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NATURAL PLANT MATERIALS AS OVERWINTERING SITES FOR ARTHROPODS IN THE COASTAL PLAIN OF SOUTH CAROLINA

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ABSTRACT

Six types of plant materials, grass hay, wheat straw, pine needles, woods litter, corn stalks and husks, and broomsedge grass clumps were compared in small plots as sites for overwintering arthropods. Significant differences were found between numbers of some insects in the materials, with the coccinellids primarily overwintering in the broomsedge clumps, while Staphylinids preferred Bermuda grass hay and wheat straw. Overall, a limited number of important predaceous and phytophagous species were found in the different materials. There were significant differences in the number of arthropods depending upon where the materials were placed in relation to open field or field edges.

RESUMEN

Se compararon en parcelas pequeñas seis tipos de materiales de plantas, heno de pastos, paja de trigo, agujas de pino, rastrojo de arboles, caña y chalas de maiz, y pasto escoba de junco, como lugares de hibernacion de artropodos. Se encontraron diferencias significativas entre los materiales en los numeros de algunos insectos, con los coccinelidos hibernando primeramente en el pasto escoba de junco, mientras que los Staphylinidos prefirieron el heno de pasto Bermuda y la paja de trigo. Sobretodo se encontro, un numero limitado de predatores importantes y especies fitofagos en los diferentes materiales, dependiendo del sitio donde se colocaron los materiales en relacion con un campo abierto on con el margen del campo.

In temperate and cold climates, arthropods have evolved a number of strategies for surviving the winter months. The habitats chosen by arthropods for overwintering are quite variable but relatively specific for individual species. Some of the early work on arthropod overwintering in the United States was done by Blatchley (1895) in Indiana

and Holmquist (1926) in Illinois. They made detailed observations of individual species and their location during the winter months. Rainwater (1941) listed several hundred species of insects that were collected from samples of woods trash, Spanish moss, cotton gin trash, and wild cotton. The majority of specimens were found in the woods trash samples. Kirk & Taft (1970) identified 405 species of Coleoptera collected during the winter in South Carolina from woods trash samples. These included 35 well-known crop pests and over 100 species from families that are mostly predaceous. Jones and Sullivan (1981) determined the overwintering sites and spring emergence patterns of 47 hemipterous species found in woods trash and open field habitats in South Carolina.

In Florida, Plagens & Whitcomb (1986) examined corn residues for overwintering arthropods and found 24 species of spiders and 25 species of predaceous Coleoptera, Hemiptera and Dermaptera. Magnolia leaf litter was found to provide overwintering sites for a large number of arthropods in Pennsylvania, including 25 heteropterans such as *Lygus lineolaris* (Palisot de Beauvois) and *Nabis roseipennis* Reuture (Wheeler & Stimmel 1988). The overwintering behavior of the predaceous Coccinellidae has been reviewed by Hagen (1962) and Hodek (1967).

There are numerous other articles in the literature on the overwintering habits of specific arthropods, but few that deal with habitat conservation and man-made or provided habitats for overwintering arthropods. In England, a great deal of research has been conducted on the relationship between winter crops, uncultivated areas, and hedgerows on the occurrence and distribution of pest and predatory arthropods (van Emden 1963, 1965, Lewis 1965, Sotherton 1984). Their efforts have shown direct relationships between habitats and ensuing populations of arthropods.

In the United States, Tamaki & Halfhill (1968) used bands of sheet aluminum lined with heavy paper and tarred burlap around the main branches of peach trees to provide shelter for predators of the green peach aphid. They found that several species of predators successfully used the bands for overwintering, but only a few pest insects used the bands for shelter. In a similar experiment, Mizell & Schiffhauer (1987) tested burlap bands, Coolpad* filters, layered cardboard and natural tree bark as overwintering sites for predators in pecan orchards. They reported all of the habitat types were useful for monitoring some arthropods but none appeared useful for augmenting overwintering populations. In another study, Fye (1985) constructed traps of layered corrugated fiberboard that effectively substituted for natural overwintering sites for some predators in pear orchards.

The purpose of the present study was to determine if several native materials located in field crop areas in South Carolina could serve as overwintering sites for arthropods and to record the important species of predaceous and phytophagous arthropods that were present in each type of material.

