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ORIGINAL ARTICLE

Arthropod prey of imported fire ants (Hymenoptera: Formicidae) in Mississippi sweetpotato fields

Tahir Rashid[1], Jian Chen[2], James T. Vogt[3] and Paul J. McLeod[4]

[1]*Alcorn State University, Extension/Research Demonstration Farm & Tech Transfer Center, Mound Bayou, Mississippi,* [2]*USDA, ARS Biological Control of Pests Research Unit, Stoneville, Mississippi,* [3]*USDA, FS, Inventory & Analysis, Knoxville, Tennessee, and* [4]*Department of Entomology, University of Arkansas, Fayetteville, Arkansas, United States*

Abstract The red imported fire ants, *Solenopsis invicta* (Buren), are generally considered pests. They have also been viewed as beneficial predators feeding on other insect pests of various agroecosystems. This study documents the foraging habits of fire ants in a sweetpotato field in Mississippi. Fire ant foraging trails connecting outside colonies to a sweetpotato field were exposed and foraging ants moving out of the field toward the direction of the colony were collected along with the solid food particles they were carrying. The food material was classified as arthropod or plant in origin. The arthropod particles were identified to orders. Fire ant foragers carried more arthropods than plant material. Coleoptera and Homoptera were the most abundant groups preyed upon. These insect orders contain various economically important pests of sweetpotato. Other major hexapod groups included the orders Hemiptera, Diptera and Collembola. The quantity of foraged material varied over the season. No damage to sweetpotato roots could be attributed to fire ant feeding. Imported fire ant foraging may reduce the number of insect pests in sweetpotato fields.

Key words foraging, imported fire ant, predation, *Solenopsis invicta*, sweetpotato

Introduction

The red imported fire ants, *Solenopsis invicta* (Buren), are considered serious pests in urban and agricultural environments (Lard *et al*., 2002). Conversely, they are viewed as "potential providers of biocontrol" due to their efficiency as generalist predators of other arthropods (Helenius, 1998). Fire ants are known to prey on a number of insect pests of agricultural and medical importance. There are documented studies of fire ant feeding on rednecked peanutworm *Stegasta bosqueella* (Chambers), sugarcane borer *Diatraea saccharalis* (Fabricius), beet armyworm *Spodoptera exigua* (Hübner), corn earworm *Helicoverpa zea* (Boddie), southern green stink bug *Nezara viridula* (Linnaeus), soybean looper *Pseudoplusia includens* (Walker), fall armyworm caterpillars *Spodoptera frugiperda* (J.E. Smith), boll weevil *Anthonomus grandis* (Boheman) and cotton aphid *Aphis gossypii* Glover (Sterling, 1978; Reagan, 1986; Nyffeler *et al*., 1987; Fuller *et al*., 1997; Vogt *et al*., 2001; Diaz *et al*., 2004). Some pests of medical importance fed upon by fire ants include lone star tick *Amblyomma americanum* (Linnaeus), horn fly *Haematobia irritans* (Linnaeus), and the mosquito species *Psorophora columbiae* (Dyar & Knab) and *Aedes albopictus* (Skuse) (Burnham *et al*., 1994; Hu & Frank, 1996). A study in Mississippi demonstrated that fire ants killed several insect species in the field during foraging (Green, 1952). In peanut fields more than 50% of fire ant foraged material consisted of arthropod origin (Vogt *et al*., 2001). Peanut plants in close proximity to fire ant mounds had significantly less pod damage than those at a distance. In another study, fire ants collected more

Correspondence: Tahir Rashid, Alcorn State University, Extension/Research Demonstration Farm & Tech Transfer Center, 294 Grainger Dorsey Road, Mound Bayou, MS 38762, USA. Tel: 662 741 3376; fax: 662 741 3370; email: trashid@alcorn.edu

plant-based liquid diets, indicative of their role as primary consumers in habitat of mixed stand of native grasses (Tennant & Porter, 1991). Wilson and Oliver (1969) reported collection of small, less active insects by fire ant foragers mostly comprising larval forms. Imported fire ants have been observed feeding on wireworms in sweetpotato fields in 2006 (T. Rashid, personal observation). Reed *et al*. (2009) reported high population levels of fire ants in sweetpotato fields later in the season and associated their presence with suppression of insect pests under the sweetpotato canopy.

In 2008, Mississippi ranked third among sweetpotato producing states in USA by growing 18% of the total national production (Anonymous, 2009). Many root and foliage feeding insects cause economic losses by direct feeding or indirectly reducing quality and yield of sweetpotatoes. Insects such as rootworms (*Diabrotica* spp.), several species of wireworms and flea beetles, sweetpotato weevil (*Cylas formicarius* Fabricius), white grubs (*Phyllophaga* spp.) and whitefringed beetles (*Graphognathus* spp.) that feed on sweetpotato storage roots may cause economic losses and are very difficult to control (Chalfant *et al*., 1990; Williams, 2005). Control of these insect pests mainly relies upon conventional pesticides. In many instances only partial and inconsistent control can be achieved resulting in over-use of pesticide, associated higher costs, and potential environmental harm or health risks. Reducing pesticide use can improve farm profitability and long-term sustainability of farming.

