POLISH ECOLOGICAL STUDIES (Pol. ecol. Stud.)	20	4-3	243 – 247	1994
"Rodens & Spatium IV"				

Oleg LUKYANOV*, Wiera WALKOWA** and Krystyna ADAMCZYK**

*Institute of Plant and Animal Ecology, Russian Academy of Sciences,
8 Marta 202, Ekaterinburg, 620219, Russia
**Institute of Ecology, Polish Academy of Sciences, Dziekanów Leśny 05-092 Łomianki, Poland

ANALYSIS OF MORTALITY AND EMIGRATION IN A HOUSE MOUSE POPULATION

A regression model is suggested, which allows the percentage of emigrants and residents in populations of the donor type to be estimated along with mortality and emigration rates based on an analysis of animals' distribution in relation to its residence in the population. The model was applied for the analysis of a house mice population kept in an outdoor, permeable enclosure. The percentage of emigrants in the population was very high and the emigration rate significantly exceeded the resident mortality rate. The percentage of male emigrants was much higher than of females. The sex ratio was in favour of females among residents, and in favour of males among emigrants.
Key words: Model, resident, emigration, mortality.

1. INTRODUCTION

The aim of the work was to develop an approach which would allow an analysis of the disappearance of small mammals from a population due to mortality and emigration, and to estimate the proportion of emigrants and residents.

2. THEORETICAL MODEL

Andrzejewski and Wierzbowska (1961), and Wierzbowska and Petrusewicz (1963) developed a method of estimating the abundance of resident and dispersing animals in a population from the duration of their stay in the population.

Another approach is suggested in our work, based on regression models. We consider a population of the donor type, where the abundance depends on natality, mortality and emigration. We suppose that the population consists of residents and emigrants, the former disappear as a result of mortality, and the latter leave at a certain period in their life.

We propose a nonlinear regression model to estimate the percentage of emigrants (p) and residents ($1 - p$) in a population at the marking moment ($t = 0$), the instantaneous mortality rate of residents (g) and the instantaneous emigration rate (m) based on the analysis of distribution of animal numbers (N_t) in relation to the duration (t) of their stay in the population:

$$N_t = N_0 [(1 - p)\, e^{-gt} + pe^{-mt}] \quad (1)$$

It is expected from the properties of equation (1), that the numbers of the initial population (at the marking moment $t = 0$) decrease gradually as a result of mortality and emigration.

We assume that the instantaneous mortality (g) and emigration rates (m) are linear functions of the animals' duration of stay (t) in a population, i.e. $g = g_0 + at$, $m = m^0 + bt$. This assumption is more realistic in comparison with an assumption of the constant mortality and emigration rates. In the simplest case when mortality and emigration rates do not depend on the animals' duration of stay in a population, (the values of a and b coefficients are statistically indistinguishable from zero), it is expected that animals disappear from a population as a result of both mortality and emigration in agreement with exponential curves.

3. MATERIALS AND METHODS

An open *Mus musculus* L. population kept in an outdoor, permeable enclosure on the northern outskirts of Warsaw was studied from April 1986 to May 1988. The enclosure measured 600 m^2. It was spontaneously inhabited by house mice from the surrounding habitats. Mice were studied by the catch-mark-release method, and were trapped regularly, (every 14–15 days by 617 live-traps).

The authors have traced the disappearance of 660 individuals (304 females, 356 males) over 281 days since the first capture (20 trapping sessions). During each trapping session food (8 kg of oats) was provided in the enclosure, thus making the habitat optimal.

4. RESULTS

The analysis of distribution of numbers of house mice in accordance with the duration of their stay in a population (Fig. 1), indicates a more intensive disappearance of individuals from a population during the first months after the marking moment in comparison with the periods which follows. This may result from mortality and emigration.

Usage of the proposed regression analysis on the empirical data (Fig. 1), shows that the house mouse disappearance from a population is most adequately described by a regression in which the instantaneous mortality (g) remains constant (the value of coefficient a is statistically indistinguishable from zero, therefore this coefficient is excluded from the equation), while the instantaneous emigration, m is a linear function of the animals' duration of stay (t) in a population ($m = m_0 + bt$) (Table 1).

