Russian Journal of Ecology, Vol. 35, No. 4, 2004, pp. 263–266. Translated from Ekologiya, No. 4, 2004, pp. 301–304.

Dispersal of Land Snails of the Genus *Xeropicta* Monterosato, 1892 (Gastropoda; Pulmonata; Hygromiidae)

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Received May 13, 2003

Abstract—Data on the parameters of migration of two land snails of the genus *Xeropicta* are presented. In relatively homogeneous habitats, the locomotor activity of these mollusks is relatively high: they can travel for up to 300 cm per day, with neither the phenotype nor size of the shell having any significant influence on the level of dispersal. The snails prefer to travel westward and southward, but the distances covered by individuals moving in different directions are similar. No connection between the directions or distances of movement on two successive days has been observed.

Key words: dispersal, locomotor activity, direction of movement, land snails, *Xeropicta*, the Crimea.

The distance covered by an animal moving from its birthplace to the place where it reaches maturity and participates in reproduction is an important parameter of population structure. It is known that the level of vagility may have a significant effect on the effective population size and the rate of gene flow, especially when the population is spatially structured relative to habitat quality or food supply. In land snails, the direction and level of dispersal may characterize a behavioral response aimed at alleviating the effect of adverse environmental factors in heterogeneous habitats (Baur, 1991). Xerophilous land snails of the genus *Xeropicta*—*X. krynickii* (Krynicki, 1833) and *X. derbentina* (Krynicki, 1836)—are among the background species in various natural climatic zones of the Crimea, However, their population ecology has been studied insufficiently (Kramarenko, 1966; Popov and Dragomoshchenko, 1997a, 1997b; Popov and Kovalenko, 2000).

The purpose of this work was to analyze the pattern of locomotor activity of these snails. It was conceived while studying the mechanism of mate choice in terrestrial mollusks (Kramarenko, 2001), taking into account the fact that the species-specific level of vagility is considered to be a factor in the selective mating of these animals (for review, see Baur, 1992).

According to A. Baur (1991), we regard *dispersal* as a distance covered by a snail during the period of its daily activity. In our experiments, this parameter was determined by measuring the length of straight lines connecting points of snail location during two successive days. As the experiments were performed in relatively homogeneous habitats, no attention was paid to the factor of directed seasonal migrations described in other species of terrestrial mollusks (Pollard, 1975; Baker, 1988a, 1988b).

MATERIAL AND METHODS

The pattern of dispersal of *Xeropicta* land snails was studied in a wasteland area in the vicinity of Simferopol, near the Regional Children's Hospital (the Malyi Salgir River valley), in September and October 1997. The experiment was performed with 100 mature *X. derbentina* and 65 *X. krynickii* snails, which were individually marked by writing a number on the shell with India ink and released from two different points (one for each species) no later than 24 h after capture. In *X. krynickii* snails, we additionally measured the major diameter of the shell (to an accuracy of 0.1 mm) and recorded its phenotype (with or without helical pigment bands).

The snails were monitored for several successive days to record the location of each individual relative to the point of release, i.e., the distance from this point (to an accuracy of 1 cm) and the angle of deviation from the north–south axis (measured using a compass to an accuracy of 1°).

The results were processed with the methods of nonparametric statistics using the STATISTICA 5.0 applications software package (Borovikov and Borovikov, 1997; *Komp'yuternaya biometrika*, 1990).

RESULTS AND DISCUSSION

Dispersal of *X. derbentina*. One day after release, 88 snails were found. The distance of their movement from the point of release (median value) was 102.5 cm (ranging from 3 to 310 cm). After two days, this dis-

[†] Deceased.

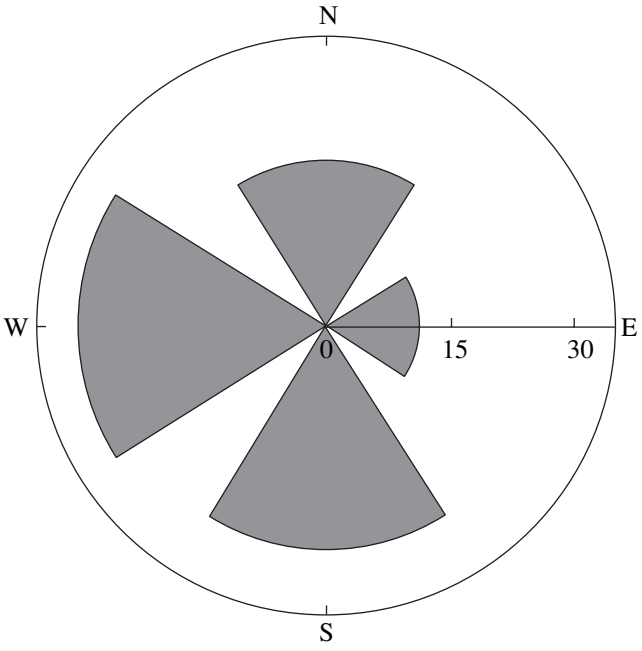

Fig. 1. Directions of daily movements of *Xeropicta derbentina* snails (absolute values) relative to the points of the compass.

