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Particularities of microtine dispersion during the population growth phase

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Abstract. In this paper, we aim to elucidate and substantiate the specific influence of ecological factors on the processes of dispersion and thermoregulation in microtine species, as well as to model this process. The dispersion of *Microtus arvalis* and *Microtus rossiaemeridionalis* occurs at peak population density or during the growth phase until resources are depleted. Typically, individuals sensitive to increasing density are the ones to migrate. When studying dispersion patterns, it is necessary to analyse the influence of temperature on this process, considering that in recent years, this parameter has shown increasingly higher values during the summer.
Keywords: dispersal, migrants, residents, thermoregulation, cohort.

Particularităţile dispersiei microtinelor la faza de creştere a efectivului numeric

Rezumat. În lucrarea de faţă ne-am pus ca scop de a elucida şi fundamenta specificul influenţei factorilor ecologici asupra proceselor de dispersie și de termoreglare a speciilor de microtine, precum şi modelarea acestui proces. Dispersia speciilor *M.arvalis* şi *M. rossiaemeridionalis* se manifestă la o densitate maximă ori la faza creşterii până la epuizarea resurselor. De obicei, migrează indivizii sensibili la majorarea densităţii. Studiind particularităţile dispersiei, e necesar de analizat influenţa temperaturii asupra acestui proces, ţinând cont de faptul că în ultimii ani se înregistrează valori tot mai mari ale acestui parametru pe parcursul verii.
Cuvinte-cheie: dispersie, migranți, rezidenți, termoreglare, cohortă.

1. Introduction

Dispersion, until the last decades, was not appreciated as one of the demographic phenomena influencing population density. This fact is explained by the difficulties of separating and attributing to individuals the status of sedentary and immigrant individuals, as well as those eliminated by emigrants. As a result of a series of experimental researches of micromammal populations, it was established that dispersal represents one of the basic mechanisms of regulating the numerical density of populations [2, p. 144]. It is considered that the intensity of dispersal is determined, first of all, by the population density, the

character of the groups and the degree of correspondence of the biotope. For microtines, dispersal is more pronounced in the growth phase and in the peak compared to the depression phase [3, p. 62]. Based on this, it is necessary to draw special attention to the ecological-physiological adaptive peculiarities of micromammals, in general, and of the microtine species – *Microtus arvalis* and *Microtus rossiaemeridionalis*, in particular, which can be explained by ontogenetic mechanisms of thermoregulation in relation to certain phases of the oscillation of the numerical population. Of particular interest is the study of the peculiarities of dispersion and oxygen consumption, as a component part of the metabolism of these species during the phase of increasing the numerical population. In the present work, we also aimed to elucidate and substantiate the specifics of the influence of ecological factors on thermoregulation processes as well as the modelling of this process.

In the present work, we also aimed to elucidate and substantiate the specifics of the influence of ecological factors on thermoregulation processes as well as the modelling of this process.

For the studied species, as well as for other rodents, thermoregulation behaviour is of great importance, which allows them to avoid extreme temperature values [4, pp. 9–14]. This process is also called ecological thermoregulation, a phenomenon widely encountered in nature. The main forms of ecological thermoregulation are: alternation of activity phases, change of burrow depth and colonization sites, etc. Elucidating the influence of abiotic factors on individuals of the studied species, it is necessary to differentiate the lower and upper temperature limits, within which microtines can survive. In the first case, the individual can independently recover from hypothermia, and the temperature that allows artificial resuscitation is determined as a result of the gradual warming of the environment in which it is located.

2. Materials and Methods

Below, we describe the methods were used to record the number of micromammals, determine the generative state and fecundity, and record the number of colonies [1, pp. 28–32]. In some cases, microtine colonies were dug up. The population size of the studied species was expressed as the number of individuals per unit area. This expression is a widely used unit of measurement in ecology and is known as absolute density. The study of the spatial structure of populations in agrocenoses, the determination of the numerical size, the activity of individuals, and the areas of individual sectors were carried out on marking grids. Individuals were captured using traps, located on 4 ha nets at a distance of 20 m, and on 1 ha nets – at a distance of 10 m from each other and directly at the colonies.

The biotope distribution was characterized by frequency and abundance indices. Oxygen consumption was determined using a respirometer for long-term recording in ecological-physiological experiments [5, p. 96].

