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WHY ARE TERRESTRIAL GASTROPODS OF POLAND THREATENED?

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ABSTRACT: Reasons for threats to land gastropods have been estimated based on literature pertaining to the native malacofauna. Both according to our own estimate, derived from ecological information on each species, and to a variety of authors, the main reason for threat is replacement of natural habitats with anthropogenic ones. Other dangers are: random events that may damage small, isolated populations, industrial pollution, mowing, grazing and tourism.

KEY WORDS: terrestrial gastropods, endangered species, Poland, anthropogenic changes, random events, industrial pollution

INTRODUCTION

The number of the World's invertebrate species described to date is ca. 1.4 mln, compared to 21,000 vertebrate species; ca. 100,000 of these invertebrates are molluscs. Numerous publications have dealt with protection of and threats to particular vertebrates or their communities, but little work of this kind has been done on gastropods (WELLS et al. 1983). The few existing publications pertain to marine taxa, mainly those threatened with overexploitation (HOLT & SEGNESTAM 1982, JOHANNES 1978, POLUNIN 1982 and literature contained therein).

With respect to protection and research on the main threats, land gastropods are in the worst situation. Reasons for danger of extinction or decreasing population abundance are known only in the case of single species or their groups, such as the Hawaiian achatinellids, or partulids from the Pacific Islands (COWIE 1992). The state of and reasons for threats to most of the World's gastropod species and communities have not been analysed; no such analysis has appeared in Poland to date. Attempts have been made only at indicating the most endangered species (in Poland WIKTOR & RIEDEL 1992), but these concentrated on categorizing the degree of threat according to the standards of the IUCN Red Data Book, rather than specifying the kind of threat. Few gastropod species are legally protected – in Poland, ironically, only the common *Helix pomatia* L. has been included in the list of protected species, because of its overexploitation in some areas.

In the case of small animals of little mobility, most often associated with a particular kind of habitat, species protection can prevent only exploitation by humans. It will not prevent extinction of populations and species that results from habitat changes; this would require first of all indetification of threats and protection of whole malacocenoses/areas.

In spite of the lack of publications on terrestrial gastropod protection and threats, numerous data on the subject could be extracted or inferred from taxonomical, ecological and faunistic papers on the native fauna. This article is a literature-based review of the main reasons for threats to terrestrial malacofauna of Poland. Since we have approached the problem in a very general way, we have not discussed in detail threats to particular species, distribution ranges and ecological requirements. All data of this kind that we have used in this article are contained in the following papers: ALEXANDROWICZ 1992, 1994, 1995, ALEXANDROWICZ & ALEXANDROWICZ 1995, BERGER 1961, 1963, Bulman 1995, Drozdowski 1966, Dyduch 1980, Dyduch-Falniowska 1991, Dzięczkowski 1966, 1971, 1972, 1974, 1978, 1988, 1989, Jackiewicz & Rafalski 1960, Kosińska 1979, Pakiet 1993, Piechocki 1990, Pokryszko 1984, 1990, Poliński 1927, Riedel 1988, Riedel & Wiktor 1974, Stworzewicz 1990, Umiński 1980, Urbański 1939, 1947, 1947a, 1948, 1958, 1962, 1977, Wiktor 1956, 1959, 1960, 1964, 1972, 1989, Wiktor & Riedel 1992.

Knowledge of the structure of malacocenoses, data on areas occupied by populations of particular species, on their abundance and on changes they undergo are very incomplete; only few papers have been devoted to these problems and they pertain almost exclusively to forest malacocenoses (Drozdowski 1966, Dyduch 1980, Dzięczkowski 1966, 1971, 1974, 1988, 1989, Dyduch-Falniowska 1991). In view of this fact any attempt at identifying threats to malacofauna is a matter of guess rather than of truly reviewing the problem. However, such attempts have to be made.

