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Paper Wasps (*Polistes* spp.) Attacking Fall Armyworm Larvae (*Spodoptera frugiperda*) in Turfgrass

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Abstract

The objective of this paper is to identify common species of paper wasps (*Polistes* spp.) attacking fall armyworm (Noctuidae: *Spodoptera frugiperda*) larvae and to investigate foraging activity in turfgrass. Three species — *Polistes exclamans*, *P. dorsalis*, and *P. metricus* — were collected while they foraged in bermudagrass turf. *Polistes* wasps forage in turf for about 10 h a day beginning a few hours after sunrise (0830 h), waning near midday, and increasing again in the late afternoon. Wasps were more abundant in plots infested with fall armyworms although these differences were statistically significant in one of three trials. The benefits of *Polistes* wasps may be conserved by scheduling insecticide applications in the early evening (0700 h or later) or by using reduced-risk insecticides.

Introduction

Paper wasps (Hymenoptera: Vespidae, Polistinae), including the common *Polistes* spp., are robust, social wasps that derive their common name from their paper nests. Nests are initiated in April by a female (foundress) that has overwintered. The foundress becomes the queen of the nest she constructs. However, if she dies or is displaced by another female, any female that successfully lays and continues to produce eggs on a nest is considered the queen (2). Colony size peaks in late July and early August. By October in coastal Mississippi, foraging in turfgrass ceases and adults are mostly observed on flowers (*personal observation*). In fall, only inseminated females seek overwintering sites and males do not overwinter (2).

Larvae of *Polistes* are fed both pulpy solids (protein sources) and liquids. Items gathered by adults include paper pulp, water, nectar, fruit, and caterpillars. About 35% of foragers return to the nest with prey (4) which are mostly caterpillars. Specialization on caterpillar prey make *Polistes* suitable for augmentative biological control of lepidopteran pests of field crops (4,5,7,9) including fall armyworms (*Spodoptera frugiperda* Smith). Lawson et al. (7) reported 50 to 90% reductions in the hornworm larvae on tobacco attributed to predation by *Polistes* and suggested outbreaks of hornworms occur in years when *Polistes* were less abundant.

The biology and role of *Polistes* in turfgrass has not been studied. Discussions of paper wasps in turfgrass textbooks [e.g., (11)] typically emphasize their stinging hazard. However, some turf managers in Mississippi suggest that activity of paper wasps (*Polistes* spp.) in turfgrass signals infestations of fall armyworm. The presences of foraging animals, insectivorous birds (e.g., armadillos and starlings) have been reported to guide sampling or control measures for certain insect pests in turfgrass (14). This paper is the first to document species of *Polistes* associated with predation of turf-infesting caterpillars and to investigate their foraging activity on fall armyworms.

Survey of *Polistes* spp. in Turfgrass

In 2004, three sites in coastal Mississippi with established hybrid bermudagrass (*Cynodon dactylon* L. × *C. transvaalensis* Burt-Davy) were sampled. Each site was selected because paper wasps were actively attacking fall armyworms. The first site, sampled on 20 August, was an athletic field in Gulfport (Harrison Co.). The second site, sampled on 27 August, was a golf course fairway and tee at the Shell Landing Golf Course in Gautier (Jackson Co.). The third site, sampled on 11 September, was a residential home lawn in Saucier (Harrison Co.). Grass height on the athletic field and golf course was maintained around 1.9 cm whereas the home lawn was maintained around 3.8 cm. All these sites were bordered on at least one side by woods consisting of pine (*Pinus* spp.), and understory plants such as yaupon (*Ilex vomittoria*) or southern wax myrtle (*Myrica cerifera*). The home lawn and athletic field sites were adjacent to one or more buildings.

Wasps were sampled using the soap solution and survey method of Held (6). A solution of dishwashing soap, 30 ml per liter, was prepared in a plastic spray bottle. This solution was sprayed on foraging wasps until they were immobilized. Commonly, fall armyworm larvae would also surface as a result of the soap solution. Wasps were then collected into 95% ethanol, later pinned, then sent to K. M. Pickett for species identification.