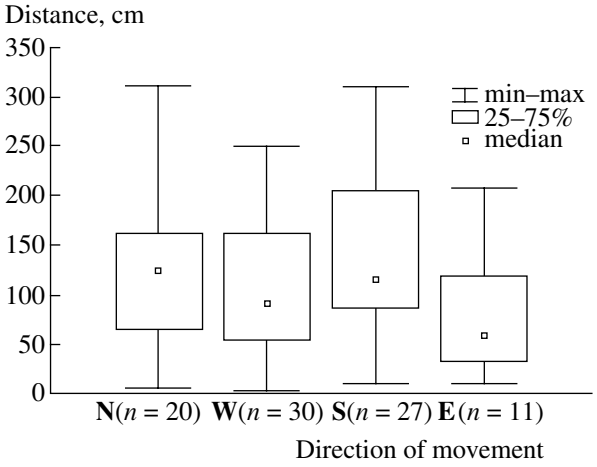

Fig. 2. Daily distances covered by *Xeropicta derbentina* snails moving in different directions.

tance increased to 156.0 cm (22–402 cm, $N = 31$). The snails did not travel in any direction with equal probability ($\chi^2 = 9.73$; $df = 3$; $p < 0.02$) but preferred to move westward and southward (Fig. 1). Statistically, the distances covered by snails moving in any direction were in the same range (the Kruskal–Wallis test: $H = 4.07$, $df = 3$, $p = 0.25$). However, the average distance of eastward movement was smaller (Fig. 2).

Dispersal of *X. krynickii*. The distance of movement from the point of release averaged 143.5 cm (16–295 cm, $N = 54$) after one day and 182.0 cm (19–370 cm, $N = 47$) after two days. The distance covered on the second day averaged 62.0 cm (3–185 cm, $n = 40$), i.e., it was significantly shorter than on the first day (the Wilcoxon test: $Z = 3.72$, $p < 0.001$; $N = 40$). Moreover, there was no correlation between these distances (the Spearman rank correlation coefficient $R_S = 0.039$; $p = 0.81$; $N = 40$).

As in the previous case, the movements of *X. krynickii* snails were nonuniform with respect to direction (generalized data over two days: $\chi^2 = 14.86$, $df = 3$, $p < 0.002$; $N = 102$). Most frequently, the snails moved southward and westward, and there was no significant difference between the directions of their movement on the first and second days ($\chi^2 = 2.97$, $df = 3$, $p > 0.35$) (Fig. 3). In analyzing the movements of individual snails, however, no correlation between their directions on the first and second days was revealed ($R_S = 0.12$; $p = 0.42$).

The distance covered by a snail moving from the point of release proved to inversely correlate with the size of its shell (after one day: $R_S = –0.34$, $p = 0.011$, $N = 54$; after two days: $R_S = –0.36$, $p = 0.013$, $N = 47$). However, no such correlation was revealed when only the distance covered on the second day of the experiment was considered ($R_S = –0.17$, $p = 0.30$, $N = 40$).

The distances covered by snails of different phenotypes—with or without helical pigment bands on the shell—did not differ statistically (the Mann–Whitney test; after one day: $Z = –0.43$, $p = 0.66$, $N = 54$; after two days: $Z = –0.71$, $p = 0.48$, $N = 47$).

These results show that the average range of daily movement in the Crimean *Xeropicta* snails is greater than in other hydromiids or helicids of similar body size. For example, this range in *Cernuella virgata* is 10–40 cm (Baker, 1988a); in *Trichia plebeja*, 90 cm (Paul, 1978); and in *Theba pisana*, 10–110 cm (Baker, 1988b). However, the longest distance that *Xeropicta* snails can cover within one day after being released is similar to those described for other species: up to 300 cm for *C. virgata* and 120 cm for *Candidula intersecta* (Cowie, 1980). A higher migration activity on the first day could be stimulated by the procedure of their capture and marking before release, as has been shown for *Cepaea nemoralis* (Cameron and Williamson, 1977). Indeed, the locomotor activity of *X. krynickii* snails on the second day was significantly lower, and the range of their movement did not correlate with that recorded on the first day. The absence of correlation between the distances covered by individual snails on two successive days has also been observed in *Arianta arbustorum* (Baur, 1986).