First, based on all available literature, we listed all possible reasons for threats to land malacofauna in order to know how to categorize the threats to our native species. Then, to obtain some guesses that could be verified, we applied three procedures and compared the results. The first procedure ("species voting" procedure) was to specify endangered species based on what is known about their occurrence and abundance, and classify them in groups according to the reasons for threats, the latter being inferred from the data on the geographic distribution and habitat requirements. The second procedure ("authors voting" procedure) was to select those authors that explicitly mention reasons for threats to species/malacocenoses and see how many vote for each reason. Since the "species voting" and "authors voting" approaches were to some extent compatible, we could specify the main reasons for threats and use these for the third procedure. This ("mapping" procedure) consisted in superimposing the most diverse and/or rarest malacocenoses mentioned in the literature on a map of the main threat factors selected as a result of the "species voting" and "authors voting" procedures.

POSSIBLE THREATS TO TERRESTRIAL MALACOFAUNA

The mere existence of land snail populations, as well as diversity and richness of terrestrial malacocenoses depend on many environmental factors, such as vegetation cover, climate, and especially microclimate, soil structure, soil and leaf litter acidity, availability of calcium ions and minimum population area (Solem 1974, Wäreborn 1970, 1982, Wells et al. 1983). A change in any of these factors may potentially affect gastropod species and communities, albeit the factors responsible for decreased species diversity or population abundance vary between species and areas.

REPLACING NATURAL HABITATS WITH ANTHROPOGENIC ONES

Replacing natural habitats with anthropogenic ones is destructive in a variety of ways: through direct physical destruction of adequate habitats of stenoecious species (deforestation, drainage of marshy areas, replacing natural forest with coniferous cultivations), through indirectly altering composition of vegetation cover (almost every plant community has its own malacocenosis; Dzięczkowski 1988), through habitat fragmentation (a patch of adequate habitat may decrease below the critical area that is necessary for a population to exist; cf. Remmert 1994) and the related edge effect (because of intermediate humidity, temperature, light and vegetation conditions in peripheral parts of small patches of adequate habitat, some species can not use these peripheral parts of the patch and as a result the effectively available area is still more limited; cf. Remmert 1994), through a decrease in the mosaic of microhabitats (the more numerous microhabitats are available, the more numerous species in the malacocenosis; cf. Dyduch-Falniowska 1991) and finally through affecting microclimate and physico-chemical properties of the soil and litter (Godan 1983, Ložek 1952, Wäreborn 1970, 1982), most of all acidity, calcium content and the form in which calcium is bound (Burch 1955, Dzięczkowski 1971, 1972, Pokryszko 1993, Valovirta 1968, Wäreborn 1982).

RANDOM EVENTS

Land gastropods are incapable of active dispersal over long distances; this is the main reason for their mosaic occurrence in habitats and uneven geographic distribution, often limited to small areas. Their ability to disperse actively and search for suboptimal habitats is very limited. This is often manifest as existence of small, isolated, insular populations. Considering different and often strict ecological requirements of particular species, each disturbance of the existing optimum results in a decreased population abundance or its complete disappearance. Small, iso-

