Hystrix It. J. Mamm. (n.s.) 17 (2) (2006): 173-177

WINTER SURVIVAL OF *APODEMUS FLAVICOLLIS* IN CRABAPPLE ISLAND (NE POLAND)

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Received 8 November 2006; accepted 12 December 2006

RIASSUNTO – ***Sopravvivenza invernale di* Apodemus flavicollis *nell'isola di Crabapple (Polonia nord orientale).*** Nel corso di nove anni consecutivi (1994-2003), la sopravvivenza invernale di *Apodemus flavicollis* è stata indagata nell'isola di Crabapple (4 ha) tramite cinque serie annuali di trappolaggi condotte tra Aprile ed Ottobre. Le condizioni climatiche invernali sono state espresse tramite 22 variabili relative a piovosità, temperatura e precipitazioni nevose. La percentuale di animali sopravvissuti è variata dal 5,3% al 51,1%, senza mostrare alcuna relazione con le variabili climatiche e con la consistenza della popolazione a inizio inverno. Tra le variabili individuali considerate (età, stato riproduttivo, massa corporea), la maturità sessuale sembra essere l'unica a favorire la sopravvivenza invernale, in contrasto con le informazioni disponibili in letteratura.

Parole chiave: *Apodemus flavicollis*, consistenza della popolazione, sesso, massa corporea, condizioni climatiche

Three papers considering winter survival of the yellow-necked mouse *Apodemus flavicollis* (Melchior, 1823) have been published so far, all of them based on the same data set sampled in Białowieża Forest, NE Poland (Pucek *et al.*, 1993; Jędrzejewski and Jędrzejewska, 1996; Stenseth *et al.*, 2002).

This paper is an attempt to analyse factors affecting winter survival of yellow-necked mice inhabiting Crabapple Island (NE Poland). Our main interest was to evaluate the potential impact on winter survival of individual features of the rodents (sex, reproductive status, body condition), because the above mentioned authors omitted such information in their publications.

The sampling site was Crabapple Island on Beldany Lake, covered with mixed deciduous forest. The entire 4 ha area of the island was sampled using a grid of 159 evenly distributed trap sites (Bujalska and Grüm, 2005). Traps were inspected twice a day, at 7.00 a.m. and 7.00 p.m., for each of the five trapping series, lasting seven days and conducted at six weeks intervals from April through October. Trapped rodents were weighed and sexed, and their identification marks and location in the grid were recorded before releasing. During nine consecutive winters (1994-2003) the number of marked mice present in October (i.e., at the end of the breeding season) were compared with the number of marked mice trapped in the following April. Mature females (i.e., either pregnant or having open vaginal orifices) were distinguished from sexually immature ones, and mature males (showing scrotal testes) from immature ones (with abdominal testes). Occasional unmarked mice, born earlier in spring (e.g., in March), were excluded from calculations. In October three age groups were distinguished: (1) over-wintered individuals (born in the previous year) which were excluded from estimates of winter survival because they do not survive two winters, (2) individuals caught for the first time in the first half of the breeding season, i.e. in June or July trapping series (called spring generation), and (3) individuals born in the second part of the breeding season, i.e. caught for the first time in September or October, called autumn generation. Winter weather was assessed using data provided by a meteorological station located some 20 km north of Crabapple Island: monthly rain-fall and/or snow-fall (seven monthly values per year, from October to April), temperature at 5 cm above ground level (seven mean monthly values from October to April), monthly number of days with snow cover (six values, from November through April), total number of days from the first snow fall to final snow melt (one estimate a year), and also maximum snow cover thickness during winter (one value a year). Thus, each winter was characterised by 22 weather variables. A cluster analysis based on these variables was performed to point up similar winters. Estimates of herb layer biomass were based on randomly taken samples (18 to 24 in each April) of 0.1 m^2. Winter survival rates of different categories of individuals were compared using the chi-square test (χ^2). Because of the great number of repeated tests on related data, the level of significance was calculated as the ratio between α and the number of tests run (Rice, 1989). The body mass in October of successively surviving and dead mice were compared by Student's t-test.

On average, 22.6% of the mice present in October survived the winter. Survival percentages varied greatly among winters: from 5.3% (4 out of 75 in winter 2002-2003) to 51.1% (23 out of 45 in winter 2001-2002). No parametric linear correlation was found between the number of mice present in October (Tab. 1) and the percentage of such mice that survived until April ($r = 0.173$, $F = 0.21$, $P > 0.6$). No single weather factor correlated with the percentage of winter survivors. Similar winters did not result in similar survival percentages (Fig. 1). As an example, a low Euclidean distance was found in the winters 1 (1994-1995) and 6 (1999-2000), whilst winter survival of yellow-necked mice varied from 11.1% to 42.1% ($\chi^2 = 10.4$; $P < 0.02$). The last winter (2002-2003) was the most severe, mean temperatures in December, January and February dropping below –20°C, and corresponded to the lowest percentage of mice survival (5.3%). No parametric linear correlation was found between the standing crop of herb layer biomass in April and both the total number ($r = -0.283$, $F = 0.61$, $P > 0.4$) and the percentage of survivors ($r = 0.014$, $F = 0.02$, $P > 0.9$).

