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Role of host plant in determining the insect community associated with the flowers of dicotyledoneous herbaceous plants

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Abstract. Flowers of dicotyledoneous plants usually host a rich community of insects consisting of herbivores, nectar and pollen feeders, carnivores seeking prey and occasional visitors. Taxonomic affiliation of the plants is an important factor determining the composition of this community but its effect is confounded by seasonality and geographic variation in the fauna of insect visitors. To exclude these effects, we studied communities of flowers of 12 herbaceous plants at a single site over a period of 5 days during the flowering period. Whole flowers were harvested, the resident insects collected and identified to species. Insect communities consisted of >50 insect species, mainly Coleoptera, Hymenoptera and Heteroptera. The most abundant species were *Meligethes aeneus* (Fabricius, 1775) and *Byturus ochraceus* (Scriba, 1790). The most diverse communities were associated with flowers of *Taraxacum* agg., *Geranium pratense* and *Crepis biennis*. The similarity between the communities associated with particular species of flowers was low at the level of taxa (mean Sørensen index S=0.243) and individual frequency (mean Renkonen index Re=0.232). The composition and diversity of the communities were not related to flower colour, size, duration of flowering or plant height. Taxonomic affiliation of plants is an important factor in determining the composition of the associated insect communities, which acts through different effective causes.

Key words. Flower, plant, insect species, *Meligethes*, *Byturus*.

INTRODUCTION

Communities of insects associated with flowers have been intensively studied (Willmer 2011). In most cases in addition to pollinators it is the florivores, pollinivores and nectar feeders that are well studied (Kevan 2002, Wackers et al. 2007). Since in most studies pollinators are the main subject of interest, most studies consist of observations on insects present on the flower surface. The insects hidden inside flowers or inflorescences that are studied are mostly endophagous species. In a parallel study (A. Honek, Z. Martinkova, J. Skuhrovec, M. Barták, J. Bezděk, P. Bogusch, J. Hadrava, J. Hájek, P. Janšta, J. Jelínek, J. Kirschner, V. Kubáň, S. Pekár, P. Průdek, P. Štys, J.

Šumpich, unpubl.), we analyzed the temporal changes in arthropod communities associated with the inflorescences of *Taraxacum* sect. *Ruderalia,* which is a complex of apomictic microspecies (Trávníček 2010). Here this complex is further referred to as *Taraxacum* agg. A result of this study was that collecting whole capitula is a prerequisite for establishing a complete inventory of their fauna. The list of species increased several times compared to earlier studies, in particular in terms of small species of Coleoptera, Diptera and Hymenoptera, which are not recorded during a superficial inspection. The floral fauna of the herbaceous species of plants included in this study is not yet complete, particularly so for *Taraxacum* agg. (von Hofsten 1954, Judd 1971, Larson et al. 2014) and to a less extent for the other species (Dlussky et al. 2000, Fox et al. 1999, Kandori 2002, Wackers 2004).

Although the rewards and resources sought by floral visitors are similar, mostly pollen and nectar, the insect communities associated with the flowers of particular species are different. This is due to several factors including geographic differences in the fauna at remote localities and seasonal variation in insect communities. In this study we compared communities associated with the flowers of species that flower simultaneously at a single locality. The hypothesis we tested is that the communities associated with the flowers of the different species are random samples of those that commonly visit flowers.

MATERIAL AND METHODS

The study was carried out in the grounds of the Crop Research Institute at Praha – Ruzyne, which is a 750×330 m area consisting of a mosaic of experimental and production fields, orchards, ornamental gardens, lawns and buildings. The flowers were collected in an ca. 2000 m^2 area centered at 50.0859° N, 14.2972° E and is in an abandoned grassy pear orchard in which there is a highly diverse herbaceous vegetation, partly shaded by trees. Communities of insects associated with the flowers of 12 herbaceous plants were recorded between 20–25 June 2011 (Table 1).

