The Good Side of the Bad Guys: Predation of Lepidopteran Pests by Solenopsis invicta Buren (Hymenoptera: Formicidae) in the Florida Panhandle

Authors: Baldwin, Jessica, Paula-Moraes, Silvana V., and Pereira, Roberto

Source: Florida Entomologist, 103(1) : 68-71

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.103.0411

The good side of the bad guys: predation of lepidopteran pests by *Solenopsis invicta* Buren (Hymenoptera: Formicidae) in the Florida Panhandle

Jessica Baldwin[1], Silvana V. Paula-Moraes[1,], and Roberto Pereira[2]*

Abstract

Solenopsis invicta Buren (Hymenoptera: Formicidae) is an aggressive invasive species in many parts of the world, including the southeastern USA. The objectives of this study were to document *S. invicta* occurrence and predation potential of lepidopteran pests in peanut and cotton fields in the Florida Panhandle. The predation potential of *S. invicta* on *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae) was evaluated in experimental areas of peanut and cotton at the West Florida Research and Education Center, University of Florida/IFAS, Jay, Florida, USA, during 2 crop seasons. Overall, we found a beneficial aspect of this invasive species in the agroecosystems of the Florida Panhandle.

Key Words: red imported fire ant; invasive species; agroecosystem; *Helicoverpa zea*; egg predation

Resumo

Solenopsis invicta Buren (Hymenoptera: Formicidae) e uma espécie invasora em muitos países, incluindo a região sudoeste dos Estados Unidos. O objetivo deste trabalho foi documentar a ocorrência de *S. invicta* e seu potencial de predação de ovos de Lepidoptera nas culturas do amendoim e algodão na região da Florida Panhandle. O potencial de predação de *Helicoverpa zea* por *S. invicta* foi avaliado em áreas experimentais, durante duas safras de amendoim e algodão na West Florida Research and Education Center, University of Florida/IFAS, Jay, Florida, USA. A ocorrência de *S. invicta* foi maior na cultura de amendoim do que no algodão. A contribuição deste trabalho é documentar a função de inimigo natural de uma especie invasora na região de Florida Panhandle.

Palavras Chave: formiga lava-pé; species invasoras; agroecossistema; *Helicoverpa zea*; predação de ovos

Solenopsis invicta Buren (Hymenoptera: Formicidae) is an invasive species that originates from central South America (Allen et al. 1974; Klotz et al. 2008; Ascunce et al. 2011). Members of this genus are most often transported in soil or untreated wooden materials that are shipped by ocean vessels, aircraft, and vehicles (Stanaway et al. 2001; Belton 2002; Klotz et al. 2008). Presently, this species is established in the southeastern USA, southern California, China, Australia, Mexico, Hong Kong, Puerto Rico, and several Caribbean islands (Klotz et al. 2008; Ascunce et al. 2011). Economic impact caused by *S. invicta* in the southern USA was estimated to be around $6 billion annually (Lard et al. 2006), and causing serious injury to humans, crops, livestock, pets, and wild animals (Klotz et al. 2008).

Solenopsis invicta may cause damage to some crops, such as potato (*Solanum tuberosum* L.; Solanaceae) (Adams et al. 1988) and soybean (*Glycine max* (L.) Merr.; Fabaceae) (Shatters & Vander Meer 2000). Injury to potatoes often results in increased crop culls and grading time, as well as damage to tubers (Adams et al. 1988). In soybean, the root (Shatters & Vander Meer 2000) and foliage Smittle et al. 1983) of the early plant stage may be damaged by *S. invicta* directly feeding on them. In addition, some of the yield loss in soybean caused by this species may be associated with the difficulty of harvesting equipment to access fields due to the presence of fire ant mounds (Adams et al. 1977; Lofgren & Adams 1981).

