

STRUCTURAL – FUNCTIONAL TRANSFORMATIONS OF RODENT COMMUNITIES IN ECOSYSTEMS OF MOLDOVA ON THE BACKGROUND OF ANTHROPOGENIC AND CLIMATIC CHANGES

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Abstract. *The transformations of anthropogenic ecosystems in the last decades provoked significant structural-functional changes, favouring an evolution of rodent community species structure, as well as a reorganisation of the mechanisms of the number dynamics of the main species. In the 80s the species of the genus Apodemus were dominant in agrocoenoses (D = 63.1%), where A. sylvaticus and A. uralensis had the abundance of 55.1%, being constant (W > 25) on the agricultural fields and in the majority of natural coenosis of the agrocoenoses. The genus Mus species had the dominance of 25% and were background species on agricultural fields, while the species M. musculus was more frequent and more abundant (D = 15%). After 2000 the dominance of some rodent species increased (A. agrarius from 2.1% to 25.8%, M. spicilegus from 12.7% to 28.8%) and the dominance of other rodent species decreased (A. sylvaticus, A. uralensis and M. musculus: 12.1%, 5.2% and 2.8% respectively). At present, certain species, such as M. spicilegus, prove to be less adapted and thus their ecological significance clearly decreases, while other species, A. sylvaticus for example, prove a high adaptive potential under these conditions due to its trophic universalism, active mode of distribution in different activity periods, and capacity to determine the optimal condition station for each existence period.*

Keywords: *small rodents, community structure, ecosystem and climatic changes.*

Rezumat. Transformări structural-funcționale ale comunităților de rozătoare în ecosistemele Republicii Moldova pe fundalul schimbărilor antropo-climatice. *Transformările în ecosistemele antropizate din ultimele decenii au provocat importante schimbări structural-funcționale, favorizând o evoluție a structurii specifice a comunităților de rozătoare cât și o restructurare a mecanismelor dinamicii numerice a speciilor de fond. În anii 80 dominante în agrocoenoze erau speciile genului Apodemus (D = 63,1%) unde A. sylvaticus și A. uralensis aveau o dominanță de 55,1%, fiind constante (W > 25) pe câmpurile agricole și în majoritatea cenozelor naturale ale agrocoenozei. Speciile genului Mus aveau o dominanță de 25% fiind specii de fondal pe câmpurile agricole, iar specia M. musculus era mai frecvent și mai abundent întâlnită (D = 15%). După 2000 a crescut dominanța unor specii de rozătoare (A. agrarius de la 2,1% la 25,8%, M. spicilegus de la 12,7% la 28,8%) și a scăzut dominanța altor specii (A. sylvaticus, A. uralensis și M. musculus: 12,1%, 5,2% și 2,8% corespunzător). În prezent unele specii (M. spicilegus) dovedesc un potențial slab de acomodare micșorându-și brusc semnificația ecologică, iar alte specii (A. sylvaticus), din contră, grație universalismului trofic, modului activ de distribuție în diferite perioade de activitate, capacității de identificare a stațiunii cu condiții optime pentru fiecare perioadă de existență, demonstrează un potențial adaptativ sporit în aceste condiții.*

Cuvinte cheie: *rozătoare mici, structura comunităților, modificări ale ecosistemelor și climatice.*

INTRODUCTION

The modifications of climatic and economic conditions of the last decades lead to the changes of ecosystems' structure and to the modification of the Republic of Moldova landscape. Vast single-crop agricultural fields from the agrarian complex of 70-80's that occupied large territories are currently divided in parcels cultivated with various annual, biannual and perennial cultures, many of which are abandoned and uncultivated. Many used lands are abandoned and at present revert to their more or less natural state as natural biotopes, such as pastures, meadows, grazing lands etc. At the same time, the processes of anthropization, urbanization and degradation of the natural ecosystems occur all over the territory of the republic.