Flowers of all the species were collected daily between 09:00–11:00 h. The weather during sampling sessions was sunny, dry with a mean temperature of 21.9–29.8° C and wind speed of 0.9–2.1 m s–1. During each sampling session 10–200 flowers of each species were collected along with associated fauna. The size of the samples varied because the flowers of particular species differed in availability with all the flowers of rare species sampled and only a sample of those of abundant species. The randomly selected flowers were approached so as to avoid casting a shadow on them or disturbing the associated fauna, and quickly plucked. With experience, this method enabled us to collect all slow moving species and a representative number of actively flying large species of Hymenoptera and Diptera. To keep the bias in sampling efficiency at a minimum the flowers of all species were collected by a single person. The samples of the flowers of different herbaceous plants were put in plastic bags, brought to laboratory and stored at 5° C. After returning to room temperature immobile insects and those that slowly left the plant material were collected using an aspirator, then killed and mounted dry (Coleoptera, Heteroptera) or preserved in 90% alcohol. The numbers of Thysanoptera were not estimated. The insects were identified to species or genera by the authors.

The insect communities associated with the flowers of particular species of plants were described using commonly accepted indices. Simpson index of dominance c calculated as $c=\sum(ni/N)^2$where ni is the number of individuals of a particular species and N is the total number of individuals in the sample. Increasing c indicates presence of dominant species. Margaleff index of species richness d calculated as $d=(S-1)/\log N$ where S is the number of species in the sample and N the total number of individuals in the sample. Increasing values of d indicates an increase in the number of species. Shannon-Wiener index of diversity H' calculated as $H' = -\Sigma(p_i \times \log p_i)$, where p_i is the proportion of the total number of individuals captured at a site belonging to species i. The value of H' increases with increasing number of species and decreasing differences in their abundance. Increasing H' indicates an increasing diversity of the community.

Similarity of the communities associated with the flowers of particular species of herbaceous plants was calculated using two indices. Sørensen index of similarity S, which indicates similarity in the presence of taxa in samples calculated as $S=2C/(A+B)$ where A is the number of species in the sample of flowers from species a, B the number of species in the sample of flower species b, C the number of species common to both samples a and b. S increases to 1 when the taxonomic composition of both samples is identical. Renkonen index Re indicates similarity in the abundance of the taxa in the samples compared and is calculated as $Re=\Sigma\min(x_{ip}, x_{jp})$, where x_{ip} and x_{jp} are the proportions of species p in the samples of flower species i and j. This coefficient ranges from 0 when there are no species common to both samples and 1 when species composition and proportions in samples are identical.

Table 1. Characteristics of the species of plants included in this study. Size of flowers in capitula and spike not indicated. Diameter (diam.) of inflorescences of the plants sampled were measured. Other data from Dostál (1989), median dimensions indicated throughout

	species	family	acronym	flower		inflorescence		flowering			plant
				colour	diameter mm	type	diameter mm	start month	end month	duration month	height m
1	*Achillea millefolium*	Asteraceae	AMIL	white	5	corymb	60	vi	x	5	0.4
2	*Coronilla varia*	Fabaceae	CVAR	white	5	umbell	30	v	ix	5	0.5
3	*Crepis biennis*	Asteraceae	CBIE	yellow		capitulum	30	v	ix	5	0.8
4	*Galium album*	Rubiaceae	GALB	white	4	terminal panicle	50	vi	vii	2	1.0
5	*Geranium pratense*	Geraniaceae	GPRA	blue	25	cyme of 2 flowers		vi	ix	4	0.6
6	*Geum urbanum*	Rosaceae	GURB	yellow	13	cyme of 2 flowers		v	viii	4	0.4
7	*Hypericum perforatum*	Hypericaceae	HPER	yellow	20	cyme of panicles	50	v	ix	5	0.6
8	*Lotus corniculatus*	Fabaceae	LCOR	yellow	5	axillary raceme	30	vi	viii	3	0.3
9	*Plantago lanceolata*	Plantaginaceae	PLAN	white		spike	25	v	ix	5	0.3
10	*Potentilla reptans*	Rosaceae	PREP	yellow	20	single flowers		vi	viii	3	0.7
11	*Taraxacum* agg.	Asteraceae	TOFI	yellow		capitulum	40	iv	xi	8	0.3
12	*Trifolium repens*	Fabaceae	TREP	white	13	congested raceme	25	v	x	6	0.1

