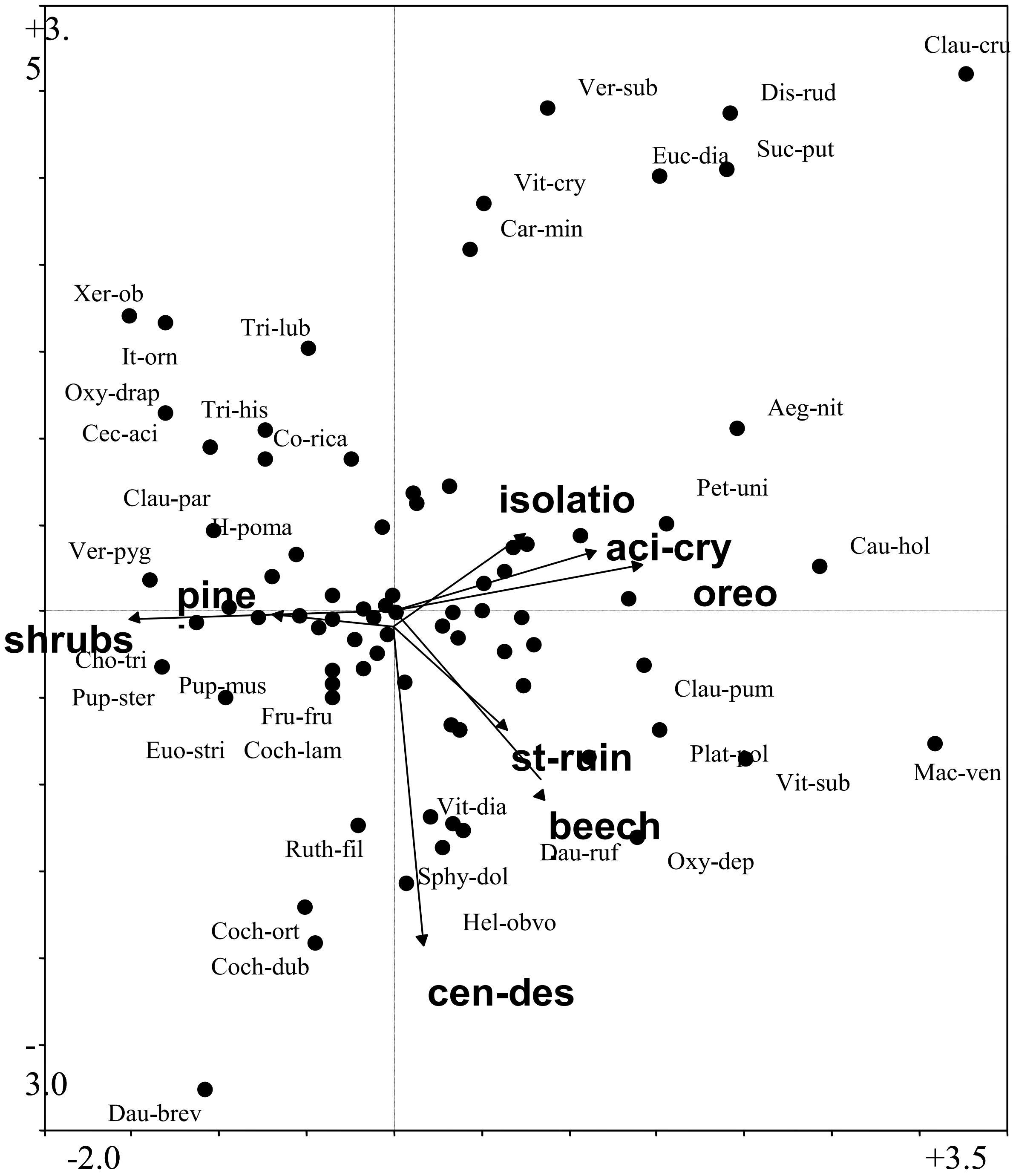

Fig. 4. Ordination diagram of constrained unimodal CCA method – species and environmental variables excluding the influence of limestone. aci-cry – acidic crystalline, isolatio – isolation of the castle, st – ruin – stage of destruction, pine, beech – surrounding vegetation, shrubs – habitat type, cen – des – century of castle destruction, limestone – geological background.

with species of open habitats (*Vertigo pygmaea*) and rocks (*Itala ornata, Clausilia parvula, Faustina faustina, Pupilla sterrii*) are on the opposite site of the axe. Most of the castles are situated in the mesophyticum. Indicator species of thermophyticum and oreophyticum (Ložek 2000) were present in very small numbers. Nevertheless, these phytogeographical areas, and the oreophyticum in particular, have a strong influence on species variability (Fig. 6). The differences are of quantitative character.

The second ordination axe distributes species especially according to the stage of the ruin (st-ruin) and the century of destruction (cen-des). Species of forest screes, i.e. *Helicodonta obvoluta, Sphyradium doliolum* and *Vitrea diaphana* prefer the more destructed ruins.

