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International journal for Ecological Problems of the Biosphere

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...árodný časopis pre ekologické problémy biosféry, ročník 20, 3/2001. Vydáva Ústav
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# ROMAN SNAIL (*Helix pomatia* L.) – CONSERVATION AND MANAGEMENT IN THE MAŁOPOLSKA REGION (SOUTHERN POLAND)


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Abstract

Dyduch-Falniowska A., Makomaska-Juchiewicz M., Perzanowska-Sucharska J., Tworek S., Zając K.: Roman snail (*Helix pomatia* L.) – conservation and management in the Małopolska region (southern Poland). Ekológia (Bratislava), Vol. 20, No. 3, 265-283, 2001.

The distribution and habitat preferences of the Roman snail (*Helix pomatia* L.) were studied in the region of Małopolska in 1997-1999. Cluster analysis was used to determine a relationship between the occurrence of snails and different habitat parameters such as habitat type, its naturalness, humidity, plant cover and soil type as well as landscape patchiness. It has been found that the species occurred most abundantly in anthropogenic habitats situated in areas of high landscape patchiness. Morphometric measurements have shown that individuals from sub-urban areas are smaller and that there is certain relationship between the shape of the shell and habitat humidity. They have also indicated a need to verify a size limit for snails collected for economic purposes. The results obtained will be used as a basis for the regional strategy of the Roman snail population management.


## Introduction

The Roman snail (*Helix pomatia* L.) is a central and East-European species, which occurs all over Poland from the Baltic Coast to lower situations in the mountains. It has been accepted that the southern part of the country belongs rather to the natural range of the species. Development of settlement, accompanying by deforestation of the country and breeding of Roman snails for culinary purposes, contributed to a considerable increase of its range in Poland.

*H. pomatia* is a species of open or semi-open areas (e.g. ecotone habitats). In addition to sites of natural and semi-natural character, as forest margins, riparian forests, xerothermic grassland, brushwood and meadows in river valleys and around water bodies, the Roman snail inhabits anthropogenic sites: urban parks, orchards, gardens, cemeteries, roadsides, railway embankments, neighbourhood of rubbish heaps and different pieces of waste land, overgrown with ruderal vegetation, often in the vicinity of buildings (Stępczak, 1976).

*Helix pomatia* L. is a species of certain economic value in Poland. Human pressure on its populations varies depending on a region of the country. On account of the unstable character and often small area of the Roman snail biotopes, and the insular character of species occurrence, its exploitation should be well-considered subject to management measures. This concerns particularly sub-montane areas.

The Roman snail has been exploited in Poland for over 40 years (Urbański et al., 1983). The extent of its take has been established individually for each region, usually without assessing the regeneration ability of the population. After the market conditions were established in the Polish economy in the nineties, the interest in exploitation of the Roman snail increased, which posed a serious threat to its populations. Intensification of building-up the new areas (particularly suburban) and changes in land use add to this threat. Floods of July 1997 and 1998 were other factors, which could strongly influence the present state of population. They certainly entailed high losses among Roman snails living in river valleys.

Following the ratification of the Bern Convention by Poland the Roman snail had been given species protection in our country (Decree of the Ministry of Environmental Protection, Natural Resources and Forestry of 6 January 1995; Dz. U. No. 13, p. 65). However, the decree allows collecting the snail in the period 1-31 May, which means that the species is protected for almost the whole of the year, except for the breeding period. In this way the recommendation of Bern Convention to provide the species a kind of protection was realised (Annex 3 of Bern Convention – Protected animal species).

In view of the above threats and valid legal acts there is a need to formulate principles of exploitation and conservation of the species. Conditions of the take should guarantee the continuity of Roman snail exploitation and maintenance of the stable population (without disturbing the breeding stock). To define these conditions, the better knowledge of the ecology of *Helix pomatia* in unstable habitats in view of quick landscape alterations is needed. Well organised monitoring of the population is also indispensable.

The present research, carried out in the region of Małopolska (southern Poland), was aimed to formulate general principles of the optimisation of *H. pomatia* exploitation, as based on the simplest habitat and population parameters. It covered:

- description of the present distribution of population in the Małopolska
- identification of preferred habitats
- assessment of the dependence of *H. pomatia* occurrence on the patchiness of landscape
- estimation of demographic parameters of the population.



## Study area and methods

Fig. 1. The study region – Małopolska.

Research was conducted in April-September (most intensively in May) in 1997-1999. The study region – Małopolska – is situated in the south part of Poland (Fig. 1) and it comprises part the Carpathians (with the Tatras, Pieniny Mts, Beskid Sądecki Mts) and its Foreland, covering in total about 15,070 km$^2$, including c. 28.5% of forests and c. 60% of agricultural land. The biodiversity of the region is relatively high and has been confirmed by 93 CORINE sites (Dyduch-Falniowska et al., 1999a).

One hundred randomly selected sites, 2 x 2 km, were examined for snails. Each site was searched for 1 hour by four researchers. The animals collected were counted, and next the height and width of the shells of all or, at least 30 individuals, were measured using a slide caliper with 0.01 cm accuracy. Each site was described according to the adopted scheme:

- location (with geographical co-ordinates),
- class of abundance of the individuals collected :
  - absent (0 ind.)
  - scarce (1-5 ind.)
  - not numerous (6-15 ind.)
  - fairly numerous (16-40 ind.)
  - numerous (> 40 ind.)
- habitat (with regard to the relief of the area and type of land use):
  - roadsides, escarpments, flood-embankments
  - neighbourhood of buildings and rubbish heaps
  - screes and ruins
  - old parks and cemeteries
  - orchards, coppices and woodlots
  - arable fields
  - meadows and grassland
  - shrubby vegetation lining water courses and water bodies
  - forests
- degree of habitat naturalness:
  - natural
  - semi-natural
  - anthropogenic
- degree of habitat humidity:
  - dry
  - moderately humid
  - humid
- patchiness of the landscape in the vicinity of a site (within a radius of 1 km):
  - small
  - moderate
  - high
- soil type (as based on observation and a soil map scaled 1:300 000):
  - rendzinas
  - alluvial soils
  - podsolic and brown soils on sand and clay
  - podsolic and brown soils on loess
  - initial (of different origin)

➤ vegetation (with identification of dominating plant species and, if possible, higher phytosociological units (class, order, alliance).

All characteristics (habitat, soil type, naturalness of habitat, patchiness of landscape, class of snail numbers etc.) were described in a binary way: "1" if a given character was present and "0" when absent. The data prepared in this way was next processed using cluster analysis to recognise relationships between the variables examined. Ward's method for joining was applied and Euclidean distance was used as a measure of distance. The analysis was successively performed for all variables (characters), for all variables except for soil type and for particular cases (sites).

For the groups of sites distinguished by joining the cluster analysis was performed to make the interpretation of their connections with habitat characters and snail abundance, easier. A significance of differences between the numbers of snails collected on sites belonging to separate groups were examined using analysis of variance (ANOVA) and the least significant difference test (Hays, 1988).

Using Gamma statistic we established the correlation of shell dimensions (height, width) and a shell slenderness index (width/height) in particular sites with the distinguished types of habitats and degree of their naturalness, soil type, patchiness of landscape and humidity of habitat.

A significance of differences in the width, height and a shell slenderness index between the groups of sites was examined using Scheffé test in analysis of variance (Hays, 1988).

