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Review of dissertation entitled "Effect of plant-animal interactions on individual performance and population dynamics of *Scorzonera hispanica*" by Zita Červenková

This thesis consists of four studies on various aspects of the biology of the rare plant *Scorzonera hispanica*. Before the four studies are presented, a general introduction first describes the life cycle of plants and reviews the literature on various influences on plant performance during different stages of the life cycle. Then the model system, *Scorzonera hispanica*, is introduced and the aims of the thesis and its main results are presented. Finally, conclusions from the individual studies are presented.

The first chapter studies the influence of various factors on seed size and seedling performance. This chapter does not quite fit into the general framework of the thesis and is not covered by its title, because it does not deal at all with plant-animal interactions. While the study is well designed, I suspect that the statistical analysis is flawed (see below). The second chapter investigates the factors potentially influencing the visitation of flowers by pollinators and the effects of various factors on seed number. The relationships between the various variables are nicely integrated and illustrated using structural equation models. Chapter 3 studies the effect of herbivory by roe deer on reproduction in *S. hispanica*. The negative effects of herbivory, although variable between years, were very strong. The final chapter investigates the effect of herbivory on the population and metapopulation dynamics of *S. hispanica* and also assesses the risk of extinction at the population and the landscape level. This chapter integrates many of the results of the other chapters as well as data from previous studies on *S. hispanica* and is a nice example of the benefits of long-term research at the same sites. An important result is that herbivory, although it only affects reproduction in *S.*

hispanica, can have a strong effect on the population dynamics of a long-lived species at the landscape level. While current levels of herbivory do not threaten the plant, slightly higher levels of herbivory could have very negative effects on *S. hispanica*. The candidate is not the first author of this chapter, but has contributed substantially to the design of the study, to data collection, analysis and writing.

The candidate has shown in her thesis that she has a good understanding of the population biology of plants. She has used in her work many different techniques and approaches and has also shown that she can use sophisticated statistical analyses. The analyses and the presentation of the results are mostly good, although there are some weaknesses. The candidate shows that she has generally a good overview of the relevant literature, and even cites papers from the current year, but some relevant studies are not cited.

The results of the thesis contribute to our understanding of the importance of plant-animal interactions, both mutualistic (pollination) and antagonistic (herbivory) for the population dynamics of plants. The thesis is also an important contribution to our understanding of the biology of a threatened species and its results may contribute to successful management of the study sites for conservation. Two chapters of the thesis have already been published.

I can recommend without hesitation to accept the thesis for a doctoral degree.

Questions to the candidate

- (1) What effects could spatial autocorrelation have on the results of the pollination study?
- (2) No pollen limitation of reproduction was found in the study; instead the results were interpreted as evidence for resource limitation of reproduction. Can pollinator limitation really be excluded, given its prevalence in plants? What selection pressures would pollen limitation exert?
- (3) In the study on herbivore effects on population dynamics at the landscape level, many assumptions for parameter values had to be made. What influence might variation in these values have on the results of the study?
- (4) What selection pressures on flowering traits would you expect from herbivory, as observed in *S. hispanica*?

Detailed comments

Chapter 1 investigates the effects of individual seed mass, traits of the mother plant and population size on seed germination and the performance of seedlings. The experiment is well designed and suitable to separate the various effects. However, I suspect that the statistical analysis is flawed, which makes it impossible to interpret the results presented. The data are analysed using a linear mixed model which is appropriate, but also difficult to check. The error df for testing the effects of seed mass, traits of the mother plant and population size are all given as 6, which I think is only appropriate for the effects of population size (7 replicate populations). I think the candidate failed to implement in the statistical model the nested design of the study in which mother plant is nested within population and seed within mother plant. The replicates for the effect of traits of the mother plants are therefore the 70 mother plants, and the replicates for the effects of seed mass are the 350 individual seeds. The effects have to be adjusted for the effects of the respective higher level. I wonder, if the effects of traits of the mother plant would be stronger if tested appropriately.

The aim of the study was to separate the effects of seed weight from those of population and mother plant. It would therefore be more appropriate to show in Fig. 2 and 3 partial regressions. i.e. the effect of seed weight on cotyledon length/leaf length controlled for the effects of mother plant identity.

The chapter would also have benefitted from more careful proof reading:

- It is stated in the text with reference to Fig. 1 that seeds from larger populations germinated more often and had higher survival. However, Fig. 1 does not show this but instead compares the germination of seeds of different weights.
- The caption of Table 4 states that the proportion of variability in seedling size explained by seedling weight is shown in the table. This is not the case, only time, the p-value and deviance (Dev) is given. Or does the column headed by "Dev" show the proportion (%) of deviance explained? This is not explained. However, in Table 3 "Dev" means total deviance due to a factor, not the proportion.
- It is stated in the discussion that there were differences in performance among offspring from different mother plants. This is not shown in the results and there is no reference for this.
- In the header of Table 2 the error df for testing the effects of all factors on seed mass is 6, whereas for the effects on performance, which includes seed weight as an additional explanatory factor, the df are 7. This is flawed. It is also not quite clear what the columns named "Dev" in the table show, deviance or the proportion of total deviance.

There are also quite a few grammatical errors.

Chapter 2

- Visitation rate is defined as the number of observed visitors per 30-s period. However, in the figures (Fig. 2 and 4) visitation rate is bounded by 0 and 1. This looks like a proportion.

In the discussion I would have wished to see a more detailed discussion of direct and indirect effects, which are shown in the structural equation model.

- The relevant literature is not always covered. As in the current study, pollination limitation has also been studied in the closely related species *Scorzonera humilis* by Colling and Matthies (2004, Am. J. Bot.) but this work is not cited and the results of the present study are not related to those of that study.

- The discussion might have benefitted from comparisons with the results of another paper on the related *Scorzonera humilis*, in which the effect of the same smut fungus on reproduction was studied, as well as its incidence (Colling & Matthies 2004, Oikos). While apparently in *S. hispanica* the systemic fungus had no effect on reproduction, it effectively sterilizes completely plants of *S. humilis*.

- This chapter would also have benefitted from a final round of proof reading. Very often two successive words have been fused. This is probably an artefact that occurred during the creation of the final pdf, but it makes reading the chapter difficult and should have been corrected. There are also quite a few grammatical errors and some words in the text that interrupt the flow and are probably leftovers from previous versions.