Dispersal of the land snail *Helicigona lapicida* in an abandoned limestone quarry

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Abstract. Dispersal was estimated in a natural population of the land snail *Helicigona lapicida* (Linné, 1758) in an abandoned limestone quarry on the Baltic island of Öland, Sweden. We released 300 marked adult individuals at 15 points on walls of the quarry and measured the distances moved over two years. Median dispersal was 1.70 m (range: 0.20–4.50 m) five months after release. Median dispersal increased to 3.43 m (range: 0.15–31.95 m) in one year and to 6.38 m (range: 0.65–24.90 m) in two years. Recovery rate of marked snails was 16.7% after one year and 4.0% after two years. The dispersal distances recorded in this population might partly be influenced by the snails' repeated returning to suitable shelter sites (fissures in the rock walls) in the quarry.

Kurzfassung. Ausbreitungsleistung der Landschnecke *Helicigona lapicida* in einem verlassenen Kalksteinbruch. – Die Ausbreitungsleistung von *Helicigona lapicida* (Linné, 1758) wurde in einem verlassenen Kalksteinbruch auf der Ostseeinsel Öland, Schweden, untersucht. Dreihundert mit verschiedenen Farbtupfen markierte ausgewachsene Individuen wurden an 15 Punkten auf den Wänden des Steinbruchs freigelassen. Die Ausbreitungsdistanzen wurden über zwei Jahre erfasst. Innerhalb von fünf Monaten breiteten sich die Schnecken 1.70 m (Medianwert) aus, mit einer Variationsbreite von 0.20 bis 4.50 m. Nach einem Jahr betrug die Ausbreitungsleistung 3.43 m (Variationsbreite: 0.15–31.95 m) und nach zwei Jahren 6.38 m (Variationsbreite: 0.65–24.90 m). Von den ursprünglich 300 markierten Tieren wurden nach einem Jahr 16.7 % und nach zwei Jahren noch 4.0 % gefunden. Die in der untersuchten Population gemessene Ausbreitungsleistung dürfte teilweise durch das wiederholte Aufsuchen von geschützten Ruheplätzen (Spalten in den Felswänden) im Steinbruch beeinflusst sein.

Key words. *Helicigona lapicida*, Helicidae, rock-dwelling gastropod, dispersal, gene flow.

Introduction

Animal movement has many important ecological and evolutionary consequences. Movements of individuals between populations facilitate gene flow and the maintenance of genetic variability (Endler 1977). Dispersal affects demographic processes in populations (Slatkin 1988) and influences rates of local extinction and colonization of depopulated or new areas (Hanski 1999). In terrestrial gastropods, dispersal results from small-scale movements made by individuals in their daily activity or from passive transportation. Data on dispersal in terrestrial gastropods are rare despite the great theoretical and practical importance. Recently, radio tagging has been successfully used for locating individuals of species with large shells [e.g., in *Helix aspersa* O. F. Müller, 1774 (Bailey 1989) and *Achatina fulica* (Bowdich, 1822) (Tomiyama & Nakane 1993)] and individuals of the slug *Arion lusitanicus* Mabille, 1868 (Grimm 1996). In snail species with smaller shells, dispersal has been estimated by recording displacements of marked individuals [mark-release-recapture methods; e.g., in *Theba pisana* (O. F. Müller, 1774) (Cowie 1984; Baker 1988) and *Arianta arbustorum* (Linné, 1758) (Baur 1986)]. However, the gastropods' nocturnal activity and hiding in dense vegetation, litter layer or in the soil result in extremely low recovery rates of marked individuals.

Here we report on a field study that was designed to record dispersal of marked *Helicigona lapicida* (Linné, 1758) in an abandoned limestone quarry over two years. *Helicigona lapicida* is a pulmonate land snail which lives in holes, crevices and fissures in rocky ground, stone walls and in old woodland and hedgerows (Kerney 1999). The species is widespread in Western and Central Europe and reaches Southern Scandinavia (Kerney et al. 1983). At night or in wet weather the snails move on rock surfaces or climb on tree stems to graze algae and lichens (FRÖBERG et al. 1993). In many countries atmospheric pollution affects epiphytes impoverishing the lichen flora. This may contribute to the decline of *H. lapicida* and other lichen feeding snails [e.g., *Balea perversa* (Linné, 1758) in England (HOLYOAK 1978; KERNEY 1999)]. *Helicigona lapicida* is on the Red List of Ireland (endangered; KERNEY 1999) and Austria (potentially endangered; FRANK & REISCHÜTZ 1994).