For the detailed morphometric analysis of *H. pomatia* shells, three sites where the species occurred fairly numerously or numerously were selected. These were: environs of the ruins of a castle in Rudno where the snails are not collected for commercial purposes (site Rudno), a mosaic of the unstable anthropogenic habitats in the sub-urban area of Kraków (Mydlniki) and a quasi-natural riparian forest in the Łososina River valley (Młynne). Only individuals with a shell diameter larger than 3 cm (i.e. "commercial-sized" individuals) were taken into account. A significance of differences in shell dimensions between selected sites was determined using Scheffé test for multiple *post hoc* comparisons in analysis of variance (ANOVA).

## Results

### *Distribution and abundance of the Roman snail*

The presence of *H. pomatia* was found in 76 of the 100 investigated sites. Scarce occurrence of the species (1-5 ind.) was noted in 15% of the sites, not numerous (6-15 ind.) in 25% of the sites, fairly numerous (16-40 ind.) in 26% of the sites, and numerous (>40 ind.) in 10% of the sites. Sites without snails concentrate mainly in the north-western and central-eastern parts of the region, while the most abundant sites in snails are scattered over the northern and central parts of the province (Fig. 2).

### *Phytosociological characteristics of H. pomatia habitats*

The Roman snail habitats were, for the most part, strongly disturbed by human activity; plant communities occurred in a fragmentary form, or showed a high share of alien species. Vegetation was often represented by patches dominated by one species, e.g. *Erigeron canadensis*. Some habitats constituted a mosaic of patches of different character, for example in river valleys the willow-poplar galleries *Salici-Populetum* were accompanied by edge communities of the alliance *Convolvulion sepium*. Gravel banks were overgrown by the association *Petasitetum hybridi* or patches of the tall-forb communities *Rudbeckio-Solidaginetum* dominated usually by one of characteristic species, most often by *Solidago gigantea*. On silt-covered ground terophyte communities of the class *Bidentetea tripartiti* occurred.



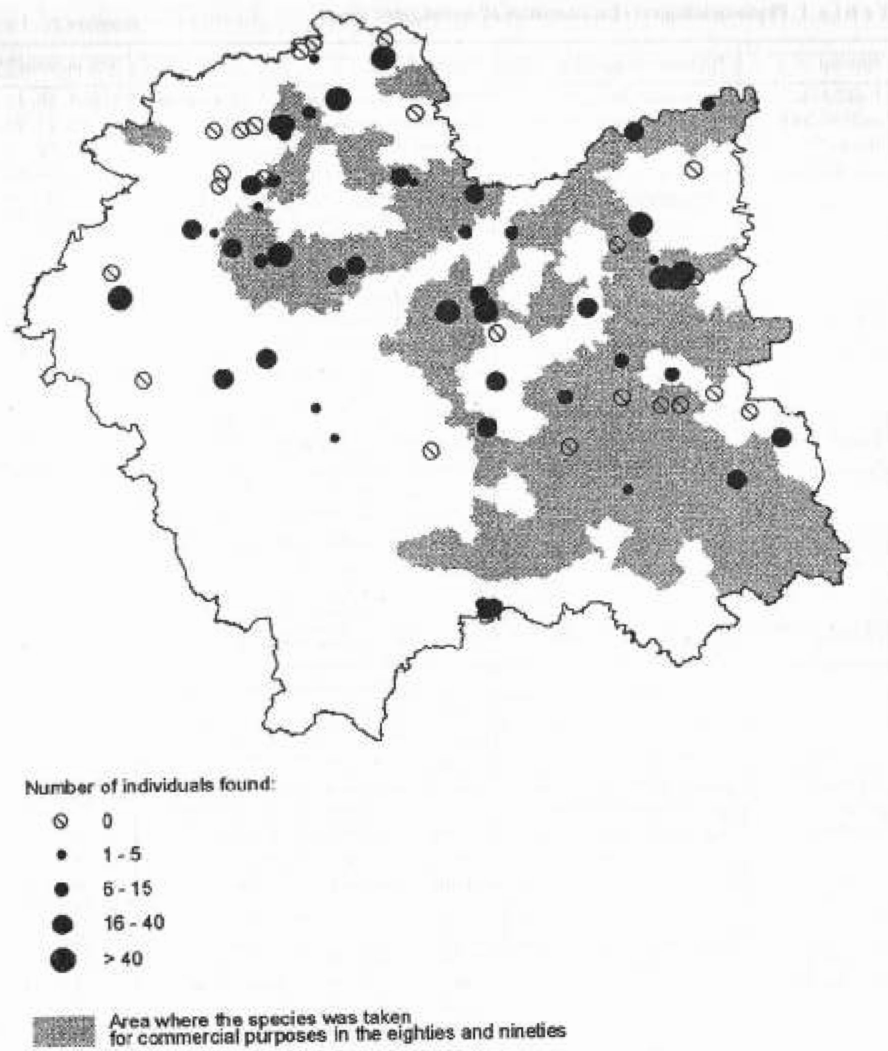


Fig. 2. Distribution of *Helix pomatia* in the Małopolska region.

Particular sites were usually described using phytosociological units of higher order: class, alliance or order. Identifying an association was possible only in few cases (Table 1). Most of the *H. pomatia* sites were located in patches of communities belonging to the class *Artemisietea vulgaris*. It comprises communities of nitrophilous perennials and biennials overgrowing ruderal habitats (roadside escarpments and ditches, rubble heaps, neigh-