Only 26 of the more than 200 described species of *Polistes* are present in North America, mostly in the southern United States (1). Three of the 26 species were collected during the study. *Polistes metricus* Say, a common species with reddish to reddish brown adults (Fig. 1), was present on all sites and the only species collected on Site 1. In addition to 13 *P. metricus* collected at Site 2, there were two adults each of *P. dorsalis* (Fabricius) and *P. exclamans*. *Polistes dorsalis* was only present on the golf course site. *Polistes dorsalis* nests in sheltered places such as hollow logs or rock piles (8). The last site, a home lawn, had ten *P. metricus* and six *P. exclamans* (Fig. 1). Paper wasp nests are annual and initiated by a foundress in the spring. Foundress females nest in locations similar to those of their parents (i.e., nest site philopatry). *Polistes metricus* and *exclamans* were observed on the same site (Coastal REC, Biloxi) for two consecutive years. Despite this, foraging females do not just forage locally and activity may vary significantly (5,9). Gould and Jeanne (5) noted wasps from transplanted nests would fly past infested plots to a nearby alfalfa field to forage on flowers and larvae. These and other factors have limited implementation of augmentive biological control programs utilizing predation by *Polistes* (4,5,7,9).

A **B**

Fig. 1. *Polistes* attacking fall armyworms in turfgrass: (**A**) *P. metricus* and (**B**) *P. exclamans*.

Daily Foraging Activity in Turfgrass

Foraging paper wasps may be active in turfgrass at times when turf managers or spray technicians want to apply pesticides for control of turf pests. Therefore, knowing the daily activity period of *Polistes* in turfgrass may provide opportunities to minimize exposure to pesticides. Wasp foraging was tracked on 5 days in June-July 2006 between 0530 h and 2030 h. On each day, a 3 × 3-m quadrat was established in a mixed stand of centipede [*Eremochloa ophiuroides*

(Munro) Hack.] and hybrid bermudagrass. During these times, an observer would count the number of wasps that landed in this quadrat for 5 min. This regime was repeated every hour until activity ceased. During this time, sunrise ranged between 0545 and 0607 h and sunset around 2000 hours. Ambient air temperature data during these experiments were retrieved from an on-site weather station (WatchDog Model 2900ET, Spectrum, Plainfield, IL).

Wasps were active in the plot for 10 h each day (Fig. 2). On 4 out of 5 mornings, landings were first recorded at 0830 h when temperatures were ≥ 26° C. On 22 June, temperature at 0630 h were > 26°C and first landings recorded at 0730 h. Alternatively, on 27 June air temperatures were not above 26°C until 0930 h and the first landings in plots were at 1030 h. Landings in plots steadily increased until around noon when temperatures were 31 to 33°C. Later in the day, the number of landings decreased and, on most days, increased again later in the day. This change in activity may be explained by changes in workers. During the hottest part of the day, wasps need water for evaporative cooling of the nest (1). This likely explains the decrease in the number of wasps foraging for prey after midday. As a result, more wasps are foraging for prey in turf in the morning and late afternoon.