Table 1 - Numbers of yellow-necked mice present in October and at the end of the winter.

N.	Winter	October	April	% of survival
1	1994-1995	36	4	11.1
2	1995-1996	51	5	9.8
3	1996-1997	139	34	24.5
4	1997-1998	65	6	9.2
5	1998-1999	39	5	12.8
6	1999-2000	64	27	42.2
7	2000-2001	65	23	35.4
8	2001-2002	45	23	51.1
9	2002-2003	75	4	5.3
	Total	579	131	22.6

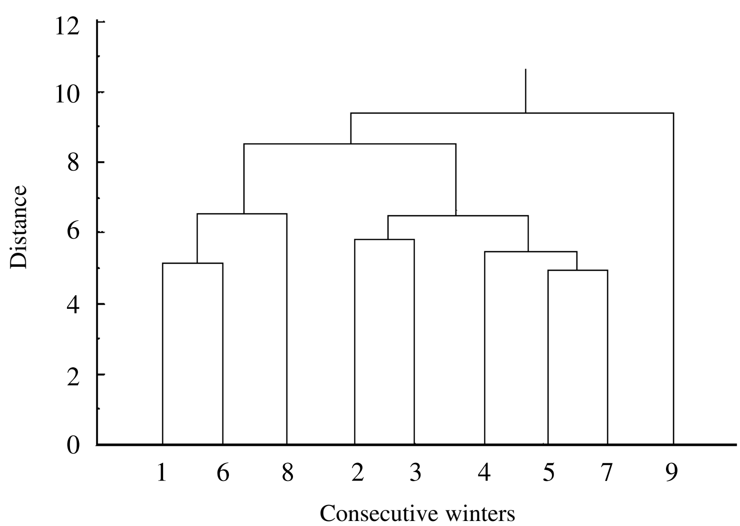

Figure 1 - Winter similarities based on 22 variables and assessed by the Euclidean distance. Numbers in the bottom denote consecutive winters (see Tab. 1).

Apart from the survival rate of the whole population present in October, individual features were also considered. Yellow-necked mice of the spring generation survived winter in higher percentages than those belonging to the autumn generation (25.1% and 17.5%, respectively; χ^2 =

4.38; P <0.05). Mature yellow-necked mice survived better (37.9%) than their sexually immature sisters and brothers of the same age (17.3%; χ^2 =10.89; P <0.001). As the percentage of adult individuals was significantly higher (χ^2 = 129.5, P <0.001) in the spring generation (88.0%) than in the autumn one (11.8%), the former generation survived winter better than the latter one. Mature females survived in higher percentages (31.4%) than immature males (11.5%; χ^2 =18.5; P <0.01), but, on the whole, winter survival did not seem to be sex related (mature males = 20.9%; immature females = 19.8%). Body mass of *A. flavicollis* assessed in October was the highest in mature males, whilst the lowest body mass was shown by immature females (Tab. 2). The body mass in October of individuals of the same category which successively survived or died during winter showed no significant difference (t = 1.2, P >0.05) (Tab. 2), with the exception of immature females (body mass of survivors slightly lower than that of the dead mice; t = 2.09, P< 0.05), and of immature males (body mass of survivors higher than that of the dead individuals; t = 2.14, P <0.05). Variation of winter survival in small rodents has been related to autumn population density, predation and food availability (Pucek *et al*., 1993; Jêdrzejewski and Jêdrzejewska, 1996; Stenseth *et al*., 2002). Also winter weather conditions have been considered, concluding that thick snow cover may favour winter survival rates (Pucek *et al*., 1993). In the present paper we found no correlation between the percentage of survivors in April and either population numbers in October or winter weather conditions. However, we cannot exclude that extremely severe winters could affect survival

Table 2 - Multiannual mean body mass (g) of yellow-necked mice in October. (S = winter survivors; D = dead; A = mature; I = immature; F = females; M = males).

Category	Sample size (N)	Mean	Min-max
AF-S	67	30.9	30.4 - 31.4
AF-D	152	30.8	30.4 - 31.2
IF-S	17	21.5	20.9 - 22.2
IF-D	72	23.2	22.7 - 23.7
AM-S	27	38.7	37.7 - 39.8
AM-D	100	38.4	37.9 - 38.9
IM-S	16	32.9	30.9 - 35.0
IM-D	119	29.7	29.0 - 30.4

rate. Yellow-necked mice in Crabapple Island provided evidence that sexual maturity enhances winter survival, therefore not supporting the suggestion that young rodents ”postpone” reproduction in order to survive to the next breeding season (Gliwicz, 1994).

ACKNOWLEDGEMENTS

We would like to express our gratitude to Alessandro Balestrieri, Luis Nieder and Claudio Prigioni for their helpful comments. This study was supported by the State Commitee for Scientific Research grants 6P04F 015 13 and 6P04F 024 20.

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