Table 2. Species of insects and numbers of individuals found in flowers of the 12 species of herbaceous plants collected on 20–25 June 2011. The different species of plants are indicated by the acronyms shown in Table 1 and the approximate number of inflorescences or flowers (indicated *) collected of each species (in bracketts). Nsp – number of species, Ni – number of individuals

		species (n flowers sampled)													
		AMIL (1000)	CVAR (2400)	CBIE (85)	GALB (900)	GPRA (300)	GURB (237)	HPER (60)	LCOR (272)	PLAN (160)	PREP (250)	TOFI (50)	TREP (100)	Nsp	Ni
Coleoptera															
Agriotes ustulatus	Elateridae		1											1	1
Anthaxia nitidula	Buprestidae			1								2		2	3
Anthaxia suzannae	Buprestidae			3								3		2	6
Anthonomus rubi	Curculionidae						2				1			2	3
Anthrenus olgae	Dermestidae	3												1	3
Byturus ochraceus	Byturidae			5		11	81					5		4	102
Cassida prasina	Chrysomelidae	1												1	1
Clanoptilus geniculatus	Malachiidae									2				1	2
Coraebus elatus	Buprestidae										1			1	1
Dasytes cf. *plumbeus*	Dasytidae		3	3		81	2	1		1		3		7	94
Limonius poneli	Elateridae						1							1	1
Mecinus pascuorum	Curculionidae									2				1	2
Meligethes aeneus	Nitidulidae		85	256		76	3	11	29		8	77	1	9	546
Mordellistena sp.	Mordellidae										2			1	2
Oedemera femorata	Oedemeridae			3		8				2	1	3		5	17
Oedemera lurida	Oedemeridae			5		2				4	7	1		5	19
Pseudostenapion simum	Curculionidae							1						1	1
Pseudovadonia livida	Cerambycidae	2												1	2
Stenurella melanura	Cerambycidae					1						1		2	2
Trichosirocalus troglodytes	Curculionidae									2				1	2
Tychius picirostris	Curculionidae												3	1	3
Zacladus geranii	Curculionidae					25								1	25
Dermaptera															
Forficula auricularia	Forficulidae											2		1	2

Diptera															
Empis sp.	Empidae			1										1	1
Episyrphus balteatus	Syrphidae		1			1								2	2
Oscinimorpha sordidissima	Chloropidae										2	3		2	5
Sphaerophoria scripta	Syrphidae			1										1	
Heteroptera															
Apolygus lucorum	Miridae						1							1	1
Corizus hyoscyami	Rhopalidae					1								1	1
Deraeocoris ruber	Miridae											1		1	1
Eurydema oleracea	Pentatomidae					1								1	1
Halticus apterus	Miridae										1			1	1
Orius sp.	Anthocoridae		1											1	1
Plagiognathus arbustorum	Miridae					1								1	1
Plagiognathus chrysanthemi	Miridae		5	1		5				4			2	5	17
Plagiognathus fulvipennis	Miridae					1	2	1						3	4
Hymenoptera															
Aprostocetus sp. 1	Eulophidae											1		1	1
Formicidae sp.					3	1			1	1	1	1	1	7	9
Hylaeus confusus	Colletidae											1		1	1
Ichneumonoidea sp.			1		1	1			6	1	5			6	15
Lasioglossum leucozonium	Halictidae											1		1	1
Lasioglossum malachurum	Halictidae											2		1	2
Lasioglossum pauxillum	Halictidae			3								1		2	4
Leptopilina sp. 1	Eucoilidae			1										1	1
Rhoptromeris sp. 1	Eucoilidae			2								1		2	3
Tetrastichus sp. 3	Eulophidae			1										1	1
Lepidoptera															
Lepidoptera larvae			3									2		2	5
Thysanoptera															
Thysanoptera sp.			+	+								+	+		
Nsp		3	8	14	2	15	7	4	3	9	10	19	4		
Ni		6	100	286	4	216	92	14	36	19	29	111	7		920

The differences between the insect communities associated with yellow and white flowers were tested using t-tests with N species, N individuals, Simpson index c, Margaleff index d or Hardy-Weinberg index H' as response variables. Correlations between inflorescence/flower diameter, plant height, flowering duration and the above characteristics of insect communities were calculated.