In Alabama, Georgia, and Texas, the predation potential of agronomic pests by *S. invicta* in agroecosystems has been reported especially on various stages of lepidopteran pests (Ruberson et al. 1994; Diaz et al. 2004; Styrsky & Eubanks 2010; Wickings & Ruberson 2016). Foraging individuals on plant canopies of cotton (*Gossypium hirsutum* L.; Malvaceae) and peanut (*Arachis hypogaea* L.; Fabaceae) have played a role as predators by removing the eggs of *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae) (Diaz et al. 2004; Wickings & Ruberson 2016). A previous report by Diaz et al. (2004) also indicated that early in the cotton season, *S. invicta* populations are attracted to the honeydew produced by aphid populations. Later in the season, fire ants become an important predator of lepidopteran pests by decreasing egg abundance (Styrsky & Eubanks 2010). These authors concluded that the reduction of herbivores in cotton by *S. invicta* and its association with cotton aphids increased the production of cotton bolls by 16% compared with plants without aphids and *S. invicta*.

Two species of *Solenopsis* have been reported in Florida, *S. invicta* and *Solenopsis geminata* (Fabricius) (Hymenoptera: Formicidae) (Collins & Scheffrahn 2016). However, there is a lack of information about this genus in the Florida Panhandle. This region consists of forested areas and field crops. Peanut and cotton are the prevalent crops with approximately 150,000 and 100,000 acres (61,000 and 40,500 ha, re-

[1]University of Florida, West Florida Research and Education Center, Department of Entomology and Nematology, Jay, Florida 32565, USA;
E-mail: jessicabaldwin2013@gmail.com (J. B.), paula.moraes@ufl.edu (S. V. P. M.)
[2]University of Florida, Department of Entomology and Nematology, P.O. Box 110620, Gainesville, Florida 32611-0620, USA; E-mail: rpereira@ufl.edu (R. P.)
*Corresponding author; E-mail: paula.moraes@ufl.edu

spectively) produced in the region, respectively. (USDA-NASS 2019). The objective of this study was to document *Solenopsis* spp. occurrence and predation potential of lepidopteran pests associated in cotton and peanut in the Florida Panhandle.

Materials and Methods

STUDY AREA

The occurrence and predation potential of *S. invicta* to *H. zea* was evaluated in experimental areas of cotton and peanut under conventional tillage during the 2017 and 2018 crop seasons at the West Florida Research and Education Center, UF/IFAS, Jay, Florida, USA (30.7771389°N, 87.1414444°W). The experimental areas were planted with Georgia 06G peanuts and non-Bt DP1441RF cotton (Delta and Pine Land Company, Scott, Mississippi, USA). Cotton (Wright et al. 2017) and peanut (Wright et al. 2016) were cultivated following the agronomic recommendations of the above researchers for the Florida Panhandle, and were conventionally tilled. The occurrence of insect pests in the experimental areas were scouted during the crop season, where defoliation and feeding on young growth parts of plants by ants in each commodity were not detected. The experimental areas did not receive insecticide applications. In the 2017 crop season, irrigated cotton and irrigated peanut were planted on 6 Jun whereas another field of each crop, planted on 26 May, was cultivated under rain-fed conditions. In the 2018 crop season, cotton under rain-fed conditions was planted on 17 May and peanut under rain-fed conditions was planted on 5 May. In the 2017 crop season, the experimental areas of cotton and peanut under irrigation and rain-fed conditions were replicated twice. Each experimental area consisted of 8 rows of 100 feet, with cotton planted at 2 seeds per foot, and peanut planted at 6 seeds per foot. In the 2018 crop season, experimental areas were cultivated only under rain-fed conditions. The experimental areas for cotton and peanut had 8 replications. The experimental area consisted of 8 rows of 100 feet with cotton planted at 2 seeds per foot and peanut planted at 6 seeds per foot.

