INFLUENCE OF GRASS SPECIES ON THE FORAGING BEHAVIOUR OF *PLATYGASTER HIEMALIS*, A PARASITOID OF THE HESSIAN FLY, *MAYETIOLA DESTRUCTOR*

T.M. WITHERS¹ and M.O. HARRIS²

¹Forest Biosecurity and Protection, Ensis, PB 3020, Rotorua, New Zealand

²Department of Entomology, North Dakota State University,
Fargo, ND 58104, USA

Corresponding author: toni.withers@ensisjv.com

ABSTRACT

Platygaster hiemalis is an egg parasitoid of the Hessian fly, *Mayetiola destructor*, a pest of both New Zealand wheat, *Triticum aestivum* (Tribe Triticeae), and prairie grass, *Bromus willdenowii* (Tribe Bromaceae). The searching and oviposition behaviour of *P. hiemalis* females in relation to Hessian fly eggs oviposited on these two grass hosts was investigated. Individual females (n=15) were observed foraging for 60 min in an array of six wheat seedlings and six prairie grass seedlings, with all plants bearing Hessian fly eggs (mean of 5-6 eggs), and plant type alternated within the array. Before being released into the array the female had oviposited but had not experienced either plant type as an adult. On average *P. hiemalis* females made 7.7 visits to plants during the 60 min observation period, with some of these being repeat visits to the same plant. Wheat plants were visited twice as frequently as prairie grass plants. Once on the plant, females on prairie grass plants were just as likely to find eggs as females on wheat plants. These results indicate that *P. hiemalis* is potentially as effective at parasitising Hessian fly in prairie grass pastures as in wheat fields.

Keywords: *Platygaster*, Platygasteridae, *Mayetiola destructor*, foraging behaviour, egg parasitism.

INTRODUCTION

Platygaster hiemalis Forbes (Hymenoptera: Platygasteridae) is found over most of the geographic distribution of Hessian fly, *Mayetiola destructor* (Say), and its primary host wheat, *Triticum aestivum* L. (i.e. U.K., Europe, North Africa, North America and New Zealand). *Platygaster hiemalis* is generally considered the most effective parasitoid of Hessian fly (Hill et al. 1939; Barnes 1956; Macfarlane 1990) and has been in New Zealand probably since 1888, which was prior to any purposeful parasitoid introductions (Macfarlane 1990). The Hessian fly is believed to have evolved in the Middle East on the ancestors of modern wheat and utilises a number of species within the grass tribes, Triticeae and Poeae (Harris et al. 1996). In New Zealand, plant hosts for Hessian fly include *Hordeum vulgare* L. (barley), *Triticum aestivum* (wheat), *Bromus willdenowii* Kunth (prairie grass) as well as the wild grasses *Elytrigia repens* (L.) Desv. (couch) and *Hordeum murinum* L. (barley grass) (Harris et al. 1996). Wheat is the preferred host for Hessian fly, receiving 2-3 times more Hessian fly eggs/plant than prairie grass (Harris et al. 2001). *Platygaster hiemalis* is known to parasitise Hessian fly eggs in New Zealand on at least barley, wheat and prairie grass (Macfarlane 1990). Little is known about the search behaviour of *P. hiemalis*. Females have been observed ovipositing into Hessian fly eggs and sometimes into newly hatched larvae as they migrate down the leaf blade to sheltered feeding sites within leaf sheaths at the base of the plant (Hill 1926).

This paper investigated the search behaviour of *P. hiemalis* females using focal animal sampling and continuous recording methods. The aim was to answer the following questions. Will females exhibit search behaviour in a small arena containing a small number of egg-infested seedling plants? Can this behaviour be observed and recorded, in spite of the small size (1 mm length) of the female? Do females distinguish between wheat and prairie grass in terms of visitation rates and searching behaviour? And finally, once on the plant, are females just as likely to find eggs oviposited on prairie grass as on wheat?

MATERIALS AND METHODS

Plants and insects

Wheat cv. Karamu and prairie grass cv. Grasslands Matua seeds were individually planted into pots (4 x 4 cm) containing a bark/soil potting mix and short term fertiliser. Pots were placed in a glasshouse (20±5°C) and plants were grown to the 2-3 leaf stage. *Platygaster hiemalis* adults were obtained from a field of Karamu wheat infested with Hessian fly in Palmerston North, New Zealand. Wheat plants were collected at weekly intervals during August and held in a controlled environment chamber (21±1°C and 12:12 h light:dark). Approximately 20 days later, adult *P. hiemalis* began emerging from pupal cases in the wheat stubble. These were collected daily before 10:00 am by aspirator and held in groups in a mesh cage (22 x 22 x 30 cm). On each day of experimental observations, *P. hiemalis* females were collected from the field and used within 24 h of emergence. Hessian fly females were from a colony continuously reared on Karamu wheat in the glasshouse as described by Harris et al. (1996). Adult females that had emerged in the morning were mated almost immediately, and these began to oviposit at midday each day.

