Seasonality of calliphorid and sarcophagid flies across Canterbury arable farms requiring pollinators

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Abstract Calliphorid and sarcophagid flies are common, widespread pollinators of vegetable and forage seed crops. Information regarding their seasonal occurrence on arable farms growing these crops may help predict their temporal effectiveness and flexibility as pollinators. Window intercept traps (12 per farm) were placed at the edges of crop paddocks across five arable farms in Canterbury for periods of 1–6 weeks from 2012 to 2015. Total trapping days for each season over the four years were: summer 128, autumn 92, winter 199 and spring 35. Flies from at least six species were commonly caught from spring to autumn. Mean farm insect counts found *Calliphora vicina* to be the most abundant species in spring (237.3), summer (89.1) and winter (3.2), while *Oxysarcodexia varia* (212.9) and *Pollenia* spp. (190.3) were most abundant in autumn. Their broad temporal abundance shows their potential to pollinate crops that flower at different times.

Keywords, annual crops, insect pollinators, diversity, abundance, trapping, Calliphoridae, Sarcophagidae

INTRODUCTION

Non-bee pollinators play a significant role as pollinators of a wide range of crops (Garibaldi et al. 2013; Rader et al. 2016), yet the role of individual species as pollinators remains poorly understood. In New Zealand, flies from the families Calliphoridae (predominantly blow flies but also cluster flies) and Sarcophagidae (flesh flies) are among the most common flower visitors of Canterbury vegetable seed crops, such as pak choi [*Brassica rapa* var. *chinensis* (L.) Hanelt], onion (*Allium cepa* L.) and carrot (Howlett et al. 2005, 2009, 2013; Rader et al. 2012; Foundation for Arable Research 2012). They are also among

the few fly families where there is information available on their effectiveness as pollinators of vegetable seed crops (Rader et al. 2009; Foundation for Arable Research 2012; Howlett et al. 2011; Howlett 2012). Many of these species have simple lifecycles with larvae feeding on animal protein or dung (Heath & Appleton 2000), and adults on nectar (Heath 1982), making them pollinators that can potentially be managed (Howlett 2012).

Calliphorid and sarcophagid flies may complement honey bee pollination by pollinating at times when honey bees are less active. For example, calliphorids can be more active under

lower light intensity and temperature than honey bees, and their abundance on crops can be more evenly distributed throughout the day (Howlett et al. 2013). Unlike honey bees, however, they cannot be as easily deployed through controlled and rapid movement of colonies. Therefore, understanding their seasonal activity patterns will assist in predicting populations relative to crop flowering, and the timing of possible strategies to manipulate their numbers.

The seasonality of calliphorid and sarcophagid flies has previously been examined at pasture sites in the North Island (Henning et al. 2005) and the South Island (Barratt et al. 2001) to assess their potential in rabbit control as vectors of rabbit haemorrhagic disease (Barratt et al. 1998; 2001). At a grassland/gorse site near Himatangi (North Island), peak abundance of *Calliphora vicina* Robineau-Desvoidy; *C. hilli* Patton; *Lucilia sericata* Meigen; *C. stygia* Fabricius; *Chrysomya rufifacies* Macquart; *Oxysarcodexia varia* Walker occurred from November to May (Henning et al. 2005). Similar patterns were also observed in a study by Barratt et al. (2001) in the South Island at 12 pasture sites in Marlborough and Central Otago

regions and the Mackenzie district. However, the study found variation in fly species' populations between months; for example, the abundance of *L. sericata* declined significantly during early autumn, whereas, *O. varia* abundance remained relatively high. Moreover, *O. varia* counts were higher in open pasture than in gorse bush (Henning et al. 2005) and were higher at pasture sites where cattle were present (Barratt et al. 2001), demonstrating that the type of farming system can influence the abundance of particular fly species.