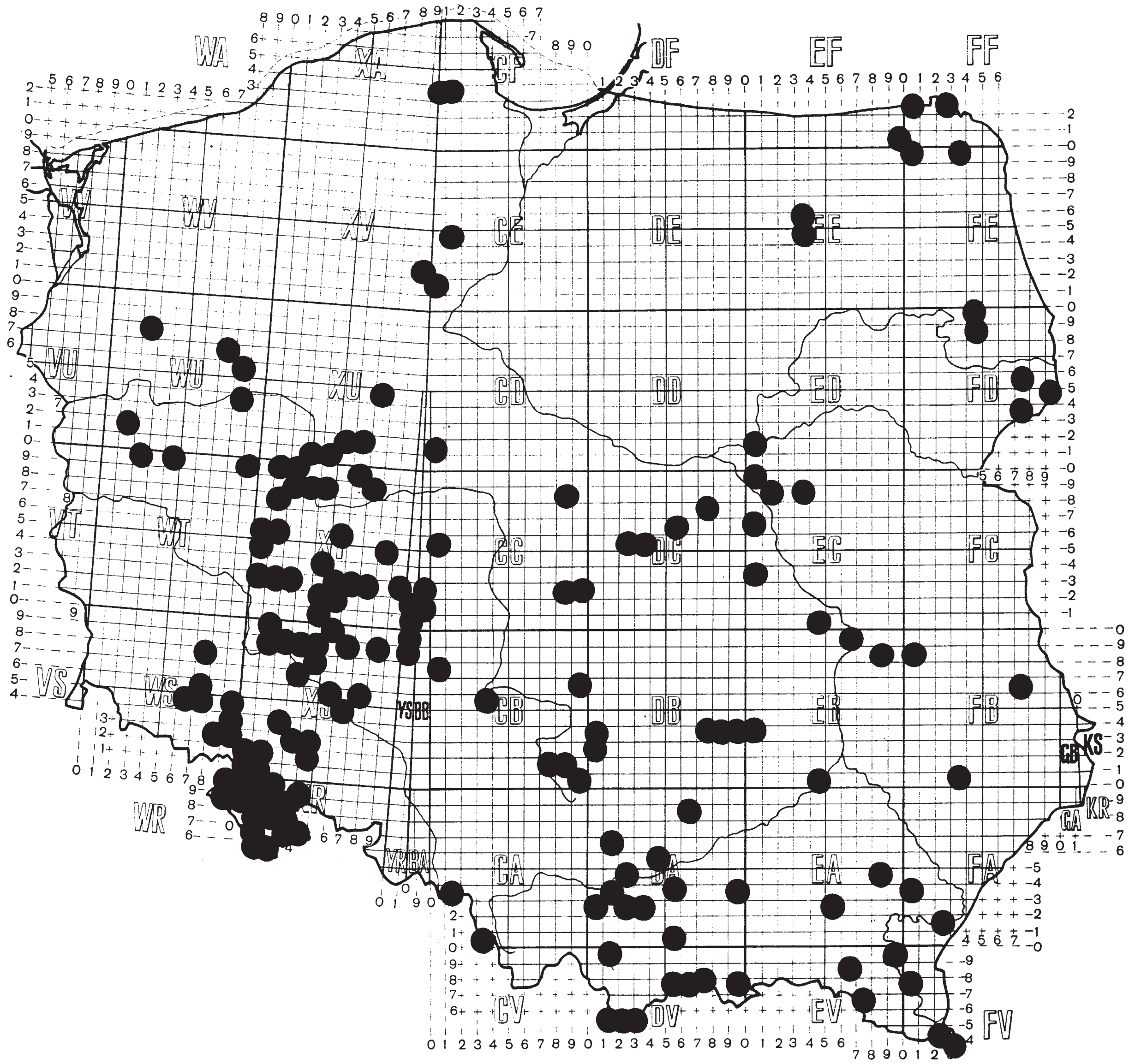

Fig. 1. Combined distribution map of two very common species (*Columella edentula* and *Vertigo pygmaea*), of different but wide and overlapping ecological tolerance; updated 1998, reflecting the uneven knowledge of the native malacofauna. When thoroughly studied, the combined distribution of these two species will probably turn out to cover all the UTM squares

lated populations on the species distribution border are always susceptible to extinction as a result of random events (floods, fires, severe winters etc.; cf. RIDLEY 1993); with any habitat disturbance their chance of extinction increases rapidly.

INDUSTRIAL POLLUTION

Compounds causing acid precipitation are the most dangerous kind of pollutants emitted by industry. Acid rains remove calcium ions from the litter and superficial soil layers and transport them to deeper layers where they become unavailable to snails (WALDÉN 1978, 1992, WÄREBORN 1982). Malacofauna of calcium-poor areas is as a rule very poor, and in areas where the calcium content decreases as a result of acid rains there is a progressive decrease in both species richness and abundance, up to a complete disappearance of malacofauna (VALOVIRTA 1968, WÄREBORN 1982, WALDÉN 1978, 1992). An-other dangerous phenomenon is dust emission. Snail mucus serves among others to clean the body surface from soil and litter particles etc. that become stuck to it (WIKTOR 1989). The greater the need to clean the body, the more mucus is secreted. Since water is lost with mucus, in a situation of high dust content the animal faces physiological drought.

COMPETITION OR PREDATION FROM INTRODUCED SPECIES

Species purposedly or accidentally introduced in new areas often create a threat for local malacofaunae. Two species introduced in Hawaii: *Achatina fulica* Bowdich and *Euglandina rosea* Crosse et Fischer, one competing with the native achatinellids, the other consuming them, provide a good example (SOLEM 1974).