Materials and Methods

A 6.9-ha field surrounded by largely undisturbed mixed deciduous and pine woodlands on the Pee Dee Research and Education Center, Florence, South Carolina was chosen for this study. The field is primarily used for experimental plots of cotton and tobacco with areas of mixed weeds and grasses. In September 1987, 4 replicates of 6 different plant materials—wheat straw, mixed deciduous woods litter, pine straw, Bermuda grass hay, corn stalks and husks, and broomsedge plants (*Andropogen virginicus* L.) (8 plants/plot—were installed in the middle (2 replicates) and along the SW side (2 replicates) of the field. Each plot of plant materials within a replicate was assigned position at random and separated by 4.5 m. Replicates were approximately 100 m apart in all directions.

Plant materials were piled to an approximate depth of 15 cm, except for the broomsedge plants, which were 15-20 cm in base diameter and approximately 0.75 m tall when

transplanted into the plots. No retaining barriers were used around the plots, but frequent checks were made during the winter to ensure that the plots were not scattered by animals or weather. The experiment was repeated in the same field in 1989-90, but with 2 more replications of each plot added so that there were 3 plots of each of the 6 types of plant material in the middle of the field, and 3 plots along the SW edge of the field. During both years the field was left fallow following crop harvest and removal of the plot materials for examination. Plots were established between 22 June and 20 September, whenever the various materials were available or best suited for transplanting (broomsedge).

During the period 27 January-8 March 1988 and 12 December 1989-1 March 1990, the plant materials within each plot were collected down to bare soil, placed in cloth bags, and brought into a field laboratory for examination. The plant materials were examined on a steel-topped table underlayed with electric resistance heat coils that maintained a temperature of approximately 44°C. Examination time varied tremendously between the different materials due to the materials themselves and moisture content when collected, but normally samples were held on the table until the material temperature reached that of the table, and/or no further arthropods were found in the material. All arthropods emerging or found alive in the materials were placed in 70% ethyl alcohol until they could be identified. Plot materials were kept in the bags in a large walk-in cooler maintained at 7±2°C until they could be examined. The arthropod collections were sorted and identified to groups or common species, and the number occurring in the various materials were compared using Fisher's Protected LSD at $P = 0.05$ after data transformation using the formula $\sqrt{n + 0.5}$. Data transformation was performed to allow analysis between groups of arthropods that varied widely in numbers in the different overwintering materials and locations. Major arthropod groups such as the spiders, carabids, etc. were grouped for analysis and most species were not identified to species unless indicated. Specimens identified to species are deposited in the collection of Clemson University at the Pee Dee Research and Education Center, Florence, South Carolina. Unless otherwise noted, all identifications were performed by the author.

Results and Discussion

A great many arthropod species were found overwintering in the different plant materials, and significant differences occurred between overall numbers of arthropods, individual insect groups, species, and plot location. Since the purpose of the experiment was to record the overwintering of predaceous and phytophagous arthropods of importance in field crops, many species observed were omitted from the results.

1987-88 Study

Interaction between the location and plant materials within the field affected the numbers of arthropods, especially the coccinellids, *Hippodamia convergens* (Guerin-Meneville) and *Coccinella septempunctata* (L), that overwintered in some plots. Broomsedge located in full-day sunlight held the largest number of overwintering *H. convergens*, and total arthropods collected (due to the higher number of *H. convergens* found) (Table 1). Plots located adjacent to the woods that received a half day or less of sunlight consistently held less coccinellids than the fully exposed plots. Only a few *H. convergens* were found in the other five types of plant materials, regardless of where they were located. *Coccinella septempuncata* is an introduced species that became established in the South Carolina Coastal Plain area in 1984 (personal observations). This species also preferred broomsedge and was not found in any other materials except pine straw.

TABLE 1. Arthropods found in 6 different types of overwintering materials whose distribution was influenced by habitat and location. 1987-1988.