To our knowledge, studies on the seasonality of these species on arable farms in the Canterbury region (South Island) have not been conducted, despite these farms growing a wide variety of annual forage and vegetable seed crops that benefit from insect pollination. To address the lack of knowledge on the seasonal abundance of these potentially important crop pollinators, window traps were placed on five arable farms in Canterbury to capture the calliphorid blow fly species *C. vicina*, *C. stygia*, *C. quadrimaculata* (Swedarius), *L. sericata* and the calliphorid cluster flies *Pollenia* spp., along with the sarcophagid flesh fly *O. varia*. The study was conducted over a 4-year period.

Table 1. Dates of window trapping and duration across five arable farms in Canterbury, New Zealand.

Farm	Location	Trap start date (Number of days that trapping was carried out)			
		Spring	Summer	Autumn	Winter
1	43°32'S, 172°04'E	30/10/2012 (14)	10/12/2012 (7)	14/03/2013 (14)	02/07/2013 (37)
2	43°33'S, 171°40'E		04/12/2013 (14)	12/03/2014 (7)	30/06/2014 (21)
			03/12/2014 (7)	10/03/2015 (9)	23/07/2015 (15)
3	43°53'S, 172°03'E		03/12/2013 (14)	11/03/2014 (7)	02/07/2014 (20)
			04/12/2014 (7)	09/03/2015 (9)	22/07/2015 (15)
4	43°53'S, 171°51'E	29/10/2012 (14)	03/12/2013 (14)	11/03/2014 (7)	02/07/2014 (20)
			04/12/2014 (7)	09/03/2015 (9)	22/07/2015 (15)
5	43°54'S, 172°07'E	28/10/2012 (15)	10/12/2012 (7)	13/03/2013 (14)	01/07/2013 (21)
			03/12/2013 (14)	11/03/2014 (7)	02/07/2014 (20)
			03/12/2014 (7)	09/03/2015 (9)	22/07/2015 (15)

Figure 1. Weekly counts from arable farms across seasons for calliphorid (A–E) and sarcophagid (F) fly species. Each black circle is a total count from each of the 12 window traps on a single farm for a single trapping period, large clear circles are mean counts across trapping periods and farms. Y axis is log scale (common).

MATERIALS AND METHODS

Window intercept traps were placed intermittently for 7 to 37 days across five arable farms over consecutive years from 2013 and 2015. Trapping was conducted across all four seasons. The location of farms, trapping periods and number of days trapped are listed in Table 1. Twelve traps were placed on each farm during each trapping period. Each trap consisted of a 6-L yellow tray that held two perpendicular Perspex windows. They were secured above the ground on a green bucket using string tied over the Perspex windows onto garden stakes positioned around the four sides

of the trap. Further details of the survey design, including within farm trap placements and trap design, specimen collection and examination are provided by Davidson et al. (2015).

The seasonal occurrence and relative abundance of each species was evaluated using the number of flies captured per week to allow for variation in the length of each trapping period.

RESULTS

A total of 6185 calliphorid and 3651 sarcophagid flies were counted across all trapping periods and all farms. Four calliphorid and one sarcophagid

species were identified to this level, while another calliphorid, *Pollenia* was recorded at the level of genus.

Of the calliphorid flies, *Pollenia* spp. were the most abundant overall, at 53.4%, followed by *C. vicina* at 39.7%. The remaining species were *L. sericata* 4.5%; *C. stygia* 1.6% and *C. quadrimaculata* 0.9%. However, there was variation in their relative abundance among farms. *Pollenia* spp. counts were very high on farm 2 [81.6% (n=1023)] but relatively low on farm 1 [14.3% (n=137)]. On farm 1, *C. vicina* was the most abundant species [80.5% (n=772)]. The number of all other calliphorid species trapped across farms was relatively low (less than 11%). All sarcophagids trapped were *O. varia*. The highest counts of this species was recorded from farm 5 (n=2102) and the lowest from farm 2 (n=188).

