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Assessment of the status of wild populations of Helix Pomatia L. in Moldova:

The effect of exploitation

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Abstract

Helix pomatia L. or Roman snail is a species faced with a growing commercial interest in Moldova. Its life history characteristics (slow maturity and recruitment, high mortality among juveniles coupled with low fecundity) along with its strong spatial aggregation can make it especially vulnerable to exploitation. In this study, differences in density, shell size and age distribution were assessed in 7 unexploited and 10 exploited sites situated in the northern and central parts of Moldova. A significant impact of exploitation on snail population densities (ANOVA GLM p=0,000), shell size in adult snails (Kruskal Wallis Anova and Median test (H=7,1428, p=0,0075) and age distribution ($\chi 2$=31,94, p=0,000) was revealed. Exploited sites had much lower densities than unexploited ones and in two places no live snails were found. This data may suggest that the exploitation is currently carried out at unsustainable level, but additional information on the demography of populations and intensity of exploitation is required in order to make inferences on sustainability and long-term population management. There was a higher proportion of adult snails in exploited sites than in non-exploited, due to current type of collection management: commercial collection affect not only adults, but also all age groups. Bigger adult shell size in exploited sites may be due to low population density, but further study is required for better inferences in this regard. Prospects for conservation are proposed through establishing well-organized monitoring systems of the populations and development of snail breeding enterprises.

Contents

Introduction

Exploitation of animal resources for economic purposes has been a topical issue in many countries. A major task in population management of species with an economic value is to ensure a sustainable harvesting rate acceptable from the ecological, economical and genetical point of view. Sustainable exploitation assumes a rate at which the individuals are extracted from a population that does not violate the possibility to maintain a continuity of exploitation and a stable population (Lyashenco, 2001). In the last decade, an intensive effort has been made to quantify sustainable exploitation in different species (Milner-Gulland E., 1994; Robinson and Redford, 1994; Heppel and Crowder, 1995; Pascual and Hilborn, 1995; Milner et al. 2001; Kitti et. al. 2002). These studies revealed that measuring the sustainability of resource use is a very complicated process, since integral data on population response to harvesting, life table data, specific life history patterns of the exploited species and also economic and social factors should be taken into consideration.

Organisms with poor dispersal, low mobility and specific life history traits (high mortality among juveniles coupled with low fecundity, slow recruitment and maturity) can be especially prone to overexploitation (Crouse et al, 1987). Ineffective management strategies along with insufficient knowledge of the biology of these species can lead to unsustainable exploitation and a fast decline in wild populations. Such factors contributed to the depletion of many once abundant species, such as sea turtles (Crouse et al, 1987; Heppel and Crowder, 1996). The Roman snail *Helix pomatia* L, with a long history being used as food by humans and still much sought after as a gastronomic delight can also be included in this category. Compared to other exploited species of edible land snails, it has suffered the most serious decline in most of the countries where it was intensely used for food, being a more preferred species for its high protein, aminoacids and mineral salt content (Rădulescu, 1980; Wells and Chatfield, 1992). Unlike most of other long-lived invertebrates, Roman snail has a high mortality among juveniles and eggs due to predation and cannibalism. Maturity is reached after 3 to 4 years and the recruitment of new adults into the population is very slow (Pollard, 1973). Only a very small proportion of hatchlings are able to survive to maturity and therefore a high survival rate and relatively long life span is needed for adults to be able to compensate the slow recruitment. Removal of large quantities of snails from the same territory over several years, during commercial collection and especially the proportions of adults, may affect the population's potential for natural recovery and increase the likelihood of extinction.

The Roman snail is the largest species of land snail occurring in the territory of Moldova and it is distributed all over the country, but mostly concentrated in northern and central parts, where more suitable conditions for this species exist. Traditionally, local people did not use this snail for food, however there are some data (Chihac, 1837), which indicate that in the past Moldavians were consuming this product during Lent. A great interest has risen toward its commercialisation especially in the last years and there is still a growing demand from Europe. The quantity of exported snails is around 100-200 tones per year (State Ecological Inspection, 2003). The high interest among local people toward commercialisation of this species along with a growing demand from Europe raises difficulties in banning the collection of Roman snail in Moldova. Such a ban might lead to illegal collection and to even bigger damage to natural populations.

Up to now, no efforts have been made in estimating the impact of exploitation on wild populations, despite the necessity for it, since records are highly necessary to allow analysis of population status and trends. A long-term management of the populations would be impossible without this kind of information.

The primary goal of this study was to assess the magnitude of impact from commercial collections for export on the populations of Roman snail, in Moldova. Some general research questions that were addressed during this study were:

What is the status of the populations under exploitation impact and is the current level of exploitation sustainable or not?
Is there an optimal quantity of snails that can be collected without threatening the wild populations?