In this context modification of the specific structure of the communities occurs, as well as changes of the social structure of small mammals, which represent an intra- and interspecific phenomenon and are determined by the adaptive capacities of the species, as well as by the relations between the populations of these species. The transition from one form of population organisation to another, from one phase of population number dynamics to another is conditioned by the adaptation strategy of the species to the environmental condition changes that include populational factors, as well as environmental factors (MUNTEANU, 1997; MUNTEANU et al., 2003, 2007; SAVIN, 2003).

MATERIAL AND METHODS

The material was collected between 1977 and 2008 in different types of natural and anthropogenic ecosystems of the Republic of Moldova. To characterize the biotopic distribution of the species there were used the index of frequency (BALOGH, 1958): $F = \frac{100p}{P}$, where P – number of samples, p – samples in which the species is present and

the index of species dominance (abundance) $D = \frac{100n}{N}$, where n – number of individuals of certain species in the sample, N – total number of individuals (both indexes are expressed in percents). The importance of a certain taxonomic group in ecosystems was emphasized by calculating the ecological significance (W_a) according to the following formula

$W_a = F_a \cdot D_a / 100$, where F_a – frequency of the group_a and D_a – abundance index. The species of the taxonomic groups with the significance less than 1% was considered accidental; 1.1 – 5% – accessory; 5.1-10% – characteristic and $W > 10\%$ – constant for the studied biocoenosis. The statistical and factorial analyses, the graphic interpretation of the results were accomplished using the computer programs Statgraf, Microsoft Excel, Word.

RESULTS AND DISCUSSIONS

The rodents are an important element of terrestrial ecosystems and have fundamental functional importance. They are secondary and tertiary production users and serve as main trophic resource for many carnivore mammals and predatory birds, thus being important links within the trophic chain. The rodents have a significant role in the formation and fertilization of the soil. The ecological significance of the rodents in various ecosystems of the republic is constant or characteristic (Table 1); this taxonomic group has the highest proportion among mammal fauna of the ecosystems.

In the ecological conditions of the 80s-90s the structure of rodent communities from natural and anthropogenic ecosystems was determined by the mosaicity of the biotope, the degree and type of their exploitation, the background of predatory pressure and anthropogenic factors (MUNTEANU et al., 1992; SAVIN, 2001; 2004).

In the conditions of large areas (about 50-150 ha) of gramineae, cultivated crops, perennial fodder herbs, multiannual culture plants (vineyards, orchards, gardens) the species of genus *Apodemus* (KAUP, 1829) were dominant in agrocoenoses ($D = 63.1\%$), where *A. sylvaticus* (LINNAEUS, 1758) and *A. uralensis* (PALLAS, 1811) had the abundance of 55.1%, being constant ($W > 25$) on the agricultural fields and in the majority of natural coenoses of the agrocoenoses (Fig. 1). The genus *Mus* (LINNAEUS, 1758) species had the dominance of 25% and were background species on agricultural fields, while the species *M. musculus* (LINNAEUS, 1758) was more frequent and more abundant ($D = 15\%$) due to refuge stations that had existed in the mentioned period (haystacks formed after the cereals harvesting, which were available during August-May period, and sometimes even several years) with the density of 3-5 per 1,000 ha.

Table 1. Ecological significance (W_A , %) of mammal taxonomic groups in natural and anthropogenic ecosystems.
Tabel 1. Semnificația ecologică (W_A , în %) a grupurilor taxonomice de mamifere în ecosistemele naturale și antropizate.

