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Pollinators of *Helleborus niger* in Slovenian naturally occurring populations

Andrej ŠUŠEK[1], Anton IVANČIČ[2]

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ABSTRACT

The study is based on documentation and analysis of the major visitors and pollinators of the Christmas rose (*Helleborus niger* L.) flowers in Slovenian naturally occurring populations. The emphasis was put on 5 groups of insects: bees, bumblebees, large flies, small dipterous flies and pollinators of minor importance. Systematic observations took place in March 2003, at two different locations: on the valley of Bohinjska Bela and on the Peca Mountain. The first location was not far from a rural area, while the second one was in an isolated area, completely in the wild. The analysis of insect activity showed that there were obvious differences in frequency of visits among the insect groups investigated, locations and time of day. In the population of Bohinjska Bela, bees were the most important pollinators, with the highest activity occurred between 10 a.m. and 11 a.m. In the isolated population in Peca the most frequent visitors were small dipterous flies. The study suggests that the Christmas rose is probably an entomophylous (the most important pollinators are insects, such as bees and flies) and predominantly cross-pollinating species. The entomophylous nature appears to be closely associated with the specific botanic characteristics of flowers. Another pollinating agent is probably wind.

Key words: Christmas rose, *Helleborus niger*, wild populations, pollination

IZVLEČEK

OPRAŠEVALCI ČRNEGA TELOHA *(Helleborus niger)* V NARAVNIH POPULACIJAH V SLOVENIJI

Raziskava je bila opravljena na črnem telohu (*Helleborus niger* L.) in obsega dokumentiranje in analizo glavnih opraševalcev črnega teloha v naravnih populacijah. Osredotočili smo se na 5 skupin insektov: čebele, črmlje, muhe, majhne dvokrilne insekte in opraševalce manjšega pomena. Sistematično opazovanje je potekalo v marcu 2003 na dveh lokacijah: v dolini Bohinjska Bela in na planini Peca. Prva lokacija je bila blizu naselja, medtem ko je bila druga lokacija daleč od ruralnega okolja v naravi. Analize opraševanja, povezane z aktivnostjo žuželk, nakazujejo, da obstajajo očitne razlike v pogostnosti obiska med proučevanimi skupinami žuželk, lokacijo in dnevnim časom. V populaciji Bohinjska Bela so bili najpomembnejši opraševalci čebele z največjo aktivnostjo med 10 in 11 uro zjutraj. V populaciji Peca so bili najpogostejši obiskovalci majhni dvokrilni insekti. Opazovanja kažejo,

[1] Senior lecturer, M.Sc., Faculty of Agriculture, University of Maribor, SI-2000, Maribor, Vrbanska 30 e-mail: andrej.susek@uni-mb.si

[2] Prof., Ph.D., Faculty of Agriculture, University of Maribor, SI-2000, Maribor, Vrbanska 30

da je črni teloh verjetno prevladujoče tujeprašna, entomofilna vrsta (najpomembnejši opraševalci so insekti, predvsem čebele in muhe). Entomofilna narava je ozko povezana z botaničnimi lastnostmi cveta. Med možne opraševalce spada tudi veter.

Kjučne besede: črni teloh, *Helleborus niger*, naravne populacije, opraševanje

1 INTRODUCTION

Christmas rose (*Helleborus niger* L.) belongs to the dicotyledonous family *Ranunculaceae* (Tamura, 1993). In natural conditions, it is a rhizomatous and evergreen perennial, 15-30 cm high, admired for its very early flowers and attractive leaves. It can grow in different geographical areas as well as in diverse climates, reliefs and bedrocks. Slovenia has at least six distinctive phytogeographical regions (Wraber, 1969), and the Christmas rose widely grows in all of them and according to our previous investigations it is highly variable (Šušek et al., 2005). Its habitats, however, appear to be less frequent in the sub-Pannonian and sub-Mediterranean regions.