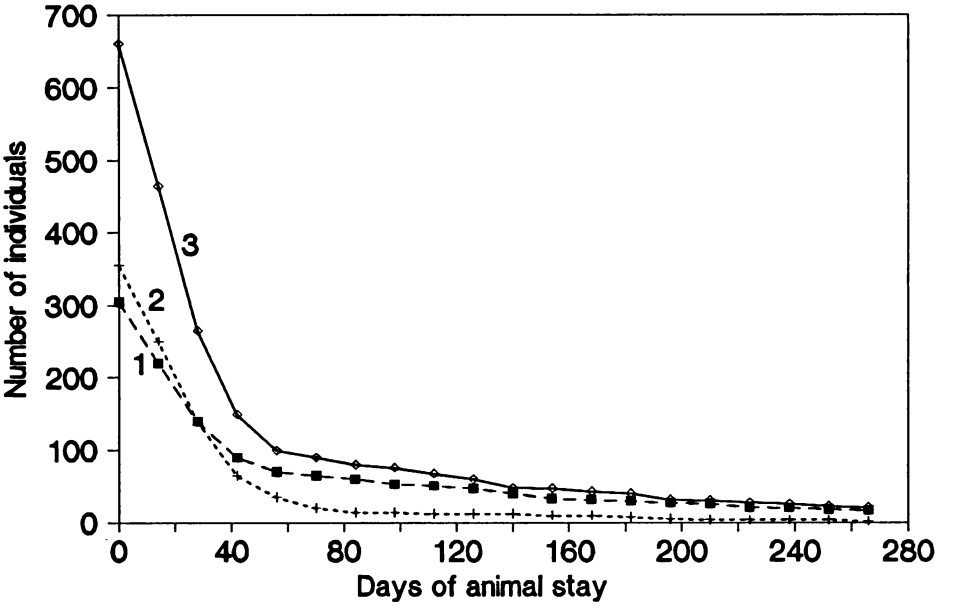

Fig. 1. Disappearance of individuals from the house mouse population
1 - females, *2* - males, *3* - total

The percentage of emigrants p in a population at the marking moment ($t = 0$) was significant (Table 1) and higher for males than females ($t = 26.2$, $p < 0.0001$). Instantaneous mortality was the same in both sexes (Table 1). Emigration (m_0), independent of the duration of stay in a population, was higher in males than in females ($t = 2.1$; $p < 0.05$). Disappearance by emigration was much higher than the mortality rate (Table 1).

Disappearance was also more intensive in males than in females. Therefore, the percentage of males gradually decreased from 54 to 19%, as their duration of stay in the population increased.

Table 1
Results of a nonlinear regression analysis of dispersal processes in an open house mouse population kept in an outdoor enclosure

Estimates	Males	Females	Total
Emigrant share, p	0.929 ± 0.006*	0.655 ± 0.009*	0.799 ± 0.004*
Instantaneous mortality, g	0.006 ± 0.00054*	0.006 ± 0.0002*	0.006 ± 0.0002*
Instantaneous initial emigration, m_0	0.016 ± 0.0006*	0.011 ± 0.0023*	0.0144 ± 0.0007*
Linear coefficient of emigration change from time, b	0.0007 ± 0.00003*	0.0013 ± 0.0001*	0.0009 ± 0.00003
Determination coefficient, R^2	0.9999*	0.9994*	0.9999*
Time 95% disappearance (days):			
residents, Tr_{95}	507	506	496
emigrants, Tm_{95}	55	45	52
total, T_{95}	81	326	235

* $p < 0.001$ - significance level of the difference of these estimates from 0.

On the basis of regression estimates, theoretical curves of distribution numbers of residents and emigrants were computed in relation to the duration of stay in a population (Fig. 2). Their shapes suggest that the higher disappearance rates in the initial period are primarily connected with emigration. As a result, the percentage of emigrants decreased rather sharply from 80% (at the marking moment), to 0 towards the 100th day, as duration of stay in the population increased.