Methods

Dispersal of *H. lapicida* was assessed in an abandoned limestone quarry (40 m × 50 m) situated 2 km south of Vickleby in the grassland Great Alvar (56° 33'N, 16° 36'E) on Öland, an island in the Baltic Sea close to the southeastern coast of the Swedish mainland. A natural population of *H. lapicida* occurs on rock walls and piles of stones in the quarry and in the adjacent grassland, which is extensively grazed by cattle during summer. Vegetation, climate and geomorphology of the Great Alvar have been described by ROSÉN (1982).

Adult individuals of *H. lapicida* were collected on vertical rock walls in the quarry on 5 October 1999. The shells of the snails were marked with two spots of differently coloured touch-up pencils. A unique colour combination was used for each release point. The animals showed no visible reaction to the marking procedure. To stimulate activity prior to release, the snails were placed in plastic dishes lined with moist paper towelling.

Three-hundred marked snails were released in groups of 20 at 15 release points on 6 October 1999. The release points were situated 6–10 m apart from each other on the same rock walls where the snails were collected the day before. Release sites were marked with a white cross on the rock walls using a touch-up pencil. The rock walls faced either to south-east (nine release points) or to north-east (six release points) and contained numerous vertically- and horizontally-running fissures.

After five months (10 March 2000), one year (7 October 2000) and two years (8 October 2001) the rock walls, stone piles and adjacent grassland were carefully searched for marked snails. Dispersal was assessed by measuring to the nearest cm the distances between the release points and the actual positions of the marked snails. At the same time marked shells of dead snails were removed. The size (shell breadth) of adult individuals was measured to the nearest 0.1 mm using vernier callipers. Shell breadth of adult *H. lapicida* averaged 16.0 mm (SD=0.7, range 14.5–17.6 mm, n=78).

Results

After a period of five months (October 1999 to March 2000), displacements ranging from 0.20 to 4.50 m (median: 1.70 m) were recorded (Fig. 1). This indicates that *H. lapicida* is active under favourable weather conditions during winter on Öland. The relatively low recovery rate of 5.3% was due to the fact that many individuals rested in deep fissures. Displacements could not be recorded in snails resting in fissures. The aspect of the rock walls on which the animals were released did not affect the snails' dispersal distances (Mann-Whitney U-test, p=0.74).

After one year, the recovery rate of marked *H. lapicida* was 16.7%. The displacements ranged from 0.15 to 31.95 m (median 3.43 m; Fig. 1). Eight out of the 50 snails recovered (16.0 %) were dead. Remains of the soft body in the shells indicated that some of these individuals died shortly before the survey. The aspect of the rock walls at the release points had no effect on the dispersal distances (Mann-Whitney U-test, p=0.30).

After two years, the recovery rate of marked *H. lapicida* dropped to 4.0 %. The snails' displacements ranged from 0.65 to 24.90 m (median: 6.38 m; Fig. 1). Five of the 12 marked individuals recovered (41.7 %) were dead. Snails found alive did not differ in distances covered from those found dead (Mann-Whitney U-test, p=0.94). The aspect of the rock walls at the release points had no effect on the snails' dispersal distances (Mann-Whitney U-test, p=0.61). Considering the entire study period, the distances covered by adult *H. lapicida* increased gradually over the two years with a mean displacement of 3.2–3.4 m per year.

