Differences in pollinator composition, species richness and flower visit abundance between *Centaurea jacea* (L.) and *Leontodon hispidis* (L.) in a meadow in Central Slovenia

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Abstract. In this pilot study, the differences in pollinator composition, species richness and pollinators' visits between *Centaurea jacea* and *Leontodon hispidis* were investigated. For 15 minutes, the pollinators visiting the plants in a particular meadow were counted. There was a difference in composition. On *C. jacea* mostly *Apis mellifera* occurred, while *L. hispidis* was visited mainly by syrphids. Furthermore, due to the frequent visits by *Apis mellifera*, the abundance of pollinators on *C. jacea* was higher then on *L. hispidis,* while the evenness was higher in *L. hispidis*. The species richness did not differ between the plant species. The reasons for differences in pollinator visitation are discussed. Furthermore, it would be advisable to survey the differences in pollinator composition and abundance between similar plant species within the tribes/families of *C. jacea* and *L. hispidis*, for a better understanding of the pollinators' choice for a plant species.

Key words: pollinators, composition, species richness, abundance, *Centaurea jacea*, *Leontodon hispidis*

Izvleček. RAZLIKE V VRSTNI SESTAVI, VRSTNEM BOGASTVU OPRAŠEVALCEV IN POGOSTOSTI NJIHOVEGA OBISKOVANJA RASTLIN VRST Centaurea jacea (L.) IN Leontodon hispidis (L.) NA TRAVNIKU V CENTRALNI SLOVENIJI - V tej pilotni študiji so avtorji preučevali razliko v vrstni sestavi in vrstnem bogastvu opraševalcev ter njihovo obiskovanje rastlin vrst *Centaurea jacea in Leontodon hispidis.* V času 15 min so prešteli opraševalce, ki so obiskali rastline na izbranem travniku. Ugotovili so razliko v vrstni sestavi opraševalcev. Na rastlini *C. jacea* je bila pristona predvsem *Apis mellifera*, medtem ko so *L. hispidis* obiskovali predvsem predstavniki družine Syrphidae. Poleg tega je bila zaradi pogostih obiskov osebkov vrste *A. mellifera* številčnost opraševalcev višja na *C. jacea* kot na *L. hispidis*, medtem ko je bila enakomernost višja na *L. hispidis*. Rastlinski vrsti se v vrstnem bogastvu opraševalcev nista razlikovali. Avtorji razpravljajo o vzrokih za razlike v obiskovanju opraševalcev. Poleg tega bi bilo priporočljivo raziskati razliko v sestavi opraševalcev in njihovi številčnosti med podobnimi vrstami rastlin znotraj plemen/družin *C. jacea* in L. *hispidis*, s čimer bi bolj razjasnili izbiro opraševalcev med rastlinskimi vrstami.

Ključne besede: opraševalci, vrstna sestava, vrstno bogastvo, številčnost, *Centaurea jacea, Leontodon hispidis*

Introduction

A large part of the plant species need pollinator for their reproductive survival. To attract many pollinators, plants have a wide variety of traits. Within a rich plant community, this complexity of traits could mean that there would be a high diversity of pollinators if pollinators specialised on certain plant species. However, this is not always the case and most pollinators use more plants for foraging (reviewed in Goulson 1999).

In literature, many plant traits are suggested for attracting pollinator species, like floral reward (Duffield et al 1993), floral scent (Andersson 2003), flower size (Shykoff et al. 1997), flower colour (Hegland & Totland 2005), flower density (Hegland & Totland 2005), etc. Mostly the continuous traits like the latter are likely to be more important to the pollinator community rather then temporal traits like the phenology (Hegland & Totland 2005).

On the other hand pollinators, too, evolved ways to get the nectar and the pollen of the flower. First of all there is a difference in the searching strategy (reviewed in Goulson 1999). However, the length of the tongue is important as well (Gilbert 1981). But sometimes pollinators gain the nectar or pollen in an »illegal« way; some bumblebees, for example, are known to »rob« the flower by making a hole in the corolla (Utelli & Roy 2001).