T a b l e 1. Phytosociological characteristics of investigated sites

| Habitat | Phytosociological units* | Plants** | Site number*** |
|---|---|---|---|
| Roadsides, escarpments, flood-embankments | *Artemisietea vulgaris, Aegopodion podagrariae, Aegopodio-Geranietum pratensis, Chenopodietea* | *Aegopodium podagraria, Arctium lappa, Artemisia vulgaris, Capsella bursa-pastoris, Chaerophyllum aromaticum, Chelidonium majus, Dactylis glomerata, Galium aparine, Geranium pratense, Lamium album, Prunus spinosa, Ranunculus repens, Rubus caesius, Sambucus nigra, Taraxacum officinale, Tussilago farfara, Urtica dioica* | 1, 3, 4, 10, 11, 13, 14, 15, 21, 25, 29, 28, 30, 32, 35, 37, 43, 45, 49, 54, 56, 60, 61, 62, 64, 65, 66, 69, 71, 72, 74, 78, 80, 82, 84, 86, 92, 97 |
| Built-up areas, rubbish heaps | *Artemisietea vulgaris, Chenopodietea* | *Aegopodium podagraria , Artemisia vulgaris, Chaerophyllum aromaticum, Chelidonium majus, Erigeron canadensis, Malva neglecta, Sambucus nigra, Urtica dioica* | 1, 6, 21, 50, 51, 56, 66, 69, 71, 73, 76, 79, 80, 85, 86, 89, 90, 93, 94, 95, 96, 99, 100 |
| Rocky debris, ruins | *Festuco-Brometea, Aegopodion podagrariae* | *Aegopodium podagraria, Anthriscus sylvestris, Clinopodium vulgare, Cornus sanguinea, Coronilla varia, Galium aparine, Glechoma hederacea, Jovibarba sobolifera, Origanum vulgare, Rubus caesius, R. idaeus, Sambucus nigra, Sedum maximum, Taraxacum officinale, Urtica dioica* | 2, 5, 6, 7, 8, 23, 24, 26, 36, 41, 42, 43, 46, 53, 68, 75, 77, 83, 89 |
| Old parks, cemeteries | *Artemisietea vulgaris* | *Aegopodium podagraria, Angelica sylvestris, Arctium lappa, Chaerophyllum aromaticum, Dactylis glomerata, Galium aparine, Rubus caesius, Rumex obtusifolius, Solidago gigantea, Urtica dioica* | 1, 15, 17, 19, 37, 38, 40, 52, 62, 67, 69, 79, 86, 87, 90, 92, 93, 95 |
| Orchards, coppices, woodlots | *Rhamno-Prunetea, Artemisietea vulgaris, Aegopodion podagrariae, Urtico-Aegopodietum* | *Aegopodium podagraria, Cornus sanguinea, Lamium maculatum, Padus avium, Prunus spinosa, Robinia pseudaccacia, Salix fragilis, S. alba, Sambucus nigra, Urtica dioica* | 3, 10, 14, 20, 24, 27, 33, 41, 44, 47, 49, 53, 56, 57, 58, 59, 61, 72, 73, 74, 75, 76, 77, 78, 81, 84, 89, 90, 92, 93, 94, 96, 97, 98 |
| Meadows, grasslands | *Molinio-Arrhenatheretea* | *Achillea millefolium, Alopecurus pratensis, Dactylis glomerata, Geranium pratense, Lotus corniculatus, Poa pratensis, Taraxacum officinale, Trifolium pratense* | 8, 10, 22, 25, 30, 31, 32, 34, 41, 44, 48, 55, 57, 58, 62, 63, 65, 66, 67, 68, 70, 81, 82, 83, 84, 85, 88, 89, 90, 91, 92, 93 |
| Waterside vegetation | *Salicetea purpureae, Salici-Populetum, Convolvulion sepium, Petasitetum hybridi, Bidentetea tripartiti* | *Aegopodium podagraria, Alnus glutinosa, Antriscus sylvestris, Barbarea vulgaris, Calystegia sepium, Euonymus europaea, Fraxinus excelsior, Festuca gigantea, Humulus lupulus, Padus avium, Rorippa palustris, Rubus caesius, Sambucus nigra, Solanum dulcamara, Solidago canadensis, Salix alba, S. fragilis, S. viminalis, S. purpurea, Tanacetum vulgare, Urtica dioica* | 2, 4, 7, 8, 10, 11, 13, 14, 18, 22, 30, 44, 46, 47, 49, 53, 54, 55, 57, 58, 59, 60, 63, 72, 73, 74, 75, 76, 82, 90, 95, 97, 99 |



T a b l e 1. (Continue)

| | | | |
|---|---|---|---|
| Forests | *Carpinion betuli, Tilio-Carpinetum, Alno-Padion* | *Acer pseudoplatanus, Carpinus betulus, Fraxinus excelsior, Padus avium, Quercus robur, Tilia cordata, Ulmus laevis, Ulmus scabra* | 2, 5, 7, 8, 9, 11, 12, 28, 29, 30, 31, 38, 43, 50, 64, 67, 70, 88, 89, 90, 91, 92, 93 |

* Patches of vegetation on particular sites were classified among phytosociological units of different rank
** The species mentioned are characteristic of phytosociological units or co-dominating in patches of communities on particular sites
*** The list of sites is given in Appendix

bourhood of rubbish heaps, cemeteries etc.) and tall-forb edge communities from the ecotonal zone between forest or brushwood and open area. On old rubble heaps, in stone quarries and young forest plantations Roman snails were observed in brushwood of the alliance *Sambuco-Salicion* belonging to the class *Rhamno-Prunetea*.

Roman snails frequently occurred in communities of the class *Chenopodietea,* and especially of the alliance *Sisymbrion,* which occur on diverse substratum, on underdeveloped, poor in humus, soils and constitute pioneer stages of succession on ruderal areas. This vegetation was represented, among others, by such associations as *Senecioni-Tussilaginetum* overgrowing rubble heaps mixed with soil, slopes of clayey excavations or escarpments, or *Urtico-Malvetum neglectae* common at fences, cottages and other places rich in ammonium compounds.

Roman snails occurred also on grassland of the class *Festuco-Brometea* developing on scree and rocky debris, and sporadically on meadows of the class *Molinio-Arrhenatheretea.* Fairly numerous they were in riparian forests of the alliance *Alno-Padion,* and single specimens were found in forest clearing and on forest roads which cut oak-lime-hornbeam stands of *Tilio-Carpinetum.*

Roman snails were not observed in forest communities of the alliance *Dicrano-Pinion* overgrowing sandy soils in the north-western part of Małopolska, as well as in arable fields in communities of the classes *Secalietea* and *Chenopodietea*.

*Presence of Roman snails and habitat characters*

The connection of *H. pomatia* occurrence with habitat characters was examined using cluster analysis for all variables and abundance classes (Fig. 3). Clustering joined the absence of snails with forests, areas of small patchiness and with leached and brown soils on sand and clay. Sites where snails were most numerous were characterised by the presence of buildings, rubbish heaps, old parks, cemeteries and arable fields on limestone rendzinas. Of the remaining classes of abundance, category "scarce" is connected mostly with natural habitats with rocky debris and ruins of average patchiness of landscape, and category "not numerous" with grassland communities on initial soils. Slightly more numerous were Roman snails in anthropogenic habitat and less so in semi-natural habitats in landscape of high patchiness on soils on loess.

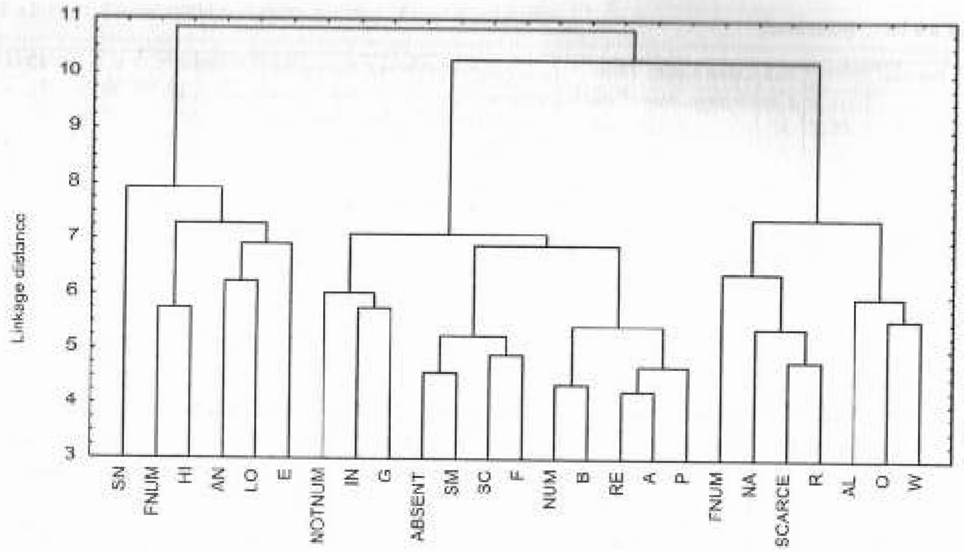


Fig. 3. Cluster analysis for all variables and classes of numerical force. Habitat types: W – waterside, E – roadside, escarpments, flood-embankments, P – old parks, cemeteries, F – forests, O – orchards, coppices, woodlots, B – neighbourhood of buildings and rubbish heaps, R – rocky debris, ruins, A – arable fields, G – grassy habitats; patchiness: SM – small, MO – moderate, HI – high; degree of habitat naturalness: NA – natural, SN – semi-natural, AN – anthropogenic; soil type: AL – alluvial soils, RE – rendzinas, SC – leached and brown soil on sand and clay, LO – leached and brown soil on loess, IN -initial soils; classes of abundance: ABSENT (0 ind.), SCARCE (1-5 ind.), NOTNUM (6-15 ind.), FNUM (16-40 ind.), NUM (> 40 ind.).