Types of coenosis	Ecological significance of mammal taxonomic groups (W_a)				
	Insectivores	Rodents	Carnivores	Artiodactyles	Cheiroptera
Arboreous-shrubby	6.22	19.4	10.8	3.7	5.9
Rocky	0.66	8.5	6.5	0.3	9.7
Pastures	1.32	13.7	4.1	-	1.1
Steppe	0.8	9.3	1.4	-	0.8
Aquatic and paludous	0.2	3.7	0.9	0.4	1.4
Synanthrope	1.1	20.8	1.1	-	5.1
Multiannual cultural plants	2.3	21.4	2.3	0.2	2.1
Annual cultural plants	0.5	37.2	0.7	-	0.7

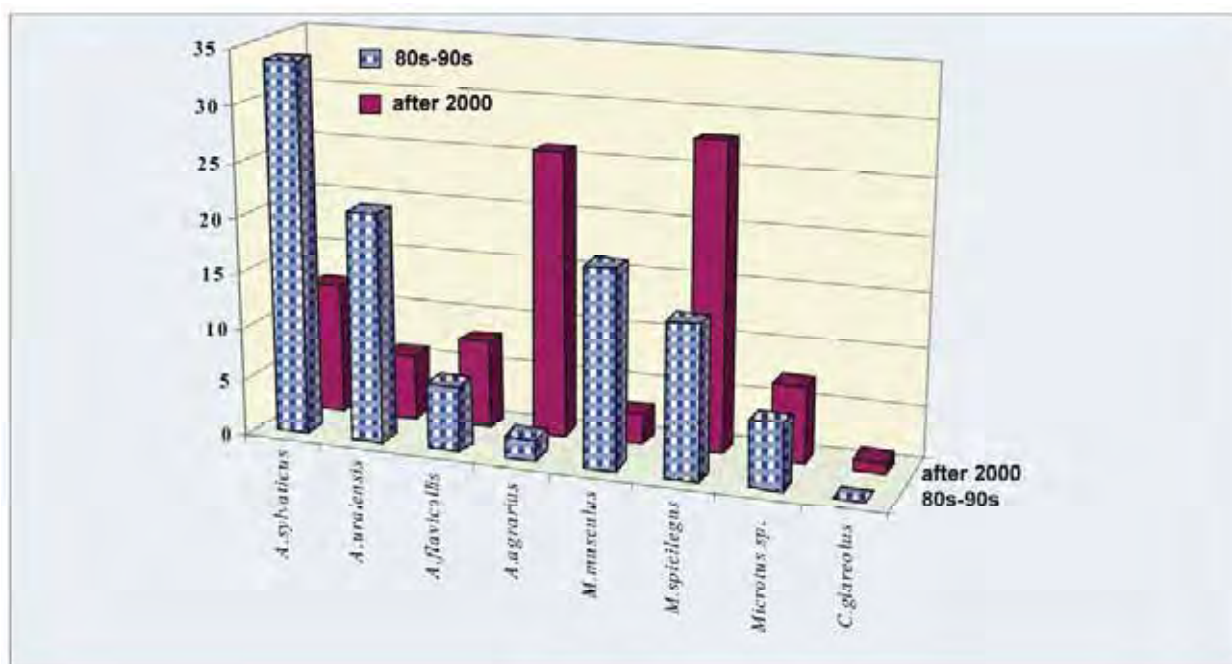


Figure 1. Evolution of rodent community structure (D, %) in agrarian ecosystems.
Figura 1. Evoluția structurii comunităților de rozătoare (D în %) în ecosistemele agrare.

The species *A. agrarius* (PALLAS, 1771) in this period had an accidental significance ($W < 1\%$) as it was recorded in some acacia shelter belts and in border sectors of clear forests.

It was established that the agrocoenosis modifications from the last two decades provoked structural changes in terrestrial vertebrate animal communities. The dominance of some rodent species increased (*A. agrarius* from 2.1% to 25.8%, *M. spicilegus* (PETENYI, 1882) from 12.7% to 28.8%) and the dominance of other rodent species decreased (*A. sylvaticus*, *A. uralensis* and *M. musculus*: 12.1%, 5.2% and 2.8% respectively).