Which age group should be selected for collection in order to minimise risk of population decline and still raise a profitable economic income from the use of this species?

A basic index of measuring sustainability of resource use is the comparison of population parameters between exploited and non-exploited sites. Therefore, attempts were made to compare if significant differences exist in the density, shell size and age distribution of populations of impacted and non-impacted sites. I also tested if there is any effect of size selective exploitation.

The current assessment is important in the development of optimal harvesting strategies and to ensure species survival and recovery. To some extent, the information from this research will also add to the knowledge on the distribution pattern and natural abundance level of this species in Moldova.

Material and methods

Study area

The Republic of Moldova is located in Eastern Europe, northeast of Romania, between latitude 45°28'-48°29' N and longitude 45°28'-48°29' W from Greenwich Meridian. The country is a hilly plain with an average elevation of 147 m and a maximum height of 429.5 m. Climate is temperate-continental with short mild winters and long hot summers and average annual rainfall of 370-560 mm.

With a rather small territory (33,76 th.km^2), the heterogeneous natural conditions of Moldova along with its geographical position contributed to a diverse soil and vegetation composition. A significant part of the country (70%) is covered by cernozioms, - carbonate rich and highly fertile soils (Crupennikov, 1973). As indicated by Pollard (1975) and Wells and Chatfield (1992), Roman snail requires mostly calcareous soils, and such conditions are mainly characteristic for the northern and central parts of Moldova.

The forests account for less than 10% of the territory, being mainly concentrated in central and northern parts of the country (along the river banks and on the upper sectors of the hills). In the Centre the forests cover 13,5 % of the territory and 7,2 % in the North (National Strategy and Action Plan on Biodiversity Conservation, 2001). Even though a favourable climate and fertile soil is characteristic for Moldova, the lack of mineral resources makes its economy rather vulnerable. Agriculture is an important economic activity and that is why the biggest part of the territory (75,6%) was converted to arable land. For example, during this study in the North of the country was observed that the Dniester riverbanks or those of its tributaries have been ploughed down to the limits of the river. This is a violation of local legislation (Law of the Republic of Moldova on river buffer and protective zones Nr.440-XIII from 27.04.95) and leads to fragmentation and destruction of habitats of the species inhabiting the riverbanks, including Roman snail.

Surveyed sites

Considering the necessity for similar environmental conditions (topography, soil type and vegetation patterns) the sampling sites were all positioned in the northern part of the country, along the Dniester river banks, except one surveyed site that was placed in the capital of the country, Chisinau. The information regarding exploited localities was compiled from the Ministry of Ecology, Constructions and Territorial Development (MECTD) of the Republic of Moldova and State Ecological Inspectorate as well as from questionnaires with local communities (focussing mainly on children of 11-13 years as they were mostly involved in collection and were acquainted with collecting sites). In addition, discussions were performed with state authorities and snail collecting companies' leaders in order to get a broader overview of the collection of this species.

A number of 10 sites impacted by exploitation and 7 non-impacted sites in the North and Centre of the Republic of Moldova were selected (See Figure 1). Their coordinates were registered using GPS 12 personal navigator and then the places were positioned on the map.
There was an insufficient number of non-exploited sites available, and hence I also investigated 5 sites placed in areas previously studied (1996-2000). Among these sites, some had highly fragmented habitats and could not be included in the analysis. Two types of habitats were examined: bushes and mixed trees and at some sites only bushes.

Most of the selected sites were characterized by canyon shaped, steep calcareous slopes, usually covered by trees and bushes. Among the most dominant tree species were *Salix alba*, *Populus alba*, *Tilia cordata*, *Fraxinus excelsior*, *Acer campestre*, *Ulmus laevis*, *Carpinus betulus, Cerasium avium*. The most common species of shrubs were *Crataegus sanguinea*, *Cornus mas*, *Sambucus nigra*, *Prunus spinosa*, *Swida sanguinea*, *Corylus avellana*, *Cotynus coggygria, Spiraea vanhoutti, Ligustrum vulgare* and *Rosa* spp. The herbs were represented mainly by *Urtica dioica*, *Pimpinella saxifraga*, *Arctium lappa* and several grass species (including *Bromus* spp. and *Poa* spp). The sites were usually humid, limestone rich and having small streams and a well-developed litterfall.

Sampling design

Fieldwork was carried out mainly during the rainy season (May-July) when the snail activity was maximal. Before any measurements were taken on the snail populations at a given site, preliminary 2 hours careful searches by four people were undertaken in the areas. Only those sites with live snails and continuous habitat, suitable for sampling (not too steep slopes) were considered for further sampling and measurements. Among exploited sites, however, I also included in the results those with no live snails, but only shells.
At each site a macroplot of 20x40 m was chosen for sampling and divided into 200 potential sampling plots and within each macroplot, a number of randomly selected 2 m^2 sampling plots were searched for all alive snails. The sampling plots were positioned randomly, using a table of random numbers and a grid-

cell method (Elzinga et al., 2001). The number of plots sampled was based on the amount of variability in the measurements assessed during a pilot sampling.