OVEREXPLOITATION

Overexploitation constitutes a threat only for those species that are of economic significance (edible species, e.g. *Helix pomatia* L.), that may be mistaken for such species or that are valued by shell collectors.

MOWING, GRAZING AND TOURISM

Mowing and grazing, especially in open areas such as meadows and swamps, decreases structural diversity of the vegetation which in turn affects the species composition and abundance of their malacocenoses (KERNEY & STUBBS 1980). Excessive tourist movement may also decrease structural diversity of vegetation - an effect very similar to mowing and grazing.

SPECIES VOTING PROCEDURE

Terrestrial malacofauna of Poland has been relatively well studied, but this pertains only to its qualitative aspect. Information on detailed distribution of even most common species (Fig. 1) is incomplete and varies between areas (WIKTOR & RIEDEL 1992). According to the present state of knowledge 173 land snail species occur in Poland, 11–15 of them being introduced (RIEDEL 1988, ŠTEFFEK et al. 1990).

The Red List of Threatened Animals in Poland (WIKTOR & RIEDEL 1992) comprises 77 land snail species, i.e. almost half of the native fauna. Based on literature data, we have included in our considerations further 11 species (underlined in the list below). Bold capital letters denote reasons for threats: DF – deforestation, MD – drainage of marshy areas, RE – random events, U – unknown.

1. <u>*Bythiospeum neglectissimum*</u> Falniowski et Šteffek, 1989 **RE**
2. *Acicula parcelineata* (Clessin, 1911) **DF**
3. *Catinella arenaria* (Bouchard-Chantereaux, 1937) **RE**
4. <u>*Cochlicopa nitens*</u> (Gallenstein, 1852) **MD**
5. *Pyramidula rupestris* (Draparnaud, 1801) **RE**
6. *Columella columella* (Martens, 1830) **RE**
7. *Truncatellina costulata* (Nilsson, 1822) **RE**
8. *T. claustralis* (Gredler, 1856) **RE**
9. *Vertigo moulinsiana* (Dupuy, 1849) **MD**
10. *V. arctica* (Wallenberg, 1858) **RE**
11. *V. ronnebyensis* (Westerlund, 1871) **RE**
12. *V. genesii* (Gredler, 1856) **MD**
13. *V. geyeri* Lindholm, 1925 **MD**
14. <u>*V. alpestris*</u> Alder, 1837 **DF**
15. *V. angustior* Jeffreys, 1830 **MD**
16. *Orcula dolium* (Draparnaud, 1801) **RE**
17. *Sphyradium doliolum* (Bruguèire, 1792) **RE**
18. *Pagodulina pagodula* (Des Moulins, 1830) **RE**
19. *Granaria frumentum* (Draparnaud, 1801) **RE**
20. *Chondrina clienta* (Westerlund, 1883) **RE**
21. *Pupilla sterri* (Voith, 1840) **RE**
22. *P. triplicata (Studer, 1820)* **RE**
23. <u>*P. alpicola*</u> (Charpentier, 1837) **RE**
24. *Argna bielzi* (Rossmässler, 1859) **RE**
25. *Vallonia enniensis* (Gredler, 1856) **RE**
26. *V. declivis* Sterki, 1893 **RE**
27. *Spermodea lamellata* (Jeffreys, 1830) **RE**
28. *Chondrula tridens* (O. F. Müller, 1774) **RE**
29. <u>*Ena obscura*</u> (O. F. Müller, 1774) **DF**
30. *Discus perspectivus* (von Mühlfeld, 1818) **RE**
31. *Arion intermedius* Normand, 1852 **DF**
32. *Eucobresia diaphana* (Draparnaud, 1805) **DF**
33. *E. nivalis* (Dumont et Mortillet, 1852) **DF**
34. *Semilimax semilimax* (Férussac, 1802) **DF**
35. *S. kotulai* (Westerlund, 1883) **DF**
36. <u>*Vitrea subrimata*</u> (Reinhardt, 1871) **DF**
37. <u>*V. contracta*</u> (Westerlund, 1871) **DF**
38. *Aegopinella nitens* (Michaud, 1831) **DF**
39. *Ae. epipedostoma* (Fagot, 1879) **DF**
40. *Nesovitrea petronella* (L. Pfeiffer, 1853) **DF**
41. *Oxychilus orientalis* (Clessin, 1887) **DF**
42. *O. glaber* (Rossmässler, 1835) **DF**
43. *O. depressus* (Sterki, 1880) **DF**
44. *O. inopinatus* (Uličny, 1887) **DF**
45. *Daudebardia brevipes* (Draparnaud, 1805) **RE**
46. *Carpathica calophana* (Westerlund, 1881) **RE**
47. *Tandonia rustica* (Millet, 1843) **DF**
48. *Limax bielzi* Seibert, 1873 **DF**
49. *Lehmannia macroflagellata* Grossu et Lupu, 1962 **DF**