RESULTS

More than 50 species of insects were recorded associated with the flowers of 12 herbaceous species of plants (Table 2). The similarity in composition of floral communities associated with particular species of herbaceous plants (Table 3) was low. The mean Sørensen index (S=0.243±0.021) indicates that the proportion of taxa common to all the communities was low. The high similarity of the *Lotus corniculatus* and *Galium album* communities (S=0.800) was an accidental coincidence due to small sample size. The numbers of insects associated with the flowers of both these plants were small even though the numbers of flowers collected of both species were large, i.e. all available flowers were collected. The highest proportion of shared species was recorded for *Taraxacum* agg. and *Crepis biennis* (S=0.563). Of the 24 insect species present in samples of flowers of these species, nine (38%) were common to both communities. The similarity was probably due to the close taxonomic position of these plants and similarity of their flowers. Average similarity in numbers of individuals in samples of particular communities was also low as indicated by mean Renkonen index Re=0.232±0.033. In the 10 pairs of herbaceous species of plants compared Re was >0.7. In all cases of high similarity this was mainly due to the dominance of *Meligethes aeneus* (Fabricius, 1775) in the samples. Except for the presence of this dominant and ubiquitous species the communities of insects associated with the flowers of particular species of herbaceous plants were rather specific.

The structure of the communities associated with the flowers of particular species of herbaceous plants differed greatly (Table 4) in terms of the numbers of species (2–19) and individuals (4–286). This was not due to sampling different quantities of flowers since the numbers sampled, which ranged from 50–2400 per species of plant, are not correlated with either the number of insect species (R=0.3672, P>0.05) or numbers of insects (R=0.1934, P>0.05) associated with the flowers of particular species of plants.

Table 3. Similarity of the insect communities associated with the flowers of 12 species of herbaceous plants, 20–25 June 2011. Sørensen index S (above diagonal) of similarity indicates the similarity of the taxa in the compared samples. Renkonen index Re (below diagonal) indicates the similarity in abundance (number of individuals) of the taxa in the compared samples. Bold – indices dicussed in the text

	AMIL	CVAR	CBIE	GALB	GPRA	GURB	HPER	LCOR	PLAN	PREP	TOFI	TREP
A. millefolium	–	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C. varia	0.000	–	0.286	0.200	0.417	0.267	0.333	0.364	0.353	0.222	0.222	0.333
C. biennis	0.000	**0.864**	–	0.000	0.414	0.300	0.235	0.125	0.364	0.261	**0.563**	0.235
G. album	0.000	0.010	0.000	–	0.222	0.000	0.000	**0.800**	0.364	0.333	0.095	0.333
G. pratense	0.000	0.413	0.402	0.009	–	0.348	0.300	0.316	0.480	0.385	0.400	0.300
G. urbanum	0.000	0.054	0.061	0.000	0.110	–	0.545	0.200	0.125	0.235	0.231	0.182
H. perforatum	0.000	**0.816**	**0.796**	0.000	0.426	0.076	–	0.286	0.154	0.143	0.174	0.250
L. corniculatus	0.000	**0.816**	**0.806**	0.194	0.359	0.033	**0.786**	–	0.333	0.462	0.182	0.571
P. lanceolata	0.000	0.090	0.042	0.105	0.131	0.022	0.053	0.080	–	0.421	0.286	0.308
P. reptans	0.000	0.286	0.304	0.207	0.329	0.054	0.276	0.470	0.332	–	0.345	0.286
T. officinale	0.000	**0.739**	**0.771**	0.009	0.468	0.099	**0.721**	**0.703**	0.072	0.348	–	0.174
T. repens	0.000	0.193	0.146	0.143	0.171	0.033	0.143	0.171	0.263	0.177	0.152	–

Table 4. The characteristics of communities of insects associated with the flowers of particular species of herbaceous plants. Nsp – number of species in the sample, Ni – number of individuals in the sample, d – Margaleff index of species richness, c – Simpson index of dominance, H' – Shannon-Wiener index of diversity

		Nsp	Ni	d	c	H'
A. millefolium	AMIL	3	6	2.57	0.389	0.439
C. varia	CVAR	8	100	3.50	0.727	0.296
C. biennis	CBIE	14	286	5.29	0.802	0.254
G. album	GALB	2	4	1.66	0.625	0.244
G. pratense	GPRA	16	217	6.42	0.280	0.699
G. urbanum	GURB	7	92	3.06	0.778	0.248
H. perforatum	HPER	4	14	2.62	0.633	0.328
L. corniculatus	LCOR	3	36	1.29	0.677	0.249
P. lanceolata	PLAN	9	19	6.26	0.141	0.899
P. reptans	PREP	10	29	6.15	0.180	0.847
Taraxacum agg.	TOFI	19	111	8.80	0.488	0.632
T. repens	TREP	4	7	3.55	0.306	0.555

Numbers of insect species or individuals associated with the flowers of the different species of plants, dominance (Simpson index c), richness (Margaleff index d) and diversity (Shannon-Wiener index H') of these insect communities varied greatly but were not correlated with one another, except for the trivial negative relationship between dominance (Simpson index c) and diversity (Shanon-Wiener index H') ($R=0.9315$, $P<0.001$) and positive relationship between number of species and community richness (Margaleff index d) ($R=0.9142$, $P<0.001$).