In the last few years, more and more studies have been focused on the plant-pollinator interaction at the community level (Herrera 1988, Dicks et al. 2002, Dupont et al. 2003, Hegland & Totland 2005). Within a community, many different species occur, which have different attractiveness to species and some even do not have any pollinators at all. Not so many studies focussed on the difference in attractiveness due to different floral traits within a plant community (Hegland & Totland 2005).

This pilot study was conducted in a meadow with an Arrhenatheretum community in Central Slovenia. In August, the most important abundant species in this meadow were *Centaurea jacea* and *Leontodon hispidis*. Common to these two species is that the flowers are easily accessible by pollinators and have both a large floral reward. Difference is the colour (*C. jacea* is purple and *L. hispidis* is yellow) and the length of the corolla. Although *C. jacea* was used already for pollinator community studies (Gilbert 1980, Hirsch et al. 2003, Hegland & Totland 2005), the pollinator community of *L. hispidis* had not yet been researched.

This research raised the following questions: Do different plant species facilitate different pollinators? Are these differences in attraction between *Centaurea jacea* and *Leontodon hispidis* for abundances of pollinator visits and species richness due to morphological differences?

Methods

Fieldwork

The fieldwork was carried out on 17th, 20th and 24th August 2006 from 9.30h till 15.30h in a meadow west of Dragomer (x = 97008.3, y = 452166.7), which is situated west of Ljubljana, Slovenia. Twenty-six samples of both *C. jacea* and *L. hispidis* were collected within these days. I sampled as following: I sat for 15 minutes at a plant specimen and counted the visiting species and the number of specimen per species in this time. Every plant was between 15 and 30 cm high and they appeared to be similar in colour and age group (e.g. just flowering and had no rotten leaves). The survey was carried out in only one place and therefore represents only one species pool. The species were determined in the field and released after counting. When the species could not be determined, the specimen was identified by an expert or written as species sp.

Analysis

I tested the difference in pollinator composition, species richness, evenness and diversity and abundance between plant species. For the analysis, the programs R-statistics (R Development Core Team 2005), and PAST (Hammer et al. 2001) were used.

The difference in pollinator community was first analysed with the Jaccard index (Jaccard 1912) and a correspondence analysis (CA). Furthermore, a Spearman correlation coefficient was used to see if the x and y axis could be explained respectively by the number of specimens and the proportion of total specimens occurring on *Leontodon hispidis*.

Count data, like species richness and abundance, generally do not follow a normal distribution. Therefore, all species data were analysed with log link models using a poisson

distribution or a quasi-poisson distribution (Crawley 2005). The models included the fixed factor »plant species«.

Results

Table 1: Number of pollinators on *Leontodon hispidis* and *Centaurea jacea* counted in samples of 15 minutes in a meadow in central Slovenia.

	Species	***Leontodon hispidis***	***Centaurea jacea***
Hymenoptera:			
Apidae	*Apis mellifera*	2	182
	Osmia leucomelana	5	2
	Halictus sp.	0	1
Diptera:			
Syrphidae	*Cheilosia sp.*	1	0
	Chrysotoxum festivum	16	6
	Eristalis arbustorum	4	0
	Eristalis tenax	11	4
	Helophilus trivitattus	0	1
	Melanostoma mellinum	1	0
	Merodon aenea	4	0
	Myathropa florea	2	0
	Sphaerophoria scripta	6	2
	Sphaerophoria sp.	4	2
	Syrphus sp.	0	2
Muscidae	*Muscidae sp. 1*	0	1
	Muscidae sp. 2	1	0
	Muscidae sp. 3	1	0
Coleoptera:			
Coccinellidae	*Coccinellidae sp.*	1	0
Lepidoptera:			
Satyridae	*Maniola jurtina*	0	1
Total		**59**	**204**

In total, 59 specimens visited *Leontodon hispidis* and 204 specimen *Centaurea jacea* (Table 1). The visits on *L. hispidis* were dominated by diptera (86.4%), followed by hymenoptera (11.9%), while *C. jacea* had dominantly hymenoptera (90.6%), followed by diptera (8.8%). Furthermore, when we take the Jaccard similarity index into account it was shown that the pollinator communities of the two plant species were not very similar (Jaccard index = 0.32).