Christmas rose is gradually becoming very popular on the market as an ornamental plant (Armstrong, 2002; Roggendorf, 2003). In its native habitats, it flowers from November to April. It does not need high temperatures for the beginning to flowering and this is very important for producers in moderate continental climate. For this reason it can be considered as a cost efficient and friendly to the environment.

The flowering period depends on several factors, such as genetic structure, age, presence of pests and diseases, soil fertility and climatic conditions. Among these, the most important appear to be the climatic factors. Snow and low temperatures may postpone the onset of flowering for two or more months. As an example, in the season 2003/2004 flowering in Slovenia began in the fourth week of November. In the following season (2004/2005), flowering began in mid February. The duration of flowering depends mainly on ambient air temperatures. When average daily temperatures are 3-5 ^{o}C, flowering is over within 2-3 weeks.

The Christmas rose differs from most other hellebores in the manner in which the flower stem emerges from the soil. After a period of low temperatures, the floral stems (peduncles) start to elongate. This process is in many ways similar to that in French beans (Ahlburg, 1989). The upper end of the peduncle, just below the base of the flower, is thinner than the lower part and sharply bent like a hairpin. The sepals are folded together like an umbrella about to be put into its cover and are also furled like an umbrella, thus forming an acute tip. The flower is not protected by being enclosed in bracts. The wrinkled neck of the peduncle pushes through the soil surface and then straightens, pulling the flower out of the soil (Ahlburg, 1989).

The Christmas rose is a predominantly cross-fertilising species. Flowers are hermaphrodite (having functional male and female sexual organs) and protogynous (Salopek-Sondi et al., 2002). Following fertilisation by February or March, the fruit starts to develop and is mature by May or June (depending on ambient temperatures). Simultaneously, the sepals, which are white or pink at anthesis, persist until the seeds

are ripe and become intensely green (in shaded plants), or dark red (in sun-exposed plants) (Salopek-Sondi et al., 2000; Salopek-Sondi et al., 2002).

Prior to this study, nothing was known about the pollinators of Christmas rose. The main purpose of this study was to determine the major flower visitors and pollinators and analyse the dynamics of their visits during the day.

2 MATERIALS AND METHODS

The pollination studies that took place in early and mid spring 2003 (from 20th to 30th March) were based on recordings of visits to the flowers by various insect species. Pollinating species assemblages may vary by time of day, time of season, or location (Heinrich 1976; Herrera 1988; Traveset et al., 1998), and for this reason the observations took place at different times of day, throughout the flowering season and at two different locations belonging to different geographical regions: (1) the valley of Bohinjska Bela (500 m a.s.l., Northwestern Slovenia) and (2) the Peca Mountain (1131 m a.s.l., Northeastern Slovenia) (Figure 1).

The first location was not far from a rural area, while the second was in an isolated area, completely in the wild. Based on previous observations, we concentrated on 5 groups of insects: (a) bees, (b) bumblebees, (c) large flies, (d) small dipterous flies and (e) pollinators of minor importance, including various species of wasps, ants, beetles and *Thysanoptera*. The observations lasted for several days; however, only 3 days were suitable for 12-hour long recordings (20-22 March, 2003) in Bohinjska Bela and 2 days on Peca Mountains (29-30 March, 2003). These observations started early in the morning (at 6 a.m.) and ended in the evening (at 6 p.m.). The recording was done by two experienced persons and each of them was responsible for monitoring 30 flowers in the close neighbourhood. Each of the monitored flowers was marked with a small label.

The recorded data were analysed using SPSS 12.0 programme.