SOLENOPSIS INVICTA OCCURRENCE

Solenopsis invicta was sampled in the canopy and ground positions, in cotton and peanut fields. Sampling consisted of baiting flip-top tubes (50-mL plastic tube, SKS Science, Saratoga Springs, New York, USA) with 5 grams of beef and pork hotdog (Oscar Mayer, Kraft Heinz Company, Glenview, Illinois, USA) (Wickings & Ruberson 2011). Tubes were placed within the 3 central plot rows for a total of 30 bait stations per plot. Samples were collected after 1 h. Contents were preserved in 80% ethanol and transported to the entomology laboratory at West Florida Research and Education Center, UF/IFAS, Jay, Florida, USA, for species identification. Identification of *S. invicta* was based on the morphological characteristics as reported by Klotz et al. (2008). In the 2017 crop season, abundance of *S. invicta* from samples were ranked on a scale of 0, 1, 5, 10, 50, 100, and > 100 ants per sample. In the 2018 crop season, the actual number of *S. invicta* collected in each flip-top tube was counted, and the associated crop phenological stage recorded.

SOLENOPSIS INVICTA EGG PREDATION

Predation potential of *S. invicta* in cotton and peanut fields was evaluated in the 2018 crop season. Evaluation was performed using eggs of *H. zea*, previously obtained from a colony established in the entomology laboratory in West Florida Research and Education Center, UF/IFAS. Paper towel (Great Value™ Ultra-strong, Bentonville, Arkansas, USA) was used as an oviposition substrate in cages with *H. zea* adults. The paper towel was cut in pieces with 15 to 30 eggs per piece. Artificial field egg infestation of plants was done by stapling pieces of paper towel with eggs of *H. zea* to the underside of mid-canopy leaves in cotton and peanut experimental areas. Eggs were monitored at 1 and 2 h for *S. invicta* presence. After 24 h, paper towels were collected from the leaves and the number of remaining eggs recorded.

STATISTICAL ANALYSIS

Data from the 2017 and the 2018 crop seasons were analyzed separately. A Pearson's Chi-squared test was performed to test the expected values against the actual values for fire ant occurrence of the 2017 crop season (R Core Team 2018). During this season, the factors of irrigation and canopy position were evaluated. Egg predation and *S. invicta* abundance data in the 2018 crop season was subjected to ANOVA. Occurrence variables were compared considering canopy position and crop phenological stage. For evaluation of egg predation in the 2018 crop season, the number of eggs remaining after 24 h of exposure to fire ant predation in cotton and peanut were compared between crops. Differences in all analyses were considered significant at $P < 0.05$.

Results

SOLENOPSIS INVICTA OCCURRENCE

Solenopsis invicta was the only species observed during the 2017 and 2018 crop seasons in both commodities. Occurrence of *S. invicta* in irrigated and rain-fed experimental areas was not significantly different in cotton ($\chi^2 = 11.58$; df = 6; $P > 0.05$) or in peanut ($\chi^2 = 10.11$; df = 5; $P > 0.05$). However, a significant difference was observed between the occurrence of *S. invicta* on canopy and ground for cotton ($\chi^2 = 20.68$; df = 6; $P < 0.05$) and peanut ($\chi^2 = 48.69$; df = 5; $P < 0.0001$) with higher numbers of *S. invicta* workers collected on the ground than the canopy (Figs. 1 & 2).

In the 2018 crop season there was no difference in the presence of *S. invicta* during different cotton phenological stages ($F = 2.879$; df = 2; $P > 0.05$). There was a significant difference between *S. invicta* occurrence in different cotton canopy positions during flowering ($F = 21.70$; df = 1; $P > 0.0001$) and flowering-open boll ($F = 19.28$; df = 1; $P > 0.0001$) with more *S. invicta* occurring on the ground than the canopy (Fig. 3). The same result was observed for peanut during different crop phenological stages ($F = 6.032$; df = 2; $P < 0.05$), with an increase in ant occurrence as the crop season progressed. Density of *S. invicta* in the peanut canopy was significantly different at the pegging-mature pod