Figures 1a and 1b show the difference in composition of pollinator species between *C. jacea* and *L. hispidis*. The x-axis explains the number of specimens of pollinators recorded on both plant species (Fig 1a: 0.897, $P < 0.00$; Fig 1b: 0.891, $P < 0.00$) and the y-axis shows the proportion of pollinators' abundance occurring on *L. hispidis* (Fig 1a: 0.584, $P < 0.00$; Fig 1b: 0.858, $P < 0.00$). On basis of the pollinator composition, the samples from *L. hispidis* cluster on the left and those from *C. jacea* on the right. The pollinator compositions of *C. jacea* and *L. hispidis* are shown in figure 1b. The x-axis shows the differences in pollinator compositions between the plant species. Almost 100% of the observations of the honey bee *Apis mellifera* were done on *C. jacea*. *Syrphus sp.*, *Helophilus trivittatus*, *Halictus sp.*, *Muscidae spp.* and *Maniola jurtina* occurred on both plants. *L. hispidis* had a large number of pollinating species, among which *Chrysotoxum festivum* with 16 specimens was the most common.

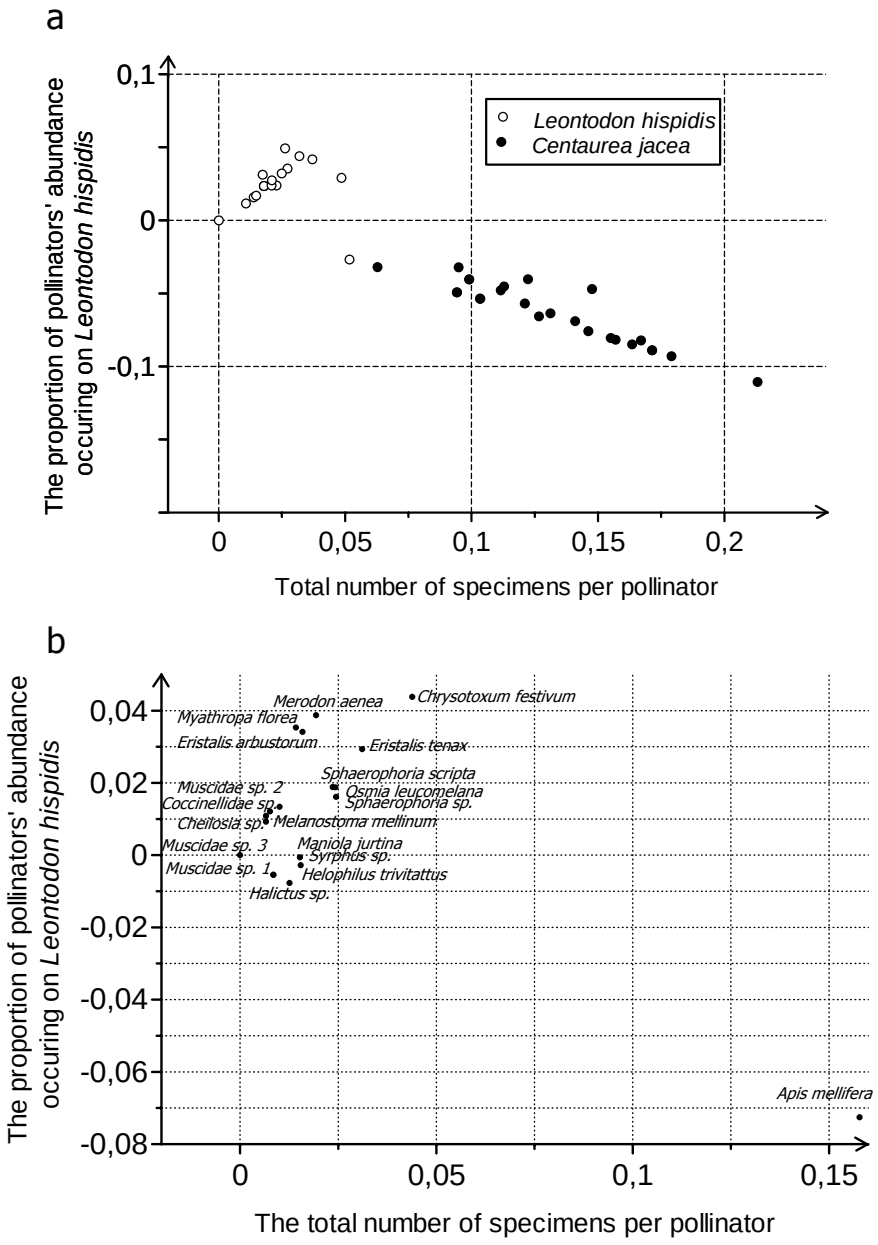