Between 2004 and 2006, in agrocoenoses and in forest ecosystems some structural-functional modifications of rodent communities were recorded by comparing with the last decades of the past century. The abundance and the frequency of the species *A. agrarius* increased considerably (Figs. 1, 3); this species was constantly recorded in agrocoenoses, as well in forests. *A. uralensis* in the republic agrocoenoses is presented as low dominance species, less than 8%. In forest ecosystems this species was recorded seldom, only at the forest edges. *A. sylvaticus* has high abundance in agrocoenoses with annual cultivated plants, where it is the dominant species, while in woods it was recorded in proportion of about 16%. In agroecosystems, *C. glareolus* (SCHREBER, 1780) was registered during the reproductive period on several fields of forage at distances of 200m away from the woods and *A. flavicollis* (MELCHIOR, 1834) was present in rather low proportion ($D = 5-8\%$). In agroecosystems, due to the modifications of agrocoenosis structure, the abundance of the species *M. spicilegus* increased (Fig. 1). The dominance of *M. musculus*, along with the disappearance from the agricultural landscape of the haystacks, decreased considerably ($D = 2-3\%$).

Along with the disappearance from the agricultural landscape of the vast alfalfa fields and emergence of many small fragmented abandoned sectors, the number cyclicality of *Microtus* (SCHRANK, 1798) genus species is deregulated and favours a slight increase of the dominance of the species, the population of which underwent a phase of numerical growth between 2004 and 2008.

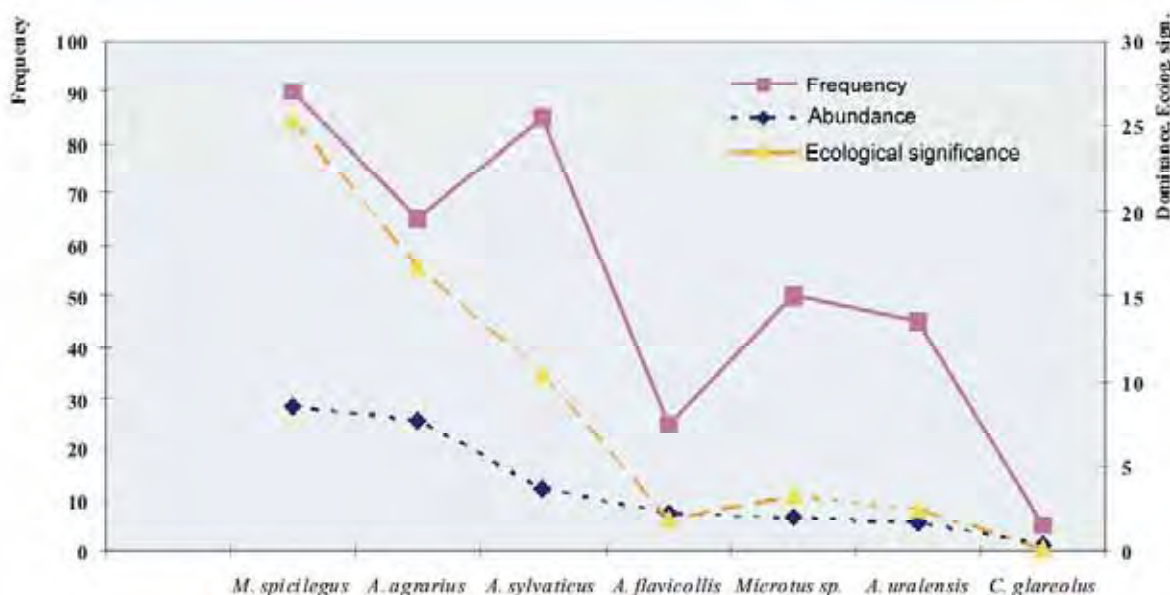


Figure 2. Species structure of small rodent communities in agrarian ecosystems in 2000-2006.

Figura 2. Structura specifică a comunităților de rozătoare mici în ecosistemele agrare în anii 2000-2006.