The numbers of species and individuals in the insect communities did not depend on the morphological characteristics of the flowers. The number of species (yellow flowers 9.5±2.51 vs. white flowers 5.2±1.39, $t=1.410$, $P>0.05$), number of individuals (94.7±41.29 vs 27.2±18.39, $t=1.389$, $P>0.05$) and diversity H' of insects (0.593±0.0946 vs. 0.438±0.1060, $t=1.094$, $P>0.05$) in the different insect communities were not related to the colour of the flowers or correlated with inflorescence/flower diameter, duration of flowering or plant height ($R=0.0141$ to $R=0.4908$, $P>0.05$).

DISCUSSION

This study revealed the composition of insect faunas associated with the flowers of 12 species of herbaceous plants growing in a small area and all flowering at the same time.

Such studies are influenced by the methods used to sample the plants. Most studies are mainly concerned with pollination and record the insects that fly to and settle on flowers and what they do when on the flowers. As a consequence most of these studies are on large and mobile species. Collecting sufficient material takes a long time and the short duration of our sampling sessions may have negatively affected the numbers of large pollinators recorded. Our method of collecting flowers and identifying the insects in the flowers results in recording many more species of small insects that are usually rarely recorded on the surface of flowers. Two factors that apparently influence the composition of the insect communities associated with flowers were excluded. Geographic differences in the faunas associated with flowers are important and particularly well illustrated by cosmopolitan species of plants like the *Taraxacum* agg. (Judd 1971, Larson et al. 2014). On a regional scale, it may be important if the distribution of the plant is more wide-ranging than that of its insect visitors resulting certain of the insects being absent at specific localities where the plant is present. The distributions of the different species of plants are better documented than that of all their insect visitors. However, the dominant species of insects associated with flowers, which includes *Meligethes aeneus*, *Byturus ochraceus* (Scriba, 1790), *Dasytes* cf. *plumbeus* (Müller, 1776), *Oedemera* sp., Syrphidae and Miridae species, are widely distributed in western Europe and thus may represent an important component of the flower fauna throughout this area. Another important factor is the seasonal variation in the community of insect species available to visit flowers or seasonal variation in the attractiveness of flowers of particular plant species (Colley & Luna 2000, Figueroa-Castro & Cano-Santana 2004). All the species of plants studied flower up until August, although duration of flowering may vary with locality. During the course of a vegetative season the species of insects visiting flowers varies. How this affects the insect fauna associated with the flowers included in this study remain to be studied.

The flowers of all species, including those of the apomictic *Taraxacum* agg., provide insect visitors with pollen and nectar. Some of the species of insects recorded in this study are pollen feeders, such as some Diptera, Syrphidae (Larson et al. 2001), Hymenoptera, Eulophidae (Hassan 1967, Jervis et al. 1993), Coleoptera, Byturidae (Mawdsley 2003), Nitidulidae (Toth et al. 2013), Oedemeridae (Sivilov et al. 2011) and thrips (Kirk 1984, Kirk 1987). Hymenoptera e.g. Apidae, Halictidae and Megachilidae are also important pollen collectors, which visit flowers to collect pollen for feeding to their offspring (Macek et al. 2010). In this study, large species of Hymenoptera were rarely recorded probably because the collecting sessions were too short. Another important food source for floral visitors is nectar (Kevan & Baker 1983). It is consumed by Diptera, Syrphidae (Laubertie et al. 2012), Hymenoptera, Ichneumonidae (Jervis 1998) and *Hylaeus confusus* Nylander, 1852 (Macek et al. 2010) and Coleoptera, Buprestidae (Barker 2005), Dasytidae (Mawdsley 2003), and Cerambycidae (O'Neill et al. 2008). Some species are predators seeking phytophagous prey, e.g. *Orius* spp., which consumes thrips in flowers of *Taraxacum* agg. (Honek et al. 2005). Phytophagous insects that feed specifically on the tissues of flowers and complete their development inside their host plant, e.g. *Zacladus geranii* (Paykull, 1800) on *Geranium pratense* (Tsuchimatsu et al. 2014), were also components of the insect community associated with flowers of particular species of plants.