Figure 1: Correspondence analyses plots for (a) samples of *Leontodon hispidis* and *Centaurea jacea*, and for (b) pollinators of *Leontodon hispidis* and *Centaurea jacea*. The x axis explains the total number of specimens per pollinator species, whereas the y-axis shows the difference in pollinator composition between *Leontodon hispidis* (upper side) and *Centaurea jacea* (lower side).

The abundance of pollinator visits (Figure 2a; t = 5.81, df = 43, $P < 0.001$) was higher with *C. jacea* and the evenness (Figure 2d; U = 141, df = 1, $P = 0.015$) was lower in *C. jacea*. The latter shows that *C. jacea* has a few dominant visitors. There was no difference in pollinator species richness (Figure 2b; Z = 0.507, df = 43, $P = 0.612$) and diversity (Figure 2c; U = 189, df = 1, P = 0.231) between both plant species.

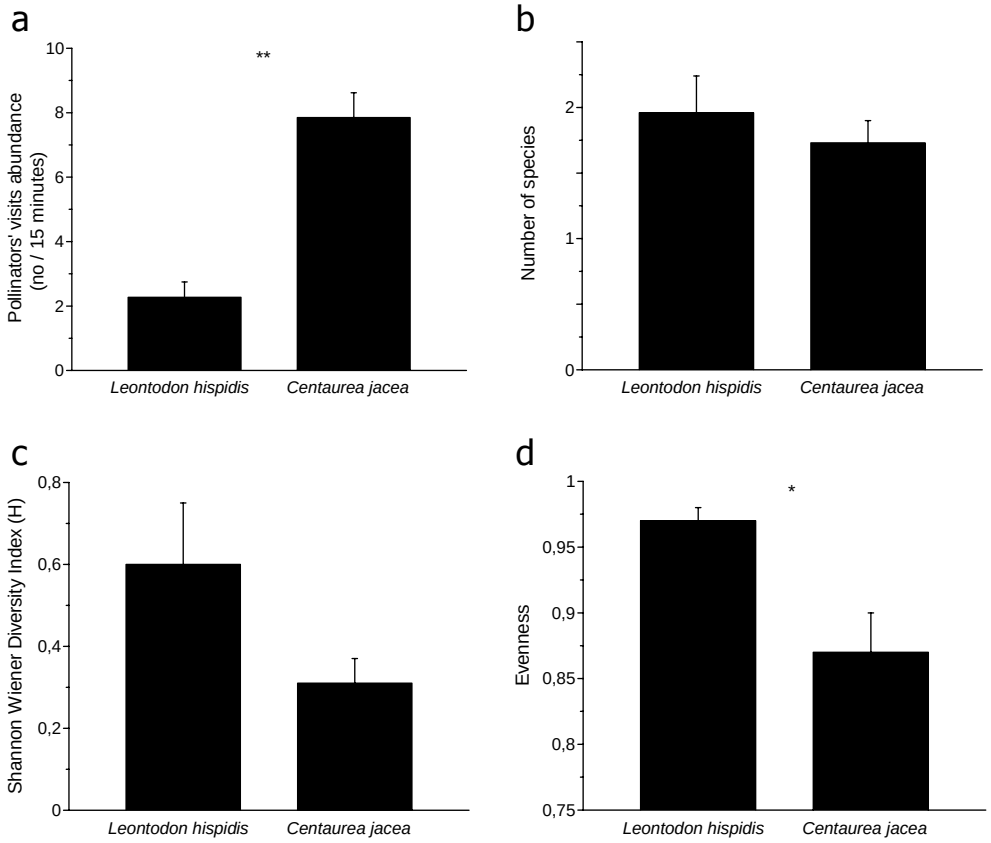

Figure 2: Difference in (a) number of pollinators' visits, (b) number of species, (c) species diversity and (d) evenness between *Leontodon hispidis* and *Centaurea jacea*. (*: P < 0.05; **: P < 0.01)

Discussion

Do the different plant species facilitate different pollinators?