Species	Shade	Mean No. per 1x2 m plot[1]					
		Broom sedge	Pine Straw	Bermuda grass hay	Wheat straw	Deciduous woods litter	Corn stalks
Hippodamia convergens	yes	1.5+1.2	0.7+0.0	0.7+0.0	1.1+0.6	1.2+0.0	1.0+0.4
	no	39.9+20.4	4.9+0.8	2.0+1.0	3.5+2.0	4.5+1.4	2.3+1.5
Coccinella septempunctata	yes	1.0+0.4	0.7+0.0	0.7+0.0	0.7+0.0	0.7+0.0	0.7+0.0
	no	4.7+0.1	1.0+0.4	0.7+0.0	0.7+0.0	0.7+0.0	0.7+0.0
Total arthropods	yes	8.7+1.5	8.6+0.9	11.1+1.1	7.3+0.4	7.8+1.0	5.3+1.4
	no	41.0+20.9	8.5+0.5	13.6+0.7	9.8+2.0	8.5+1.6	5.7+1.8

[1]Means ± SD. Data transformed by $\sqrt{N+0.5}$. Habitat x location interaction LSD's using Fishers Protected Test at P = 0.05; Hippodamia = 12.5; Coccinella = 0.36; Total arthropods = 13.4.

TABLE 2. Predaceous arthropods found in 6 different types of plant materials provided as overwintering sites during 1987-1988.

Species	Mean No. per 1x2 m plot[1]					
	Broom sedge	Pine Straw	Bermuda grass hay	Wheat straw	Deciduous woods litter	Corn stalks
Coleomegilla maculata (D-G)	2.8±1.1 a	0.7±0.0 b	0.8±0.3 b	0.7±0.0 b	1.0±0.3 b	0.8±0.3 b
Carabids[2]	3.3±1.1	3.5±1.0	2.1±0.5	1.8±1.2	2.5±1.3	1.8±0.3
Staphylinids[2]	1.9±1.2 b	2.0±0.6 b	9.7±2.2 a	3.5±0.7 b	1.7±1.0 b	2.2±0.8 b
Scymnus spp.[3]	1.1±0.7	0.7±0.0	0.8±0.3	0.8±).3 b	0.7±0.0	0.7±0.0
Spiders[2]	3.0±1.4	2.9±0.6	2.9±1.0	2.5±0.3	3.3±0.6	1.6±0.8
Harvestmen[4]	0.7±0.0 b	2.9±1.9 a	2.9±1.2 a	2.6±1.3 a	2.5±0.7 a	2.2±0.7 a
Geocoris spp.[5]	1.1±0.7 ab	1.3±0.7 ab	1.7±2.0 a	1.9±2.0 a	1.1±0.4 ab	0.8±0.3 b
Reduviids[2]	1.0±0.4	0.7±0.0	0.8±0.3	0.9±0.4	0.8±0.3	0.8±0.3

[1]Means ± SD. Data transformed by $\sqrt{N+0.5}$. Row means followed by same letters are not significantly different, using Fisher's Protected LSD at P = 0.05. No letter indicates nonsignificance.
[2]Mixed species.
[3]*Scymnus loweii, S. creperus.*
[4]*Hadrobunus* spp., Opiliones: Gagrellildae (Identified by Dr. James Cokendolpher).

Other predaceous arthropods found in the plots are shown in Table 2. *Coleomegilla maculata* (De Geer) occurred most frequently in broomsedge and only a few were found in any of the other materials. The carabids were found in broomsedge and pine straw more than the other materials except for woods litter. In previous surveys of undisturbed woods litter Kirk & Taft (1970), and Rainwater (1941) reported 47 and 53 species of carabids, respectively, as occurring in the Coastal Plain area of South Carolina. The Staphylinids occurred significantly more often in Bermuda grass hay. This is another large family with 50 species previously reported by Kirk & Taft (1970) and 37 species by Rainwater (1941) from the Coastal Plain area. A few *Scymnus* beetles, primarily *S. loewii* and *S. creperus* were found overwintering in 3 of the plots, but numbers were insignificant.