When soil type was neglected, connections between the variables became clearer (Fig. 4). The highest classes of abundance (in the central part of the dendrogram) joined anthropogenic habitats in the vicinity of buildings (rubbish heaps, old parks, cemeteries) with high patchiness of landscape. Scarce occurrence of *H. pomatia* was connected with average patchiness of landscape and simultaneously, with natural habitats, especially mountain ones (rocky debris) and less so with woodlots, orchards, coppices and alluvial brush. In the same part of dendrogram there is class "not numerous" linked mostly with semi-natural habitats, particularly on escarpments, roadsides and flood-embankments. The absence of Roman snails is connected with a variety of habitats (forests, arable fields, meadows and grassland) whose common feature is location in landscape of small patchiness and these variables are most distant from the others on the tree diagram (Fig. 4).

### *Habitat preferences of the Roman snail*

Cluster analysis for cases divides all sites into three distinct groups which comprise successively 44, 30 and 26 sites, and the average number of snails per site in each group is 26.2,



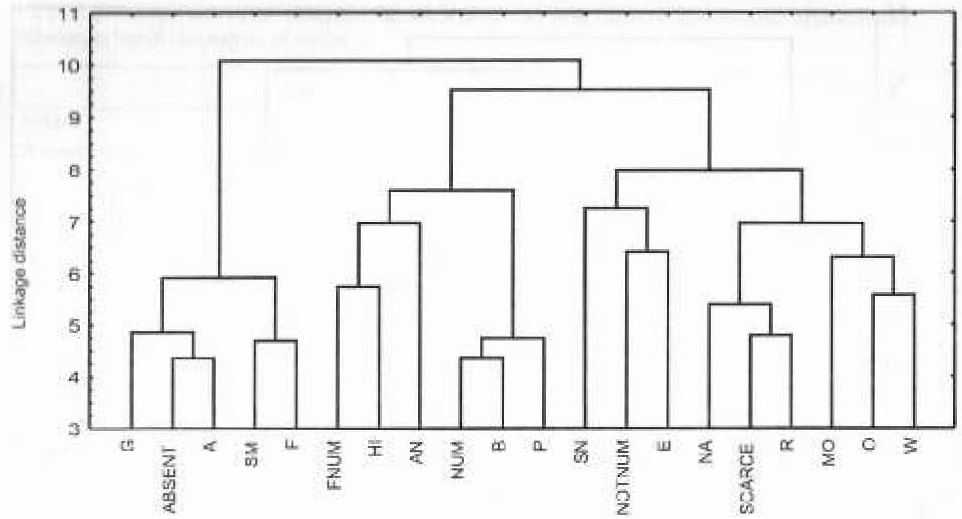


Fig. 4. Cluster analysis for variables describing habitat character (except for soil type). Explanation for abbreviations as in Fig. 3.

23.3 and 3.3 individuals, respectively (Table 2). Dendrogram of relationships for examined variables and classes of abundance shows that sites with the highest average number of snails (group I) were situated in landscape of high patchiness and habitats mostly of anthropogenic character and moderate humidity of substratum (Fig. 5). Sites of group II are linked by average patchiness of landscape. This group comprises a wide spectrum of mostly moist habitats, mainly natural and semi-natural, from non-forest (rocky debris, ruins) through different types of brushwood to forest ones. Sites of group III are connected with dry habitats. A common feature of this group is also a small patchiness of landscape. This group comprises a variety of habitats: arable fields, forests, meadows and grasslands. In most of these sites no Roman snails were found (see Appendix, Fig. 5). Analysis of variance for the

T a b l e 2. Differences in numbers of the snails collected for the groups of sites

| | Group I | Group II | Group III |
|---|---|---|---|
| Number of sites in a group | 44 | 30 | 26 |
| Average [ind./site] | 26.2 | 23.2 | 3.3 |
| Group I | × | n.s. | <0.01 |
| Group II | n.s. | × | <0.05 |
| Group III | <0.001 | <0.05 | × |

ANOVA, n.s. – statistically not significant differences

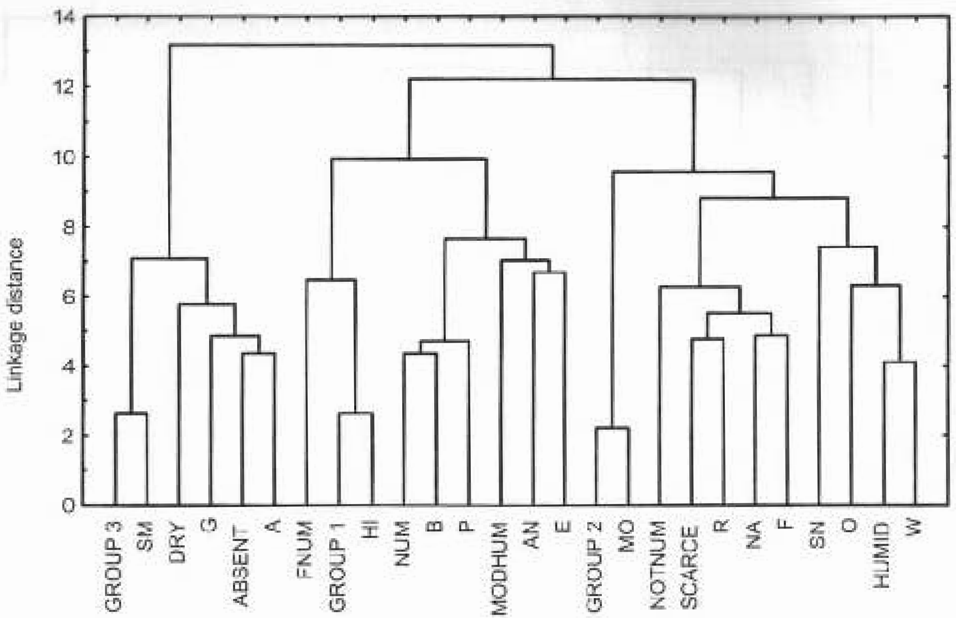


Fig. 5. Cluster analysis for groups of species, classes of numerical force and variables describing habitat character. Degree of habitat humidity: dry, modhum = moderately humid, humid. Other explanations as in Fig. 3.

abundance of snails collected in a site, with division into groups, shows that sites of group III harboured significantly less snails than sites of groups I and II ($p<0.05$; Table 2).