For many agricultural pests there are commercially available biological control agents such as predaceous ladybird beetles, parasitic wasps and insect-killing nematodes. Given the pests' importance and the rising popularity of sustainable agriculture, a need exists for more research on the management of insect pests by using environmentally friendly methods such as biological control agents and replacing synthetic chemical insecticides with reduced risk procedures. Since sweetpotato storage roots are mostly attacked by soil insects (Reed *et al*., 2009), imported fire ants can potentially reduce the pest insect populations by feeding on them. This study examined the potential effectiveness of fire ants as natural enemies of pest insects by documenting the prey of imported fire ants in sweetpotato fields in the Mississippi Delta.

Materials and methods

A sweetpotato field was planted with Beauregard (B14) during June, 2007 at the Alcorn State University Extension and Research Demonstration Farm and Technology Transfer Center, Mound Bayou, Mississippi. The 1.3 ha field was double disked and hipped before planting. Sweetpotato slips were transplanted with a 2-row MT mechanical planter at 0.6 m between plants and 0.9 m between rows. The field had been planted with sweetpotatoes for more than three consecutive years. The preplanting burndown herbicides Gramoxone® (Syngenta Crop Protection, USA) and Roundup® (Monsanto Company, USA) were applied at 2.3 and 1.8 L/ha, respectively. The herbicide Valor® (flumioxazin) (Valent U.S.A. Corporation) was applied at 0.18 L/ha seven days before transplanting. Escape weeds were removed by hoeing and/or hand-weeding throughout the growing season. No insecticide was applied to the field. The field was furrow irrigated as needed during the season. The north and south sides of the field were bordered by permanent access roads with relatively undisturbed shoulders (with the exception of periodic mowing), and the east and west sides were bordered by turn rows. Crops in neighboring fields during the study included cotton (north), sweetpotato (east, south) and sweet corn (west).

Fire ant foragers were collected with a mouth-operated aspirator (Gempler's, Madison, WI, USA) along with the materials they were carrying from within the sweetpotato rows. The aspirator's tube was protected by a fine 220-mesh nylon to prevent accidental inhalation. The sampling was conducted every 7 to 20 days depending on the temperature suitable for optimum foraging from June through November, 2007. Maximum foraging activity of fire ants has been reported to occur between 22°C and 36°C (Porter & Tschinkel, 1987), or between 25°C and 35°C (Drees *et al*., 2007). Shallow (5 cm deep, 5 cm wide) trenches of variable lengths (5–10 cm) were dug with a hand trowel to expose foraging trails leading from the field to adjacent colonies. It took approximately 30 min for ants to resume foraging across the bottom of a trench. Only foragers with solid food particles were collected for 1 h after they resumed the foraging trail. The ants along with the foraged material were frozen for later identification. For root damage analysis, 3 m rows of sweetpotatoes were harvested from 25 randomly selected locations within the field. Each sweetpotato root was visually inspected for insect damage.

Data were analyzed with ANOVA and means separated with Student's *t*-test to determine differences in number of foraged particles and retrieval time (SAS Institute, 2010).

Results and Discussion

The mean number of collected particles per hour was 41.3 (range 8.83–94.03) (Fig. 1). The foraging ants collected a diverse group of arthropod (56.9%) and plant (43.1%)

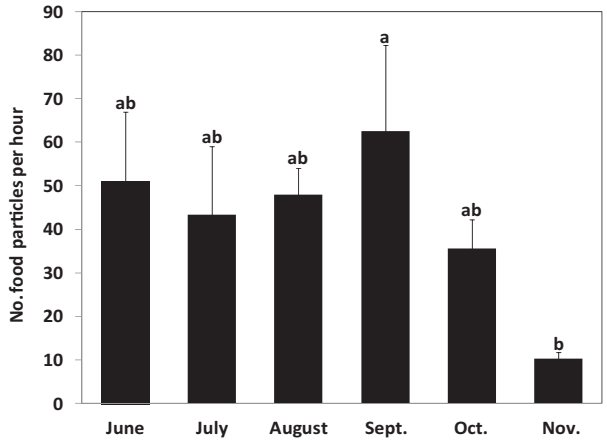

Fig. 1 Mean number of imported fire ant foragers collected per hour carrying solid food particles in sweetpotato during each month.