Sex ratio at the marking moment was in favour of females amongst residents (81.4%, n = 130), and in favour of males amongst emigrants (62.2%, n = 530).

Verification of the model was based on direct observations on migration in the house mouse population (Walkowa, Adamczyk and Chełkowska 1989). It was satisfactory judging from the characteristics available for the comparison, including resident's life span, emigrants' duration of stay in the population (for 85–90% of individuals), and sex ratio among residents.

5. CONCLUSION

1. A regression model is proposed which permits the percentage of emigrants and residents in a population of the donor type to be estimated together with

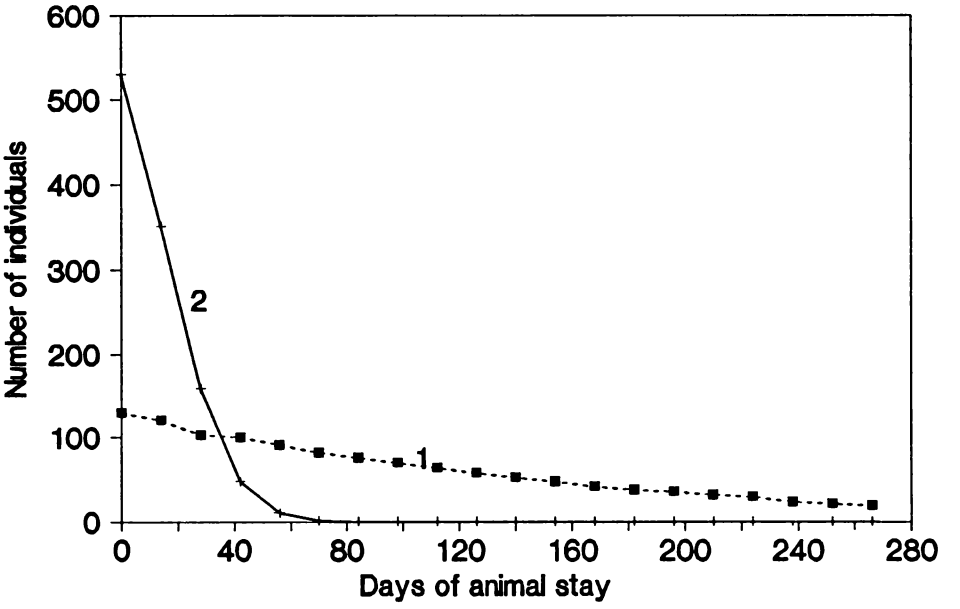

Fig. 2. Disappearance of residents (1) and emigrants (2) from the house mouse population

an evaluation of mortality and emigration rates based on the distribution of animal numbers versus duration of their stay in a population.

2. A high percentage of emigrants was typical of the investigated house mouse population. The emigrant disappearance rate significantly exceeds the mortality rate of residents. As a result, the phenomenon of "juvenile dispersal" arises, when most emigrants leave the population during a short period after the marking moment.

3. The percentage of emigrants at the marking moment was significantly higher in males compared with females. The sex ratio among residents was in favour of females, while among emigrants it was in favour of males.

This paper was prepared in the Institute of Ecology, PAS, as a part of the scientific programme "Animal Populations: Models of organization and dynamics" and supported by the Russian Fund for Fundamental Investigations (93-04-6944, 93-04-7888).

6. REFERENCES

Andrzejewski R. and Wierzbowska T. 1961 - An attempt at assessing the duration of residence of small rodents in a defined forest area and the rate of interchange between individuals - Acta theriol. 5: 153-172.

Walkowa W., Adamczyk K. and Chełkowska H. 1989 - Characteristics of migrants in a free-living population of the house mouse - Acta theriol. 34: 305-313.

Wierzbowska T. and Petrusewicz K. 1963 - Residency and rate of disappearance of two free-living populations of the house mouse (*Mus musculus* L.) - Ekol. pol. Ser. A, 11: 557-574.