In this study, the insect communities associated with flowers of particular species of plants differed substantially but the differences were not correlated with prominence and flower traits as has been demonstrated several times (Wackers 2004, Witting et al. 2007). The insects may be attracted by stimuli associated with flowers and not directly by a particular food source (Primante & Doetterl 2010). Or they may be attracted by traits of their host plants other than flower characteristics (Fox et al. 1999) or even by other plants flowering close by (Bruckman & Campbell 2014, Sydenham et al. 2014).

Thus, the hypothesis that the insect communities associated with the flowers of different species of plants are random samples from a common pool of flower visitors present at the study site was falsified. A proportion of the insect visitors are specialist feeders on specific species of plants and are not found on other species of plants. The communities differed even though the site sampled was small as all the species recorded were winged as adults and probably good fliers and the weather was suitable for flight. The insects had more than sufficient time to spread evenly among the flowers of the different species. In this study the composition of the different insect communities was not significantly associated with the morphology, colour or other characteristics of the flowers.

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REFERENCES

Barker S. 2005: Nine new species of Castiarina Gory & Laporte, 1838 (Coleoptera: Buprestidae). *Zootaxa* **1602**: 57–68.

Bruckman D. & Campbell D. R. 2014: Floral neighborhood influences pollinator assemblages and effective pollination in a native plant. *Oecologia* **176**: 465–476.

Colley M. R. & Luna J. M. 2000: Relative attractiveness of potential beneficial insectary plants to aphidophagous hoverflies (Diptera: Syrphidae). *Environmental Entomology* **29**: 1054–1059.

Dlussky G. M., Lavrova N. V. & Erofeeva E. A. 2000: Mechanisms of restriction of pollinator range in Chamaenerion angustifolium and two Geranium species (G. palustre and G. pratense). *Žurnal Obŝej Biologii* **61**: 181–197.

Dostál J. 1989: *Nová květena ČSSR 1*, *2* [*The New Flora of Czechoslovakia*. *Volume 1*, *2*]. Praha: Academia, 1552 pp (in Czech).

Figueroa-Castro D. M. & Cano-Santana Z. 2004: Floral visitor guilds of five allochronic flowering Asteraceous species in a xeric community in central Mexico. *Environmental Entomology* **33**: 297–309.

Fox L. R., Ribeiro S. P., Brown V. K., Masters G. J. & Clarke I. P. 1999: Direct and indirect effects of climate change on St John's wort, Hypericum perforatum L. (Hypericaceae). *Oecologia* **120**: 113–122.

Hassan E. 1967: Untersuchungen über die Bedeutung der Kraut- und Strauchschicht als Nahrungsquelle für Imagines entomophager Hymenopteren. *Zeitschrift für Angewandte Entomologie* **60**: 238–265.

Honek A., Martinkova Z., Hurka K. & Stys P. 2005: Insect community in maturing capitula of dandelion (Taraxacum officinale). *Biologia*, *Bratislava* **60**: 559–565.

Jervis M. 1998: Functional and evolutionary aspects of mouthpart structure in parasitoid wasps. *Biological Journal of the Linnean Society* **63**: 461–493.

Jervis M. A., Kidd N. A. C., Fitton M. G., Huddleston T. & Dawah H. A. 1993: Flower-visiting by hymenopteran parasitoids. *Journal of Natural History* **27**: 67–105.

Judd W. W. 1971: Studies on the Byron Bog in southwestern Ontario. XLV. Insects associated with flowering dandelion, Taraxacum officinale Weber. *Proceedings of the Entomological Society of Ontario* **101**: 59–62.

Kandori I. 2002: Diverse visitors with various pollinator importance and temporal change in the important pollinators of Geranium thunbergii (Geraniaceae). *Ecological Research* **17**: 283–294.

Kevan P. G. 2002: Flowers, pollination and the associated diversity of flies. *Biodiversity* **3**: 16–18.

