Parasitism of Aphids in Canola Fields in Central Oklahoma[1]

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J. Agric. Urban Entomol. 30: 59–64 (2014)

ABSTRACT Three aphid species (Hemiptera: Aphididae) typically infest winter canola, *Brassica napus* L. (Brassicales: Brassicaceae), fields in central Oklahoma. They are the turnip aphid, *Lipaphis pseudobrassicae* (Davis), the cabbage aphid, *Brevicoryne brassicae* L., and the green peach aphid, *Myzus persicae* (Sulzer). The expansion of canola acreage in Oklahoma and the ubiquitous nature of aphid infestations in the crop indicate the need to understand the role of natural enemies in controlling aphid infestations. This study determined the parasitoid species attacking aphids in canola during the flowering through pod development growth stages, when aphid populations often build to the point requiring insecticide treatment. *Diaeretiella rapae* (M'Intosh) (Hymenoptera: Braconidae) was the dominant parasitoid species. Individuals of all three aphid species were parasitized by *D. rapae*. Percent parasitism ranged from 0 to 45% depending on aphid species, field, and sample date. An *Aphelinus* sp. (Hymenoptera: Aphelinidae) was recovered from cabbage aphids from one field on a single sample date. Parasitism of turnip aphid on 20 May 2013 (17–45%) was greater than parasitism for cabbage aphid (2–12%) on that date. Parasitism of green peach aphid was not significantly different from that of cabbage aphid. Parasitism of cabbage aphid and green peach aphid initially increased but then decreased over the course of the study, while parasitism of turnip aphid continued to increase over time.

KEY WORDS *Brassica napus*, *Lipaphis pseudobrassicae*, *Brevicoryne brassicae*, *Myzus persicae*, *Diaeretiella rapae*, biological control, Aphididae

Winter canola, *Brassica napus* L. (Brassicales: Brassicaceae), has recently become the primary rotational winter crop with wheat in central Oklahoma. Winter canola production in Oklahoma increased from essentially zero hectares in 2001 to 40,500 ha by 2011 (NASS 2011), and canola acreage is projected to continue to increase. Three aphid species typically infest canola fields in central Oklahoma. They are the turnip aphid, *Lipaphis pseudobrassicae* (Davis), the cabbage aphid, *Brevicoryne brassicae* L., and the green peach aphid, *Myzus persicae* Sulzer (Hemiptera: Aphididae). Annual aphid pest outbreaks in canola have resulted in 75–90% of winter canola producers applying broad spectrum insecticides each year (Franke et al. 2009) around the time of flowering. Insect

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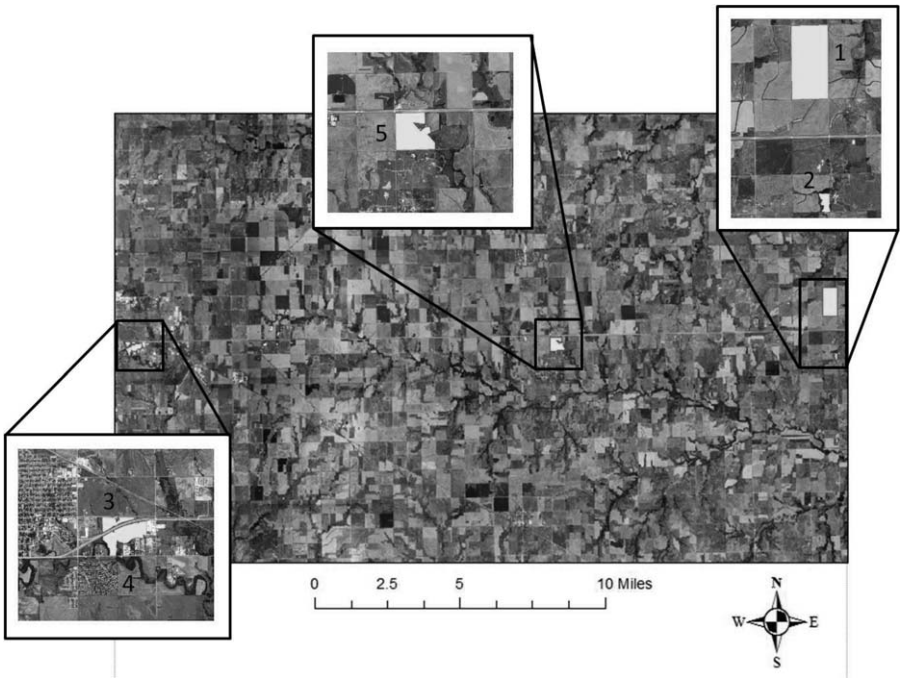