50. *L. nyctelia* (Bourguignat, 1861) **RE**
51. *Bielzia coerulans* (M. Bielz, 1851) **DF**
52. *Deroceras praecox* Wiktor, 1973 **DF**
53. *D. rodnae* Grossu et Lupu, 1965 **DF**
54. *D. moldavicum* (Grossu et Lupu, 1961) **DF**
55. *Cecilioides acicula* (O. F. Müller, 1774) **DF**
56. *Cochlodina costata* (C. Pfeiffer, 1828) **DF**
57. *Charpentieria ornata* (Rossmässler, 1836) **RE**
58. *Ruthenica filograna* (Rossmässler, 1836) **DF**
59. *Macrogastra ventricosa* (Draparnaud, 1801) **DF**
60. *M. badia* (C. Pfeiffer, 1828) **DF**
61. *M. latestriata* (A. Schmidt, 1857) **DF**
62. *M. tumida* (Rossmässler, 1836) **DF**
63. *Clausilia parvula* Férussac, 1807 **DF**
64. *C. bidentata* (Ström, 1765) **DF**
65. *C. cruciata* (Studer, 1820) **DF**
66. *Balea perversa* (Linnaeus, 1758) **RE**
67. *Pseudalinda fallax* (Rossmässler, 1836) **DF**
68. *P. stabilis* (L. Pfeiffer, 1847) **DF**
69. *Vestia elata (Rossmässler, 1836)* **DF**
70. *V. gulo* (E. A. Bielz, 1859) **DF**
71. *V. turgida* (Rossmässler, 1836) **DF**
72. *Bulgarica cana* (Held, 1836) **RE**
73. *Candidula unifasciata* (Poiret, 1801) **RE**
74. *Helicopsis striata* (O. F. Müller, 1774) **RE**
75. *Perforatella dibothrion* (M. Kimakowicz, 1884) **DF**
76. *P. umbrosa* (C. Pfeiffer, 1828) **DF**
77. *Trichia villosula* (Rossmässler, 1838) **DF**
78. *T. plebeia* (Draparnaud, 1805) **DF**
79. *T. unidentata* (Draparnaud, 1805) **DF**
80. *T. bielzi* (E. A. Bielz, 1860) **DF**
81. *T. bakowskii* (Poliński, 1924) **DF**
82. *T. lubomirskii* (Ślósarski, 1881) **DF**
83. *Helicodonta obvoluta* (O. F. Müller, 1774) **DF**
84. *Helicigona lapicida* (Linnaeus, 1758) **U**
85. *Chilostoma rossmaessleri* (L. Pfeiffer, 1842) **RE**
86. *Ch. cingulellum* (Rossmässler, 1837) **RE**
87. *Causa holosericeum (Studer, 1820)* **DF**
88. *Helix lutescens* Rossmässler, 1837 **RE**

Of the potential threats listed above, only two categories seem to have been identified as applying to endangered species in Poland. The most numerous species are threatened by replacement of natural habitats with anthropogenic ones (drainage of marshy areas, deforestation and/or replacing natural forests with coniferous cultivations). The next largest groups comprises very rare species, which in Poland reach their distribution border, live on isolated localities and are thus threatened by random events. One species from the list – *Helicigona lapicida* – is not particularly rare but its abundance has decreased considerably within the last decades, while the reasons are difficult to establish (STWORZEWICZ 1990).