In 2000-2006 in the agrocoenoses all over the country (Fig. 2) *M. spicilegus* is the most abundant and numerous species, its ecological significance in agroecosystems is the highest ($W = 25\%$). In all the regions of Moldova the adaptation of this species to the new ecological conditions caused by the modification of the economy type can be observed in the last years. If in the previous decades the mounds of this species could be registered in autumn period after the harvest gathering only on the edges of the large one-crop fields, at present the mounds can be observed in large quantity on the whole surface of the lands after harvesting, starting with the second half of the summer. The mound building mouse starts to build the mounds from the beginning of August till October, when it can reach considerable dimensions (about 3 m in diameter and several meters under the soil surface). In such lands the density of *M. spicilegus* is very high – about 150-250 individuals per ha).

The species *M. musculus*, which 20 years ago found favourable conditions in the spring – autumn season in agricultural lands and reached high densities in the autumn period, at present it can be recorded rather rarely and in low frequency in agrocoenoses. This fact is due to the changes in the agriculture type, to the mosaicity of agrocoenoses, to the disappearance of the haystacks that offered shelter and trophic resources in cold period, as well as to the competition with *M. spicilegus* species. The last one, on the contrary, increased considerably in abundance and density in the last years and evolved from the structural-functional organisation point of view. Due to its higher ecological tolerance by comparing to the majority of other rodent species, the mound building mouse find favourable conditions in various types of agrocoenoses. Due to its higher aggressiveness by comparing to all rodent species, including *M. musculus*, *M. spicilegus* eliminates the house mouse from the optimal biotopes, and other rodent species that occupy similar

ecological niches are suppressed and forced to move to marginal biotopes. The mound building mouse possess a number of adaptive characters, which allow them to survive under the conditions of intense agriculture (SOKOLOV et al., 1990). Some of these peculiarities are:

- building of the mounds with trophic supply for winter period; the underground galleries and nidicole chambers are relatively deeply situated, which protect them from being destroyed during the land working;
- higher reproductive potential that allows them to restore in a short time period the population number after the winter period and after the agro-technical activity of the man;
- intense migratory activity – migration on other lands and in survival stations after the land working activities;
- diverse composition of the trophic base (vegetation), which allows the mound building mouse to populate the lands cultivated with various agricultural and forage plants, as well as the abandoned, virgin lands etc.; they easily shift from one food type to another;
- the phenomenon of torpor in the cold period of the year as physiological adaptation to surviving in unfavourable conditions (MUNTEANU & LARION, 2007; KOTENKOVA & MUNTEANU, 2007).