Fig. 1. Locations of five canola fields in central Oklahoma sampled for aphids.

natural enemies, both predators and parasitoids, colonize canola due to the large aphid infestations that develop in the crop.

The expansion of canola acres in Oklahoma and the ubiquitous nature of aphid infestations in the crop indicate the need to understand the role of natural enemies in controlling aphid infestations. Knowledge of the aphid parasitoid species that colonize the crop and their seasonal patterns of occurrence may help in understanding their role in suppressing aphid infestations, and provide valuable information on ways to enhance aphid biological control through conservation of natural enemies. We assessed parasitism of aphids in canola fields in central Oklahoma from just prior to flowering through early pod fill. The purpose of this research was to determine the parasitoid species attacking aphids in the crop and the progression of parasitism during this critical period, when aphid populations often build to the point requiring insecticide treatment.

Materials and Methods

We sampled five canola fields in central Oklahoma during May 2013 (Figure 1). The choice of fields was based on two criteria. The first criterion was that no field would be sprayed with insecticide during the sampling period. The second criterion was that the field was typical of production fields in the region, for example not heavily infested with weeds or lacking proper fertilization.

Five canola fields were sampled on 1, 10, and 20 May 2013. Sampling was accomplished by walking through each field and visually inspecting plant

terminals and leaves for the presence of aphids. Aphid-infested terminals and leaves were cut and placed in plastic zip lock bags that were transferred to the laboratory. Approximately 100 m was traversed within each field during the visual sampling, and over 50 terminals and leaves were collected from each field.

In the laboratory, aphids were placed on canola seedlings growing in 10-cm-diameter pots. Each pot contained 2–3 seedlings that had been planted about three weeks prior to being infested with aphids. Twenty mid-size aphids, presumed to be in the 2^{nd}–3^{rd} instar, of a particular species were placed on the plants in each pot using a fine artists brush. If there were enough aphids in the sample, a total of five pots were set-up (100 aphids) for each aphid species encountered from each field sampled. In some cases, a plant would have fewer than 20 aphids if there were fewer than 20 aphids available to put on it. The plants were covered by a cylindrical plastic cage (5.8 by 30 cm) with holes for airflow in the side and top covered with fine mesh cloth. The caged plants were maintained at 22 ± 0.5°C and 16L:8D in Percival E-30B (Percival Scientific, Inc., Perry, IA) controlled environment chambers. Plants were watered every 2 days and maintained in the chamber for seven days. After seven days, each plant was inspected for the presence of mummies. All mummies that formed on a plant were removed, placed in a plastic petri-dish (5 cm by 1.4 cm), and maintained at room temperature and lighting for emergence of adult parasitoids. All adult braconid parasitoids that emerged were identified to species, and all aphelinid parasitoids were identified to genus.

The proportion of aphids parasitized was calculated by dividing the number of mummies that formed on a plant by the number aphids placed on the plant. The proportion of aphids parasitized as reported in Table 1 was the mean across all plants for a particular aphid species from a particular field.

Statistical analyses consisted of ANOVAs to test for differences in the proportion of aphids parasitized within a field for the three aphid species, variation in the proportion of individuals of each aphid species parasitized among canola fields, and variation in the proportion of each aphid species parasitized over time. The number of aphid species, fields, and dates included in ANOVAs varied because not all aphid species were recovered from all fields and/or on all sampling dates. ANOVAs were accomplished using the PROC GLIMMIX procedure in SAS 9.3 (SAS Institute 2013), where the models chosen were for a binomial response variable (number of aphids parasitized out of the total number of aphids on the potted plant) and estimation was accomplished using maximum likelihood.