Species endangered as a result of deforestation constitute the largest group – 49 species i.e. ca. 56% all endangered species. There are three reasons for this situation. Firstly, among the land snails reported from Poland forest species constitute ca. 80% (data from RIEDEL 1988). Secondly, most species, besides being associated with forests, have a limited geographic distribution within the country which increases the danger. Thirdly, damage to forests is not only a result of clear-felling, but also destruction by air pollution. A relatively high proportion (32 species – over 32%) is formed by species that in Poland have few or even single isolated localities. The group includes mainly species whose distribution borders cross Poland - mainly Carpathian and South-East European species (RIEDEL 1988). The fewest species (5) belong to the group endangered by drainage of marshy areas. This however does not indicate that drainage as a threat factor is of little importance: marsh-dwelling malacocenoses are generally of low species diversity (cf. POKRYSZKO 1993, in press), but many of their components are rare species.

The list of species recorded from Poland and the list of endangered species make it possible to specify higher taxa, of family level, which are the most endangered. The terrestrial malacofauna of Poland includes 25 families, with 173 species. Four families: Vertiginidae, Zonitidae, Clausiliidae and Helicidae, with 97 species represented in Poland, constitute together over half of the native malacofauna. The remaining 21 families have few or single representatives in Poland. The number and percentage of endangered species in each of these speciose families are presented in Table 1. The Clausiliidae are the most endangered which results probably from the fact that almost all native clausiliids are forest-dwellers.

Table 1. Number and percentage of endangered species in the most speciose families in Poland

Family	Recorded from Poland	Threatened	%
Vertiginidae	17	9	53
Zonitidae	24	11	47
Clausiliidae	24	17	71
Helicidae	33	16	50

AUTHORS VOTING PROCEDURE

The authors who explicitly point to threatened species and/or malacocenoses list reasons falling within three categories: replacement of natural habitats by anthropogenic ones (plus its consequences), industrial pollution and mowing, grazing and excessive tourism. In the first category the most numerous authors mention anthropogenic transformations of natural plant communities: mainly deforestation and replacement of natural forests by planted coniferous forests (BERGER 1961, BULMAN 1995, DROZDOWSKI 1966, DYDUCH 1980, DYDUCH-FALNIOWSKA 1991, DZIĘCZKOWSKI 1966, 1971, 1972, 1974, 1988, 1989, JACKIEWICZ & RAFALSKI 1960, PAKIET 1993, POKRYSZKO 1984, STWORZEWICZ 1990, URBAŃSKI 1939, 1947, 1947a, 1948, 1962, 1977, WIKTOR 1956, 1959, 1964, WIKTOR & RIEDEL 1992), fragmentation of habitats (BULMAN 1995, DYDUCH-FALNIOWSKA 1991, DZIĘCZKOWSKI 1988, PIECHOCKI 1990, POKRYSZKO 1984, STWORZEWICZ 1990, WIKTOR 1956, 1959, 1964) and deteriorating water supply (KOSIŃSKA 1979, POKRYSZKO 1990).

Contrary to the species voting procedure, no random effects are mentioned. Instead, some authors vote for mowing, grazing and tourism as destructive factors (DYDUCH-FALNIOWSKA 1991, DZIĘCZKOWSKI 1978, POKRYSZKO 1990, STWORZEWICZ 1990, WIKTOR 1959), and the fewest are in favour of industrial pollution as contributing to the impoverishment of our malacofauna (KOSIŃSKA 1979, POKRYSZKO 1990, STWORZEWICZ 1990, WIKTOR 1959).