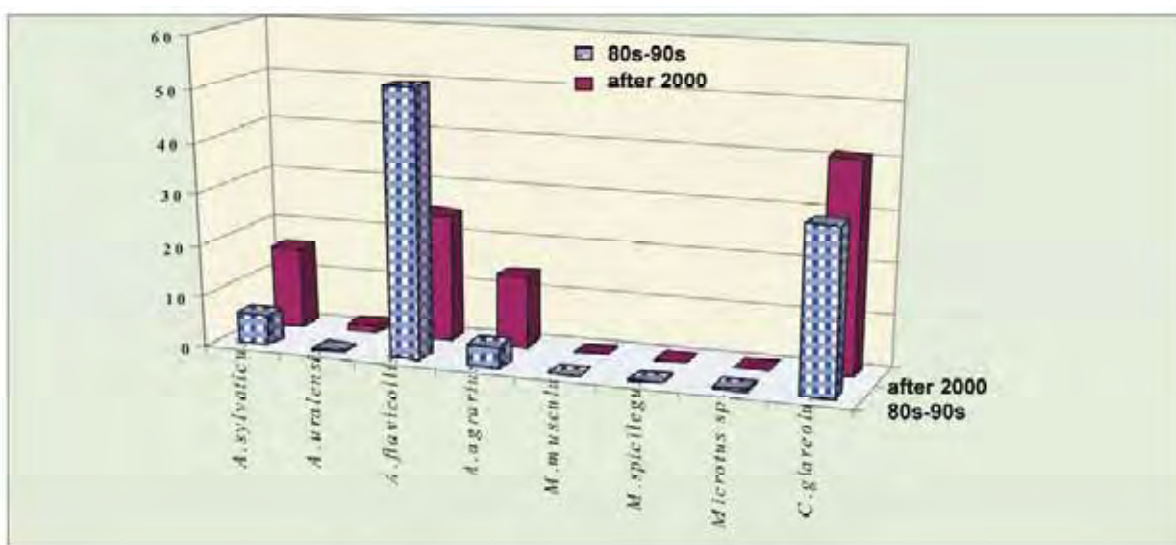


Figure 3. Evolution of rodent community structure in forest ecosystems.
 Figura 3. Evoluția structurii comunităților de rozătoare în ecosistemele silvice.

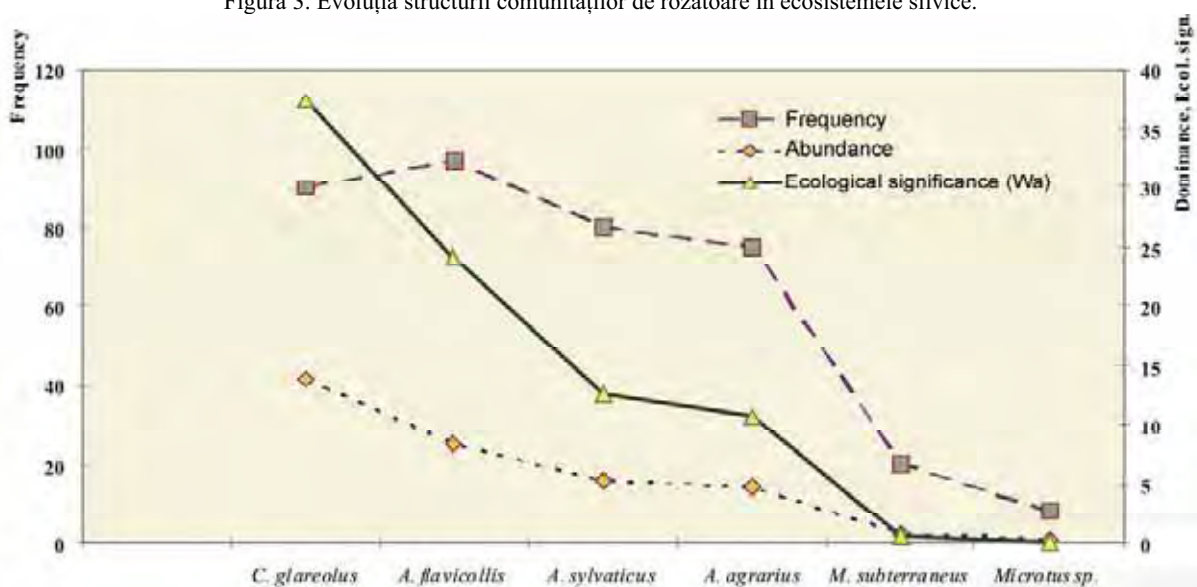


Figure 4. Species structure of small rodent communities in forest ecosystems between 2004 and 2006.
 Figura 4. Structura specifică a comunităților de rozătoare mici în ecosistemele silvice în anii 2004-2006.

A. agrarius became the second dominant species in agroecosystems. Although it is more a hygrophilous species its adaptation to the existence in more arid biotopes can be observed, where it find favourable trophic and shelter conditions. The characteristic significance ($W_a = 9.8$) for *A. uralensis* in agrocoenoses was recorded only in southern regions of the republic in specific biotopes. The forest ecosystems suffered in this period less pronounced changes, still the massive forest cuttings and clearings, the recreational factors from the central woods also caused some changes in the structure of rodent communities, where it can be recorded (Figs. 3, 4) an increase of the species *A.*

sylvaticus and *A. agrarius* abundance along with the proportion decrease of the typical forest species *A. flavicollis*, which points out the vulnerability of forest ecosystems particular for the last decade. Under the pressure of the climatic conditions from the last years, characterized by severe drought during the summer, a total depression in rodent population in agrocoenoses, as well as in forest ecosystems can be observed (Fig. 5). Under such conditions dense rodent communities are forming in some biotopes with wet microclimate near various aquatic basins.

