

STUDY OF THE POPULATION DYNAMICS OF *LINUM DOLOMITICUM* BORBÁS (LINACEAE)

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The population dynamics of the narrowly endemic *Linum dolomiticum* was investigated between 2001 and 2005. Population size, seed production and fertility rate were determined. Ratio of the new and extinct individuals was calculated.

Key words: *Linum dolomiticum*, population dynamics, population size, seed production

INTRODUCTION

Protection and possible recovery of rare or endangered species require an understanding of the biological status of their populations, and the ecological and genetic factors that affect the growth, survival and reproduction of the populations (SCHEMSKE *et al.* 1994). A rare species may continue to be at risk of extinction, due to demographic or environmental stochastic factors that may limit the resilience or ability of the population to recover. When population size is reduced, demographic and environmental stochasticity become increasingly important (MENGES 1986). Demographic monitoring can provide information about population growth rates, survival, reproduction and structure, and can be used to identify critical life history stages and those factors that affect them. Demographic studies can be used to predict future population changes, and to analyse specific, targeted action that may be needed to increase the likelihood of a species' survival (TRAVIS and SUTTER 1986, MENGES 1986).

Population dynamics and demographic characteristics of several plant species were studied in Hungary of late years. Demographic parameters and life history of *Taraxacum serotinum* in different habitats were analysed by MOLNÁR and BOKROS (1996). Demographic study and monitoring of a number of rare and protected plant species (*e.g.* *Digitalis lanata* Ehrh., *Ferula sadleriana* Ledeb., *Himantoglossum adriaticum* Baumann, *Orchis ustulata* L., *Botrychium virginianum* (L.) Sw. were also carried out (POZSONYI 1999–2000, KALÁPOS 1998, BÓDIS and ALMÁDI 1998, BÓDIS 1998, BAGI *et al.* 2004, BAGI 2006).

Monitoring and demographic study of *Linum dolomiticum* were proposed by the National Biodiversity Monitoring Program (TÖRÖK 1997), which set up a general purpose of monitoring of rare plant species, mapping distribution areas, identi-

fying population sizes, assessing and following up on the status of endangered species and their likelihood of survival and/or extinction.

In the framework of this monitoring project the mapping of the total distribution area of *Linum dolomiticum* was made in 2001 and 2004 at a scale of 1 : 200 (DOBOLYI 2001, 2004). Purpose of this mapping was to follow up on the changes of at least 0.5 m in diameter of the *Linum dolomiticum* patches.

The narrowly endemic *Linum dolomiticum* has only one population, situated in a region of 1 km² in the Buda Hills near Pilisszentiván (Hungary). It consists of several stands separated by closed forest. Characteristic habitat of this species is open and closed dolomite rock grasslands (DOBOLYI 2003a, 2005a). The spatial pattern of the distribution of *Linum dolomiticum* is not homogenous, i.e. the individuals do not occur randomly on the ground, but usually form groups and patches of size of 0.01–3 m² (DOBOLYI 2004). Although the total area of distribution is standing under nature protection, *Linum dolomiticum* is considered to be an endangered species (HORVÁTH *et al.* 1995). Important threatening factors are tourism, several kinds of sport activity (first of all cross-country motorbiking) and spontaneous spreading of the introduced black pine (*Pinus nigra*) plantations through its upcoming seedlings.

Since dynamic processes have a crucial role in the survival of endangered species, the process of distribution mapping was coupled with a survey of the population dynamics of *Linum dolomiticum* between 2001 and 2005. The purpose of this complex study was:

- to determine the size of the population;
- to follow up on the change of the number of individuals;
- to establish the rate of the new and the extinct individuals;
- to determine the seed production;
- to make observations on the spreading and reproduction strategy.

In this paper I present a summary of the results of this five-year demographic and monitoring study.

MATERIAL AND METHODS

A sample area of 64 m² was marked in the field for following up on the individual changes, consisting of 16 sample squares (size of 2 m × 2 m), which are marked by numbered iron pegs. *Linum dolomiticum* individuals were localised by a net of hole size of 10 cm × 10 cm stretched on the sample squares and a map of the individuals was outlined at a scale of 1 to 14 in 2001 (DOBOLYI 2001). Exact number of the individuals was determined in the sample area by counting. (According to DNS studies, average size of individuals is 5–15 cm (MAJOR and DOBOLYI 2006). Mapping of the individuals was repeated in 2003 and 2005 with the same method as was made in 2001 (DOBOLYI 2003b, 2005b). Maps made in 2001, 2003 and 2005 were projected to each other to determine the changes of the indi-

Table 1. Demographic data observed in the sample area.