3. Results

Dispersal of *M. arvalis* and *M. rossiaemeridionalis* occurs at maximum density or during the growth phase until resources are exhausted. Usually, individuals sensitive to increased density migrate. Dispersal during the peak population phase is characterized by the emigration of surplus individuals, often referred to as "social outcasts", primarily consisting of subadults and senile individuals. During the population growth phase, microtine dispersion from perennial herbaceous habitats to adjacent grassland sites begins. This process was observed in the second half of autumn and continued into December, when colony density in these habitats reached approximately 350 colonies per hectare. The colonies were evenly distributed throughout the grass field, with no signs of aggregation. They were distributed almost rectilinearly in the direction of the seed rows at a distance of 3-5 m from each other, being joined by paths. The rows of colonies, oriented in one direction, were located at a distance of 7-10 m from each other [2, p. 144]. The largest groups of colonies were located at a distance of 10-20 m from the edge of the field, where the first migrants from the neighbouring alfalfa field dispersed. In February of the following year, females comprised the majority (64.7%) of migrants from the cereal field, while males predominated among residents of the grove and those remaining in the alfalfa field (56.7% and 58.3%, respectively). These groups also differ in their age structure. In the cereal fields, the population consisted of 3-4 cohorts. More than 28% of the specimens belonged to the spring-summer cohort. Individuals of the autumn cohort constituted 48%. The population of residents on the alfalfa field, as well as that of migrants from the straw bales, consisted of 2-3 cohorts. The majority of the individuals from the straw bales (70.7%) belonged to the summer cohort, 27.6% – to the autumn one and only 1.7% – to the spring cohort. The cessation of perennial grass growth, along with damage caused by burrow entrances, degraded the nutritional base. In the neighbouring wheat field, the nutritional base was abundant. This type of dispersal resembles the previously described pattern but differs in that the majority of migrants are individuals that initiate reproduction earlier than those remaining at their original location [3, pp. 62–63].

4. Discussions

The intensity of dispersal is largely influenced by the duration of population presence in the habitats. For example, dispersal patterns in the spring differ depending on whether

the cereal crop population was established in the previous autumn or the same spring. Competition among microtines affects emigration and immigration primarily when population density reaches its maximum. At a maximum density, migrants predominate. Increased mortality is also confirmed by the frequent replacement of some individuals with others on the marking net. Only 50% of previously captured individuals remain on the net, decreasing to 15% after 1.5 months [2, p. 144].

The sharp decline in microtine numbers in agrocenoses during the following year – when population were in the depression phase and factors such as density and competition no longer favoured dispersal – is explained more by mortality than by dispersal. In studying the peculiarities of dispersion, it is necessary to analyse the influence of temperature on this process, taking into account the fact that in recent years, increasing values of this parameter have been recorded during the summer [3, p. 63].

The influence of infrared radiation depends on the thermal level and the duration of action. High temperature over a long period of time results in the cessation of reproduction and resorption of embryos. For the studied species, the upper limit temperature is 37 °C. Being exceeded, it causes the mortality of individuals in the amount of 100% (Fig. 1). For the species *M. arvalis*, the share of eliminated individuals is insignificantly higher than for *M. rossiaemeridionalis*. The maximum temperature limit supported by the organism depends on humidity and the duration of the influence. At a humidity of 95%, the lethal temperature for *M. arvalis* is 35 °C, while for *M. rossiaemeridionalis* it is 36 °C.

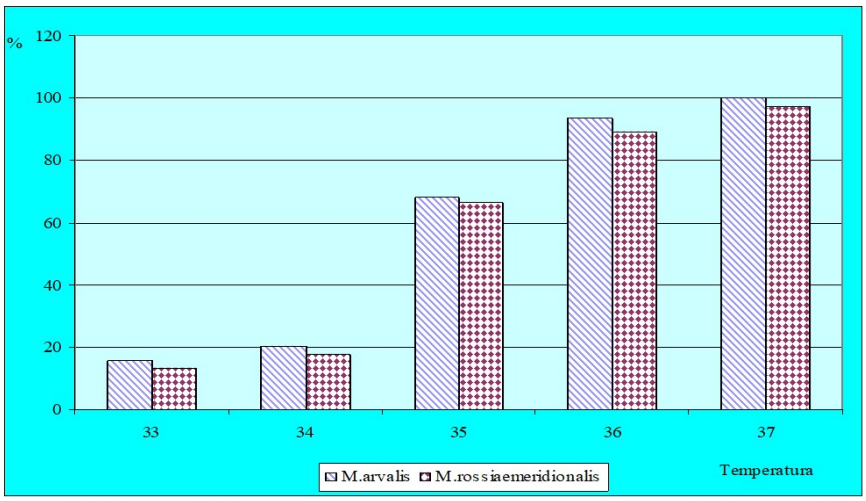
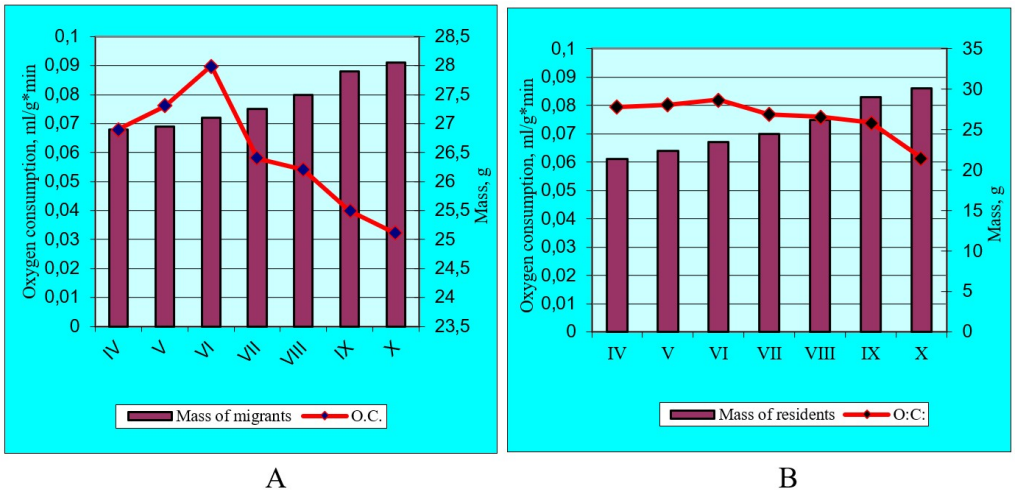