*Morphometric analysis of "commercial-sized" snails*

The average shell dimensions of "commercial-sized" Roman snails were: width – 39.6 mm (mediana 39.9) and height – 37.9 mm (mediana 38.1). Of the three sites chosen for detailed morphometric analysis, the snails collected in the Łososina River valley (Młynne) had the greatest shell width (43.3 mm) and those from the environs of Rudno castle the greatest shell height (45.4 mm). The smallest dimensions (35.5×33.2 mm) characterised the shells of Roman snails from the sub-urban areas of Kraków. All results of multiple comparisons are statistically significant (ANOVA, $p<0.001$), except for the correlation between shell widths in sites Rudno and Młynne ($p>0.05$, Table 3).

*Shell size and habitat characters*

Few significant correlations between shell size in *H. pomatia* and the habitat types distinguished, their humidity, degree of naturalness, soil type and landscape patchiness was shown



Table 3. Comparison of the width and the height of Roman snail shells on sites: Rudno, Mydlniki and Młynne, as based on analysis of variance

| | Site | Rudno | Mydlniki | Młynne |
|---|---|---|---|---|
| **Width** Average [mm] | | 41.2 | 35.5 | 43.3 |
| | Rudno | × | <0.0001 | n.s. |
| | Mydlniki | <0.0001 | × | <0.0001 |
| | Młynne | n.s. | <0.0001 | × |
| **Height** Average [mm] | | 45.4 | 33.2 | 41.2 |
| | Rudno | × | <0.0001 | <0.001 |
| | Mydlniki | <0.0001 | × | <0.0001 |
| | Młynne | <0.001 | <0.0001 | × |

n.s. = statistically not significant differences

(Table 4). The positive correlation for shell size was found with the variable "natural habitats" and negative with "built-up areas and rubbish heaps" and for shell width only – with "anthropo-

Table 4. Gamma statistics of Roman snail shell dimensions with variables describing habitat and landscape

| Variable | Height | Width | Width/height |
|---|---|---|---|
| W | 0.0471 | 0.0389 | -0.1365 |
| E | -0.0688 | -0.0996 | -0.0221 |
| P | -0.4091 | -0.4364 | -0.1545 |
| F | 0.1618 | 0.0565 | -0.4020* |
| O | -0.0604 | -0.0145 | 0.1473 |
| B | -0.4000* | -0.3778* | 0.0844 |
| R | 0.0952 | 0.1192 | 0.1270 |
| A | – | – | – |
| G | -0.0041 | 0.1002 | 0.3225 |
| AL | -0.1682 | -0.1557 | -0.0853 |
| RE | -0.0702 | -0.0797 | -0.2456 |
| SC | -0.1132 | -0.3691 | -0.7484* |
| LO | -0.0821 | -0.0048 | 0.3816* |
| IN | 0.1912 | 0.1961 | 0.0245 |
| NA | 0.3278* | 0.3478* | 0.1036 |
| SN | 0.0277 | 0.0806 | -0.0230 |
| AN | -0.2282 | -0.3153* | -0.0306 |
| SM | 0.0816 | 0.0102 | -0.3306 |
| MO | 0.1211 | 0.0909 | -0.0895 |
| III | -0.1517 | -0.0851 | 0.2644 |
| DRY | -0.1241 | -0.1154 | 0.3014 |
| MOHUM | -0.1313 | -0.1603 | -0.1866 |
| HUMID | 0.1377 | 0.1681 | -0.0483 |

* = statistically significant correlations, abbreviations for variables as in Fig. 3

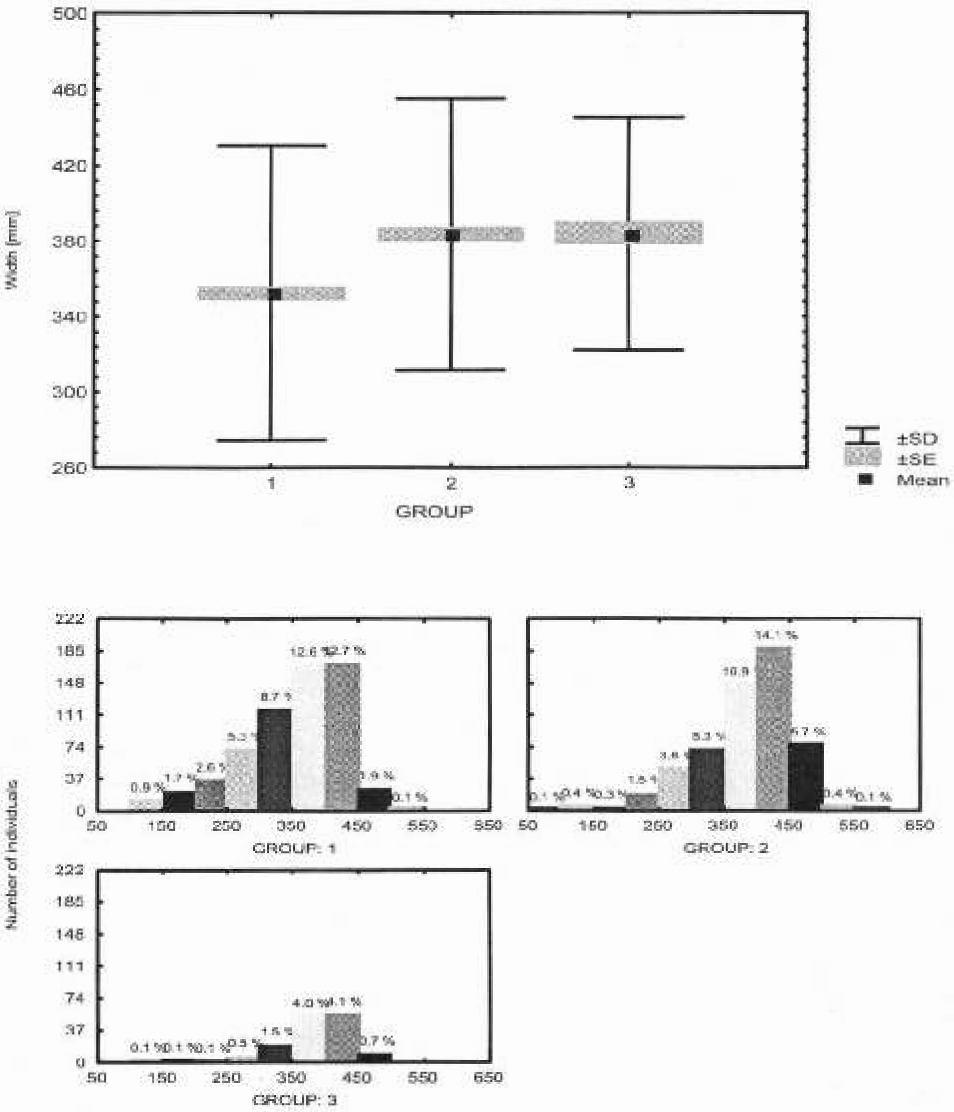


Fig. 6. Roman snail shell width and histograms of distribution for three groups of sites.