MAPPING PROCEDURE

Quantitative data on terrestrial malacocenoses in Poland are scarce and mostly limited to deciduous and mixed forests; faunistic papers contain at least information on species composition of malacocenoses. The richest malacofauna is found in beech forests, mixed deciduous forests and mixed deciduous-coniferous forests growing on calcium-rich substratum. In Poland these are Carpathian beech forest, and especially the beech forest of the lower forest zone in the Tatra Mts (DYDUCH-FALNIOWSKA 1991, DZIĘCZKOWSKI 1988) and Pieniny Mts (URBAŃSKI 1939), mixed forests of the Cracow-Częstochowa Upland (especially Ojców National Park) (STWORZEWICZ 1990, ŠTEFFEK et al. 1990), oak-hornbeam forests (DZIĘCZKOWSKI 1974, 1988) and some lowland mixed forests (DYDUCH 1980). Malacocenoses of such habitats include from 20 to 60 species. Examples: nature reserve Muszkowicki Las Bukowy with 58 species (WIKTOR 1972), some plant communities of the Białowieża National Park and Niepołomice Forest (DYDUCH 1980), mixed forest in the gorge Wąwóz Myśliborski with 49 species (POKRYSZKO 1984), beech reserve Spadowiec in the Tatra Mts (DYDUCH-FALNIOWSKA 1991) or some mixed forests of the Kłodzko region (WIKTOR 1964). Generally, except the Białowieża National Park, the richest forest malacocenoses concentrate in the southern part of the country.

Malacocenoses of xerothermic and marshy habitats are much poorer (a few to a dozen or so species), but they include rare species with only a few localities in our country. Examples are thermophilous malacocenoses from the nature reserve Stawska Góra near Chełm Lubelski (URBAŃSKI 1958) with *Abida frumentum*, xerothermophilous malacocenosis from the Wielkopolski National Park (DZIĘCZKOWSKI 1978) with *Candidula unifasciata*, malacocenosis of a calcareous fen near Niedzica (ALEXANDROWICZ 1992) with *Pupilla alpicola*, and xerothermophilous malacocenoses from the Ojców National Park (STWORZEWICZ 1990, ŠTEFFEK et al. 1990), or marshes in the vicinity of Białowieża with *Vertigo moulinsiana* and *V. angustior* (POKRYSZKO 1990).

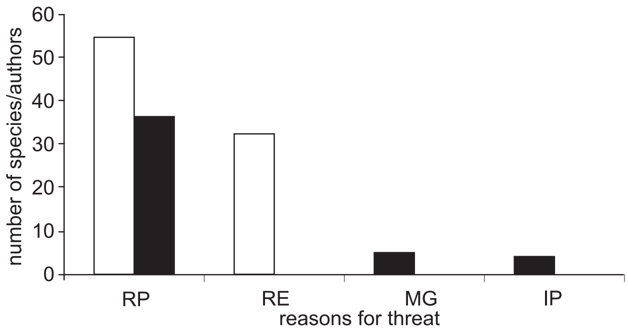

Fig. 2. Results of species voting (white bars) and authors voting (shaded bars) procedures. RP— replacement of natural habitats with anthropogenic ones; RE – random events; MG – mowing, grazing and tourism; IP – industrial pollution

Figure 2 represents comparison of the species voting and authors voting procedures. Both are compatible as far as replacement of natural habitats with anthropogenic ones is concerned: this is decidedly the main reason for threat. On the remaining points the procedures differ: the former stresses random events, the latter mowing, grazing and tourism, and industrial pollution.

Of the factors selected through species voting procedure, deforestation plus drainage of marshy areas,