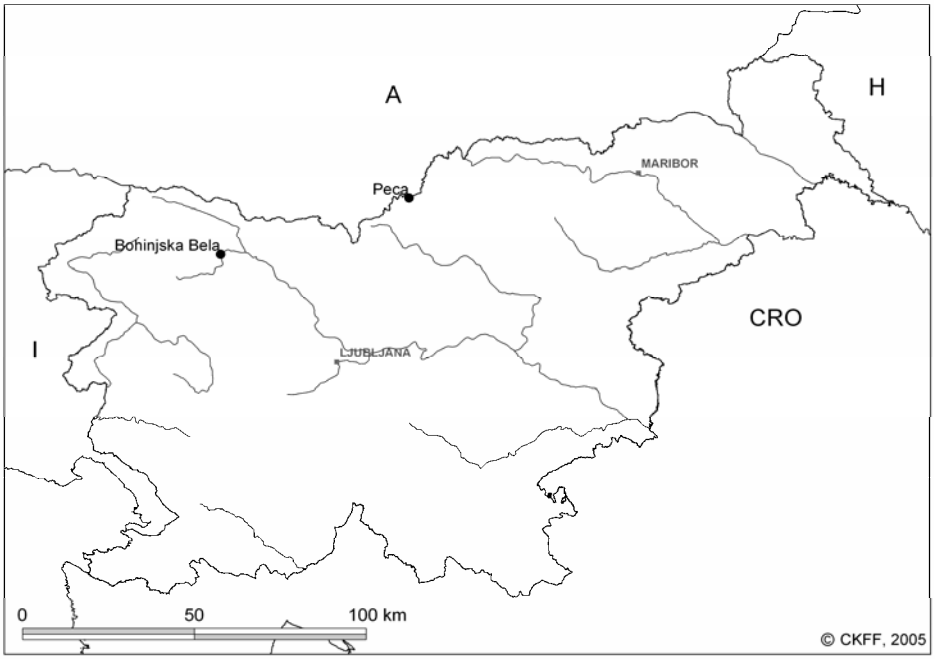

Figure 1: Studied locations (●) of *Helleborus niger* in Slovenia. The map was adapted with the permission of the CKFF (the Slovenian Centre for Cartography of Fauna and Flora).

3 RESULTS AND DISCUSSION

Natural pollination in both locations was found to be successful. The indicators were numerous well developed seeds. The study suggests that the Christmas rose is a predominantly entomophylous species. The main attractants for insects are the shape and colour of flowers, and the presence of pollen and nectar (Bronstein, 1994; Kearns, 1997). Odour is generally not very strong or attractive to the main pollinators (bees); however, it appears to be sufficiently attractive to flies. Flies were found to be important pollinators only in the isolated area of Peca. This was probably because wild bees were rare and there were no bee keepers within the area.

The analysis of insect activity showed that there were obvious differences in frequency of visits among the insect groups investigated, locations and time of day (Table 1, Figure 1). Bees were the most important pollinators in the population of Bohinjska Bela. Most of these probably came from apiaries in the nearby villages. The highest activity occurred between 10 a.m. and 11 a.m. (on average 2.067 visits per plant within of two days of observation). The second most common visitors in this population were small dipterous flies belonging to the families *Drosophilidae* and *Sciaridae*, which were most active between 12 a.m. and 1 p.m., and between 2 p.m. and 3 p.m. (on average 0.333 visits per plant). The presence of the remaining groups of pollinators such as bumblebees, wasps, ants, beetles and *Thysanoptera* was insignificant (less than 2.3 % of visits).

In the isolated population on the Peca Mountain, the most frequent visitors were small dipterous flies, with the highest activity between 10 a.m. and 1 p.m. and between 4 p.m. and 5 p.m. (on average 0.033 visits per plant). Similar frequencies of visits were also found for larger species of flies belonging to the family *Syrphidae* (these were most active between 8 a.m. and 10 a.m., and between 11 a.m. and 1 p.m.), bees (these were most active between 9 a.m. and 10 a.m.) and the remaining group, including wasps, ants, beetles and *Thysanoptera,* (these were most active between 12 a.m. and 13 p.m.).