The results of some investigations suggest that the level of locomotor activity of terrestrial mollusks correlates with shell size. Thus, in a laboratory experiment with *Punctum pygmaeum*, the average distance covered over 12 h proved to be greater in larger snails (Baur and Baur, 1988). Conversely, observations on *A. arbustorum* in forest and meadow habitats showed that juve-

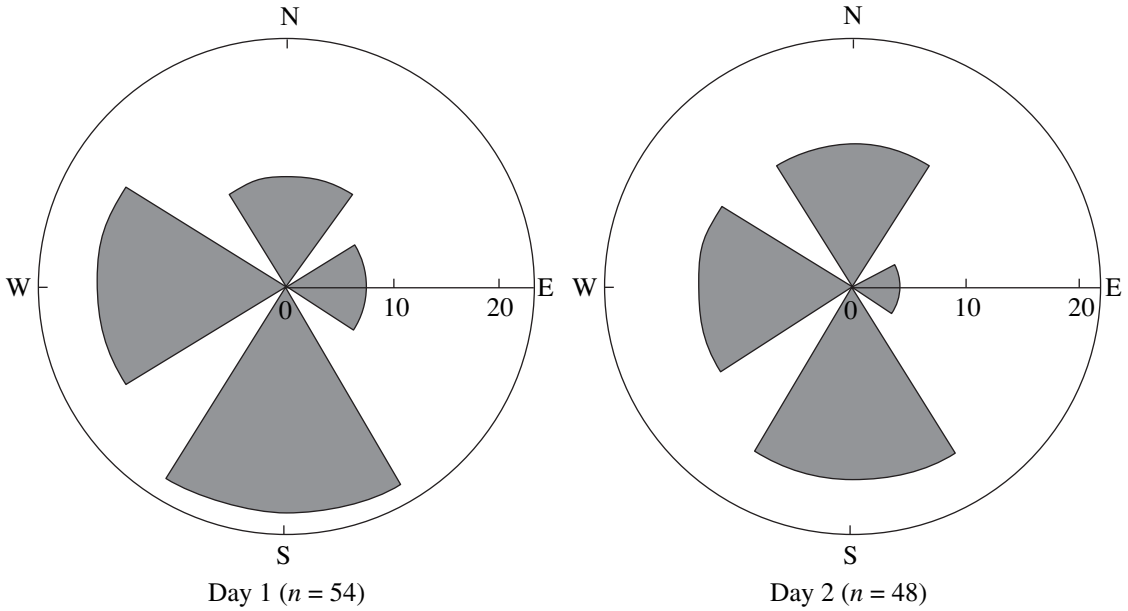

Fig. 3. Directions of daily movements of *Xeropicta krynickii* snails on the first and second days of the experiment.

nile snails moved at a higher rate than mature snails (Abdel-Rehim, 1983).

However, the rate of movement does not always correlate directly with the distance covered (Deloor *et al.*, 1990). Moreover, long-term studies on the migration activity of snails have shown that the range of their movement depends on body size, but this dependence remains significant only until the period of movement exceeds one day (Baur and Baur, 1995). Analyzing the pattern of dispersal in *Eobania vermiculata*, Zeifert (1988) has shown that a significant positive correlation between shell size and the distance covered by a snail is observed only if this distance is less than 1.25 m. The situation with respect to *X. krynickii* snails proved to be similar: such a correlation (in our case, negative) manifested itself only on the first day after release; on the second day, snails differing in shell size moved to similar distances.

The range of movement and shell phenotype in *X. krynickii* did not correlate. Earlier, we also failed to reveal any significant differences in the pattern of vertical distribution between *X. krynickii* snails of different morphotypes (Kramarenko, 1996).

In most cases, land snails move randomly, and any correlation between the directions of movement on successive days is absent (Baur and Baur, 1988; Baur, 1993). In our experiment, conversely, *Xeropicta* snails generally preferred to move westward or southward, although the directions of movement of individual snails on the first and second days did not correlate.

The distances covered by *X. krynickii* snails moving in different directions did not differ significantly, and the same has been observed by other authors (Baur, 1993; Baur and Baur, 1994). In studies on *A. arbustorum* snails in a long, narrow biotope, these mollusks proved to move much farther along the biotope than across it (B. Baur, 1986, A. Baur, 1990) In an alpine meadow, these snails dispersed in all directions more or less uniformly, but the distance of their movement up the slope was much longer than down the slope (Baur and Gosteli, 1986). Conversely, Crimean snails *Brephulopsis bidens* manifested no negative geotaxis: they moved mainly along the slope, left or right relative to the point of release, but the distances of movement in various directions did not differ significantly (Kramarenko, 1999).

Thus, the results of this work show that land snails of the genus *Xeropicta* are characterized by a relatively high locomotor activity and can travel for up to 300 cm per day, with neither the phenotype nor size of shell having any significant influence on the level of dispersal. Snails prefer to travel westward and southward, but the distances covered by individuals moving in different directions are similar. No connection between the directions or distances of movement on two successive days has been observed.

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