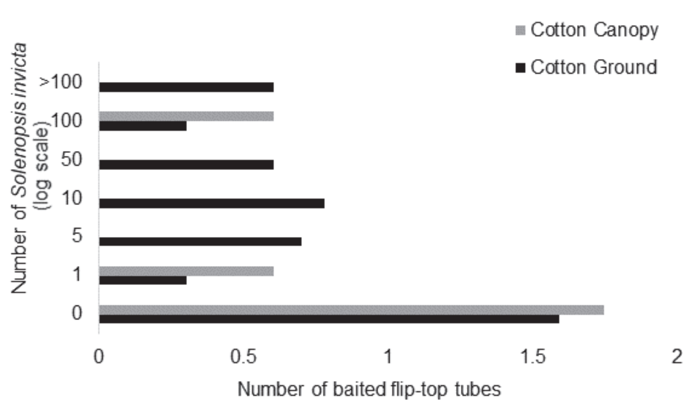

Fig. 1. Occurrence of *Solenopsis invicta* in hotdog-baited flip-top tubes placed on the ground and on the canopy of cotton fields during the 2017 crop season (log scale). West Florida Research and Education Center, Jay, Florida, USA. *P*-values from Pearson's Chi Square analysis ($\chi^2 = 20.68$; df = 6; $P = 0.0021$).

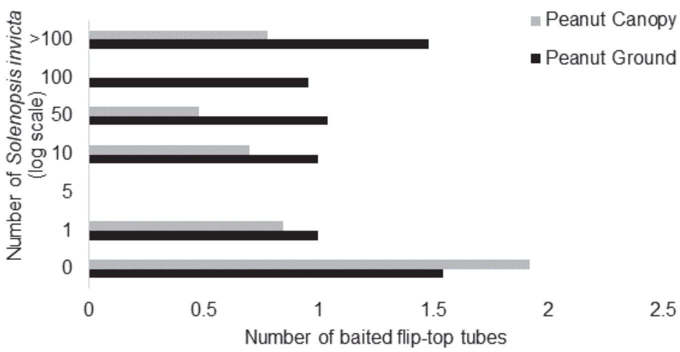

Fig. 2. Occurrence of *Solenopsis invicta* in hotdog-baited flip-top tubes placed on the ground and on the canopy of peanut fields during the 2017 crop season (log scale). West Florida Research and Education Center, Jay, Florida, USA. *P*-values from Pearson's Chi Square analysis ($\chi^2 = 48.69$; df = 5; $P = 2.7 \times 10^{-9}$).

stage ($F = 10.55$; df = 1; $P < 0.05$) with more *S. invicta* occurring on the ground than the canopy (Fig. 4), but not during the peanut flowering stage ($F = 2.081$; df = 1; $P > 0.05$).

Overall, *S. invicta* occurrence increased during reproductive stages of cotton and peanut with the ants' presence greater on the ground than the canopy (Figs. 3 & 4).

SOLENOPSIS INVICTA EGG PREDATION

Predation of *H. zea* eggs was detected in cotton and peanut plant canopies. The difference in *H. zea* egg predation between both commodities was significant ($F = 32.97$; df = 1; $P > 0.0001$). More eggs were removed from peanut than cotton. Over half of the eggs placed within either of the experimental areas were removed from the plant canopy after 24 h (Table 1).