Generally, fewer than five individuals of any species were captured per week during the winter (Figure 1A–F). However, the weekly counts varied among species across the other three seasons. Weekly counts of *Pollenia* spp. were highest in autumn (mean = 190.3/farm) and summer (mean = 75.3/farm) (Figure 1A). *C. vicina* counts were, on average, highest in spring (mean = 6.2/farm), declining through summer (mean = 3.8/farm) and autumn (mean = 1.3/farm) (Figure 1B). *C. stygia* and *C. quadrimaculata* counts were low (mostly < 5 per trap per week) throughout all trapping periods (Figures 1C, D), but the data suggest similar trends among seasons to those of *C. vicina* (Figure 1B). *L. sericata* counts remained similar from spring (mean 13.5/farm) to autumn (mean 10.4/farm) (Figure 1E), while *O. varia* counts were highest in autumn (mean 212.9/farm) (Figure 1F). *C. vicina* (Figure 1B) was the most commonly captured species during winter, followed by *Pollenia* spp. (Figure 1A).

DISCUSSION

Spring and summer are critical periods for seed crops that benefit from insect pollination for increased yield. At least five calliphorid species and one species of sarcophagid were frequently captured by window traps placed on Canterbury arable farms from spring to autumn,

indicating their potential value as pollinators of a range of flowering crops. This includes spring flowering (September–October) forage brassica crop (such as *B. rapa* L., *B. napus* L., *B. oleracea* L.) cultivars (Stewart 2002), and summer flowering (December–January) vegetable seed crops such as pak choi (*B. rapa* ssp. *chinensis*), carrot [*Daucus carota* subsp. *sativus* (Hoffm) Arcang], onion and radish (*Raphanus sativus* L.).

The trends reported in the present study indicated that some fly species, such as *Pollenia* spp., became increasingly active over spring and summer, to reach a peak in flight activity by autumn. Other species, such as *C. vicina*, exhibited the opposite trend. However, the relative abundance of *Pollenia* spp. and *C. vicina* in traps in summer were similar, so it may be that both species could contribute equally to pollination of summer-flowering crops. In contrast, *O. varia* numbers peaked in autumn, after the flowering time of key vegetable seed crops.

Despite this study providing insights on how fly activity patterns might relate to the timing of crop flowering, detailed analysis was limited by the nature of the data collection. To date, the data have predominantly been collected within specific months within each season, i.e. October–November (spring), December (summer), March (autumn) and June–July (winter). Peaks and troughs in fly activity may have been missed during the other months. Moreover, this study did not consider how within-farm landscape or weather may affect patterns of fly activity and distribution. These factors have are known to influence the abundance of most of these fly species (Barratt et al. 2001; Henning et al. 2005). The relationship between trap counts and fly activity on actual crops was not conducted in this study. However, Howlett et al. (2009) did find correlations between window trap versus direct observation counts within peak flowering onion and pak choi crops.

Further consideration also needs to be given to other beneficial and negative impacts that these flies can have in agricultural landscapes. Blow and flesh flies are considered useful vectors of rabbit haemorrhagic disease virus to control rabbits

(Barratt et al. 1998; 2001). However, some of the species are also primarily responsible for sheep fly-strike (cutaneous myiasis). In New Zealand, *L. sericata* and *L. cuprina* are considered the most problematic species, although *C. stygia* is also a primary fly-strike species (Morris 2005). *C. vicina* and *C. quadrimaculata*, are considered to be very minor contributors to fly-strike (Heath & Bishop 1995). *L. sericata* and *C. stygia* were present in relatively low numbers in this study (Figure 1); however, counts from the flowers of arable crops across farms in Canterbury and elsewhere in New Zealand indicate they are often amongst the most common flower visiting species (Howlett et al. 2013). Careful selection of diet types favourable to specific species (Heath & Appleby 2000) may offer the potential to manipulate populations of more desirable species rather than problematic species.

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