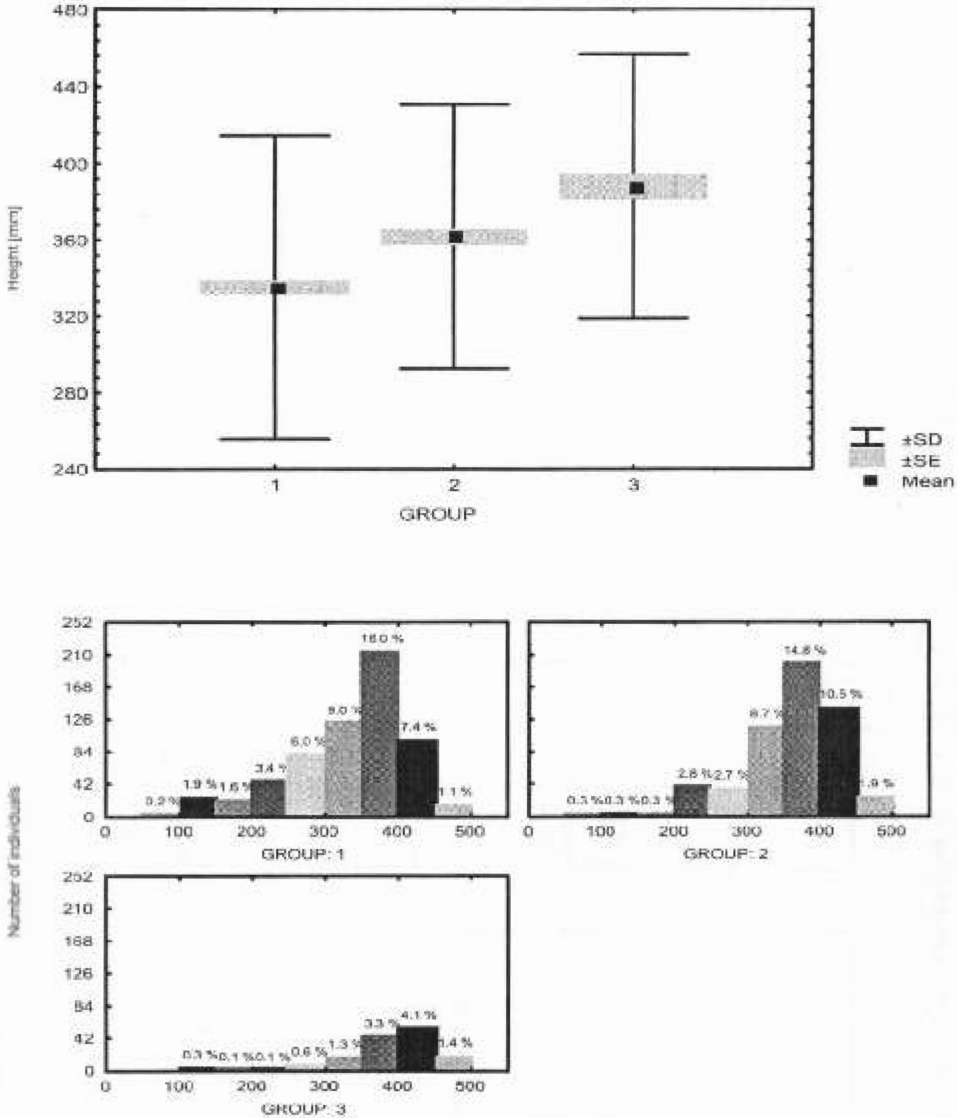


Fig. 7. Roman snail shell height and histograms of distribution for three groups of sites.

genic habitats". The shell slenderness coefficient is negatively correlated with leached and brown soils on sand and clay and "forests" and positively with leached and brown soils on loess.

The average values of shell width for sites belonging to groups II and III are almost the same (Fig. 6). This value is significantly lower for sites of group I (ANOVA, $p<0.0001$).

The shell height on sites belonging to separate groups is greatly varied. It is the least for group I, and the highest for group III (Fig. 7). All these differences are statistically significant (ANOVA, $p<0.001$). The shell slenderness coefficient for snails belonging to groups

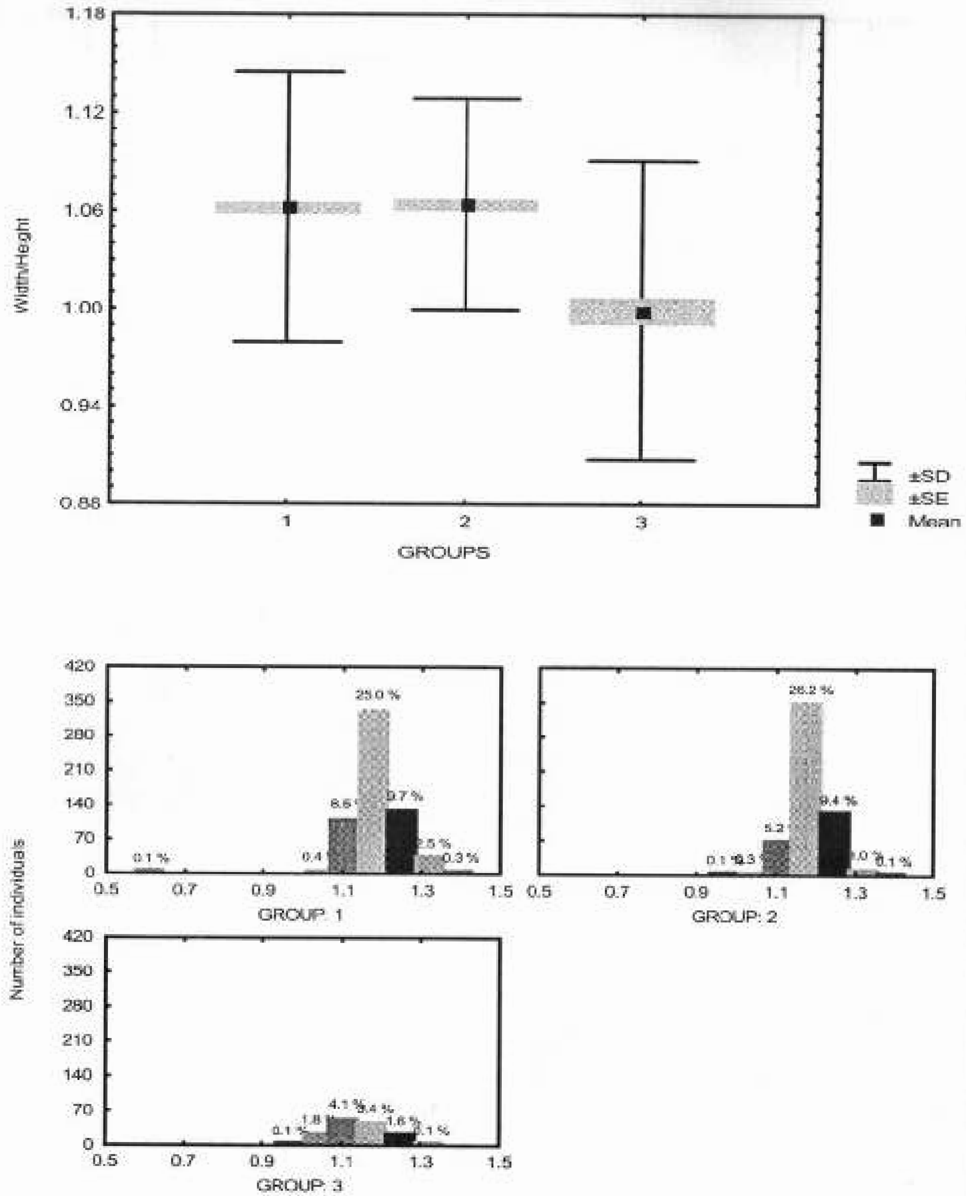


Fig. 8. Shell slenderness coefficient and histograms of distribution for three groups of sites.