Results and Discussion

The three aphid species were parasitized by *Diaeretiella rapae* (M'Intosh) (Hymenoptera: Braconidae), which was the dominant parasitoid of aphids in canola, and one of only two parasitic hymenopteran species recovered. Percent parasitism ranged from 0 to 45% depending on aphid species, field, and sample date (Table 1). *Diaeretiella rapae* is a specialist parasitoid of *Brassica*-feeding aphids (Gabrys et al. 1998), and our observations are consistent with the previously reported dominance of this species as a parasitoid of aphids in canola in other parts of the world (Mussury & Fernandes 2002, Desneux & Ramirez-Romero 2009, Sayed & Teilep 2013). A single *Aphelinus* species was recovered

Table 1. Percent parasitism by *Diaretiella rapae* of aphids from canola fields in central Oklahoma in 2013. Each potted plant was infested with 20 mid-instar aphids of a particular species.

Date	Field	Aphid species	Number of potted plants	Mean % parasitism (SE)
5/01	1	Cabbage	5	5 (2.3)
5/01	2	Turnip	5	16 (2.7)
5/01	3	Cabbage	1	13 (—)
5/01	3	Green Peach	4	12 (4.2)
5/01	4	Cabbage	5	1 (1.1)
5/01	4	Green Peach	5	1 (1.1)
5/01	5	Cabbage	5	0 (0.0)
5/10	1	Cabbage	5	11 (2.0)
5/10	1	Green Peach	5	27 (7.5)
5/10	2	Turnip	5	19 (3.5)
5/10	3	Cabbage	5	8 (4.1)
5/10	3	Green Peach	5	24 (0.9)
5/10	4	Cabbage	4	2 (2.0)
5/10	4	Green Peach	4	11 (4.5)
5/10	5	Cabbage	5	16 (3.2)
5/20	2	Turnip	2	36 (13.5)
5/20	3	Cabbage	4	5 (3.4)
5/20	3	Green Peach	4	7 (1.5)
5/20	3	Turnip	4	45 (13.8)
5/20	4	Cabbage	4	12 (6.2)
5/20	4	Turnip	4	19 (4.7)
5/20	5	Cabbage	4	2 (2.0)
5/20	5	Turnip	4	17 (4.1)

from cabbage aphids from field 5 on 10 May, but this species was not recovered from aphids collected from other canola fields or from field 5 on other sample dates. This *Aphelinus* sp. is probably an uncommon parasitoid of aphids in canola fields in central Oklahoma.

Cabbage aphids and turnip aphids were abundant in fields 3, 4, and 5 on 20 May. Parasitism of turnip aphid on this date was greater than that of cabbage aphid in each of the three fields, ranging from 17–45% for turnip aphid to 2–12% for cabbage aphid (Table 1). The difference in percent parasitism for these two species was significant ($F = 25.9$; $df = 1, 20$; $P < 0.0001$).

Cabbage aphids and green peach aphids were abundant in fields 3 and 4 on 1 and 10 May, and in field 3 on 20 May. Parasitism of green peach aphids was often slightly higher than that of cabbage aphids (Table 1), with the greatest difference occurring for field 3 on 10 May, when 8% of cabbage aphids were parasitized compared to 24% of green peach aphids. On one occasion, a greater percentage of cabbage aphids than green peach aphids was parasitized (field 3 on 1 May). The difference in percent parasitism of the two species within fields was not significant ($F = 2.63$; $df = 1, 34$; $P = 0.1144$).