The results suggest that there is a difference in species composition for the two plant species with several similar species. There is no difference in species richness between *Centaurea jacea* and *Leontodon hispidis*, but the real difference is in the flower visits per plant species per pollinator species.

During this research, no difference in species richness was found between the examined plant species, however, for other plant species these differences in species richness do exist (Sahli & Conner 2006).

The species richness of *C. jacea* is known to be much higher and can be visited by different pollinator families as established during this research (Gilbert 1980, Hirtsch et al. 2003, Sahli & Conner 2006). One of the explanatory factors can be that the species richness was suppressed by one particular species, here the honey bee *Apis mellifera*. The honey bee was very common in this area probably due to the fact that there was a beehive in the vicinity, and can be very aggressive towards other pollinators. Therefore other pollinators did not feed that much on *C. jacea*.

On the other hand, Sahli and Conner (2006) showed that often species have preference for certain type of flowers, but the results have shown that occasionally they also visit other plant species, affecting the pollinator species richness of the plant species. This pollinator species facilitation for other plant species has been reported by some other researchers as well (Thomson 1978, 1981, Campbell and Motten 1985, Laverty 1992).

Are these differences in attraction between *Centaurea jacea* and *Leontodon hispidis* for abundances of pollinator visits and species richness due to morphological differences?

Centaurea jacea and *Leontodon hispidis* differ largely in colour and morphology, like the depth of the corolla. Other possible floral traits like flower symmetry and shape are similar, although the latter are important discriminating traits for flies, which like open, actinomorphic flowers (Hegland & Totland 2005).

Hegland and Totland (2005) did not find any evidence that flower colour is an important general trait for the basis of the choice of the pollinator. However, we found that especially bees were occurring on the pink purple *C. jacea*. This could be explained by the fact that research on bees showed that colour is important for imprinting of rewarding flower types with the same colour, even when there are large morphological differences (reviewed in Goulson 1999). Species with the same morphology but with a different colour were not visited (reviewed in Goulson 1999). This would explain why the bees did not visit frequently the flowers of *Leontodon hispidis*.

Another factor, which can explain the occurrence of pollinators on flowers, concerns the morphological differences. The hoverflies, for example, choose the flowers which are best accessible according the length of their tongue (Gilbert 1980, 1981). *Centaurea jacea* has a relatively deep corolla (Gilbert 1980) and there are fewer visits of hoverflies in such deeper corolla (Gilbert 1981). This would explain the higher abundance of hoverflies on *Leontodon hispidis*.

Another not investigated but important explanation for attraction of pollinators is the quality and quantity of reward (Bosch et al. 1997). Bees and bumblebees make probe visits to the flowers, if they have a high quality of nectar (reviewed by Goulson 1999). This behaviour was observed several times during the investigation, also among hoverflies. However, further research should be carried out to the discriminating effect of reward quality (but see Andersson 2003).

At last it has to be said that the difference in pollinator structure can not be explained only by one floral trait, however pollinators base their choice on different traits. It is also possible that pollinators base their choice not only on one flower trait but on more (Hegland & Totland 2005).

Conclusive remarks

This pilot study shows that the coexistence of *Centaurea jacea* and *Leontodon hispidis* does attract different pollinator species, which enhance the pollinator diversity within the community. Although plant specialisation is rare among pollinator species (reviewed in Goulson 1999), except in many bee species, we see in this study that plant species are visited by different groups. In this study, only *C. jacea* and *L. hispidis* were used for a comparison and it would be useful to take also other comparable plant species of the same tribes with the

same colour and morphology into account to address the question about the effect of less obvious differences between the plant species like scent and floral reward quality to the flower use of pollinators.

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