I and II have a similar value (Fig. 8), while in group III it is significantly lower than in the remaining groups (ANOVA, p<0.0001).

## Discussion

### *Occurrence of Helix pomatia in Małopolska*

The majority of *H. pomatia* sites are located in the northern and central part of Małopolska (Fig. 2). The sub-montane areas of the Carpathians lie on the limit of ecological range of the species, as already mentioned by Urbański (1963), and in the very mountains the Roman snail does not occur, except for the Pieniny Mountains. It appears there quite numerously, most probably thanks to the specific microclimate of these mountains, warmer and drier than in adjacent ranges and limestone substratum. Sites with Roman snails were situated mostly within the area where the species was taken for commercial purposes in the eighties and nineties (Fig. 2).

### *Numbers of H. pomatia and habitat characters*

The univocal interpretion of the results of clustering for the variables describing sites and classes of abundance is difficult. The highest category of *H. pomatia* numbers (numerous) is in the same part of the dendrogram as categories "absent" and "not numerous" (Fig. 3). Neglecting difficult to explain random factors, one may look for causes of such a distribution of variables in their inappropriate selection and categorisation. One should remember that cluster analysis is not a typical statistical test but a set of different algorithms which – to simplify – shows the most significant possible arrangement of variables (without testing this significance). The results obtained inform only about a general character of connections. To examine the effect of particular variables on the occurrence of *H. pomatia*, further analyses are needed, using more refined statistical measures (i.e. principal component analysis, regression techniques). However, they need more detailed parameters of habitats than only simple characteristics, which we could find for large areas.

Selection of variables for analysis is probably of key importance, all the more so as there are sites where habitat conditions seem to be suitable for *H. pomatia* and not any has been found. Pilot observations indicated that habitat quality could be of decisive importance for the Roman snail that is why we made a wide selection of variables describing its characters, including landscape patchiness which is interesting in the context of adaptations of species to changes occurring in the environment.

Categorisation of variables presented difficulties, which concerned their transformation in such a way so that qualitative characters could be treated as quantitative ones. It has been accepted that a binary (0-1) mode of the description of variables is burdened with a relatively small error. The presence of Roman snails in strongly transformed habitats (roadside ditches, rubbish heaps) where only fragmentary plant communities (often of an unidentifiable systematic status) develop at the utmost, suggested that the species is confined rather to food plants than to specific associations. That is why the authors gave up making phytosociological records.

Observations showed that of all habitat characters that were taken into account, soil type had the least effect on the differentiation of *H. pomatia* occurrence. The dependence of the species on this habitat character may be indirect through, for example, vegetation characteristic of a given soil type. A too generalised division into soil types, adopted in this work, could also be a possible source of error. One may suppose that direct identification of a soil type in the field might have yielded more reliable results. When in further analysis soil type was neglected, clustering showed a positive correlation of *H. pomatia* abundance with anthropogenic habitats (particularly old parks, cemeteries, rubbish heaps) and high landscape patchiness and negative, with arable fields, meadows and forests and small landscape patchiness (see Fig. 4). Observation in the field indicated that in case of forests snails occurred mainly on their margins or along forest roads, or cuttings. On one hand this may suggest a positive effect of forest fragmentation on the occurrence of Roman snail and on the other hand, that extension of the area of arable land conduces to unfavourable changes in its populations.

Cluster analysis for groups of sites, classes of abundance and variables describing the habitat shows the correlation of the occurrence of *H. pomatia* with habitat humidity (Fig. 5). The species was absent in the majority of dry sites and it was more numerous in sites of moderate humidity than in the most humid sites. This confirms the correlation of Roman snail occurrence with humidity that was observed in detailed way by Łomnicki (1971).

### *Size of individuals*

A morphometric analysis of "commercial-sized" (more than 30 mm) individuals from three sites suggests that Roman snail populations in sub-urban areas may be threatened by over-exploitation because of gathering mature specimens from population. According to information based on the inquiry in stations purchasing snails, most of the delivered animals were collected in such areas. In places where snails are not collected (Młynne, Rudno) the average dimensions of snail shells were significantly higher (Table 3). Lessening of the average shell size in the population may be dangerous and cause a decrease in the population of Roman snail in Małopolska and even a decline of the species in some areas. Thus it would be advisable to increase the conservation size limit for *H. pomatia* from 30 mm to 35 mm, as it was already proposed (Urbański, 1963; Łomnicki, 1971; Dyduch-Falniowska et al., 1999b), or even more in the region under studies (i. g. the average size of *H. pomatia* in northern Poland is smaller (Stępczak, 1976).

A significance of differences in the width and height of Roman snail shells between the groups of sites suggests that the smaller shell size is connected with high landscape patchiness and areas in the vicinity of buildings (old parks, cemeteries, rubbish heaps, escarpments, flooding embankments, roadsides). The result obtained may be an effect of exploitation, or higher mortality of snails in anthropogenic habitat (resulting for example from its persecution in allotments, all the more so as the species occurs more numerously in such sites – see Fig. 4) in comparison with natural habitats. A similar conclusion stems from the



Appendix

The list of investigated sites: I – site number, II – site name, III – number of individuals *H. pomatia* found, IV – group