The results of the pilot study revealed a clustered snail distribution. In order to avoid the risk of missing the clusters and underestimating the true snail density, the number of plots was increased until the average number of snails per plot stabilized. Based on these preliminary estimations, the number of plots was set at 55.

Within each plot, measurements were made on:

Snail number. I considered the total number of snails per site (Ss) and also the mean density of snails per plot (Sp);

Shell width - This parameter (used by authorities in collection recommendations) was measured by a vernier calliper to the nearest 0.1 mm in each snail; for the specimens in copula or laying egg, no measurements of the shell width were done.

Age distribution. External features of the shell (growth breaks and lip layering as described by Pollard et al. (1977) were used for categorizing snail age. Four age groups were selected: Age IV – adults older than 4 years; Age III – adults of 3-4 years that were newly matured are ready to mature snails; Age II – young specimens of 2 to 3 years, Age I- juveniles of 1-2 years old.

Soil humidity and calcium content. The soil samples were collected in metal phials and then analysed in the Laboratory of Hydrobiology and Ecotoxicology, Moldovan Academy of Sciences. The soil samples were weighed and then dried at 105 ºC down to a constant weight. The humidity was calculated as the differences between the wet and dried soil (Obrejanu, 1964). Calcium content was identified according to a compleximetric method (Arinushkina, 1961).

Data analysis

In order to see if there is any significant difference between the number of snails in exploited and non-exploited sites (log transformed), I used an ANOVA General Linear Model (Minitab 13 for Windows), including environmental factors (soil humidity and calcium content) as covariates. For those parameters that did not achieve the requirements of a normal distributions even after log transformation (shell size), a Kruskal Wallis Anova and Median non-parametric test (Statistica 5.0) was applied. In order to test the difference in the proportion of snails in different age groups in exploited and non-exploited sites, a χ square test was performed.
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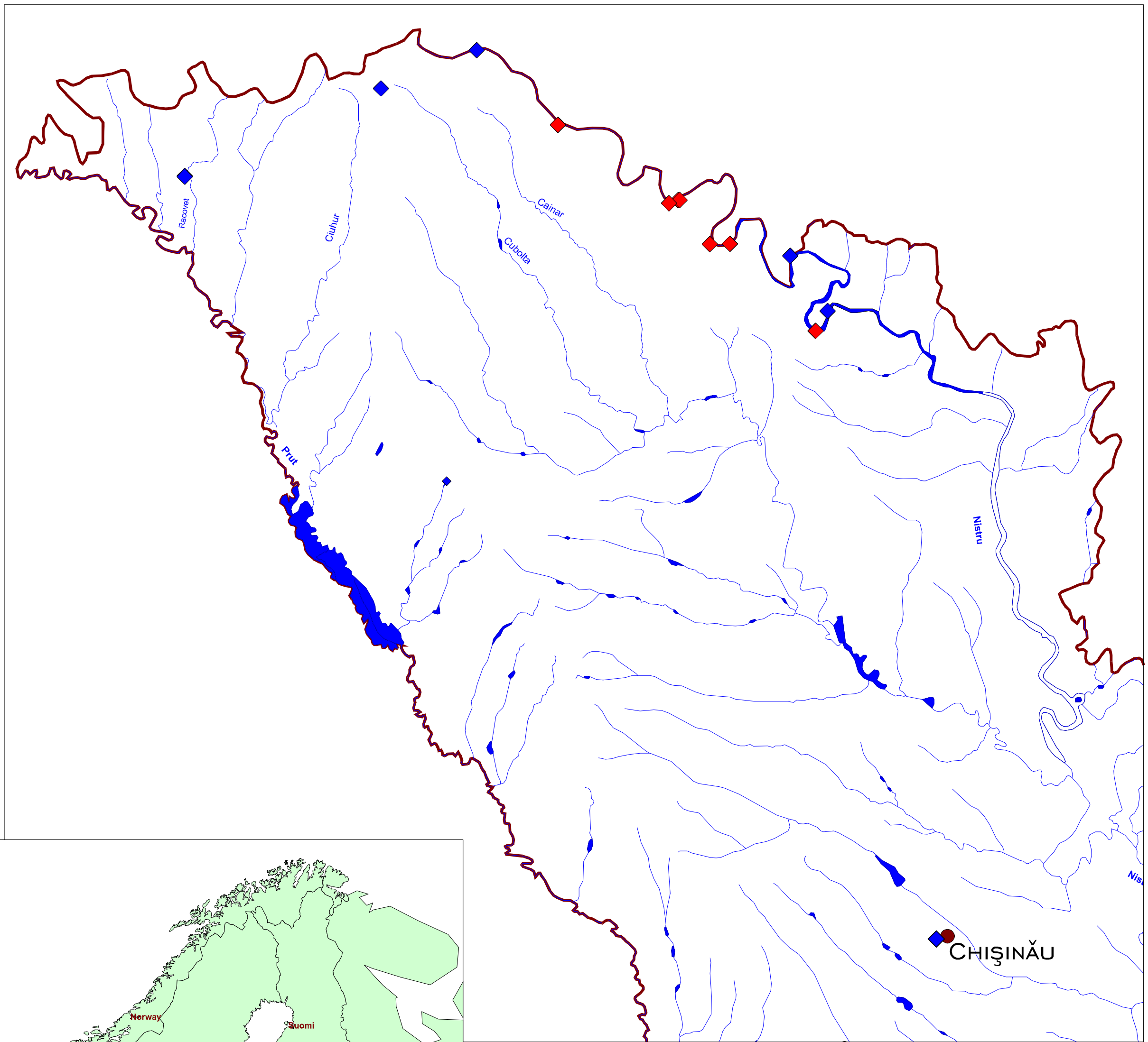