Discussion

In the agroecosystem, *S. invicta* can best be described as a generalist predator, because this species is a predator of pest species and their natural enemies, such as *Syrphus* sp. (Diptera: Syrphidae) and *Hippodamia convergens* Guérin-Méneville (Coleoptera: Coccinellidae) (Vinson & Scarborough 1989). The potential pest predation by *S. invicta* has been reported in several agroecosystems. According to Olson and Ruberson (2012), the most important predator of stink bug eggs in cotton was *S. invicta*. A field study in corn (Knutson & Campos 2008) provided evidence that *S. invicta* greatly reduced pre-pupa of *H. zea* when getting ready for pupation on the ground, although this ant was not effective in reducing the population of larvae and eggs within the corn canopy. In our study, greater numbers of eggs were removed from the peanut than cotton field. Peanut is a prostrate plant, so it spreads just above the ground, unlike cotton, where the canopy is erect and away from the soil. The close proximity of peanut plants to the soil favors greater foraging access of *S. invicta* to *H. zea* eggs. The greater than 50% predation of *H. zea* eggs in the canopy of all sampled areas we observed is similar to the egg removal of lepidopteran pests documented in Georgia and central Texas (Ruberson et al. 1994; Diaz et al. 2004). Moreover, the position of *S. invicta* on a crop was reported to be influenced by *Aphis gossypii* Glover (Hemiptera: Aphididae) infestation (Kaplan & Eubanks 2002; Styrsky & Eubanks 2010), and potentially other honeydew producing hemipterans. The foraging behavior of *S. invicta* on the cotton plant canopy was reported to be more often on plants with *A. gossypii* than plants without *A. gossypii* (Kaplan & Eubanks 2002; Styrsky & Eubanks 2010). The infestation of aphids in the experimental areas of the present study was inspected and was extremely low during both crop seasons. Thus, the potential effect of aphids on *S. invicta* canopy presence in peanut and cotton was unable to be evaluated.

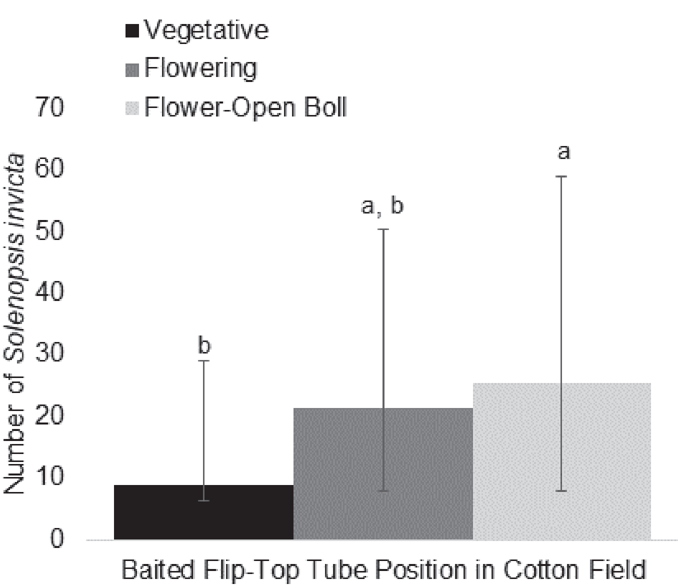

Fig. 3. Comparison of mean *Solenopsis invicta* between cotton canopy zones during different phenological stages, 2018 crop season. West Florida Research and Education Center, Jay, Florida, USA. Means with different letters are significantly different $P < 0.05$ (Tukey's mean separation test).

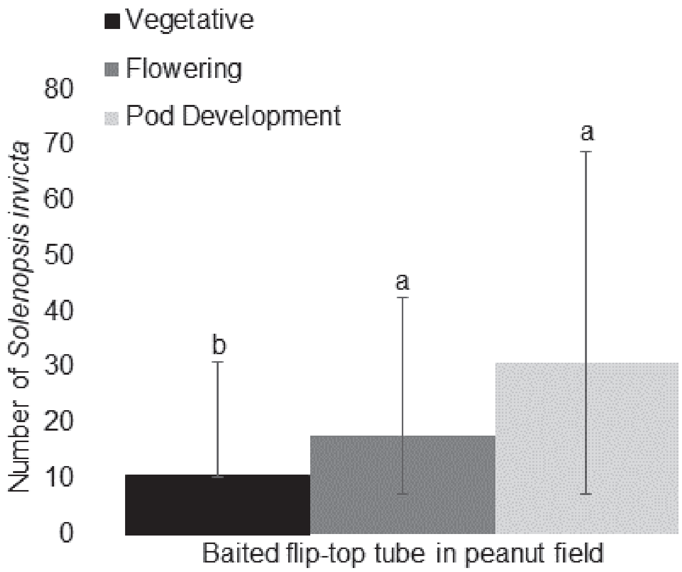

Fig. 4. Occurrence of *Solenopsis invicta* in different peanut phenological stages during the 2018 crop season. West Florida Research and Education Center, Jay, Florida, USA. Means with different letters are significantly different $P < 0.05$ (Tukey's mean separation test).