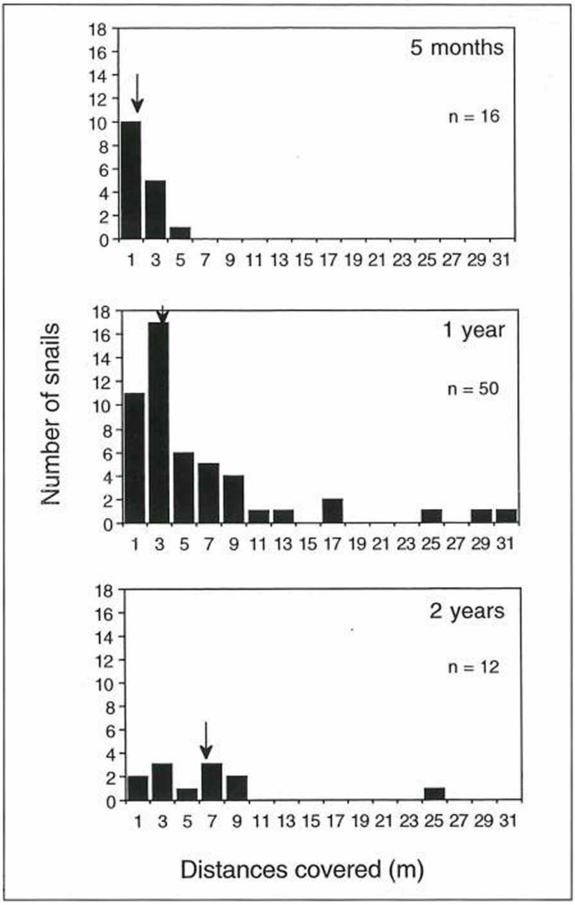

Fig. 1. Displacements of marked *H. lapicida* after five months, one year and two years. Arrows indicate median distances and figures at the top right-hand corner of each histogram refer to sample size.

Discussion

The present study showed that *H. lapicida* also moves during winter in this Swedish population. As in the rock-dwelling land snails *Chondrina clienta* (Westerlund, 1883) and *B. perversa* hibernation in *H. lapicida* is not deep and foraging individuals can be observed under mild conditions in winter (Schlesch 1937; Baur & Baur 1991).

Dispersal in land snails has been shown to be affected by the type and form of the habitat (Baur & Baur 1993; 1995), the type and height of the vegetation (Cain & Currey 1968; Cowie 1984; Baker & Hawke 1990), local population density (Greenwood 1974), snail size (Szlavecz 1986; Baur & Baur 1988) and homing tendency (Cook 1979; 2001; Bailey 1989). However, little information on snail dispersal over longer periods is available. In *Cepaea nemoralis* (Linné, 1758), a mean displacement of 9.7 m within two years (maximum distance covered: 25 m) was recorded in a garden in France (Lamotte 1951) and of 32.1 m (maximum 67 m) in a meadow in Germany (Schnetter 1951). *Helicigona lapicida*, which is smaller than *C. nemoralis*, covered a shorter distance (6.38 m) in two years. In a previous study, we assessed dispersal in *C. clienta* on the same rock walls of the limestone quarry on Öland (Baur & Baur 1995). Marked individuals of *C. clienta* showed a mean dispersal of 1.39 m over 2 years. *C. clienta* is a typical rock-dwelling species and much smaller (shell height of adults 5.5–6.9 mm; Baur 1988) than *C. nemoralis* and *H. lapicida*. *C. clienta* rarely leaves the rocky habitat.

Dispersal estimates by mark-release-recapture methods rely on several assumptions. Among others, it is assumed that all marked individuals – whether they move short or long distances – have equal chances of being recovered. Furthermore, it is assumed that crowding at release points in experiments does not influence the snails' movement behaviour. The first assumption is rarely fulfilled in any dispersal study with tagged animals since the probability of finding individuals which have left the investigation area might be low. In the population investigated, *H. lapicida* leaves the rock walls of the quarry to forage and deposit her eggs in the adjacent grassland. However, the snails usually return to the rocky habitat to rest. We carefully searched for marked snails in the adjacent grassland and piles of stone. However, the huge stone piles in the quarry provide a highly structured habitat to the snails which results in relatively low recovery rates of marked individuals. On the other hand, searching for snails in rocky habitats does not damage the snails' habitat to the same extent as does searching in dense vegetation. Thus, our searching activity may not have influenced the snails' dispersal behaviour. Concerning the second assumption, several experimental studies with different numbers of snails at single release points showed that moderate densities during release did not affect subsequent dispersal [in *C. clienta* (Baur 1993), *Chondrina avenacea* (Bruguière, 1792) (Baur & Baur 1994) and *Helicella itala* (Linné, 1758) (Oggier 1995)]. In the wild, individuals of these species rest, aestivate and hibernate in large aggregations (Cook 2001). Thus, situations with crowded snails occur in the normal life of *H. lapicida*, and consequently, may not bias the distances moved.

Like other rock-dwelling land snails, individuals of *H. lapicida* tend to rest in aggregations deep in fissures or on the underside of stone plates. A combination of different abiotic factors might create spots which are particularly favourable to resting snails (e.g. protected against wind and direct radiation). It is, however, unknown whether social factors (mucus trail following, dilution of predator risk) contribute to this aggregative behaviour.

Acknowledgements

We thank Martin Baur for field assistance and the staff at the Ecological Research Station of Uppsala University on Öland for their hospitality.

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Received on May 18, 2005, accepted on August 9, 2005.