Fig. 1. Map of Moldova with surveyed sites.
Two collecting and two non-collecting sites are overlapping due to close GPS indications, that is why 12 sites are indicated instead of 14

Figure 1. **The map of Moldova with surveyed sites**

Results

Snail density

The results of statistical analysis showed that there was a significant difference between the snail densities in non-exploited and exploited sites. The density of snails in each plot in non-exploited sites varied within a large range (Table 1). Most of the exploited sites had densities several times lower than in non-exploited areas (Figure 2). Sites 11 and 16 had very low snail densities and in two sites (8 and 17) no live snails, but only shells were found. Non-exploited sites were characterised by higher snail densities compared to exploited ones. Site 3 however, presented some signs of habitat fragmentation caused by land use. When visited the area during 1996, this population had a more continuous habitat and not ploughed down to the river level.

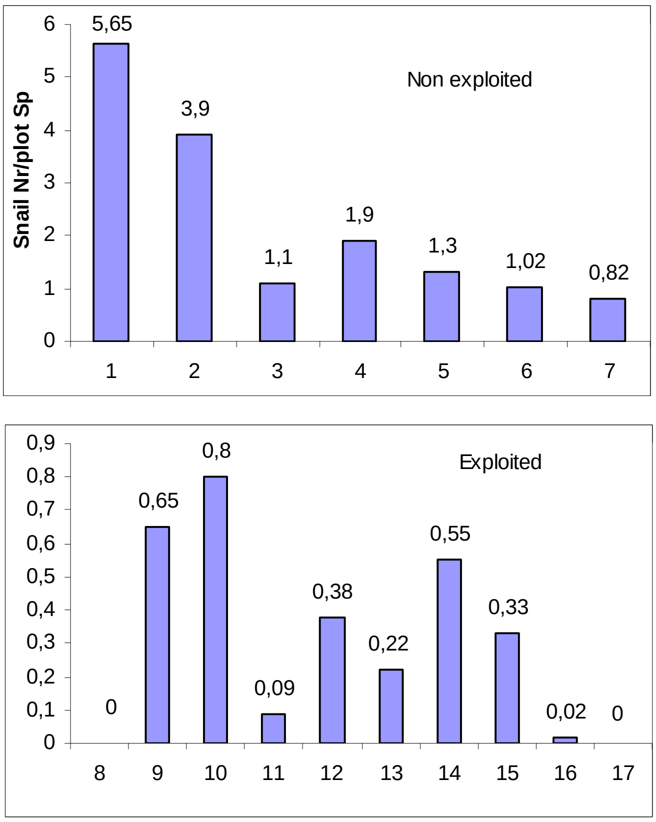


Figure 2. Snail density per plot (Sp) in non-exploited and exploited sites.

As can be seen in Table 1, the value of Ss in exploited territories were much lower than in unexploited sites, ranging from 0 and to 41, therefore several times lower than in non exploited. Also the snail number in every plot varied from 0 to 4, while in non-exploited – from 0 to 77.

Snail number	Non exploited				Exploited			
	Mean	N	Min	Max	Mean	N	Min	Max
Ss	124	7	45	317	16.7	10	0	41
Sp	2.28	7	0	77	0.43	10	0	4

Table 1. Ss – total number of snails and mean density per plot Sp
Total snail number for all sites: unexploited – 870, exploited – 167.

The results of an ANOVA, General Linear Model test indicated a significant evidence for exploitation impact (Table 2). The response variable was Log Ss and the model included Exploitation as a main effect and Log Ca and Log hum as covariates. The impact of covariates was not significant for Log Ca and it was significant for Log humidity. Between factor interaction of exploitation and soil humidity (log transformed) showed no significant results (p=0,547), in a separate test.