Table 1. Predation of *Helicoverpa zea* eggs by *Solenopsis invicta* in cotton and peanut fields. West Florida Research and Education Center, Jay, Florida, USA, 2018 crop season.

Field	Number of eggs placed per field	Number of samples with presence of *S. invicta*		% Egg loss
		After 1 h	After 2 h	
Cotton	80	15	34	60.0
Peanut	79	34	67	96.2

We found that *S. invicta* was the only ant species detected in samples collected during the 2017 and 2018 crop seasons. Previous studies performed in cotton, peanut, and corn in the southeastern USA also reported the occurrence of *S. invicta* associated with these agroecosystems (Ruberson et al. 1994; Diaz et al. 2004; Olson & Ruberson 2012). The potential to decrease the abundance and diversity of other ant species in systems where *S. invicta* is present has been documented previously (Porter & Delores 1990). Porter and Delores (1990) reported that the occurrence of *S. invicta* in natural areas caused a 70% decline in native ant species.

Predation by *S. invicta* could play an important (but unrecognized) role in the control of lepidopteran pests in the Florida Panhandle by decreasing the demand for insecticide applications in peanut and cotton. Moreover, the suppression of pest populations targeted by Bt cotton may consequently decrease the selection pressure for resistance in the Florida Panhandle. More importantly, the actual extent of yield loss due to *S. invicta* in the region has not been documented and reports from farmers have not indicated any damage in cotton and peanut. However, in areas where *S. invicta* has become established already, the role and value of this invasive ant species as beneficial predators in agroecosystems should be considered.

Acknowledgments

This study is based on work supported by the National Institute of Food and Agriculture, USDA, NIFA CPPM EIP project no. 005649, NIFA hatch project No. 00558, and 2017–2019 Florida Checkoff funds.

References Cited

Adams CT, Banks WA, Lofgren CS. 1988. Red imported fire ant (Hymenoptera: Formicidae): correlation of ant density with damage to two cultivars of potatoes (*Solanum tuberosum* L.). Journal of Economic Entomology 81: 905–909.

Adams CT, Plumley JK, Banks WA, Lofgren CS. 1977. Impact of red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae) on harvest of soybean in North Carolina. Journal of the Elisha Mitchell Society 93: 150–152.

Allen G, Buren W, Williams R, Menezes M, Whitcomb W. 1974. The red imported fire ant, *Solenopsis invicta*; distribution and habitat in Mato Grosso, Brazil. Annals of the Entomological Society of America 67: 43–46.

Ascunce M, Yang C, Oakey J, Calcaterra L, Wu W, Shih C, Goudet J, Ross K, Shoemaker D. 2011. Global invasion history of the fire ant *Solenopsis invicta*. Science 331: 1066–1068.

Belton D. 2002. Hazard identification and import release assessment: the introduction of red imported fire ants into New Zealand via the importation of goods and arrival of craft from Australia, the Caribbean, South America, and the USA. Ministry of Agriculture and Forestry, Wellington, New Zealand.

Collins L, Scheffrahn RH. 2016. Red imported fire ant, *Solenopsis invicta* Buren (Insecta: Hymenoptera: Formicidae: Myrmicinae). UF/IFAS Extension publication EENY-195. Department of Entomology and Nematology, University of Florida, Gainesville, Florida, USA.

Diaz R, Knutson A, Bernal J. 2004. Effect of the red imported fire ant on cotton aphid population density and predation of bollworm and beet armyworm eggs. Journal of Economic Entomology 97: 222–229.