Plants used in experimental arrays were infested with Hessian fly eggs by confining a single female Hessian fly in a mesh cage with six wheat plants and six prairie grass plants until each plant was infested with between 3 and 12 eggs (mean of 5.6 eggs on wheat and 5.8 eggs on prairie grass). Infested plants were used within the next 4 days to set up a 3 x 4 square array of alternating wheat and prairie grass plants in a glasshouse. Pots holding the individual plants were sunk into potting mix so that the distance between plants within rows and columns was 4 cm. The plant array was surrounded by a cylindrical clear plastic cage (30 cm diameter x 35 cm high) and covered by a nylon mesh ceiling.

Experimental methods

Prior to each experiment, a screening method was used to select females in a physiological state that allowed attack of Hessian fly eggs (females do not need to be mated to oviposit, Hill 1926). Between the hours of 10:00 and 16:00, a single *P. hiemalis* was removed from the holding cage and introduced into a glass vial (2.5 cm diameter x 7 cm length) that contained Hessian fly eggs on the glass walls. If the female *P. hiemalis* exhibited oviposition behaviour within 3 min it was allowed to oviposit into two or three eggs. *Platygaster hiemalis* that did not exhibit oviposition behaviour in the glass vial were discarded. Female *P. hiemalis* exhibiting oviposition behaviour were removed by aspirator immediately from the glass vial and introduced onto a wheat or prairie grass plant in the test arena so the observations could begin. The plant species used for this introduction was alternated from one female to the next. Each *P. hiemalis* was used for one experimental observation before being discarded, and a fresh plant array was also used for each observation.

Audio tapes were used to record the following behavioural information: arrival on a plant, type and location of the plant, rapid movement over the leaf surface, arrival times at the tip or the base of a leaf blade, contact with Hessian fly eggs, and arching of the abdomen (which includes oviposition). Individual *P. hiemalis* were observed continuously for 60 min or a shorter time if the female stopped moving for 5 min during the observation period. In the latter case, the observation was terminated after this 5 min of inactivity. The data comprise nine females observed for 60 min, and six females observed for a mean of 46 min. At the end of each observation, the number of Hessian fly eggs per

leaf per plant, and the number of leaves per plant was recorded. Data were compared using Chi square tests or a Welch ANOVA (JMP Statistical Software, SAS 1995). The Welch ANOVA can be used when treatment variances are not homogeneous.

RESULTS AND DISCUSSION

Despite their small size, detailed observations were successfully completed on the female *P. hiemalis* within the experimental arena described above. Immediately after being released onto a wheat or prairie grass plant, female *P. hiemalis* exhibited search behaviour. This consisted of the female moving rapidly up and down individual leaf blades, with the head swinging from side to side while the antennae were repeatedly and rapidly brought into contact with the leaf surface. Upon direct contact with Hessian fly eggs, females stopped and examined eggs with the antennae by repeatedly touching and finally stroking the eggs (also see description in Hill, 1926). The female then arched her abdomen and dragged the tip over the eggs before settling and ovipositing into a particular Hessian fly egg (hereafter both behaviours are referred to together as 'arching'). Time devoted to arching ranged from 10-110 s ($n=316$ observations) with a median arching time of 35 s. After the female completed oviposition, the tip of the abdomen was again dragged over the surface of the egg. It was not possible to ascertain whether each instance of arching behaviour resulted in an egg being laid into the host egg, but in the majority of cases this is thought to have been the case.

The behavioural sequence leading from arrival on the plant to oviposition suggests that, while on the plant, *P. hiemalis* locate Hessian fly eggs through physical and/or chemical cues contacted during search behaviour, rather than through the perception of host cues at a distance from eggs. The observation of Hill (1926) that *P. hiemalis* females will probe, with the ovipositor, areas of the leaf from where Hessian fly eggs have been recently removed indicates that arching can be triggered purely by contact chemical cues associated with host eggs.

In addition to search behaviour on individual plants, female *P. hiemalis* moved from one plant to another within the experimental array. Most commonly, movement between plants was achieved by short hops, from one leaf blade to another, or by walking across the soil or across 'bridges' formed when leaf blades of two plants touched. Such interplant movement resulted in females making 7.7 ± 1.6 (mean $\pm$ SE) plant visits during the 60 min observation period. This brought females into contact with an average of 33% of the plants in the 12-plant array, with plants commonly visited more than once.

