SMALL FLOWER-VISITING ARTHROPODS IN NEW ZEALAND PAK CHOI FIELDS

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ABSTRACT

Flower-visiting small arthropods (body length <3 mm) that may vector pollen can be carried via air currents over long distances. Therefore, assessing their diversity, abundance and distribution within crops is an important step in determining their role in the transfer of pollen between crops and weeds leading to crop contamination. A window trap survey of eight flowering pak choi field trials in the North and South Islands of New Zealand demonstrated that small arthropods, particularly flies and thrips, were highly abundant within all fields, greatly dominating arthropod counts. However, the relative abundance of different taxa could vary substantially. For example, Drosophilidae individuals represented 65.5% of total arthropod individuals counted in a Pukekohe field and only 7.0% in a Hastings field. The large representation of small arthropods within flowering fields across New Zealand warrants further investigation of their contribution to pollination and pollen flow.

Keywords: flower visitors, Diptera, Thysanoptera, seed purity, pollen flow, pollination, New Zealand, *Brassica*, wind.

INTRODUCTION

Flower-visiting arthropods are widely recognised as pollen vectors, carrying grains within and between crops and other plants present within agro-ecosystems (Ramsay 2005). The movement of pollen between closely related crop and weed plant species can significantly affect crop seed purity (Stewart 2002). In New Zealand, species within the *Brassica* genus are grown widely for forage, seed, vegetable and oilseed production (Stewart 2002) but *Brassica* weed species are also common in the same environs (Peltzer et al. 2008). Within the assemblages of pollinators that may bring about desirable (within crop) or undesirable pollination (between weed species and crops) the role of small arthropods (body length <3 mm) is often overlooked (Howlett et al. 2009). Determining the composition of crop flower visitor assemblages and their effectiveness as pollinators is important for further understanding their potential contribution to pollen flow leading to crop contamination (Howlett et al. 2005a).

Many small arthropods are commonly found on and within the inflorescences of crop plants (Bohart et al. 1960; Bohart et al. 1970; Watanabe et al. 2006) and contribute to their pollination. Thrips alone have been implicated in the pollination of at least 24 crop species (Kirk 1997 and references therein). Small arthropods could also potentially contribute to long distance pollen flow due to their propensity to be dispersed widely via wind currents (Lewis 1997; Pathak et al. 1999).

In this investigation the composition and relative numbers of small (body length <3 mm) and large (body length >3 mm) arthropods was assessed in eight flowering pak choi (*Brassica rapa* L. ssp. *chinensis* L. Hanelt.) fields located in four regions of New Zealand (two North Island and two South Island).

MATERIALS AND METHODS

Survey regions, traps and field sites

Arthropod assemblages were assessed in eight pak choi fields of the same cultivar across the North and South Islands of New Zealand during a period of 4 years. Each field had an area of 50 m × 50 m. Two fields each were surveyed from four locations: Pukekohe (37°12'16.43"S; 174°51'43.25"E, field P04 sampled on 20-24 Dec 2004, field P05 sampled on 25-29 Dec 2005); Hastings (39°36'27.43"S; 176°54'53.70"E, field H04 sampled on 22-26 Dec 2004, field H05 sampled on 27-31 Dec 2005); Lincoln (43°38'24.91"S; 172°29'03.01"E, field L06 sampled on 4-8 Dec 2006, field L07 sampled on 19-23 Feb 2007); and Gore (46°06'51.77"S; 168°54'51.90"E, field G05 sampled on 24-28 Dec 2005, field L07 sampled on 29 Jan to 2 Feb 2007). Landuse adjacent to trial fields varied between regions. Pukekohe fields were surrounded by other vegetable crops with neighbouring shelter belts (holly and pine) present. Hastings fields did not have neighbouring shelter belts but were surrounded by grass and vegetable crops and nearby apple orchards. Lincoln fields had neighbouring shelterbelts (gorse and pine) and nearby grass and vegetable crops. Gore fields had neighbouring shelter belts (Eucalypt) and fields that contained livestock and pasture. Surveys were undertaken when crops were at peak flowering, as defined in Howlett et al. (2009).