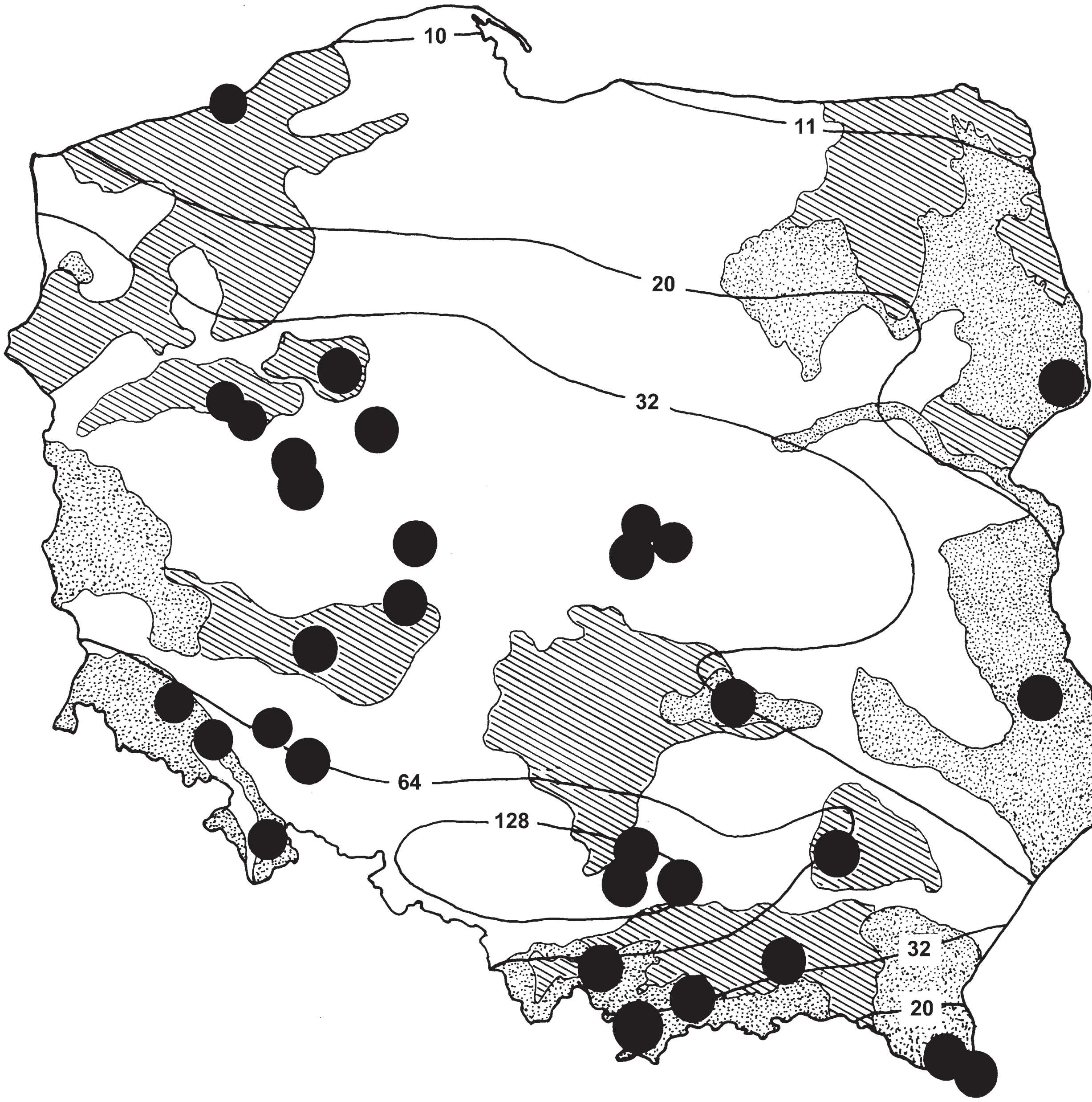

Fig. 3. Map indicating anthropogenic transformations of natural habitats (white areas), unchanged or little changed areas (dotted), areas with larger fragments of natural habitats still preserved(hatched); mean annual isolines of sulphur dioxide concentration in µg/m^2 (lines) and sites of rich, diverse and/or rare malacocenoses (solid circles)

as well as mowing, grazing and tourism have been indicated jointly on the map in Figure 3, as the degree of anthropogenic transformation of natural habitats. Of industrial pollution we have indicated only the most important component: emission of sulphur dioxide causing acid precipitation. Random events have not been indicated on the map for rather obvious reasons. The map has been based on the Atlas Zasobów, Walorów i Zagrożeń Środowiska Geograficznego Polski (Atlas of Resources, Values and Threats to the Geographic Environment of Poland), Polska Akademia Nauk, Instytut Geografii i Przestrzennego Zagospodarowania, Warszawa 1994. The localities of rich, diverse and/or rare malacocenoses plotted on the map have been taken from the literature cited in this chapter.

The richest localities of the malacofauna are by no means concentrated in the little changed or unchanged areas; often they occupy small patches of undamaged habitat within otherwise humantransformed regions which makes them all the more threatened. Some of them are additionally within isolines of high suphur dioxide emission. The fact that rich localities are almost absent from the relatively unaffected north-eastern corner of Poland results probably from the area being very poorly studied (cf. Fig 1).

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