

## SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

**Action number: CA18201**

**STSM title: Estimating the rate of population spread in the endangered species**

***Minuartia smejkalii***

**STSM start and end date: 06/01/2020 to 15/03/2020**

**Grantee name: Jinlei Zhu**

### PURPOSE OF THE STSM:

The main purpose of the STSM is to estimate the rate of population spread of the endangered species *Minuartia smejkalii*. Specifically, we want to answer the following questions: 1) How does fecundity of *M. smejkalii* respond to vegetation density? 2) How far can seeds of *M. smejkalii* be dispersed in different environments? 3) Which factors will improve or hinder the spread of population in *M. smejkalii*? 4) How much is the escape probability from the canopy and the probability of long-distance seed dispersal in *M. smejkalii*?

### DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

- 1) 6 – 17 January 2020: I assembled data about the dispersal environment, including wind speed, vegetation height, soil chemistry, soil depth, soil water content, and vegetation composition, and we started measuring seed release height.
- 2) 20 – 24 January 2020: I went back to the Institute of Landscape and Plant Ecology, University of Hohenheim to measure seed terminal velocity.
- 3) 27 – 31 January 2020: I developed and tested a mechanistic model to simulate seed dispersal distance.
- 4) 3 – 14 February 2020: I analysed the relationship between dispersal trait (seed terminal velocity) and vegetation composition, soil chemistry and soil depth.
- 5) 17 – 21 February 2020: We measured more seed release heights.
- 6) 24 February – 15 March 2020: I simulated more seed dispersal, estimated the rate of population spread with vegetation projection matrices, analysed the results, and prepared the COST report.

### DESCRIPTION OF THE MAIN RESULTS OBTAINED

Seed dispersal distance of *M. smejkalii* was critically limited. In the five populations of *M. smejkalii*, namely “B1”, “DK2”, “DK4”, “DK5”, and “H”, the mean seed dispersal distance (mean  $\pm$  SD) was predicted to be 0.0044

( $\pm 6.3 \cdot 10^{-6}$ ) m, 0.0084 ( $\pm 1.2 \cdot 10^{-5}$ ) m, 0.0059 ( $\pm 8.1 \cdot 10^{-6}$ ) m, 0.0058 ( $\pm 8.3 \cdot 10^{-6}$ ) m, and 0.0206 ( $\pm 3.7 \cdot 10^{-5}$ ) m, respectively; the maximal seed dispersal distance (mean  $\pm$  SD) was 0.23 ( $\pm 0.04$ ) m, 0.61 ( $\pm 0.15$ ) m, 0.39 ( $\pm 0.07$ ) m, 0.39 ( $\pm 0.11$ ) m, and 1.51 ( $\pm 0.29$ ) m, respectively; the mean escape probability of seeds from the canopy (mean  $\pm$  SD) was 0.77 ( $\pm 0.0004$ ), 0.91 ( $\pm 0.0002$ ), 0.85 ( $\pm 0.0004$ ), 0.85 ( $\pm 0.0003$ ), and 0.82 ( $\pm 0.0003$ ), respectively; the maximal long-distance dispersal (LDD; threshold 0.5 m) probability (mean  $\pm$  SD) was 0.0003 ( $\pm 0.0006$ ), 0.2060 ( $\pm 0.0371$ ), 0.0186 ( $\pm 0.0205$ ), 0.0554 ( $\pm 0.0699$ ), and 0.9656 ( $\pm 0.0277$ ), respectively. There was a positive correlation between the maximal dispersal distance and the maximal long-distance dispersal probability (max.disp.dist =  $0.32 + 1.24 \cdot \text{max.ldd.prob}$ ;  $R^2 = 0.895$ ,  $F_{1,48} = 416.3$ ,  $p < 0.001$ ).