	Symbol	Formula ¹	2001	2003	2005
Total number of the individuals	I	$I_{03} = I_{01} - E_{03} + N_{03}$ $I_{05} = I_{03} - E_{05} + N_{05}$	1091	1040	1017
Number of the extinct individuals	E		–	248	210
Number of the new individuals	N		–	197	187
Change of the individual number	ΔI	$\Delta I_{03} = N_{03} - E_{03} = I_{03} - I_{01}$ $\Delta I_{05} = N_{05} - E_{05} = I_{05} - I_{03}$	–	–51	–23
Ratio of the extinct individuals (%)	e	$e_{03} = (E_{03}/I_{01}) * 100$ $e_{05} = (E_{05}/I_{03}) * 100$	–	22.7	20.2
Ratio of the new individuals (%)	n	$n_{03} = (N_{03}/I_{01}) * 100$ $n_{05} = (N_{05}/I_{03}) * 100$	–	18.1	18.0
Ratio of change of the individual number (%)	c	$c_{03} = (\Delta I_{03}/I_{01}) * 100 = n_{03} - e_{03}$ $c_{05} = (\Delta I_{05}/I_{03}) * 100 = n_{05} - e_{05}$	–	–4.6	–2.2

¹The year of the data is indicated in index

vidual number and position. Ratio of the new and extinct individuals and the change of individual number between 2003 and 2005 were calculated.

The population of *Linum dolomiticum* is too large to simply count the individuals, so the size of the population was determined in the following way: 1) cover and number of the individuals were determined in the sample area; 2) total cover of *Linum dolomiticum* was estimated based on the distribution map of a scale of 1 to 200 (DOBOLYI 2001, 2004); 3) total individual number was calculated with the following formula: $I = I_s * C_p / C_s$, where I = total individual number of the population; I_s = individual number of the sample area; C_p = total cover of *Linum dolomiticum* in the population; C_s = cover of the individuals in the sample area.

Method of determination of the seed production: 1) fruits were counted in the sample area; 2) seeds were counted in circa 150 fruits and seed/fruit ratio (average number of seeds per fruit) was determined (one fruit can contain up to 10 seeds); 3) total seed production of the population was calculated with the following formula: $S_p = s_f * F_s * I/I_s$, where S_p = seed production of the population; s_f = seed/fruit ratio; F_s = number of fruits in the sample area; I and I_s as above.

Population dynamic parameters were calculated with formulas given in the Table 1.

RESULTS AND DISCUSSION

The most important result of this study is that we now have a determined size of the entire population of *Linum dolomiticum*. Total individual number of the full population is circa 42,000; exactness of the estimation: about 10%.

Average seed number per fruit: 4.95. Since maximum seed number per fruit is ten, fertility rate is 0.495 seed/fruit. Total seed production: 74,600 seeds/year ($\pm 10\%$).

Demographic data of the sample area and data of change of population are given in the Table 1.

The number of individuals within the sample area has slightly decreased over the four years of the investigation. Since no sign of degradation was detected in the area, this can be explained by the extreme dry and hot weather during the study. However, the mapping of distribution has verified that the number of individuals has increased in several parts of the population. The total number of individuals in the whole population seems to be stable (DOBOLYI 2004).

The strikingly high ratio (circa 20%) of the new and disappeared individuals is an indication of intensive dynamic processes within the population of *Linum dolomiticum*. This reproductive dynamism is regarded as a positive sign of a healthy and strong ability of survival. Large empty areas surrounding the *Linum dolomiticum* patches of high density offer the possibility of future colonisation.

After analysing the maps of the sample area made in 2001, 2003 and 2005 it has become clear that a certain portion of the “extinct” individuals in fact has not died: some of those present in 2001 but absent in 2003 have re-appeared in 2005. These “old-new” individuals had to survive in the ground for two years without sprouting. The size of these individuals was found between 5 and 10 cm, which prove that they are not seedlings. This observation revealed that *Linum dolomiticum* can remain in dormant state for several years. About 10–20% of the new individuals were found to be seedlings (of 1–2 cm).

At this stage of the research it is concluded that the estimated population size – with regard to the considerable seed production and the high reproductive ability – appears to be large enough for the long term survival of this species, however, the effective population size has to be determined during future monitoring studies.

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