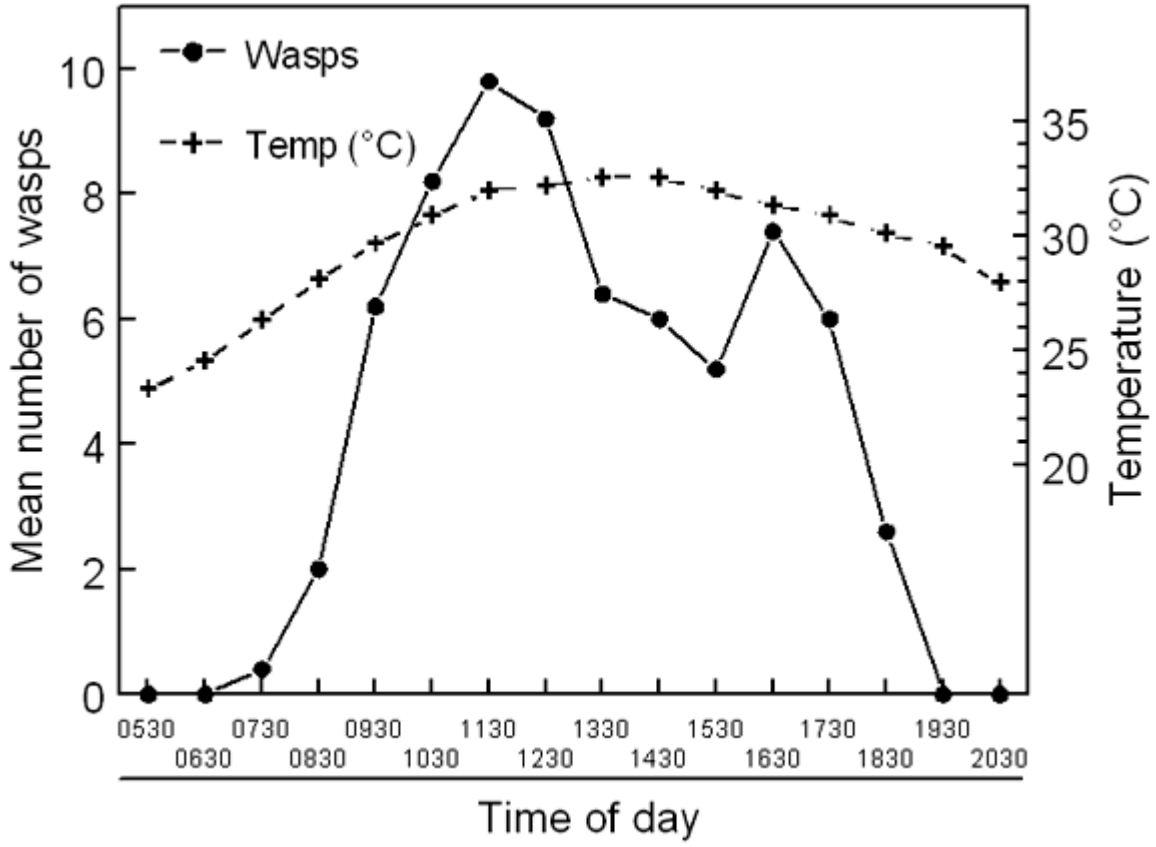

Fig. 2. Daily foraging activity of *Polistes* spp. in turfgrass.

Does Foraging by *Polistes* Indicate a Caterpillar Infestation?

Trials were conducted to examine claims that *Polistes* wasps are an indicator of turf-infesting caterpillars. All trials were conducted in a stand of mixed centipede and bermudagrass on the grounds of the Coastal REC in July-September 2007. Quadrats 3 × 3-m were established in pairs with a 1-m border. On 27 July, six pairs of quadrats were established in the morning. One of each was randomly assigned to receive larvae. These quadrats were then infested with 40 fifth and sixth instar fall armyworm larvae reared on diet in a laboratory colony. The other quadrat in each pair was left uninfested. Larger larvae were used because larval size influences foraging behavior of *Polistes* (9). After about 15 min, observers watched each pair of quadrats for 5 min and recorded the

number of wasps in each. Wasps merely flying over were not counted and wasps that landed, regardless of successful foraging, were counted. The same methods were used on 21 August and 18 September. Fall armyworms were of the same size, but the number of armyworms available from the colony at the correct stage varied. Therefore, the number of replicates used in each trial varied (Table 1). Numbers of paper wasps per quadrat were totaled for the entire trial period (7 or 8 h) and replicates with no wasps were omitted before analysis. For each trial, larvae-infested and uninfested plots were compared by paired *t*-test ($P < 0.05$).

Table 1. Numbers of wasps visiting turfgrass quadrats that were either infested with fall armyworm larvae (*Spodoptera frugiperda*) or not infested.