Source	DF	MS	F	P
Exploitation	1	2.21	31.80	0.000
Log Hum	1	0.02	0.26	0.025
Log Ca	1	0.48	6.94	0.624
Error	10	0.069		
Total	13			

Table 2. Shell size- Analysis of variance (General Linear Model) for the impact of exploitation and environmental (covariates) on snail number Ss (N=14)

No evidence of size selective effect of collection in terms of removing larger animals from the populations was observed. Rather, shell sizes of age 4 and 3 (adults and subadults or newly matured snails) were larger in exploited than in non-exploited sites (Table 3).

Shell size	Non exploited		Exploited	
	Mean ±SD	n	Mean ±SD	n
Age IV	40.36±1.53	407	42.75±1.47	123
Age III	38.96±1.66	146	40.5±2.06	35
Age II	31.42±1.11	208	30.97±0.80	17
Age I	21.11±4.35	109	18.24±5.64	13

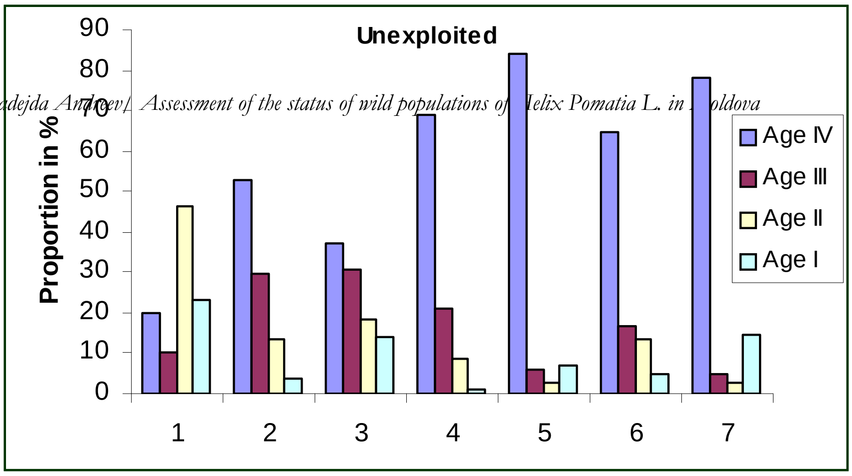
Table 3. Shell size (mm) in different age groups in exploited and non-exploited sites.

A Kruskal Wallis Anova and Median test revealed a significant difference in the shell size of age 4 between exploited and non-exploited sites (H=7,1428, N=14, df=1, p=0,0075). The shell widths of age 3, 2 and 1 did not differ significantly between exploited and non-exploited sites (Age 3 – H=0,285, df=1, p=0,285; Age 2 – H=0,285, df=1, p=0,59; Age 4 – H=2,57, df=1, p=0,11).

Since snail activity and therefore their growth rate and shell size are highly dependent on such environmental factors as humidity and soil calcium content (Goodfriend, 1986), attempts were made to see the effect of these factors on shell size. The strength of relationship between shell width of age 4 and humidity factors was significant (Pearson correlation: n=14, r=0.582, p=0,02 for soil humidity). For calcium content, however the correlation was not significant (r=-0,43, p=0.65).

Age distribution

As was reflected earlier, the collection had a significant impact on snail populations on their density as a whole. Also it had an impact on age groups in particular. Comparing age distribution, we could find that while at non-exploited sites all four groups of snails were present; in exploited sites some groups were missing (Figure 2). For example, at site 11, where collection took place for several years in the same area, only a few adults were found, while all other groups were missing.



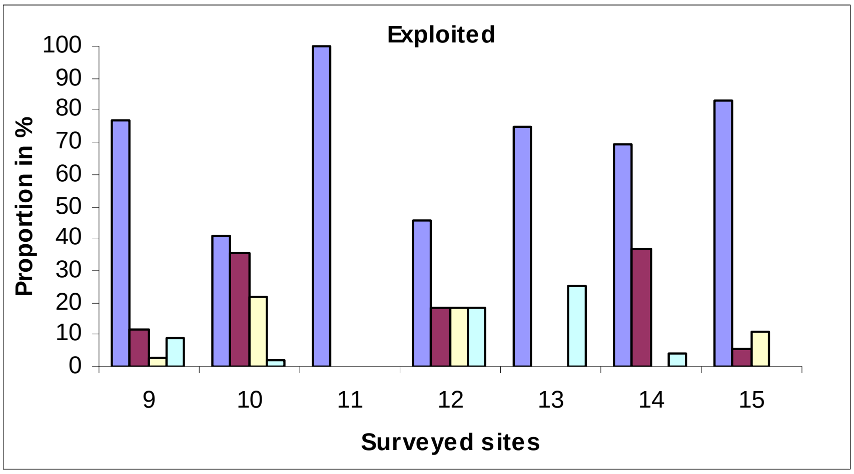


Figure 2. Age distribution in exploited and unexploited sites

Also in other sites (13 and 14) some age groups were absent. Most affected were groups III and II (newly matured or ready to mature snails and juveniles of 2 years old) that were absent from three sites, but also juveniles of Age I were absent from two sites.