A relatively low number of insect visits on the Peca Mountain (some of the insect visitors were not pollinators) and numerous well developed seeds suggested that wind could also be one of the pollinating agents. The indicators of the predominant entomophyly are: large flowers (the largest flowers have a diameter up to 13 cm), stigmas of the female are generally above anthers (mechanism that helps to prevent self-pollination); presence of odour during flowering and protected sexual organs (they are not exposed like in typical anemophylous plants, e.g. in hazel nuts, European walnut, and maize). Flowering Christmas rose plants are usually mixed with other plants such as small trees, shrubs, dry ferns and grasses, which are usually taller than Christmas roses and in this way reducing the wind velocity, and consequently the efficiency of wind pollination. However, it is important to mention that Christmas rose flowers produce relatively large quantities of pollen, which is light and dry and could be easily carried by wind.

Table 1: Visits to flowers by insect-pollinators in two naturally occurring populations in Bohinjska Bela and Peca Mountain (20-22 and 29-30 March, 2003).

Hours	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Bohinjska Bela: bees													
Mean	0	0.10	0.12	1.27	2.10	1.67	0.75	0.40	0.52	0.03	0.03	0.07	0
S.d.	0	0.40	0.37	1.70	2.00	1.87	0.95	0.67	0.87	0.18	0.18	0.31	0
Max.	0	2	2	6	8	9	4	3	4	1	1	2	0
Sum	0	6	7	76	124	100	45	24	31	2	2	4	0
Peca: bees													
Mean	0	0	0	0.03	0.03	0	0.02	0	0	0.02	0	0.02	0
S.d.	0	0	0	0.18	0.18	0	0.13	0	0	0.13	0	0.13	0
Max.	0	0	0	1	1	0	1	0	0	1	0	1	0
Sum	0	0	0	2	2	0	1	0	0	1	0	1	0
Bohinjska Bela: bumblebees													
Mean	0	0	0	0	0.05	0.02	0.02	0.05	0.02	0	0	0	0
S.d.	0	0	0	0	0.22	0.13	0.13	0.39	0.13	0	0	0	0
Max.	0	0	0	0	1	1	1	3	1	0	0	0	0
Sum	0	0	0	0	3	1	1	3	1	0	0	0	0
Peca: bumblebees													
-	0	0	0	0	0	0	0	0	0	0	0	0	0
Bohinjska Bela: large flies (belonging to the families *Muscidae* and *Syrphidae*)													
Mean	0	0	0.07	0.27	0.13	0.22	0.05	0.02	0.08	0	0.05	0	0
S.d.	0	0	0.31	0.73	0.43	0.78	0.22	0.13	0.33	0	0.22	0	0
Max.	0	0	2	4	2	4	1	1	2	0	1	0	0
Sum	0	0	4	16	8	13	3	1	5	0	3	0	0
Peca: large flies (belonging to the family *Syrphidae*)													
Mean	0	0	0.03	0.03	0.05	0.03	0.03	0	0	0	0	0	0
Sd.	0	0	0.18	0.18	0.22	0.18	0.18	0	0	0	0	0	0
Max.	0	0	1	1	1	1	1	0	0	0	0	0	0
Sum	0	0	2	2	3	2	2	0	0	0	0	0	0
Bohinjska Bela: small dipterous flies (belonging to the families *Drosophilidae* and *Sciaridae*)													
Mean	0	0.083	0.13	0.18	0.15	0.18	0.33	0.23	0.33	0.07	0.12	0.27	0
S.d.	0	0.334	0.34	0.39	0.40	0.43	0.70	0.59	0.77	0.31	0.37	0.48	0
Max.	0	2	1	1	2	2	3	3	4	0	2	2	0
Sum	0	5	8	11	9	11	20	14	20	4	7	16	0
Peca: small dipterous flies (belonging to the families *Drosophilidae* and *Sciaridae*)													
Mean	0	0	0.02	0.05	0.03	0.03	0.03	0.02	0.05	0.07	0.03	0	0
S.d.	0	0	0.13	0.29	0.18	0.18	0.18	0.13	0.29	0.36	0.26	0	0
Max.	0	0	1	2	1	1	1	1	2	2	2	0	0
Sum	0	0	1	3	2	2	2	1	3	4	2	0	0
Bohinjska Bela: other insects (various species of wasps, ants, beetles and *Thysanoptera*)													
Mean	0	0	0	0.05	0.02	0.03	0.05	0.03	0	0.02	0.03	0	0
S.d.	0	0	0	0.22	0.13	0.18	0.29	0.18	0	0.13	0.18	0	0
Max.	0	0	0	1	1	1	2	1	0	1	1	0	0
Sum	0	0	0	3	1	2	3	2	0	1	2	0	0
Peca: other insects (various species of wasps, ants, beetles and *Thysanoptera*)													
Mean	0	0	0	0.02	0	0	0.03	0	0	0	0	0	0
S.d.	0	0	0	0.13	0	0	0.18	0	0	0	0	0	0
Max.	0	0	0	1	0	0	1	0	0	0	0	0	0
Sum	0	0	0	1	0	0	2	0	0	0	0	0	0