Trial	No. of larvae / infested quadrat	No. of repli-cates	Mean no. of wasps ± SE (and total no.)		*t* value*	*P*	*df*
			Artificially infested	Not infested			
1	40	6	5.2 ± 1.2 (31)	0.7 ± 0.3 (4)	3.3	0.01	5
2	12	4	2.3 ± 1.3 (9)	0.5 ± 0.5 (2)	1.1	0.19	2
3	30	6	10.8 ± 1.4 (43)	4.5 ± 2.9 (19)	1.8	0.08	3

* Zone-tailed *t*-test

In all trials, the number of *Polistes* in infested plots was greater than the number recorded in uninfested quadrats (Table 1). This difference was only statistically significant ($P < 0.05$) for the trial in July. Trials in July and September had more larvae per quadrat and subsequently more wasps. Higher prey densities typically result in greater numbers of visits by *Polistes* (9). Therefore, prey density may explain why differences in the number of wasps in uninfested and infested plots were only significant for the trial in July.

Conclusions and Recommendations

Polistes wasps reportedly attack 40 species of day-active caterpillars including pests of ornamentals and turfgrass (3). Their gregarious nesting and role as predators has been the subject of numerous studies seeking to augment biological control of caterpillar pests. Since this is the first report of *Polistes* as a predator in turfgrass it is important to discuss the role *Polistes* wasps might have in management of turf-infesting caterpillars.

Polistes wasps forage in turfgrass at densities of 30 or 40 fall armyworm larvae per 9 m^2 (0.3 and 0.4 larvae per square foot, respectively). There was no significant difference in quadrats infested with 12 larvae, however, more than four times as many wasps were recorded from infested quadrats in that trial. In all instances, wasps were foraging in turf when caterpillar populations were less than one per square foot. This strengthens the argument that wasps may be a useful indicator of caterpillar infestations in turfgrass. The seasonal activity period of these wasps (June-September) also overlaps the period for problems with fall armyworms.

Despite the benefits of *Polistes* wasps as predators in turfgrass, the armyworm-infested athletic field and golf course sites surveyed in 2004 still required treatment. This was in response to both a fall armyworm infestation and the sting hazard posed by *Polistes*. Since only females forage (2), the risk of being stung is indeed valid. Rau (13) states human attacks by *Polistes* typically occur near the nest and result in pain and localized swelling. However, throughout the course of this study, there were no indications that these wasps were aggressive while away from their nest foraging (David W. Held, *personal observations*).

The hunting behavior of *Polistes* spp. observed during these experiments in turfgrass is similar to those previously described for other species (4,9). Wasps fly into infested areas, land, and conduct a ground search moving up and down through the grass canopy. Once located, prey is masticated into a small ball (Fig.

1) before being taken to the nest (4,9,13). Foraging times for individual *P. jadwigae* attacking a 6th instar larvae of *Spodoptera litura* averaged 4.26 min (range: 0.9 to 13.7 min) (9). Estimates of seasonal foraging efforts vary widely based on the variables used to calculate these estimates. More conservative estimates (466 to 567 larvae per 90 days season per nest) are based on nest averages for the numbers of foragers and number of prey taken (5).

Predatory arthropods are important buffers against outbreak of many turfgrass pests (12). Foraging in close contact with turfgrass may expose these wasps to lethal insecticide residues. Several reduced-risk insecticides such as spinosad (Conserve, Dow AgroSciences LLC, Indianapolis, IN) or halofenozide (Mach2, Dow AgroSciences LLC) labeled for caterpillar pests may reduce the impact on paper wasps (10,12). However, surface-applied pyrethroids such as bifenthrin are still commonly used for caterpillar control. Residues of bifenthrin and chlorpyrifos applied to turf resulted in ≥ 90% mortality of another wasp, *Tiphia vernalis*, when exposed for 48 h to treated turf cores in the laboratory (10). The toxicity of insecticide residues on turfgrass to *Polistes* is unknown. Studies similar to Oliver et al. (10) are planned to evaluate the impact of surface-applied insecticides to foraging paper wasps. Until these data are available, insecticides for caterpillar control should be applied in the evening (0700 h or later) allowing 11 to 12 h for residues to age before wasps begin foraging the following morning. This strategy and use of reduced-risk insecticides should conserve the benefits of *Polistes* wasps foraging in turfgrass.

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