Stochastic population growth rate ( $\lambda$ ) of “B1”, “DK2”, “DK4”, “DK5”, and “H” was 1.55, 0.88, 1.03, 1.01, and 1.17, respectively. Therefore, populations “B1” and “H” were predicted to expand their population sizes in the future. On the other hand, the other three populations could face the extinction risk. For populations “DK4” and “DK5” the quasi-extinction probability (mean  $\pm$  SD) was 0.016 ( $\pm 0.005$ ) and 0.42 ( $\pm 0.023$ ) in 50 years, respectively. Worse, the quasi-extinction probability of the population “DK2” could drastically increase in 15 years, and the population could go extinct in 40 years. For all the populations, the elasticity of  $\lambda$  to survival of large adults was the greatest among all life-history stages.

The rate of population spread in *M. smejkalii* was critically limited. In four out of five populations of *M. smejkalii*, namely “B1”, “DK4”, “DK5”, and “H”, of which the population growth rate ( $\lambda$ ) was larger than one, the mean spread rate (mean  $\pm$  SD) was  $2.2 \cdot 10^{-3}$  ( $\pm 7.9 \cdot 10^{-4}$ ) m/year,  $6.3 \cdot 10^{-4}$  ( $\pm 2.4 \cdot 10^{-4}$ ) m/year,  $3.8 \cdot 10^{-4}$  ( $\pm 1.3 \cdot 10^{-4}$ ) m/year, and  $3.8 \cdot 10^{-3}$  ( $\pm 2.0 \cdot 10^{-3}$ ) m/year, respectively; the maximal spread rate (mean  $\pm$  SD) was  $8.7 \cdot 10^{-3}$  ( $\pm 6.4 \cdot 10^{-3}$ ) m/year,  $2.1 \cdot 10^{-3}$  ( $\pm 1.4 \cdot 10^{-3}$ ) m/year,  $1.3 \cdot 10^{-3}$  ( $\pm 5.3 \cdot 10^{-4}$ ) m/year, and  $3.8 \cdot 10^{-3}$  ( $\pm 2.0 \cdot 10^{-3}$ ) m/year, respectively. There was a significant positive correlation between the rate of population spread and the maximal dispersal distance (spread.rate =  $4.2 \cdot 10^{-4} + 5.5 \cdot 10^{-2} \cdot \text{max.disp.dist}$ ;  $R^2 = 0.869$ ,  $F_{1,398} = 2645$ ,  $p < 0.001$ ).

#### **FUTURE COLLABORATIONS (if applicable)**

In this project I show that the rate of population spread in the endangered species *M. smejkalii* is critically limited, and the species is facing severe dispersal limitation. I would suggest that future efforts should be made to largely assist seed dispersal to increase spread rate. For example, at the individual level, one could remove the neighbouring vegetation of the target plants to decrease aerodynamic roughness of the habitat, thus increase the windspeed experienced by individual seeds during dispersal process, or one could increase windspeed with “mini-wind-tunnel” in the field during the seed dispersal season. At a larger scale, one could also vary the landscape configuration to influence the dispersal environment. For example, one could vary the understory surface using mechanic structures, such as rocks with various sizes, to increase wind turbulence nearby the populations, which could in turn increase the probability of long-distance seed dispersal. Additionally, one could directly sow seeds or transplant seedlings of *M. smejkalii* to other potentially suitable sites to assist the species to overtake the dispersal limitation.

Meanwhile, in some populations, for example, “DK2”, measures should be taken to increase the population growth rate ( $\lambda$ ) to avoid the population going extinct. Specifically, adult plants should be well protected so that they can produce seeds for longer period.

This project promotes at least two manuscripts involving cooperation among different research institutions. Additionally, the project also promotes cooperation between early-career researchers and brings expertise from different areas together. For example, the other applicant (S. Lozada) in the same action of the COST project and I are planning to combine dispersal and genetic analysis, using the existing data from our own study. Furthermore, this project promotes a future cooperative research project between the Institute of Landscape and Plant Ecology, University of Hohenheim and the Institute of Botany, Czech Academy of Sciences, aiming to explore context-dependence of wind-driven seed dispersal and population spread, in which we will carry out common garden experiments testing how seed dispersal traits respond to variation in intra-specific competition and soil nutrients, and we will quantify the effects of context-dependent seed dispersal on the rate of population spread. Combining experiments and mechanistic modelling, this project will lead to deeper understanding how seed dispersal and thus population spread respond to environmental variation caused by biotic and abiotic factors.