Although wheat and prairie grass plants occurred in identical densities within the array wheat plants were visited twice as often (Table 1). As wheat plants in the 2-3 leaf stage are larger than prairie grass plants, both in leaf blade width and length (M. Harris, unpubl. data), the greater frequency of visits to wheat may have been because wheat leaves comprised more of the leaf area in the arena. Alternatively or additionally, *P. hiemalis* females, like Hessian fly females (Foster & Harris 1992), may be able to distinguish between plant species prior to physical contact by perceiving differences in volatile plant chemicals. In addition to visiting wheat plants more frequently than prairie grass plants, females spent more time searching wheat plants, perhaps simply because they were bigger, or perhaps because they show a preference for searching wheat plants. Females visited a greater percentage of the leaves on a wheat plant (Table 1) and searched the plant for a longer time (Table 1). Females appeared to walk faster on wheat than on prairie grass leaves and moved from one side of the leaf blade to the other with greater ease. A cursory examination of the leaf blades under magnification revealed that, while the hairs on wheat leaves are denser than those of prairie grass, they are also shorter and lie flat against the leaf surface. The long hairs of prairie grass leaves stood almost at right angles to the leaf surface giving it a 'bristly' appearance. The density, size and alignment of leaf hairs have been shown to influence the walking speed of other small parasitoids (van Lenteren et al. 1995), and the right-angled hairs on prairie grass leaves may also be negatively affecting searching behaviour of *P. hiemalis*.

In spite of differences in search behaviour on wheat and prairie grass, females on both plants were equally successful in finding Hessian fly eggs. Neither the probability of finding eggs per visit, nor the time from arrival on the plant to the first location of Hessian fly eggs, nor the total time spent in arching behaviour on Hessian fly eggs differed between the two plant species (Table 1). As prairie grass leaves were narrower and shorter than wheat leaves, any difficulties the female experienced in moving over prairie grass leaf surfaces may have been offset by their smaller leaf surface area.

TABLE 1: Mean ($\pm$ SE) duration (in sec) and frequency of various behaviours exhibited by *P. hiemalis* females on wheat and prairie grass plants infested with Hessian fly eggs.

Plant	Total no. visits ¹	% leaves visited ²	% visits eggs were found ¹	Search time/visit ²	Latency to first egg contact ²	Total time arching ²	Total time/visit to each plant ²
Wheat	77	87.5 (3.8)	42	376.9 (50.5)	181.6 (34.1)	226.3 (33.3)	470.9 (65.1)
Prairie grass	36	69.8 (5.2)	33	233.8 (73)	115.8 (54.8)	239.4 (54.3)	312.2 (95.2)
	P<0.01	P<0.05	ns ³	P<0.05	ns	ns	P<0.05

¹Numbers, combined over all visits by all females, were compared by Chi Square test.

²Data for wheat and prairie grass were compared by a Welch ANOVA test.

³ns = Means were not significantly different (P>0.05).

The data suggest foraging behaviour of *P. hiemalis* females is influenced by the plant species on which the female searches for host eggs. However, although *P. hiemalis* did visit wheat plants (the preferred host plant of Hessian fly) more frequently, females were just as effective in locating and parasitising host eggs on prairie grass, a less preferred grass species from a different grass tribe (Harris et al. 2001), as they were on wheat. These results suggest that *P. hiemalis* has the potential to be as effective a control agent at parasitising Hessian fly populations in prairie grass pastures as in wheat fields. In New Zealand, the percentage of parasitism by *P. hiemalis* of Hessian fly attacking wheat was recorded one season as 5–15% in the North Island (Withers et al. 1995). These behavioural observations suggest similar levels of parasitoid attack may be possible where Hessian fly infests alternative grass hosts (Harris et al. 1996), but it is also possible that the shorter times *P. hiemalis* spent searching prairie grass plants (Table 1) will equate to less effective parasitism of Hessian fly infesting prairie grass in the field. Field sampling could now be undertaken to examine this possibility.

CONCLUSION

This was our first investigation into the searching behaviour of the Hessian fly egg parasitoid *P. hiemalis*. Despite its small size, searching behaviour and arching on eggs laid on plants in a small mixed species array was successfully observed. Wheat plants were visited twice as frequently as prairie grass plants. However, once on the plant, females on prairie grass plants were just as likely to find eggs as females on wheat plants. The results indicate that *P. hiemalis* has the potential to also parasitise Hessian fly on prairie grass in pastures, as well as in wheat fields, but how effective it will be in the pasture habitat remains unknown.

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