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SHORT COMMUNICATIONS

Seasonal Biorhythms in Captive Voles *Microtus rossiaemeridionalis* Ognev, 1924

M. I. Cheprakov, D. Yu. Nokhrin, and M. S. Shlyapnikova

Institute of Plant and Animal Ecology, Ural Division, Russian Academy of Sciences, ul. Vos'mogo Marta 202, Ekaterinburg, 620144 Russia

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In studying ecological features of individual species, it is important to use experimental models of the processes that take place in natural populations. Seasonal rhythms can be manifested to various degrees and differ even in closely related species (Cheprakov, 2002). We studied seasonal changes in body weight, exterior characters, and the frequency of chromosome aberrations in captive *Microtus rossiaemeridionalis* voles ($2n = 54$) under conditions of a photoperiod close to the natural photoperiod at temperate latitudes and smoothed seasonal fluctuations in temperature. The study period was divided into the following seasons: January 16–April 15, April 16–July 15, July 16–October 15, and October 16–January 15.

We observed changes in body weight by season in different age groups. At the age of one month, the greatest body weight was recorded in animals born from July to October, and the smallest body weight in animals born from October to April (differences are significant when compared to other seasons taken together, $p < 0.05$). The voles born from April to July outweighed all other voles by the age of three months ($p < 0.01$) and grew to their definitive body size by the age of five months, whereas other voles had a lower body weight at this age ($p = 0.05$) and continued growing until the age of seven months. Beginning from this age, animals born in different seasons did not differ in body weight. The absolute values of this parameter depended on the period when it was determined: from mid-spring to midsummer, the body weight of adult animals was greater than in other seasons ($p < 0.01$).

At the age of one month, the greatest body lengths (as well as weight) were observed in the voles born from mid-July to mid-October ($p < 0.05$). Voles born from April to July at the age of three to five months were larger than the remaining voles ($p < 0.01$) and reached their definite size at the age of five months. At the age of seven months and older, animals born and collected in different seasons did not differ in body length.

Seasonal differences with respect to the tail length at the age of one month were absent ($p > 0.10$). By the age of three months, the tail in voles born from April to October reached their definite size; in other voles, this occurred at the age of five months ($p < 0.01$). Seasonal differences in the tail size were also observed at an older age: in voles born from mid-April to mid-July, the tail was longer than in other animals ($p = 0.02$).

Foot size in voles born from October to April were smaller. This difference first manifested itself at the age of one month and remained in older animals ($p < 0.05$). Beginning from the age of three months, the age-related changes in foot size were nonsignificant.

At the age of one month, the ears of animals born from July to October were larger than in other animals ($p < 0.01$). Among adult animals, the smallest ear size was observed in voles born from October to April ($p > 0.05$).

It is known that the growth rate of voles, especially in the nesting period, may depend on litter size. In our case, the animals included in the sample of one-month-olds and born in different seasons were taken from litters differing in size. For instance, voles born in July–October were from a litter of size 6.0; in other cases, litter size at birth averaged 4.5 ($p < 0.01$). Based on differences in litter size, a slower growth in the first month of life and, consequently, a smaller body size could be expected in one-month-old voles born from midsummer to mid-autumn, but we observed the inverse. Thus, juveniles born within this period appeared to have a higher growth potential in the first month of life, which could be due to a greater female contribution to the offspring in this season. At an age older than one month, voles born from late spring to early summer had the highest growth rate (their body size was greater than that of other voles at the ages of three and five months).

After the completion of growth in all seasonal groups, body length in voles ceased to change by seasons; however, according to body weight, seasonal biorhythms were still observed, although they differed from biorhythms related to the birth season. Differences in the definite sizes of exterior traits such as tail, foot, and ear lengths in animals born at different times of the year were related to differences in growth rate.

The litter size depended on both the birth season of the litter ($p < 0.05$) and the birth season of the female ($p < 0.01$). When these factors were combined (a two-way scheme), the influence of only the "female birth period" factor proved to be significant ($p = 0.02$) (Table 1). Among females born from mid-spring to midsummer, two females were conspicuous because of early maturation: they produced the first litters before the age of two months. The litter size in these females reached 6.8 ($n = 6$) and was greater than in other voles (5.2; $n = 10$, $p < 0.01$, residual variance 2.17). The litter size in the founder females was the same as in females born in the second season, averaging 5.8 ($n = 20$). Most females that were brought from nature and produced litters in captivity might have been born beginning from the second part of April to May inclusive, i.e., in the period when the most fertile females are born.

The dependence of litter size on the time of birth of the female in *M. rossiaemeridionalis* could also be related to differences in growth rate. The greatest litter size was recorded in females born from April to July, and the voles born in this period proved to reach their definite size more rapidly and, correspondingly, had a higher average growth rate than other voles. The fact that early-maturing females can have a greater litter size than those maturing later was observed in wood lemming (*Myopus schisticolor*) (Cheprakov, 2000). Apparently, the same is characteristic of *M. rossiaemeridionalis.*

The frequency of chromosome aberrations depended on season and was independent of the "age" factor (Table 2), as well as of "generation" and "sex" factors. Seasonal differences in this parameter manifested themselves as early as at the age of one month and occurred in older animals. Chromosome aberration frequency was also independent of the sizes of litter at birth and at the age of five days ($p > 0.10$), but such a dependence appeared upon weaning ($p < 0.05$). This fact indicated that chromosome aberration frequencies typical of seasonal groups were established within the period between days 5 and 25–30 after birth and could differ between litters with and without juvenile mortality in this period. The factor "mortality-dependent change in litter composition" with two gradations (− and +) and the season of litter birth proved to be related at the level of a tendency ($0.05 < p < 0.10$). In voles born between midsummer and mid-autumn, the frequency of aberrant cells in complete litters was 1.58 (number of animals = 45/number of cells = 2275), compared to 2.55 (11/550) in reduced litters. In voles born in other seasons, the respective frequencies were as follows: from late autumn to mid-spring, 1.42 (24/1200) and 0.50 (12/600); and from mid-spring to midsummer, 0.96 (32/1675) and 1.14 (7/350). Chromosome aberration frequency in complete litters was independent of the season of birth ($p > 0.05$); in the case of reduced litters, it was higher in voles born between July 16 and October 15 than in voles born between October 16 and April 15 ($p < 0.05$).

Table 1. Season-dependent litter size variation in females born at different times of the year (average/sample size)

Period of female birth	Period of litter birth		Residual variance
	July 16–October 15	October 16–July 15	
April 16–July 15	6.30/10	5.00/6	2.22
July 15–April 16	4.00/2	3.94/31	

Table 2. Age-dependent variation in chromosome aberration frequency by seasons in *M. rossiaemeridionalis* (aberrant cell frequency, %/number of individuals/number of cells)

Age, months	Period of birth		Values of F test
	October 16–July 15	July 16–October 15	
1	0.89/21/1125	1.79/14/725	"Season" (A)–5.15*
3–5	1.07/30/1500	1.76/17/850	"Age" (B)–0.01
7 and older	1.17/24/1200	1.76/25/1250	AB–0.08

* $0.01 < p < 0.05$.

These data are indicative of seasonal changes in the vector of selective mortality of animals with aberrant cells. In other words, mortality in a certain season may be higher among animals with chromosome aberrations; in another season, among animals without aberrations; finally, mortality in both these groups may be equal. Seasonal biorhythms in the frequency of chromosome aberrations may be related to differences in the growth rate of voles in their first month of life. There is a direct correlation between the body weight of voles at this age and the proportion of cells with chromosome aberrations in the litters whose size has changed because of juvenile mortality.

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