The spiders as a group were fairly evenly distributed among the plots, as were the harvestmen (primarily *Hadrobunus* spp.), *Geocoris*, spp., and reduviids. Many of the specimens of these groups collected except *Geocoris*, were immature, and species identifications were not attempted. A few phytophagous species of insects were found in the plots, but none of the known crop nests were found in significant numbers in any habitat (Table 3). This was somewhat unexpected since several species of pentatomids, *L. lineolaris*, and many other phytophagous species are known to overwinter in woods litter (Rainwater 1941). Only one rice stink bug, (*Oebalus pugnax* (Fabricius) and one *Thyanta custator* (Fabricius) were taken from the plots (both from woods trash), and no *L. lineolaris* were found in any of the materials. Crickets were found in all the different plant materials but slightly more frequently in the pine straw, woods litter and broomsedge.

Considering the total numbers of arthropods collected from the different plant materials, the broomsedge, primarily because of the large number of coccinellids, held the highest number of overwintering arthropods, followed by the Bermuda grass hay. However, excluding broomsedge, the other 5 plant materials harbored similar numbers of arthropods. Overall, the corn residues appeared to be the least attractive, since no groups or species inhabited this residue in significantly greater numbers than the other plant materials.

1989-90 Results

Interaction of location and plant materials occurred again in the 2nd year of the study, but the number and species of insects involved were different (Table 4). *Coccinella septempunctata* again showed distincly higher numbers in the unshaded broomsedge as did *Geocoris* spp., *L. lineolaris* and the other miscellaneous Heteroptera. *Hippodamia convergens* was present in much smaller numbers during 1989-90, but broomsedge contained higher numbers than the other materials (Table 5). High variability between the broomsedge locations is characteristic of this species since it aggregates in only a few sedge clumps in a field area regardless of the number of apparently suitable sites available. *Coleomegilla maculata* was present in slightly higher numbers than in the previous year of this study, and the broomsedge had significantly more beetles than the other materials. The carabids as a group also showed similar distributions in the materials as in 1987-88, with a fairly general scattering among the materials, Staphylinids were much more generally distributed in 1989-90 than in 1987-88, and no clear site preferences were noticeable. *Scymnus* spp. occurred in very low numbers during both years of the study and were not numerous enough to compare differences in locations in 1989-90.

Spiders as a group were more numerous the second year of the study in all plots, but little differences in number was noticeable except for a scarcity of spiders in the corn residues. The same was true of the harvestmen, which was different from 1987-88 only in that broomsedge was also populated by similar numbers as the other materials.

TABLE 3. Phytophagous insects found in 6 different types of plant material provided as overwintering sites during 1987-1988.

Species	Mean No. per 1x2 m plot[1]					
	Broom sedge	Pine Straw	Bermuda grass hay	Wheat straw	Deciduous woods litter	Corn stalks
Hemiptera-Heteroptera[2]	2.5+1.5	2.0+0.6	1.7+0.5	1.7+0.5	2.4+0.8	1.0+0.6
Flea beetles[2]	1.0+0.4	0.8+0.3	0.7+0.0	1.2+0.1	1.1+0.8	0.7+0.0
Crickets (*Cryllus* spp.)	2.6+1.5 ab	3.8+0.9 a	2.3+0.5 b	1.7+0.8 b	3.6+0.7 ab	2.3+1.0 b
Vegetable weevil[3]	1.3+0.4	0.9+0.4	1.3+0.7	0.8+0.3	0.8+0.3	0.8+0.3

[1]Means ± SD. Data transformed by $\sqrt{N+0.5}$. Row means followed by same letters are not significantly different, using Fisher's Protected LSD at P = 0.05. No letter indicates nonsignificance.
[2]Mixed species.
[3]*Listroderes costerostris obliquus* Klug.

TABLE 4. Insects found in 6 different types of overwintering materials whose distribution were influenced by habitat and location. 1989-1990.