Also comparisons were made between the overall proportions of snails in exploited and non-exploited sites. There was a higher proportion of adult snails in exploited sites. A χ^2 test performed indicated a significant difference of the age proportions between exploited and non-exploited sites (χ^2=31,94, df=3, p=0,000).

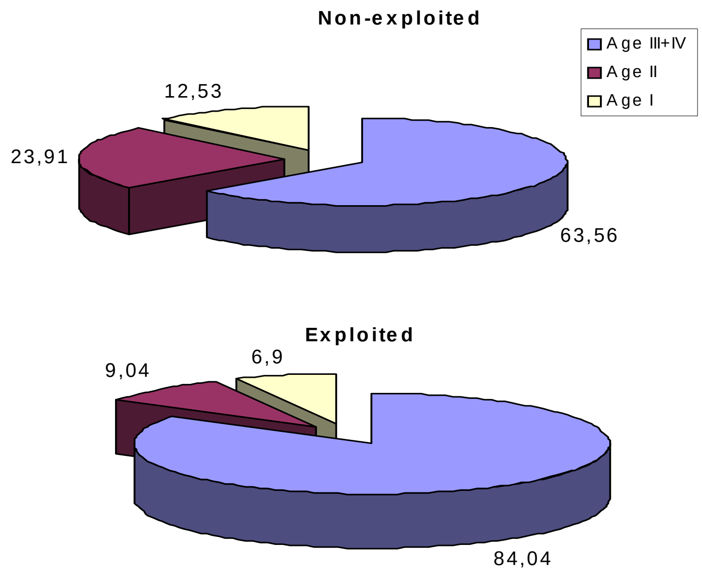


Figure 3. The proportion of snails of different age groups in exploited and non-exploited sites

DISCUSSION

Snail density

As revealed by current results, collection has a marked effect on the wild population of *Helix pomatia* in Moldova. Soil humidity also showed a significant effect on snail density. As remarked by Pollard (1975) this factor, including rainfall can be crucial in snail activity. Therefore, it is important to consider humidity levels as well, when measuring the impact of exploitation.

Significantly lower densities of snails in exploited sites compared to unexploited ones as well as the absence of any live snails in some of the collected places can be regarded as a warning sign for decision makers to undertake appropriate conservation measures. Further research is needed in order to measure if this level of resource exploitation is unsustainable or not.

In order to be able to assess the sustainability of resource use it is important to consider other data like the extent and variation in exploitation patterns, productivity of the populations and also life table data of the species (Robinson and Redford, 1994; Novaro, 1995; Alvard et al., 1997). Such data would allow the development of population models that are important for effective management strategies as well as for the survival of the species (Crouse et al., 1987; Heppel and Crowder, 1996; Heppel et al., 1999; Johnson and Braun, 1999).

The current low snail abundance in collected areas (ranging from 0 to 41 specimens per site) should be a warning since this can lead to population extinction, as most probable happened in a number of sites. At very low densities, the reproduction success can fail to a level that will not allow the natural recovery of the population (Hobday et al., 2001). As Roman snail has a poor dispersal and low mobility, the animals may not be close enough to accomplish fertilization ("allee effect"), which can lead to a decrease in birth rate. The observed age distribution supports this argument. Such environmental factors as droughts, frequently occurring in Moldova and having a marked effect on snail life can also add to the likelihood of local extinctions.

According to the information given by locals, collection occurs many times on the same territory, consequently resulting in very low densities. Some of the life history traits of Roman snail (mortality, fecundity and recruitment) and also their dispersal make it prone to overexploitation. As suggested by Pollard (1975) dispersal of this species seems to be very poor. The results of this study revealed that snails are highly aggregated in space. Field studies carried out during 1998-2000 demonstrated that *Helix pomatia* form big clusters especially during reproduction season. In Moldova the species is protected over reproduction period (June-July) by collection regulations (Anonymous, 2001). However, the regulations are subject to change adapting them to the requirements of collectors, rather than protecting the species. For example, during 2003, MECTD extended the collection to 15 of July (Letter Nr 2206 –07-07 from 17.06.03), motivated by "impossibility of finding snails due to the dry spell".

Drought season significantly restricts snail activity and makes them completely inactive through long aestivation. This can lead to reduced egg laying success (Pollard, 1975). During dry spells it is difficult for collectors to find snails and therefore commercial collection is not profitable. Extension of the collection period involves a high risk of overexploitation, as egg laying will occur only after suitable rainfall conditions. As mentioned above, due to the tendency to aggregate, the snails can easily be collected during the reproduction season. There is also a high risk that most of the snails will be collected even before they are able to lay eggs, since collections take place immediately after rainfall.