The sampling protocol and trap design, arthropod collection, identification and storage methods are described in Howlett et al. (2009), which also describes in further detail the differences between land usage for each region. Briefly, each window trap consisted of two transparent acrylic glass uprights (the windows) that intersected perpendicularly. This was placed in a grey rectangular tray containing water (4 cm deep) and 2 ml detergent (to reduce water surface tension). Each trap was supported at flower height by 4 plastic coated steel poles. The traps were placed at each corner (5 ± 1 m from the field edges), and in the centre of each field. In this study all traps were activated to collect arthropods over a continuous 96 ± 2 hour period. Arthropods collected were generally identified to order level but Acari were identified to sub-class level and Diptera to family level. For each arthropod taxa, the trap tallies from the five sample points per study area were totalled to give an overall field tally.

Small arthropods associated with inflorescences

Small arthropods were collected from pak choi flowering inflorescences from four fields (P04, H04, L06, G05) by placing a plastic bag over the top of a single inflorescence (each with a minimum of eight open flowers), and severing the inflorescence stem from the plant while inside the bag. An aliquot of 70% ethanol (200 ml) was added and the bag sealed. Twenty inflorescences were collected from each field, with four inflorescences randomly sampled within 5 m of each trap. The collected inflorescences were then dissected using forceps and vigorously shaken in 70% ethanol to collect the arthropods, which were identified to the same taxon level as arthropods collected using window traps.

RESULTS

The total number of arthropods counted in the window traps from all eight fields was 41,487 (Table 1). Small arthropods were substantially more abundant in traps than large arthropods representing 87.9% of total arthropod individuals captured across all fields. Field L07 contained the highest proportion of small arthropods (95.7% of all trapped arthropods) whereas field L06 (in the same region) contained the lowest (53.4%). The most numerous small arthropod order was Diptera (57.3%), followed by Thysanoptera (39.4%) and all other orders (3.3%). However, in fields L06 and G07 the number of Thysanoptera individuals counted exceeded the number of small Diptera (Table 1). Large arthropods were dominated by Diptera (60.8% of total large arthropod individuals) and Hymenoptera (25.8%), while other arthropod orders comprised 13.3% of the catch (Table 1).

Of the small Diptera, Drosophilidae was the most abundant family (48.4% of all individuals captured) followed by Ephydridae (33.2%). Both families were common in all fields although numbers varied between fields, as was the case for several other small dipteran families (Table 1).

All of the arthropod orders, the sub-class Acari and 11 of the 15 dipteran families captured in traps were also found to be associated with *Brassica* inflorescences as indicated by their presence in ethanol-washed inflorescences (Table 1).

TABLE 1: Total counts of small and large arthropod taxa collected from window traps from eight pak choi fields across four regions throughout New Zealand, and the presence of these arthropods on *Brassica* inflorescences.