Species	Shade	Mean No. per 1x2 m plot[1]					
		Broom sedge	Pine Straw	Bermuda grass hay	Wheat straw	Deciduous woods litter	Corn stalks
Coccinella septempunctata	yes	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.9±0.3	0.7±0.0
	no	5.9±2.5	0.7±0.0	0.7±0.0	0.9±0.3	0.7±0.0	0.7±0.0
Geocoris spp.[2]	yes	0.7±0.0	1.2±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0
	no	3.6±2.0	1.7±1.3	1.6±0.5	1.1±0.7	0.9±0.3	1.3±0.5
Lygus linolaris (P.B.)	yes	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0
	no	1.3±0.6	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0
Miscellaneous predators[3]	yes	1.1±0.3	0.9±0.3	0.7±0.0	0.7±0.0	0.9±0.3	0.9±0.3
	no	1.8±0.3	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.9±0.3
Miscellaneous Homoptera[4]	yes	0.7±0.0	0.7±0.0	0.7±0.0	0.9±0.3	0.7±0.0	0.7±0.0
	no	1.6±0.5	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.9±0.3

[1]Means ± SD. Data transformed by $\sqrt{N+0.5}$. Habitat x location interaction LDS's at P = 0.05: *Coccinella* = 126; *Geocoris* = 1.16; *Lygus* = 0.29, Misc. predators = 0.37; Mis. *Homoptera* = 0.31
[2]*Geocoris punctipes* Say, *G. uliginosus* Say, *G. floridanus* Blatchley.
[3]Primarily *Scymnus* spp.; *Notoxus* spp.

TABLE 5. Predaceous arthropods found in 6 different types of plant material provided as overwintering sites during 1989-1990.

Species	Mean No. per 1x2 m plot[1]					
	Broom sedge	Pine Straw	Bermuda grass hay	Wheat straw	Deciduous woods litter	Corn stalks
Hippodamia convergens (G-M)	3.2±4.6	0.8±0.2	0.9±0.3	0.7±0.0	0.8±0.2	0.9±0.4
Coleomegilla maculata (D-G)	4.4±2.8 a	0.9±0.6 b	0.7±0.0 b	0.7±0.0 b	0.7±0.0 b	0.8±0.2 b
Carabids[2]	3.3±0.6 a	2.4±1.8 ab	2.0±0.9 bc	2.1±0.6 bc	1.6±1.1 bc	1.3±040 c
Staphylinids[2]	1.8±0.6	2.6±1.5	3.2±1.4	1.4±1.1	1.4±0.8	2.5±1.0
Spiders[2]	4.0±1.3 abc	5.5±1.8 a	5.1±1.5 a	3.5±1.6 bc	4.2±2.7 ab	2.7±0.7 c
Harvestmen[3]	2.8±0.9	2.2±1.2	2.0±0.9	2.4±1.5	1.4±1.1	2.1±0.9
Assassin bugs[2]	1.2±0.4	1.1±0.3	0.8±0.2	1.2±0.6	1.0±0.4	0.9±0.4
Nabidae[4]	1.4±0.4 a	0.7±0.0 b	0.7±0.0 b	1.2±0.8 ab	0.7±0.8 b	1.1±0.5 ab

[1]Means ±SD. Data transformed by $\sqrt{N+0.5}$. Row means followed by same letters are not significantly different, using Fisher's Protected LSD at P = 0.05. No letter indicates nonsignificance.
[2]Mixed species.
[3]*Hadrobunus* spp., Opiliones: Gagrellidae (identified by Dr. James Cokendolpher).
[4]Primarily *Reduviolus* spp., *Hoplisloceles* spp. and *Nabis americoferus*.

TABLE 6. Phytophagous insects and total arthropods found in 6 different types of plant material provided as overwintering sites during 1989-1990.

Species	Mean No. per 1x2 m plot[1]					
	Broom sedge	Pine Straw	Bermuda grass hay	Wheat straw	Deciduous woods litter	Corn stalks
Crickets (*Gryllus* spp.)	1.1±0.5	1.7±1.0	1.9±0.5	1.4±0.8	1.6±0.4	1.6±0.8
Spotted cucumber beetles (*Diabrotica*)	0.9±0.6	1.1±0.7	0.7±0.0	1.0±0.6	0.8±0.2	0.9±0.5
Stink bugs[2]	0.9±0.3	1.2±0.4	0.9±0.6	1.0±0.4	1.0±0.6	0.9±0.3
Misc. Hemiptera[3]	4.8±1.7 a	2.2±0.9 b	1.7±1.1 b	2.1±1.8 b	1.6±1.1 b	1.3±0.6 b
Vegetable weevil[4]	1.7±0.7	1.5±0.7	1.10.6	1.6±0.8	0.9±0.4	1.2±0.5
Total arthropods	13.2±3.6 a	10.3±3.2 ab	9.6±1.4 b	8.7±2.9 bc	7.6±2.8 bc	6.6±0.9 c