Studies (Pollard, 1975) have revealed that snail activity including reproduction is higher early in the season, since the soil contains more suitable moisture than during July-August. Therefore, dry spells occurring during April-June, as this year, have probable a negative impact on snail populations and the extension of the collection period increased the pressure and the likelihood for population depletion even more.

One important step in managing the collection of populations of snail species and avoiding population depletion would be the control over specific collecting areas and alternating the collection so that exploited populations may recover. This survey demonstrated that the type of collection management now employed is not effective. Every collecting company has been awarded a fixed collecting quota and its right to exploit a specific territory and they must present reports on the quantity of collected snails, but the collection is organized through collecting centres, and people bring snails from everywhere, not only from the specific designated area. This means that there is a failure in controlling the territories, where collections take place. One of the respondents indicated that during 1994-1996, when there was free access to the opposite side of the Dniester river, they collected snails even from the neighbouring country (Ukraine), since they owned a boat. Currently this access has been limited due to frontier guard controls. This can explain the lack of exact data on collecting places either at the MECTD or Local Ecological Inspections. The lack of information on post-collection status of the populations makes the situation even worse. Only data on pre-collection status of the populations is available (and still these data are highly unreliable), which shows that snail purchasers have only an immediate interest in populations with high density suitable for collections but are not concerned about the future of the populations.

One site among the non-exploited, with a high snail density has demonstrated signs of habitat fragmentation. As agricultural land use is one of the main sources of income for local communities in Moldova, this factor can add significantly to decline in the populations of Roman snail, as in many places people plough the land down to the river limits. This is especially important for the populations close to big rivers (such and Dniester and Prut) or their tributaries.

Shell size

As indicated by statistical tests, adults of 4 years old and older had bigger shells in exploited sites than in non-exploited. I assumed that collection would be size selective and eliminate bigger specimens from the population and therefore exploited populations could have smaller adult specimens, but current findings do not support this assumption. The collection recommendations (1995) set the shell width restrictions between 28 and 34 mm, therefore implying an age specific commercial collection, but they have changed in 2001 with a minimum shell size set at 30 mm. If the Ministry would use only the first recommendation, this would employ a size specific collection, therefore the adults (probable most sensitive group) would be protected, since the above indicated shell size correspond mainly to juveniles of age II. However, the regulation has changed, posing now a higher risk to the populations and to adult snails. Since the prices for one kg of live snails is very insignificant (from 50 bani to3-4 lei[1]), my assumption was that there is a tendency that collectors select bigger snails, otherwise not economically profitable. The information given by locals indicated however that collectors not only select bigger specimens and adults, but also collect all live snails they find, considering that this way they can gain more profit. The adequate sizes are selected only at the collecting centres, where animals are passed through special sieves.

The larger size of adult snails in exploited sites compared to unexploited could probable be explained as an effect of density – at lower densities larger shell sizes are expected. A number of studies on gastropods (Oosterhoff, 1977; Cameron and Carter, 1979; Goodfriend, 1986) and fish (Campbell, 1971) indicated a negative association between body size and density. It has been demonstrated by laboratory studies (Cameron and Carter, 1979; Dan and Bailey, 1982) that in land snails, at high densities there is a lower growth rate due pheromones from the mucus, which has an inhibitory effect on other specimens.

There was a significant positive correlation between shell size and soil humidity. Goodfriend (1986) indicates moisture conditions of the soil as being one of the best-documented environmental correlates with shell size.

Age distribution

The absence of some age groups from exploited sites might be an indicator of reduced birth rate of these populations due to very low density. Sites with the lowest densities were characterized by an absence of some age groups as well. For example, at site 11 with the lowest Sp, only adults older than 4 years were present, while others-absent. Even though specimens were found laying eggs, the future of this population is uncertain due to high mortality rates among juveniles caused by predation.

[1] 1 dolar is equivalent to approximately 14 lei

Other sites with low densities, such as 13 and 16 were also characterized by the absence of juveniles (Age I and II) and newly matured or ready to mature snails (Age III).

Robinson and Redford (1994) demonstrated that age distribution can be an indicator of sustainability of exploitation, exploited populations having usually a decreased proportion of adults than those free of exploitation. The current research however, did not demonstrate this pattern, as there was a higher proportions of adults in exploited sites compared to unexploited ones. As mentioned above, collectors do not select the biggest specimens, but collect all live snails. Since people are not rewarded for small sizes (less than 30 mm), the juveniles are simple thrown away. Sometimes when the purchases are poorly organized, for example when the purchasers do not appear at all, many animals perish.