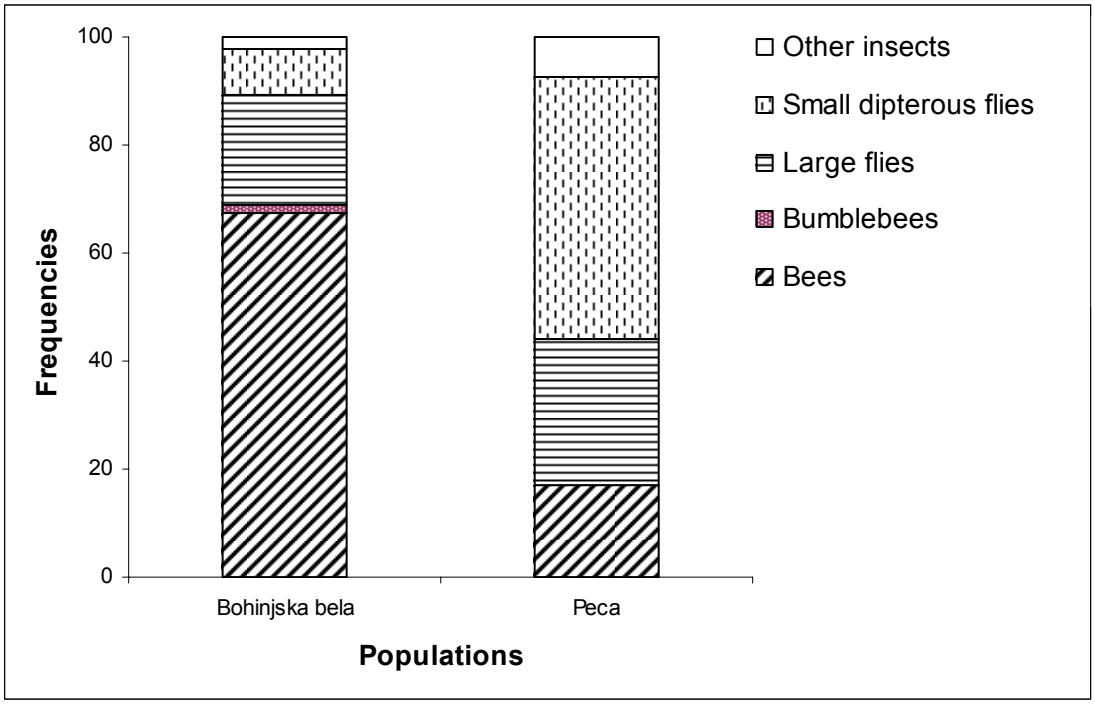

Figure 1: Frequencies of pollinators visiting *Helleborus niger* based on two days of observation in two Slovenian natural populations

4 CONCLUSIONS

According to our observations, the Christmas rose appears to be a predominantly entomophylous and a cross-pollinating species. The most important pollinators are insects, such as bees and flies. Their activity depends on several factors such as species characteristics, location and day time. Some of the visiting insects were probably not pollinating agents. Relatively low frequency of insects visitors on the Peca Mountain and the presence of numerous well developed seeds suggest that wind could also be one of the pollinating agents. Self-pollination was probably rare, due to protogynous nature of flowers and specific floral structure.

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