Figure 1. Percentage of eliminated individuals of the susceptible species *M. arvalis* and *M. rossiaemeridionalis* depending on temperature (°C)

Forced insolation causes the death of individuals within 5 minutes. A correlation of oxygen consumption with body mass was determined in migratory males of the species *M. arvalis*. With the increase in body mass from spring to autumn, oxygen consumption also increases from April to June, then decreases until October (Fig. 2).



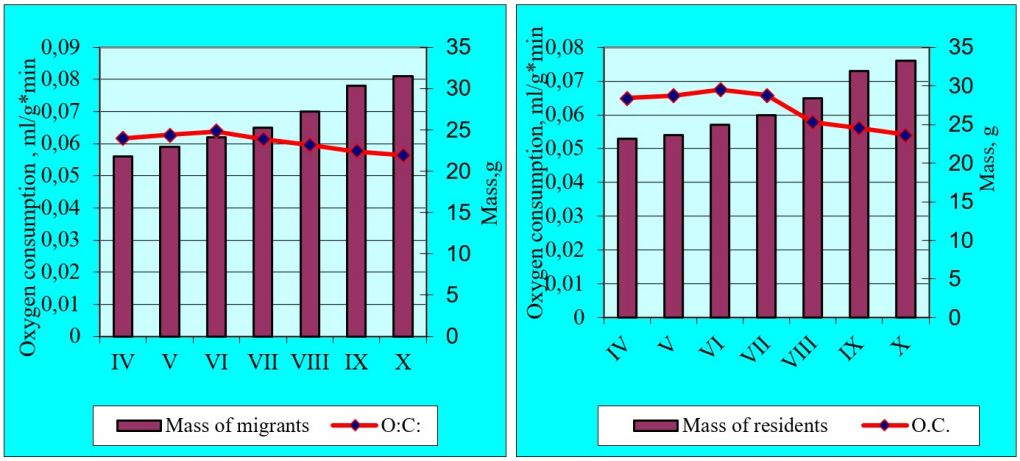
A B

Figure 2. Monthly dependence of oxygen consumption on body mass in migratory (A) and resident (B) males of *M. arvalis*. Legend: O:C: – oxygen consumption (ml/g*min)

The proportion of emigrating individuals do not depend on population density. Young specimens disperse more intensively. These migrants mature faster, reproduce and survive better than young residents. During spring and autumn, increased dispersal is associated not only with population growth but also with disruption of the social structure. In determining the dispersal patterns of animals inhabiting heterogeneous environments, biotope structure – i.e., external environmental factors – is more influential than endogenous factors. It is believed that emigration is a means of increasing the adaptation of rodents. Dispersion develops in response to the behaviour of parents. The possibility of migration to different intrapopulation groups varies, being determined in each specific case by the social structure. Intrapopulation groups are different in their qualitative composition, which determines a certain hierarchical structure of them. The dispersion of microtines in agrocenoses is explainable by the mechanism of the relationships between individuals.

For resident males of the species *M. arvalis*, we established the same trend: body mass was higher than in migratory males, while oxygen consumption was lower. However, these differences were not statistically significant (Fig. 3). Oxygen consumption

is insignificantly higher for *M. arvalis*, whose individuals are more aggressive than *M. rossiaemeridionalis*.



A B

Figure 3. Monthly dependence of oxygen consumption on body mass in migratory (A) and resident (B) males of *M. rossiaemeridionalis*. Legend: O:C: – oxygen consumption (ml/g*min)

As in the case of the *M. arvalis* species, the mass of migrants is lower than that of residents, and oxygen consumption is higher.

5. Conclusions

It was determined that during the population growth phase, females predominated among migrants in the cereal field (64.7%), while males were more numerous among residents in the forest and those remaining in the alfalfa field (56.7% and 58.3%, respectively).

It was found that as temperature increases to 20 °C, oxygen consumption decreases in both species. However, at 35 °C, oxygen consumption increases in *M. arvalis* but continues to decrease in *M. rossiaemeridionalis*.

In *M. arvalis*, as body mass increases from spring to autumn, oxygen consumption rises from April to June, then declines through October. Oxygen consumption is insignificantly higher for *M. arvalis*, whose individuals are more aggressive than *M. rossiaemeridionalis* individuals.

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