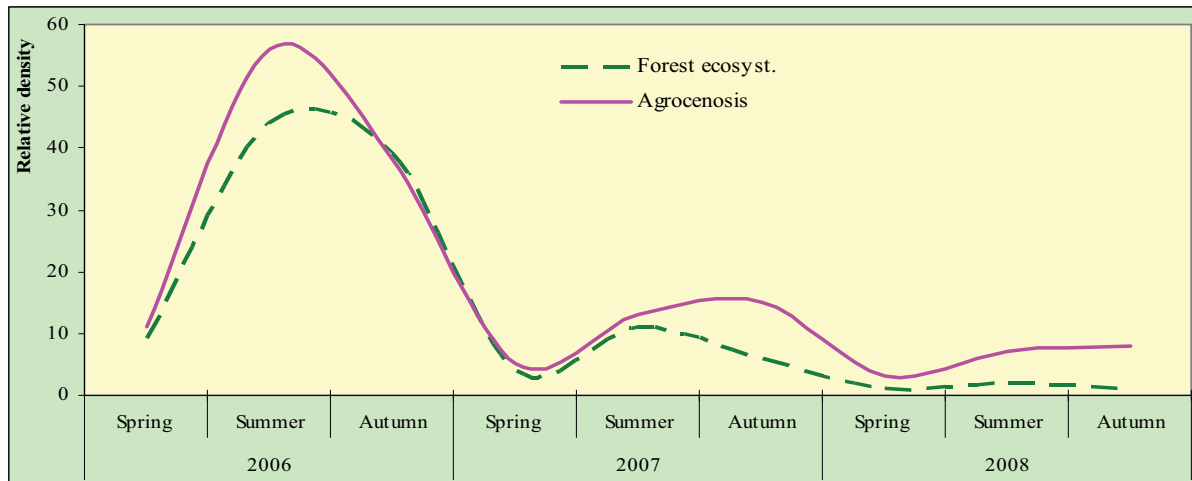


Figure 5. Multiannual dynamics of small rodent density in the ecosystems of the Republic of Moldova.
 Figura 5. Dinamica multiannuală a densității rozătoarelor mici în ecosistemele Republicii Moldova.

In the last years under the influence of exceptional climatic conditions some species (*M. spicilegus*) prove poor adaptive potential; they suddenly decrease their ecological significance, in spite of some adaptations recorded in the last few years to the conditions of modern agrocoenoses. Other species (*A. sylvaticus*) on the contrary increase their limits of ecological valence.