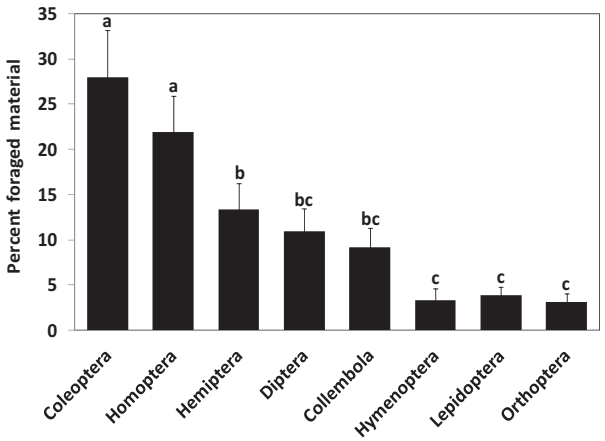

Fig. 2 Overall mean percentage of foraged material in different hexapod groups recovered from imported fire ant foragers in sweetpotato.

materials. Unidentifiable arthropod material accounted for 8.5%. The recovered insects consisted of both whole bodies and body fragments. The percentages of some major hexapod groups are presented in Figure 2. The most abundant group (27.9%) recovered in foraging material were Coleoptera, 59.8% of which consisted of Carabidae. Homoptera constituted the next abundant group, accounting for 21.9% of total arthropod material, 61.6% of which was Cicadellidae. Hemiptera, Diptera and Collembola were other major groups with 13.3%, 10.9% and 9.2% of collections, respectively (Fig. 2). Hymenoptera, Lepidoptera and Orthoptera were also recovered in low numbers.

Table 1 presents the percentages of foraged material in different arthropod groups recovered from imported fire ants during the sweetpotato growing season from transplanting to harvest. During the early planting season in June the fire ant foragers collected significantly higher (59.5%) number of Coleoptera than other insect orders indicating abundance, ease of capture, or a combination thereof. The economically important Coleopteran insect pests of sweetpotato are wireworms (Elateridae), sweetpotato weevil (Curculionidae), cucumber beetles and flea beetles (Chrysomelidae) and white grubs (Scarabidae). The order Homoptera includes sweetpotato foliar insect pests such as aphids and whiteflies, which were recovered in significant numbers during August. In September percent collection material from Hemiptera was also significantly higher than other sampling months. Other important arthropod groups collected in this study were Diptera and Collembola, which were collected in relatively consistent numbers throughout the collection period from June to November. Hymenoptera were collected in significantly higher numbers during the early season of sweetpotato transplanting than during the rest of the growing season, and none were collected near the harvest. On the other hand, Orthoptera were collected in significantly higher percentages in October than in other months.

Table 1 Mean percentage ± SE of total material per hexapod group foraged by imported fire ants in sweetpotato during the season.

Collection period	Percent foraged material (± SE)							
	Coleoptera	Homoptera	Hemiptera	Diptera	Collembola	Hymenoptera	Lepidoptera	Orthoptera
June	59.5 ± 2.5 a	1.6 ± 1.4 c	4.8 ± 1.9 b	2.7 ± 1.0 b	8.2 ± 5.5 ab	10.3 ± 3.9 a	0.5 ± 0.3 b	1.7 ± 0.4 b
July	28.0 ± 7.0 b	26.7 ± 11.4 b	7.8 ± 1.9 b	24.0 ± 7.1 a	3.7 ± 0.3 b	4.4 ± 3.3 ab	0.9 ± 0.5 ab	0.9 ± 0.5 b
August	9.0 ± 2.3 b	44.9 ± 2.3 a	12.6 ± 5.7 b	10.0 ± 5.3 ab	4.8 ± 3.8 b	0.4 ± 0.2 b	6.5 ± 2.8 a	1.8 ± 0.6 b
September	8.5 ± 0.8 b	22.7 ± 4.2 b	39.2 ± 5.9 a	10.0 ± 1.1 ab	8.0 ± 5.0 ab	1.6 ± 0.3 b	7.9 ± 3.2 a	1.0 ± 1.0 b
October	25.7 ± 16.9 b	14.6 ± 1.8 bc	15.0 ± 5.3 b	8.3 ± 8.3 ab	18.9 ± 6.0 a	0.0 ± 0.0 b	4.5 ± 2.4 ab	9.7 ± 3.5 a
November	25.4 ± 4.3 b	19.8 ± 1.3 b	11.9 ± 6.6 b	14.3 ± 6.9 ab	15.3 ± 0.5 ab	0.0 ± 0.0 b	4.5 ± 0.8 ab	4.5 ± 0.8 ab

Means followed by different letter in a column are significantly different at $P < 0.05$.

On multiple occasions, fire ant foragers were observed carrying fragments or whole bodies of wireworm, *Conoderus vespertinus* (Fabricius) and *C. falli* (Lane) larvae. Both are considered important economic pests of sweetpotatoes throughout sweetpotato growing states. Wireworm collection comprised 5.5% of the total Coleoptera recovered in this study. At no time did we observe damage to sweetpotato roots by fire ants. High temperatures and fire ant decapitating flies (Diptera: Phoridae) may significantly impede ant foraging activity (Porter & Tschinkel, 1987; Mottern *et al*., 2004). In this study occasional disruption in foraging activity was also observed when Phorid flies were seen hovering over the ant foraging trails. The parasitic flies were collected and identified as *Pseudacteon curvatus* Borgmeier (Vogt *et al*., 2008).

Imported fire ant foraging in sweetpotato can potentially reduce the insect pest numbers during favorable temperatures and in absence of Phorid flies.

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Disclosure

The authors have declared that there are no potential conflicts of interest, specific financial interests or relationships and affiliations pertaining to work described in this manuscript.

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