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SHORT COMMUNICATIONS

Timing of Cessation of Breeding in Forest Voles Depending on Climatic Factors after Large-Scale Windfall Damage to Forests in the Middle Urals

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Rodents, voles in particular, are typical *r*-strategists (MacArthur and Wilson, 1967; Stearns, 1992). Therefore, the length of the breeding period is of special significance for them, since high mortality at other phases of the population cycle, especially in the winter season, is not counterbalanced by population recruitment processes. The effective length of this period may decrease in years of high animal abundance (Koshkina, 1965). Moreover, adverse climatic conditions can result both in a delayed onset of breeding in spring and its early cessation in the summer season (Okulova and Myskin, 1973; Zhigalski, 2002). On the other hand, there are reasons to assume that abiotic factors under certain conditions can stimulate prolongation of breeding, with its cessation shifting to later dates. In this context, it is relevant to consider the results of continuous stationary studies performed over many years on the western macroslope of the Central Ural Mountains, in the zone with a sharply continental climate and a short snow-free season. Different combinations of abiotic and biotic factors in years with contrasting ecological conditions provide the possibility of considering the above issues from different viewpoints.

The data used in this study were obtained in the course of long-term stationary research (1997–2009) in Shalinskii raion of Sverdlovsk oblast, the Middle Urals. The initial field material included the results of irreversible removal of animals on permanent trap-line transects as well as the results of comprehensive studies in an unfenced stationary plot (0.5 ha) located in a primary-type biotope characteristic of the southern taiga subzone. Animals were marked according to Naumov (1951). Methods used in the study were described in detail previously (Dobrinskii, 2005).

Two most abundant rodent species, the bank vole (*Clethrionomys glareolus*) and northern red-backed vole (*C. rutilus*), were selected as model objects. The first species dominated both in the marking plot and in a fairly large forest area (5 ha) totally damaged by windfall, where regular censuses of rodents on permanent trap-line transects were taken every year to determine their relative abundance. The only exception was in the autumn of 2005, when both species were equally abundant in the windfall area. Over the study period (1997–2009), a total of 1208 these voles were trapped and marked in the plot, and 4200 their entries into traps were recorded. The work with trap lines located 900 m from the marking plot amounted to 2600 trap–days, and more than 400 voles of both species were trapped during the spring and summer seasons. This material was processed following standard procedures for determining the reproductive status of voles and classifying them into age and functional groups (Olenev, 2002).

The results of continuous observations on voles in the Middle Urals indicate that it is expedient to estimate the levels of their absolute and relative abundance by the following criteria: depression, 0–2 ind./100 trap–days, or 0–9 ind./ha; low abundance, 3–5 ind./100 trap–days, or 10–20 ind./ha; medium low abundance, 6–10 ind./100 trap–days, or 20–40 ind./ha; medium abundance, 11–15 ind./100 trap–days, or 40–60 ind./ha; high abundance, 16–19 ind./100 trap–days, or 60–80 ind./ha; and peak abundance, beginning from 20–25 ind./100 trap–days, or 80–100 ind./ha.

The length of the breeding period depends on the dates of both the onset and cessation of breeding. The early stages of rodent breeding in the study region were difficult to monitor because of the great amount of residual snow cover and its uneven distribution in spring. The dates of snow disappearance widely vary between years, and the local pattern of snow-melting in a given year does not always allow the onset of breeding to be determined reliably. Moreover, the density of overwintered voles in spring is relatively low and does not have and significant effect on preparation for breeding; hence, all animals of this age group become involved in this process when conditions for it turn favorable. In the second half of the summer season, conversely, the density of rodents reaches a maximum, and the bulk of their population consists of young of the year, which sensitively respond to biotic and reliably monitorable weather-climatic factors. This study deals with specific features and chronological aspects of reproductive processes in *Clethrionomys* voles at final stages of the annual breeding cycle.

The abundance of the two model vole species in the study area reached the maximum possible level in 1997, two years after the disastrous windfall in 1995, and its upper limit remained at peak values until 2004. The population of rodents in that period began to function in a special regime, without significant long-term cyclic fluctuations of their total abundance in summer. Thus, their total absolute abundance on the 0,5-ha marking plot over the period from 1998 to 2004 (except for 2002, when trapping was performed relatively late) averaged 66.7 ± 0.8 ind. The results obtained after 1995 were presented and analyzed in detail previously (Dobrinskii, 2005). Here, the data obtained in 2002, 2005, and 2009 are considered. The total abundance of model vole species in the marking plot at the end of the corresponding breeding seasons was at a medium level (40–60 ind./ha), but local ecological conditions had certain specific features in each year.