[1]Means ± SD. Data transformed by $\sqrt{N+0.5}$. Row means followed by same letters are not significantly different, using Fisher's Protected LSD at P = 0.05. No letter indicates nonsignificance.
[2]8 *Thyanta* spp., 11 *Mormidea* spp.; 1 Oebalus pugnax; 1 *Brochymena* spp.; 1 *Acantholonidea*; 2 *Homaemus* spp.
[3]Mixed spp., primarily *Pachybrachia* spp., *Ischnodemus* spp.; *Arhyssus* spp., *Blissus* spp.
[4]*Listroderes costerostris obliquus* Klug.

Reduviids were found in low numbers in all materials in 1989-90 while nabids were more frequently collected than in the previous year. The nabid genera *Reduviolus* and *Hoplistoceles* were more frequently collected in 1989-90 and were responsible for the increases shown in Table 5.

Photophagous insects and total arthropods found in the various plant materials are shown in Table 6. Low numbers of pest insects were present in all the plant materials, just as in 1987-88. Most of the stink bug species collected are usually not serious crop pests (*Mormidea* spp.; *Thyanta* spp.) and the miscellaneous hemipteran species such as *Pachybrachia* and *Ischnodemus* are largely unknown as pests of agricultural crops. The vegetable weevil (*Listroderes costerostris obliquus* Klug) is a serious pest of many field crops and was relatively evenly distributed among the overwintering habitats and occurred in fairly low numbers.

Total arthropod numbers found in the various plant material plots were also similar to those found in 1987-88, except in magnitude. Overall, more arthropods were found in the broomsedge than any material except pine straw, while corn stalks and leaf litter remained low in numbers similar to the first year of the study.

The inability of the small plots of plant materials to attract many of the major predaceous or phytophagous species could be due to a number of factors, such as proximity to the much more expansive woodlands that satisfy climatic preferences such as shading, moisture level, and depth of the soil humus layers, all of which moderate weather changes. Coccinellid species that aggregated, such as *H. convergens* and *C. maculata* may exhibit hypsotaxis as well as chemotaxis which attracts them to more specific microhabitats such as the unshaded broomsedge clumps or isolated trees with thick layers of soil humus. In areas with limited woodlands or uncultivated areas, plots or strips of various decomposing plant materials could be more attractive to a wider range of arthropods. Some of the coccinellids, however, are apparently aided in overwintering by the presence of thick broomsedge clumps in open areas in the coast plain of South Carolina.

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HOSTS OF A PHONOTACTIC PARASITOID AND LEVELS OF PARASITISM (DIPTERA: TACHINIDAE: *ORMIA OCHRACEA*)

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ABSTRACT

In central Texas, females of *Ormia ochracea* (Bigot) find hosts, *Gryllus integer* Scudder (Orthoptera), by homing on the hosts' calling songs. *O. ochracea* is abundant each fall in Alachua County, Florida, where *G. integer* does not occur. *Gryllus rubens* Scudder and *G. firmus* Scudder were collected by three methods and held for emergence of *O. ochracea*. Of 185 *G. rubens* and 100 *G. firmus* collected during January to August, none were parasitized. Levels of parasitism during the remaining months never exceeded 10% except at sound-baited traps—but these attracted larvipositing *O. ochracea* as well as *G. rubens*. For specimens collected in pitfall traps and by searching under objects, levels of parasitism of *G. rubens* and *G. firmus* and of males and females were unexpectedly similar—though *O. ochracea* is not attracted to *firmus* calls and female *Gryllus* do not call. When muted and nonmuted reared males of *G. rubens* were experimentally exposed in the field in the fall for 5 days, no muted males were parasitized but 7 of 13 nonmuted males were.

RESUMEN

En la parte central de texas, las hembras de *Ormia ochracea* (Bigot) encuentran sus hospederos, *Gryllus integer* Scudder (Ortoptera) al ser atraidos por el huesped. *O. ochraceae* es abundante cada otoño en el condado Alachua, Florida, donde no se encuentra