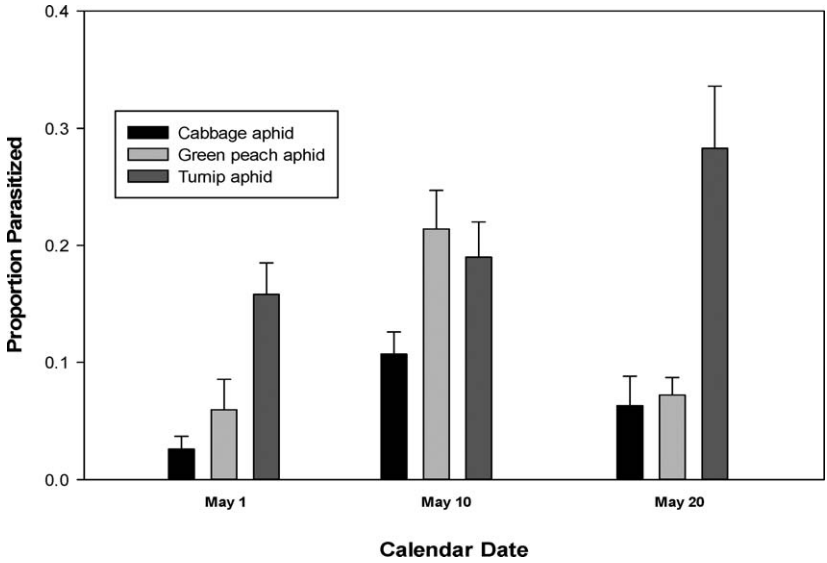

Fig. 2. Mean (with standard error bars) proportion of aphids parasitized by *D. rapae* in samples from five canola fields in central Oklahoma.

A greater percentage of turnip aphids than cabbage aphids was parasitized in all fields in which the two species were abundant enough to permit comparison, but there was no difference in percent parasitism between cabbage aphids and green peach aphids. The difference in parasitism rate may have been related to inherent preference by *D. rapae* for turnip aphid compared to cabbage aphid. Alternatively, differences in microhabitat or timing of colonization of the crop could have influenced parasitism rates. Turnip aphids were found predominantly on the undersides of leaves, whereas cabbage aphids and green peach aphids were primarily located on the stems of inflorescences. Perhaps plant microhabitat influences host foraging by *D. rapae* and concomitantly affects the parasitism rate.

Parasitism of the three aphid species varied over the course of the study (Figure 2). Parasitism of turnip aphid by *D. rapae* increased from 15 to 28% from 1 May to 20 May for all fields combined. Parasitism of cabbage aphid and green peach aphid increased from 1 May to 10 May, but then decreased from 10 May to 20 May (Figure 2). The decrease in parasitism for cabbage aphid and green peach aphid corresponds to the period of very rapid population increase of the two aphid species on stems of inflorescences (N. C. Elliott, unpublished). The decrease in parasitism rate suggests that parasitism by *D. rapae* was insufficient to keep pace with the rate of aphid population increase.

The parasitoid fauna in canola in central Oklahoma is essentially composed of one species, *D. rapae*, at the present time. The observation that parasitism by *D. rapae* did not keep pace with the rate of aphid population growth in canola during the flowering through pod filling growth stages suggests limited potential for this parasitoid to maintain aphid infestations below economically damaging levels. Field to field variation in percent parasitism was observed ($F = 4.93$; $df = 4, 81$;

$P = 0.0013$). Variation in parasitism rate among fields could result from variation in timing and rates of colonization of fields by aphids and/or *D. rapae*. Both timing and rate of colonization could be affected by the landscape context within which a field is embedded (Theis et al. 2005, Martin et al. 2013). Wissinger (1997) hypothesized that effective biological control strategies in annual crops must include provision of permanent habitats to act as reservoirs for natural enemies such as *D. rapae* whose life histories depend on the cyclic colonization of multiple habitats. The dominance of *D. rapae* as a parasitoid of aphids in canola suggests potential for habitat management to provide alternate hosts for the parasitoid within the landscape during the off season for canola to increase its effectiveness at biological control of aphids in canola.

Acknowledgment

We thank Tim Johnson for technical assistance with this project. Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. The USDA is an equal opportunity provider and employer.

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