	Pukekohe		Hastings		Lincoln		Gore		On
Order/Family	P04	P05	H04	H05	L06	L07	G05	G07	flower[2]
Small arthropods									
Diptera	**1580**	**2159**	**863**	**1756**	**546**	**5238**	**5448**	**3293**	
Drosophilidae	917	1804	91	854	146	4721	687	896	Yes
Ephydridae	403	29	519	606	207	255	4033	873	Yes
Chloropidae	28	4	15	4	16	5	5	1	Yes
Sepsidae	0	0	0	1	0	0	0	0	No
Lonchopteridae	32	5	3	38	9	2	35	12	Yes
Phoridae	20	16	7	7	13	36	6	21	Yes
Sphaeroceridae	85	197	9	131	28	9	103	151	Yes
Agromyzidae	10	4	23	28	31	13	382	462	Yes
Culcidae	0	0	1	0	0	0	1	5	Yes
Sciaridae	63	82	189	61	32	121	44	150	Yes
Mycetophilidae	14	7	1	1	15	12	14	149	Yes
Cecidomyiidae	2	9	1	12	5	26	56	42	Yes
Chironomidae	3	1	2	3	25	18	35	176	No
Psychodidae	3	1	2	10	19	20	33	270	Yes
Simuliidae	0	0	0	0	0	0	14	85	No
Thysanoptera	**1104**	**412**	**119**	**617**	**945**	**3139**	**2509**	**5511**	Yes
Collembola	**7**	**2**	**11**	**2**	**30**	**23**	**6**	**20**	Yes
Psocoptera	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**5**	Yes
Hemiptera	**90**	**11**	**48**	**33**	**274**	**89**	**108**	**59**	Yes
Aphididae	7	1	12	20	213	16	5	27	Yes
Other Homoptera	7	2	11	2	30	23	6	20	Yes
Other Heteroptera	76	8	25	11	31	50	97	12	Yes
Coleoptera	**17**	**15**	**17**	**16**	**32**	**18**	**44**	**5**	Yes
Acari[1]	**0**	**5**	**2**	**5**	**17**	**32**	**20**	**39**	Yes
Araneida	**0**	**0**	**1**	**1**	**0**	**1**	**2**	**0**	No
Hymenoptera	**8**	**2**	**24**	**10**	**8**	**35**	**10**	**3**	Yes
Large arthropods									
Diptera	**529**	**56**	**50**	**110**	**781**	**42**	**195**	**1301**	No
Hymenoptera	**44**	**49**	**101**	**33**	**715**	**140**	**145**	**73**	No
Other arthropods	**32**	**41**	**63**	**88**	**122**	**205**	**83**	**38**	No
TOTAL arthropods	**3411**	**2752**	**1299**	**2671**	**3470**	**8967**	**8570**	**10347**	

[1]Acari = Subclass (not Order).
[2]Yes= recorded in pak choi inflorescences washed in ethanol; No=not found on these samples.

DISCUSSION

This 4-year investigation indicated that small arthropods are very abundant in flowering pak choi fields and that the taxa are common to all the study areas. It would seem likely, given the distribution of those areas, that similar arthropod taxa are likely to be found on pak choi crops throughout New Zealand. However, the relative abundances of the different taxa may be highly variable between and within regions. Howlett et al. (2005a) likewise found the relative abundances of flies and bees visiting onion flowers in fields throughout the South Island to be highly variable. Arthropod abundance can be influenced by landuse (Tscharntke et al. 2005), landscape features such as hedgerows (Pollard & Holland 2006) and climatic variation (Henning et al. 2005). These factors may have greatly influenced the relative abundance of arthropods found within the pak choi fields.

These findings may also apply equally to other brassica crops and weed brassicas, which can attract a diverse array of flower-visiting species (Free 1993). Therefore, the present study highlights the need to further understand the role of small arthropods, particularly Diptera and Thysanoptera, as pollinators and potential vectors for pollen movement between crops and weeds that could affect seed purity. The role of larger insects, particularly bees, as *Brassica* pollinators and as vectors for pollen flow between crops is readily acknowledged (Williams 2001; Cresswell & Osborne 2004), but studies often ignore the possible role of small arthropods.

Small arthropods are known to be important pollinators of a range of other plant species. These include the Dipteran families Cecidomyiidae (Yuan et al. 2007), Ephydridae (Nagasaki 2007), Drosophilidae (Miyake & Yafuso 2005), Sciaridae and Mycetophilidae (Mesler et al. 1980), Phoridae (Rulik et al. 2008), Chironomidae (Murugan et al. 2006), Psychodidae (Albre et al. 2003), small Coleoptera (Krantz 2004; Blanche et al. 2006), small Hymenoptera (Herre et al. 2008) and Thysanoptera (Kirk 1997). Moreover, the propensity for small arthropods, which may carry pollen, to be carried in air currents over many kilometres suggests a possible route for inter-crop and crop-weed pollen movement and may elevate the importance of these arthropods in the contamination of seed crops.

To fully understand the contribution that unmanaged flower-visiting arthropods make to crop pollination and pollen flow, it is important to evaluate the entire crop flower visitor assemblage. Small arthropods are more difficult to study than large arthropods because they are more difficult to observe directly (Howlett et al. 2005b) yet this study clearly indicates they may be significant pollinators and warrant investigation as such.

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