Kaplan I, Eubanks M. 2002. Disruption of cotton aphid (Homoptera: Aphididae) - natural enemy dynamics by red imported fire ants (Hymenoptera: Formicidae). Environmental Entomology 31: 1175–1183.

Klotz J, Hansen L, Pospischil R, Rust M [eds.]. 2008. Urban Ants of North America and Europe: Identification, Biology, and Management. Cornell University Press, New York, USA.

Knutson A, Campos M. 2008. Effect of red imported fire ant, *Solenopsis invicta* on abundance of corn earworm, *Helicoverpa zea*, on maize in Texas. Southwestern Entomologists 33: 1–13.

Lard CF, Schmidt J, Morris B, Estes L, Ryan C, Bergquist D. 2006. An economic impact of imported fire ants in the United States of America. Department of Agricultural Economics, Texas A&M University, Texas Agricultural Experiment Station, College Station, Texas, USA.

Lofgren CS, Adams CT. 1981. Reduced yield of soybeans in fields infested with the red imported fire ant, *Solenopsis invicta* Buren. Florida Entomologist 64: 199–202.

Olson D, Ruberson J. 2012. Crop-specific mortality of southern green stink bug eggs in Bt- and non-Bt cotton, soybean and peanut. Biocontrol Science and Technology 22: 1417–1428.

Porter S, Dolores S. 1990. Invasion of polygyne fire ants decimates native ants and disrupts arthropod community. Ecology 71: 2095–2106.

R Core Team. 2018. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Ruberson J, Herzog G, Lambert W, Lewis J. 1994. Management of the beet armyworm (Lepidoptera: Noctuidae) in cotton: role of natural enemies. Florida Entomologist 77: 441–453.

Shatters RG, Vander Meer RK. 2000. Characterizing the interaction between fire ants (Hymenoptera: Formicidae) and developing soybean plants. Journal of Economic Entomology 93: 1680–1687.

Smittle BJ, Adams CT, Lofgren CS. 1983. Red imported fire ants: detection of feeding on corn, okra, and soybeans with radioisotopes. Journal of the Georgia Entomological Society 18: 78–82.

Stanaway MA, Zalucki MP, Gillespie PS, Rodriguez CM, Maynard GV. 2001. Pest risk assessment of insects in sea cargo containers. Australian Journal of Entomology 40: 180–192.

Styrsky J, Eubanks M. 2010. A facultative mutualism between aphids and an invasive ant increases plant reproduction. Ecological Entomology 35: 190–199.

USDA-NASS – United States Department of Agriculture–National Agricultural Statistics Service. 2019. Southern region news release crop values. United States Department of Agriculture–National Agricultural Statistics Service Southern Region. https://www.nass.usda.gov/Statistics_by_State/Regional_Office/Southern/includes/Publications/Crop_Releases/Crop_Values/CropValues2018.pdf (last accessed 16 Dec 2019).

Vinson S, Scarborough T. 1989. Impact of the imported fire ant on laboratory populations of cotton aphid (*Aphis gossypii*) predators. Florida Entomologist 72: 107–111.

Wickings KG, Ruberson J. 2011. Impact of the red imported fire ant (Hymenoptera: Formicidae) on epigeic arthropods of cotton agroecosystems. Annals of the Entomological Society of America 104: 171–179.

Wickings KG, Ruberson J. 2016. The red imported fire ant, *Solenopsis invicta*, modified predation at the soil surface and in cotton foliage. Annals of Applied Biology 169: 319–328.

Wright D, Small I, DuFault N. 2017. Cotton cultural practices and fertility management. UF/IFAS Extension publication SS-AGR-194. University of Florida, Gainesville, Florida, USA.

Wright D, Tillman B, Small I, Ferrell J, DuFault N. 2016. Management and cultural practices for peanuts. UF/IFAS Extension publication SS-AGR-74. University of Florida, Gainesville, Florida, USA.