Prospects for conservation

The Roman snail plays an important role in terrestrial ecosystems. They provide food and shelters for a large number of invertebrates and vertebrates (Uvalieva, 1990). Reference data (Striganova, 1975, 1980) indicate that together with other species of land snails and depending on their biomass and environmental factors, they can speed up litter degradation 3-8 times. Turcek (1970) has estimated that a population of this species with a biomass of 34 kg/ha can consume during an entire active period up to 650 kg/plant of fresh and senescent plants. Unlike other invertebrates the Roman snail has a very high food assimilation rate (81%) (Turcek, 1970) and therefore it is a crucial contributor to organic matter decomposition. Its significant role in ecosystem functioning should imply an increased concern for species conservation.

Being of a commercial value, this species should be subject to rational and sustainable exploitation. The slow growth rate and high mortality among eggs and juveniles as well as its capacity for spatial aggregation makes it vulnerable to exploitation. That is why a well-established system for assessment of pre-collection and post-collection status of the populations is critical for avoiding overexploitation. In addition to density, age and shell size distributions, data on mortality and fecundity as well as age-specific demographic information are significant in order to build effective management strategies for the survival of the species and prevention from the threat of extinction.

As there is a growing demand for Roman snail in Moldova among local people (who are interested in starting some innovative business), and from abroad, it would be almost impossible to ban the collection of this species as it may bring more significant damage to the populations through illegal collection. The development of snail breeding enterprises may act as "win win" alternatives. Through captive breeding it would be possible to get the necessary amount of snails required by the market and consequently there would be a decrease in pressure on the wild populations. As agriculture is one of the main income sectors of the country, research aimed at its improvement, especially development of innovative areas should be encouraged. It is important to mention here also the differences in the flesh quality of collected and farmed snails – the collected one having an inferior taste quality due to their feeding on toxic or bitter plants and the absence of a cleaning period before snails being sold (International Farming Institute, 1998). Also, regarding health safety, the snails collected from the wild might contain an increased level of heavy metals as being macroconcentrators of these substances (Andreev et al. 1998).

Discussion with many parties regarding snail growing, demonstrates that there is an interest in Moldova for establishing snail-breeding enterprises, and some have already been started. However, the lack of know how in this area, non availability of investment funds as well as discouraging biological traits of Roman snail (slow maturity and high mortality among hatchlings and juveniles) force many entrepreneurs still to consider snail farming as a risky business. Moreover, there are suggestions to introduce another species to Moldova, the non-native *Helix aspersa*. This species has a faster maturity rate and therefore could reach a higher abundance and biomass. In some countries where it has been introduced, it is regarded as a serious pest for many crops and ornamentals and native species of land snails (Baker and Watts, 2002). Trough resource competition, habitat change and disease transmission, it may also pose a threat to the wild populations of *Helix pomatia* in the Republic of Moldova. Only through rational efforts would it be possible to safeguard the populations of Roman snail in this country that are presently seriously threatened by exploitation. Good knowledge of its biology could help in setting effective management strategies for its conservation.

Conclusions

The current results demonstrated a significant impact of collection on snail populations, which are reflected in density, shell size and age distribution. The absence of live snails from a number of exploited sites might be an indicator that populations have been exterminated by collection in these areas and should serve as a warning sign in urgency of conservation measures. A very low density may contribute to „Allee effects" followed by a reproductive failure and local extinction of the populations. Further research and life table data are required for allowing the assessment of sustainability of exploitation and effective population management.

Bigger adult shells in exploited sites might be subject to reduced population density. Additional studies are suggested for a better explanation of this effect.

The absence of some age groups from exploited sites is probable a longer-term effect of exploitation on the populations and might be an expression of reduced reproductivity in such populations. A higher proportions of adults in exploited sites is due to the collection of all available snails rather than a size selective exploitation. Changing the current collecting management strategies is critical for species conservation. A size specific collection (shell size restrictions of 28-34 mm) would be more appropriate, since it will protect the adults, but further development of population models would allow to make more concrete inferences in this regard. It is important that in heavily exploited areas, as indicated by a very low density, collection should be stopped for 3-5 years to enable populations to regenerate. It is important that collecting areas alternate so that no potential for repeated collection on the same territory exist.
Due to their propensity for high spatial aggregations, especially during reproductive season, Roman snail is especially vulnerable to exploitation. Therefore, it is recommended that collection is suspended during June-July, which corresponds to the reproductive period of this species in Moldova. Long dry spells may have an additional negative impact on the populations of Roman snail. In such years, due to potential reduced reproductivity, commercial collection should not be performed until at least two weeks later after the start of rainfall following the dry spells.

It is important to identify areas with high populations densities and favourable habitat conditions that can be given protected status and can serve as sources of genetic variation for the improvement of affected populations, captive breeding and release programs. Signs of habitat fragmentation in non-exploited sites may indicate that this factor can add to the impact of overexploitation and lead to population depletion.

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