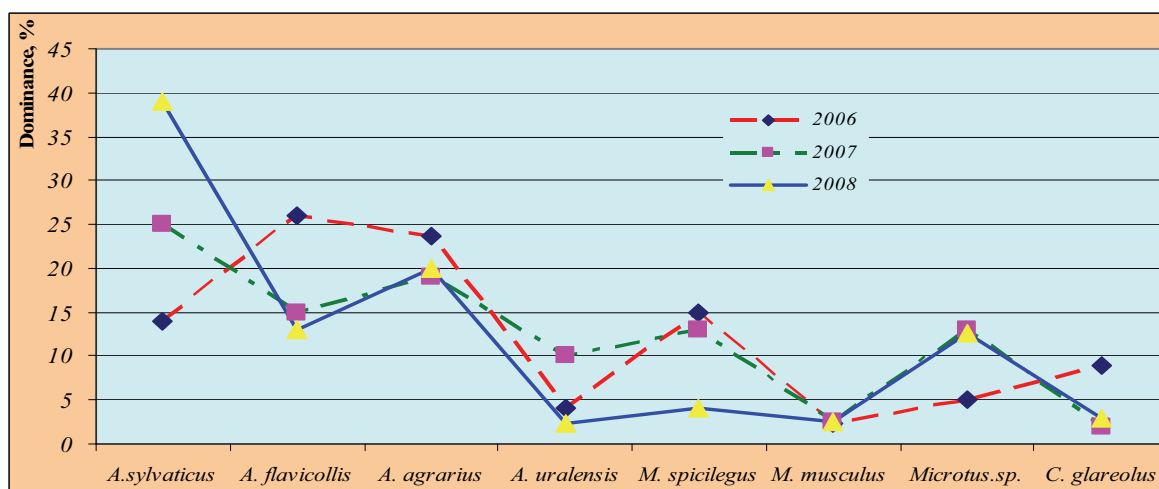


Figure 6. Structure dynamics of small rodent communities in the last years in the ecosystems of Moldova under the influence of environmental factors.
 Figura 6. Dinamica structurii comunităților de rozătoare mici în ultimii ani în ecosistemele R. Moldova sub influența factorilor de mediu.

After analysing the species structure of rodent communities in the republic ecosystems (Fig. 6) from the last years, we observe a dominance decrease of the sylvicolous species (*A. flavicollis* and *C. glareolus*) and of the species *M. spicilegus*. The considerable reduction of the dominance and, especially, of the density of these species populations is caused, along with the climatic factors that influence the trophic regime of the mentioned species, by the increasing number (by tenfold times) of myophagous predators (fox, marten, weasel). The populations of *M. spicilegus* species, adapting to the ecological conditions from the last years, intensely inhabits the gramineae fields and build on the stubbles summer mounds, which are already finished toward September. The late ploughing of the stubbles (September-October), particular for the last years, leads practically to the destruction of this species population that cannot re-establish its mounds toward the cold period of the year.

Under these conditions *A. sylvaticus* manifests remarkable adaptive capacities and have the dominance of about 40% in various ecosystems. This species with large limits of ecological valence has the ability to quickly adapt to

the modifications of the ecological conditions. Therefore, in the last two years, in spite of extremely droughty and arid conditions, the wood mice are the most prosperous species among the rodents, being dominant and constant in the republic ecosystems. The adaptive potential of *A. sylvaticus* consists in the solitary way of life, the use of a large trophic resources spectrum, use of most various biotopes as refuge stations, intense migration to optimal habitats during the year, the high reproductive potential, as well as the extensive period of reproduction activity. (MUNTEANU et al., 2007; SAVIN, 2001; 2003). Among the ethological adaptations of the species there can be mentioned the high degree of exploratory activity that is manifested by a high mobility of the individuals, to faster explore and to better orientate in new conditions, as well as by the high degree of "suspiciousness" toward the new environment (MUNTEANU & CEMIRTAN, 1997), which made them less exposed to the predator attacks.

CONCLUSIONS

The social and agricultural transformations in the anthropogenic ecosystems of the republic at the millennium transition provoked significant structural-functional changes in their ecological aspect, favouring an evolution of rodent community species structure, as well as a reorganisation of the mechanisms of the number dynamics of the main species.

Under the conditions of ecosystem aridization *M. spicilegus* prove to be less adapted, the trophic deficit connected to the vegetations peculiarities under drought conditions and several agrotechnical factors that are characteristic for the moment became fatal for this species. *A. sylvaticus* due to its trophic universalism, to its active mode of distribution in different activity periods, to its capacity to determine the optimal condition station for each existence period, proves a high adaptive potential under these conditions. Thereby we have to mention that the stability and equilibrium state of each ecosystem is insured by the optimum of its biodiversity and is maintained in biotic and abiotic conditions favourable for the quantitative and qualitative biologic balance between producers and consumers within the trophic chains. The applied aspects of these relationships consist in the ecological rehabilitation of the degraded ecosystems under the influence of anthropogenic pressure, in the formation of artificial ecosystems that could optimise the environment and in the determination of exploitation parameters of the functional elements with the aim to preserve the ecosystem stability.

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