Kevan P. G. & Baker H. G. 1983: Insects as flower visitors and pollinators. *Annual Review of Entomology* **28**: 407–453.

Kirk W. D. J. 1984: Pollen-feeding in thrips (Insecta: Thysanoptera). *Journal of Zoology*, *London* **204**: 107–117.

Kirk W. D. J. 1987: How much pollen can thrips destroy? *Ecological Entomology* **12**: 31–40.

Larson B. M. H., Kevan P. G. & Inouye D. W. 2001: Flies and flowers: taxonomic diversity of anthophiles and pollinators. *Canadian Entomologist* **133**: 439–465.

Larson J. M., Kesheimer A. J. & Potter D. A. 2014: Pollinator assemblages on dandelions and white clover in urban and suburban lawns. *Journal of Insect Conservation* **18**: 863–873.

Laubertie E. A., Wratten S. D. & Hemptinne J. L. 2012: The contribution of potential beneficial insectary plant species to adult hoverfly (Diptera: Syrphidae) fitness. *Biological Control* **61**: 1–6.

Macek J., Straka J., Bogusch P., Dvořák L., Bezděčka P. & Tyrner P. 2010: *Blanokřídlí České republiky I. Žahadloví* [*Hymenoptera of the Czech Republic. I. Aculeata*]. Praha: Academia, 520 pp (in Czech).

Mawdsley J. R. 2003: The importance of species of Dasytinae (Coleoptera: Melyridae) as pollinators in western North America. *Coleopterists Bulletin* **57**: 154–160.

Miller F. 1956: *Zemědělská Entomologie* [*Agricultural Entomology*]. Praha: Nakladatelství Československé Akademie Věd, 1056 pp (in Czech).

O'Neill K. M., Fultz J. E. & Ivie M. A. 2008: Distribution of adult Cerambycidae and Buprestidae (Coleoptera) in a subalpine forest under shelterwood management. *Coleopterists Bulletin* **62**: 27–36.

Primante C. & Doetterl S. 2010: A syrphid fly uses olfactory cues to find a non-yellow flower. *Journal of Chemical Ecology* **36**: 1207–1210.

Sivilov O., Atanassova J. & Zlatkov B. 2011: Food plant spectrum of Oedemeridae species (Insecta, Coleoptera) based on pollen analysis (a preliminary study*). Comptes Rendus de l'Academie Bulgare des Sciences* **64**: 225–230.

Sydenham M. A. K., Eldegard K. & Totland O. 2014: Spatio-temporal variation in species assemblages in field edges: seasonally distinct responses of solitary bees to local habitat characteristics and landscape conditions. *Biodiversity and Conservation* **23**: 2393–2414.

Toth P., Hrudova E., Sapakova E., Zavadska E. & Seidenglanz M. 2013: Species of the genus Meligethes occurring in oil-seed crop fields in the Czech Republic. *Plant Protection Science* **49**: 177–186.

Trávníček B. 2010: Sect. 8. Ruderalia Kirschner, H. Ollgaard et Štěpánek. Pp.: 103–269. In: Chrtek J., Kaplan Z. & Štěpánková J. (eds.): *Květena České republiky. 8.* [*Flora of the Czech Republic*. *Volume 8*]. Praha: Academia, 706 pp (in Czech).

Tsuchimatsu T., Yoshitake H. & Ito M. 2014: Herbivore pressure by weevils associated with flower color polymorphism in Geranium thunbergii (Geraniaceae). *Journal of Plant Research* **127**: 265–273.

von Hofsten C. G. 1954: *Studies on the Genus Taraxacum with Special Reference to the Group Vulgaria DT in Scandinavia.* Stockholm: LTs Förlag, 431 pp.

Wackers F. L. 2004: Assessing the suitability of flowering herbs as parasitoid food sources: flower attractiveness and nectar accessibility. *Biological Control* **29**: 307–314.

Wackers F. L., Romeis J. & van Rijn P. 2007: Nectar and pollen feeding by insect herbivores and implications for multitrophic interactions. *Annual Review of Entomology* **52**: 301–323.

Willmer P. 2011: *Pollination and Floral Ecology.* Ewing, New Jersey: Princeton University Press, 832 pp.

Witting B. E., Orr D. B. & Linker H. M. 2007: Attraction of insect natural enemies to habitat plantings in North Carolina. *Journal of Entomological Science* **42**: 439–456.