| I | II | III | IV |
|---|---|---|---|
| 1 | Olszowa | 0 | I |
| 2 | Roztoka | 7 | III |
| 3 | Skamieniałe Miasto | 0 | II |
| 4 | Kąśna Góma | 0 | III |
| 5 | Gromnik | 8 | III |
| 6 | Komorów | 5 | I |
| 7 | Uście Solne | 8 | III |
| 8 | Rylowa | 1 | II |
| 9 | Brzeźnica | 0 | III |
| 10 | Głów-Gródek | 59 | II |
| 11 | Łenny Potok | 8 | III |
| 12 | Goła Góra | 6 | III |
| 13 | Książ Wielki 1 | 21 | I |
| 14 | Libusza 1 | 6 | II |
| 15 | Łąkta Góma 1 | 12 | I |
| 16 | Wytrzyszczka 1 | 7 | I |
| 17 | Bochnia 1 | 34 | I |
| 18 | Cikowice | 21 | I |
| 19 | Dębno | 24 | I |
| 20 | Cholerzyn 1 | 7 | II |
| 21 | Cholerzyn 2 | 4 | II |
| 22 | Cholerzyn 3 | 2 | II |
| 23 | Wąwóz Mnikowski 1 | 24 | II |
| 24 | Wąwóz Mnikowski 2 | 1 | II |
| 25 | Kopce | 3 | III |
| 26 | Rudno | 28 | I |
| 27 | Zator | 133 | II |
| 28 | Ispina | 11 | III |
| 29 | Lipówka | 1 | III |
| 30 | Pławowice | 28 | II |
| 31 | Smęgorzów | 0 | III |
| 32 | Szczucin | 10 | III |
| 33 | Samocice 1 | 21 | I |
| 34 | Sromowce | 0 | II |
| 35 | Miechów 1 | 28 | I |
| 36 | Miechów 2 | 14 | I |
| 37 | Parcele-Unicjów | 2 | III |
| 38 | Kępie | 0 | III |
| 39 | Kwiatówka | 0 | III |
| 40 | Książ Wielki 2 | 41 | II |
| 41 | Racławice | 0 | III |
| 42 | Jerzmanowice | 18 | I |
| 43 | Mętków | 0 | III |
| 44 | Samocice 2 | 2 | I |
| 45 | Mydlniki 1 | 76 | I |
| 46 | Biertowice | 39 | I |
| 47 | Kalwaria Zeb.1 | 35 | I |
| 48 | Chocznia | 0 | III |
| 49 | Łężkowice | 46 | II |
| 50 | Bochnia 2 | 184 | I |
| 51 | Bochnia 3 | 17 | I |
| 52 | Wiśnicz | 0 | II |
| 53 | Łąkta Góma 2 | 30 | I |
| 54 | Młynne | 21 | I |
| 55 | Dobra | 0 | III |
| 56 | Mydlniki 2 | 63 | I |
| 57 | Wytrzyszczka 2 | 6 | I |
| 58 | Tęgoborze | 0 | III |
| 59 | Paszyn | 1 | II |
| 60 | Szymbark | 19 | I |
| 61 | Libusza 2 | 25 | II |
| 62 | Rożnowice | 0 | I |
| 63 | Rzepiennik | 0 | I |
| 64 | Kraków 1 | 30 | I |
| 65 | Kraków 3 | 33 | I |
| 66 | Sąspów | 0 | III |
| 67 | Przeginia | 0 | III |
| 68 | Czubrowice | 0 | III |
| 69 | Braciejówka | 0 | III |
| 70 | Jangrot | 0 | III |
| 71 | Trzyciąż | 0 | III |
| 72 | Gołcza 1 | 15 | I |
| 73 | Niegardów | 34 | II |
| 74 | Piotrowice Małe | 4 | I |
| 75 | Pcim | 1 | II |
| 76 | Stróża | 4 | II |
| 77 | Trzy Korony | 17 | II |
| 78 | Miechów 3 | 16 | I |
| 79 | Miechow 4 | 200 | II |
| 80 | Kalwaria Zeb.2 | 8 | I |
| 81 | Kalwaria Zeb.3 | 11 | I |
| 82 | Mydlniki 3 | 10 | I |
| 83 | Mydlniki 4 | 9 | I |
| 84 | Kraków 2 | 8 | II |
| 85 | Gołcza 2 | 2 | I |
| 86 | Pogwizdów | 0 | II |
| 87 | Ostrzysz 1 | 38 | I |
| 88 | Dolina Bolechowicka | 5 | II |
| 89 | Grodzisko | 10 | I |
| 90 | Imbramowice | 9 | II |
| 91 | Ojców | 10 | II |
| 92 | Ostrzysz 2 | 22 | I |
| 93 | Ostrzysz 3 | 11 | I |
| 94 | Tarnów 1 | 23 | I |
| 95 | Tarnów 2 | 24 | I |
| 96 | Tarnów 3 | 50 | I |
| 97 | Tarnów 4 | 6 | II |
| 98 | Tarnów 5 | 100 | I |
| 99 | Tarnów 6 | 15 | I |
| 100 | Tarnów 7 | 0 | II |

analysis of histograms of the distribution of shell dimensions for the three groups of sites (Fig. 6 and 7). They are not symmetrical (skew on the right side), which can indicate that the age structure of *H. pomatia* population has not been shaped by natural factors.

The shell slenderness index (width/height), as independent from the age of an individual, has probably a greater diagnostic value reflecting a relationship between shell size and habitat characters. In this case the analysis of variance showed that correlation for groups is inverse than for each dimension separately: the lowest values characterised group III. Despite the insignificant correlation of the coefficient with habitat humidity (Table 4), a dendrogram illustrating the results of agglomeration of the groups of sites, classes of abundance and habitat variables (Fig. 5) indicates relationship between the shell shape and habitat humidity; shells were slenderer on dry sites. Histograms of the distribution of coefficient values for the three groups of sites have almost symmetrical normal distribution (Fig. 8), which confirms the hypothesis that the age structure of the population in the investigated area is influenced mainly by exploitation.

## Conclusions

I. Concerned with population characters:

1. It was found that 76% of the investigated sites in the region of Małopolska harboured *Helix pomatia*; on about 36% of the sites the snail was sufficiently numerous to be collected for commercial purposes (i.e. 1-hour search yielded a crop of at least 30 individuals).
2. The species occured more numerously in anthropogenic habitats (old parks, cemeteries, neighbourhood of rubbish heaps) in areas of high landscape patchiness than in arable fields, meadows, pastures, and forests in the landscape of small patchiness where it was scarce or absent.
3. Shell size in "commercial-sized" individuals varied significantly depending on the habitat character. The average width of shells in *H. pomatia* from Malopolska is 39.6 mm and the height, 37.9 mm. In built-up area the size of shells was smaller than in other habitat types.
4. The shape of shell is correlated with habitat humidity: *H. pomatia* shells are slenderer in dry habitats.
5. Collection of snails for commercial purposes significantly influences the age structure (distribution of size classes) of Roman snail population.

II. Concerning the strategy of Roman snail population management:

1. It is necessary to increase a conservation size limit for the Roman snail to 35 mm to prevent its over-exploitation. To establish precisely an average size of adult individuals in sub-montane areas, further studies are needed.
2. Management of the Roman snail population should be based on the principle that exploitation must not threaten regeneration abilities of the population. Taking into account the biology of the species, each 3-4 years a 1-year break in exploitation should be introduced to improve the demographic structure of the population. The shortening of the period of collection from one month to two weeks could be an alternative solution.



3. One may also suggest the limitation of exploitation to urban and sub-urban areas when the species occurs more numerously, with monitoring of the population structure, based on randomly taken samples. The species would not be collected in natural and semi-natural habitats where it is much less abundant.
4. Permanent monitoring of the species on selected sites, at two-year intervals for the first six years, should be introduced. Later on, this frequency would be diminished if the results of observation indicate the stability of population.

*Translated by M. Makomaska-Juchiewicz*

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Dyduch-Falniowska A., Makomaska-Juchiewicz M., Perzanowska-Sucharska J., Tworek S., Zając K.: **Slimák záhradný** (*Helix pomatia* L.) **– ochrana a manažment v Malopoľskom regióne (južné Poľsko).**

V práci sme skúmali rozšírenie stanovišťa slimáka záhradného (*Helix pomatia* L.) v Malopoľskom regióne v rokoch 1997-1999. Zhlukovú analýzu sme použili na určenie vzťahu medzi výskytom slimákov a parametrami rôznych stanovišť, ako je typ stanovišťa, jeho prirodzenosť, vlhkosť, rastlinná pokrývka a pôdny typ, ako aj rôznorodosť krajiny. Zistili sme, že tento druh sa najhojnejšie vyskytuje na antropogénnych stanovištiach nachádzajúcich sa v územiach s vysokou rôznorodosťou krajiny. Z morfometrických meraní vidieť, že jedince zo suburbánnych území sú menšie a že jestvuje vzťah medzi tvarom ulity a vlhkosťou územia. Naznačovali i nevyhnutnosť kontroly limitu veľkosti pre slimákov zbieraných z ekonomických dôvodov. Získané výsledky sa môžu využiť pri určovaní regionálnej stratégie pre manažment slimáka záhradného.