In the middle of May 2002, the initial animal density in the marking plot was about 10 ind./ha (only bank voles were trapped). The relative abundance of voles in the windfall area in early July was only 4 ind./100 trap–days even in preferred "donor" habitats, which was a consequence of unfavorable wintering conditions. In the second half of summer, the abundance of voles in the marking plot increased more than fivefold and, after a slight decrease, amounted to 52 ind./ha in early October (only bank voles were trapped). The dynamics of vole abundance on trap lines were similar, with the total catch over the year 2002 including only one northern red-backed vole (among bank voles). Between September 27 and October 2 (with weather-climatic parameters being at the long-term average level), the catch of voles on the marking plot included only one male weighing 12 g and four females weighing 12.5 g (19% of the total). In the windfall area, no animals with such a body weight were recorded. Two out of 12 females weighed 13.5 and 14.5 g, and only the largest two females (38 and 26 g) had distinct placental scars from two pregnancies. None of 20 males trapped (the maximum body weight 21 g) showed any indication of participation in breeding.

In the spring of 2005, not a single vole of any species was trapped in the marking plot or windfall area (for the first time since 1985). In this connection, special attention should be paid to the unusually low abundance of young of the year in 2004, which was explained by the extremely high density of overwintered voles in the spring of that year (110 ind./ha). This factor, combined with unfavorable ecological conditions during wintering, accounted for the fact that the density of voles in the marking plot even in the first 10-day period of August 2005 was only 18 ind./ha, and only one northern red-backed vole was recorded among trapped animals. In the subsequent period, when weather-climatic parameters were at the long-term average level, the total relative abundance of both model vole species in the windfall area reached a peak value of 24 ind./100 trap–days (according to the results of trapping on September 13–15). Among a total of 10 bank voles and 11 northern red-backed voles, only one female bank vole had a body weight of 14.5 g, two females (16–18 g) were not involved in breeding, and the remaining four (20–24 g) had placental scars from one or two pregnancies. Only one out of 13 males weighed 12.5 g; all others weighed from 17 to 24 g and had no signs of participation in breeding.

In 2009, the amount of snowfall in winter was abnormally small; as a consequence, the abundance of rodents at the beginning of the summer season was at a depression level (for the second time over the study period): only 4 ind./ha in the marking plot, with no voles being trapped in the windfall area. According to the results of autumn trapping series, the vole population density in the marking plot on September 20–25 increased to 60 ind./ha, with only one northern red-backed vole being recorded in catches; on October 1–3, the relative abundance of voles on the permanent trap-line transects reached a peak level of 40 ind./100 trap–days. Such a rapid and significant increase in abundance (by a factor of more than 15) was probably accounted for by mass in-migration of young of the year from nearby "refugia" located in atypical ecotopes, where they concentrated because of the aforementioned anomalous conditions of snow cover formation and melting during the previous autumn–winter and spring seasons.

During the trapping series on September 20–25, 2009 (i.e., on the same dates as in 2002), the total catch in the marking plot amounted to 29 voles, including eight bank voles (28%) weighing from 9.8 to 12.5 g and two voles weighing 13 g each. Along with bank voles, one northern red-backed vole was recorded (in 2002, only bank voles were trapped). At the peak of abundance on October 1–3, 2002, 24 bank voles and 12 northern red-backed voles were trapped on permanent transects in the windfall area. Among bank voles, three animals weighed 11.6, 12.3, and 12.9 g; all northern red-backed voles weighed more than 15.5 g.

A comparative analysis of data over 3 years with medium values of the total vole abundance in the marking plot in summer showed that the proportion of the youngest age group (with a body weight below 13 g) increased from 19% in 2002 to 28% in 2009. Catches made on trap-line transects under conditions of medium rodent abundance on September 29, 2002 contained no bank voles weighing less than 13.5 g; at a peak abundance of 24 ind./100 trap–days on September 15, 2005, only one northern red-backed vole in catches weighed 12.5 g, while all other voles of either species weighed more than 16 g.

The method proposed by Olenev (2009) provides the possibility to reliably estimate the timing of cessation of breeding in years with contrasting ecological conditions. In 2002, when weather-climatic parameters were close to long-term average values and rodent abundance was medium (52 ind./ha), the latest birth date of animals from the last summer cohort according to our data was August 26. In 2005, at a peak rodent abundance (24 ind./100 trap–days) and comparable weather-climatic conditions, this date was August 14. The last summer month and early autumn of 2009 were unusually warm and dry, with the weather remaining unchanged until October, and the density of rodents in the marking plot was fairly high (60 ind./ha). The latest birth date of animals from the last cohort in this year appears to be September 1. The same date is indicated by data from trap-line transects in the windfall area, where a peak level of rodent abundance was recorded (40 ind./100 trap–days).

Thus, comparative analysis of the results of long-term monitoring research provided evidence that favorable abiotic conditions in the Middle Urals in 2009 provided for the maintenance of breeding intensity at either medium or peak levels of local rodent abundance and prolonged the breeding period of voles by almost a week, compared to 2002 (until September 1). As compared to 2005, when climatic factors were at long-term average levels for the study region, the breeding period in the unusually warm and dry year 2009 was 178 days longer.

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