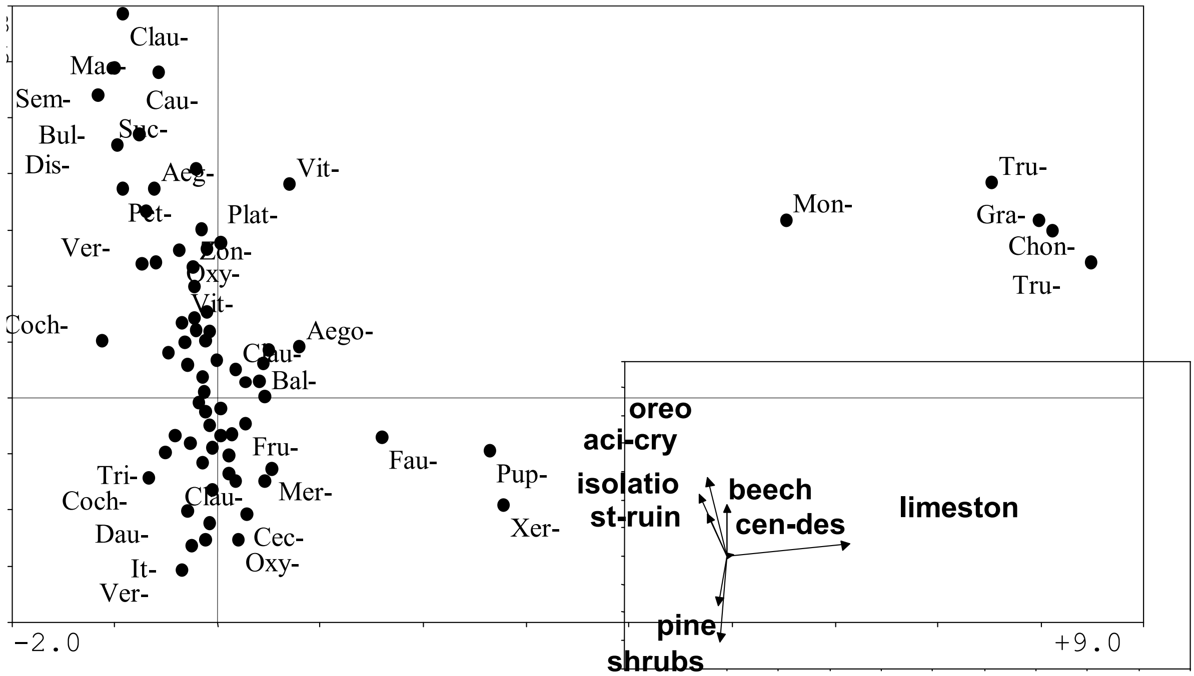

Fig. 5. Ordination diagram of constrained unimodal CCA method – species and environmental variables. For explanation of the abbreviations see chapter Material and methods. aci-cry – acidic crystalline, isolatio – isolation of the castle, st – ruin – stage of destruction, pine, beech – surrounding vegetation, shrubs – habitat type, cen – des – century of castle destruction, limestone – geological background.

Daudebardia rufa, Oxychilus depressus and *Platyla polita* correlate with destructed ruins incorporated into the natural surroundings. On the other hand, species of secondary open habitat as *Xerolenta obvia*, the synantropic species *Oxychilus draparnaudi* or mollusc weeds as *Trichia hispida* and *Cochlicopa lubrica* prefer castles in good repair. It seems that beech is a substitute variable, which is positively correlated with woodland species and negatively correlated with species of open habitat and mollusc weeds. Open-ground species stand up better to isolation (isol) than woodland and hygrophilous ones.

We were interested in indicator species of particular environmental variables. The constrained RDA method was used to show paired correlations of species and environmental variables: The most important indicator species of the oreophyticum in castles is *Discus ruderatus*, of the mesophyticum *Oxychilus cellarius* and of the termophyticum *O. draparnaudi*. The occurrence of the small species *Pupilla muscorum* and *Truncatellina cylindrica* in small patches on the edges of walls correlates with isolated castles. The woodland species *Helicodonta obvoluta* and *Daudebardia rufa* prefer desolated castles, the species of the initial stages of succession (*Cochlicopa lubrica* and *Punctum pygmaeum*) and species of open habitats prefer castles in good repair. The species *Pupilla muscorum* and *Trichia hispida* prefer high attendance, but there are no species whose occurrence would correlate with the low attendance of a castle. All responsive forest species, except for the anthropophilous *Monachoides incarnates*, are not to be considered indicators of the forest in castles.

Discussion

Two castles showed a very high species diversity – Oheb near the Seč Dam and Hláska near the Sázava River were both examined in detail in the past (Culek, 1944; Jandečka, 1935). We revisited them after more than 50 years. The malacocenoses of both localities are still very diverse and relatively similar as in the past (with most of the indicator species present). Many castles were examined in the past by non-quantitative methods. If we compare these old data with our present data by means of the presence or absence of indicator species, we can observe no important changes.

Two castles – Sion near Kutná Hora and Vízmburk near Trutnov – were completely excavated 40 and 30 years ago. We can therefore observe the succession in these localities. In the Sion castle there now live 32 species (species isolated in this locality are *Helicodonta obvoluta* and *Causa holosericea)*. The 12 species living in Vízmburk is also a relatively high number in view of the fact that this castle lies completely isolated in a spruce monoculture. These castles are an indirect evidence of the long–range transport of snails by birds and other animals.

The castles are situated in the landscape at selected places. This is why their situation is coincided with ecological phenomena. Species of habitats, which were present in the surrounding landscape, occurred in the castles thanks to this fact. The ecological phenomenon results from a specific complex of processes and habitats with characteristic fauna and flora reflecting the geological and geomorphological conditions that are very different from the local landscape matrix (Ložek, 1988, 1994b). However the environmental conditions of the castle ruins may also be considered an ecological phenomenon. It is a complex of man-made habitats, which is also very different from those of the surrounding landscape. For this reason, the castle ruins represent islands of very high habitat diversity, which considerably increase the species richness of the landscape in question.

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