Populations of Stink Bugs (Heteroptera: Pentatomidae) and their Natural Enemies in Peanuts[1]

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Abstract The objective of this on-farm study was to determine if peanuts harbor populations of stink bugs (Heteroptera: Pentatomidae) and their natural enemies in Georgia. Eight species of phytophagous stink bugs were found in peanuts over the 5-yr study. The predominant stink bug species were *Nezara viridula* (L.), *Euschistus servus* (Say), *Euschistus quadrator* (Rolston), and *Oebalus pugnax pugnax* (F.). The remaining 4 species, *Acrosternum hilare* (Say), *Euschistus tristigmus* (Say), *Euschistus ictericus* (L.), and *Thyanta custator accerra* McAtee, were found in relatively low numbers. All developmental stages of *N. viridula*, *E. servus*, *E. quadrator*, *A. hilare*, and *O. p. pugnax* were collected at various times in the study indicating that these 5 species of stink bugs were developing on this crop. Seasonal abundance of *N. viridula* and *E. servus* nymphs and adults provided further support that these 2 species of stink bugs developed on peanuts. At least 1 generation of *N. viridula* and *E. servus* occurred in peanuts each year, and generally some of the adults that developed on peanuts oviposited on peanuts producing another generation of nymphs in this crop. Because only adults of *T. c. accerra*, *E. tristigmus*, and *E. ictericus* were found in peanuts, these 3 stink bug species probably were not developing on this crop. Adult stink bugs were parasitized by the tachinid parasitoids *Trichopoda pennipes* (F.) and *Cylindromyia* spp. Stink bug eggs were parasitized by the scelionids, *Trissolcus basalis* (Wollaston), *Trissolcus thyantae* Ashmead, *Trissolcus brochymenae* (Ashmead), *Telenomus podisi* Ashmead, and *Gryon obesum* Masner, and an unknown encyrtid species. *Geocoris punctipes* (Say), *Geocoris uliginosus* (Say), *Orius insidiosus* (Say), *Podisus maculiventris* (Say), and *Oxyopes salticus* Hentz preyed on stink bugs in peanuts. Peanuts harbor populations of stink bugs and their natural enemies, and thus the role peanuts play in landscape ecology of stink bugs needs to be ascertained to better understand how to manage stink bug populations in landscapes in which peanuts are associated with other crops.

Key Words seasonal abundance, peanuts, stink bugs, *Nezara viridula*, *Euschistus servus*, *E. quadrator*, *Oebalus pugnax pugnax*

In the southeastern US, the dynamics of stink bug populations have changed over the past several years. One clear indication of this phenomenon is the recent increased importance of stink bugs as pests of cotton, *Gossypium hirsutum* L. Because stink bug distribution and abundance is closely linked to crop phenology and seasonal succession of host plants (Velasco and Walter 1992, Ehler 2000), cotton probably is not the only crop impacted by the observed changes in stink bug populations. In Georgia, peanuts, *Arachis hypogaea* L., are grown in rotation with cotton. In the past,

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peanuts have been considered to be an interim host for stink bugs (McPherson and McPherson 2000). But, with the recent change in stink bug population dynamics, the role of peanuts in the phenology of stink bugs needs to be further investigated. Consequently, the objective of this 5-yr on-farm project was to determine if peanuts harbor populations of stink bugs and their natural enemies in Georgia.

Materials and Methods

Stink bugs and their natural enemies were collected weekly during the peanut growing season in 2003, 2004, 2005, 2006, and 2007. A sweep sample covered 0.91-m of row in 2003, 3.66-m of row in 2005, and 7.31-m of row in 2004, 2006, and 2007. After collection, each sample was put in a 3.79 L Ziploc™ bag which was then placed in a cooler and transported to the laboratory. Insect species, developmental stage, and sex (for adults only) were identified and recorded in the laboratory. In 2003, only *Nezara viridula* (L.) and *Euschistus servus* (Say) were recorded. For the other 4 yrs, all stink bug species were recorded. Stink bug eggs and adults with at least one tachinid egg on the exoskeleton were held in the laboratory for emergence of adult parasitoids. Voucher specimens of all insects are held in the USDA-ARS, Crop Protection & Management Research Laboratory in Tifton, GA.

All peanut fields in this 5-yr study were operated by well-established peanut producers in Irwin Co., GA, who followed all recommended agricultural practices for production of peanuts including application of herbicides for essentially weed-free peanuts. However, if any weeds were present in a field, they were not sampled. Fields ranged from 4-18 ha in size. For all peanut fields, one edge of the field was adjacent to an edge of a cotton field, and so cotton along the edge of the peanut field also was sampled. Whole-plant sampling was used in cotton, and a sample consisted of all *N. viridula* and *E. servus* adults on all plants within 0.91-m of row in 2003 and on all plants within 1.82-m of row for the other 4 yrs of the study. The same sampling scheme was used for sampling peanuts and cotton. In 2003, two peanut fields were sampled. The first field was planted on 12 May in the 02-C variety of peanuts, and the second was planted on 14 May in GA Green peanuts. For each field, sweep samples were obtained from 7 locations, rows 1, 40, 80, 120, 160, 200, and 240 from the outside edge of the side of the field along the common boundary of the peanut and cotton field. For each sampling date, 6 sweep samples were collected from each of the 7 sampling locations.

In 2004, eight peanut fields were sampled. The one field with the C99R variety of peanuts was planted on May 10. For the remaining seven fields, GA Green peanuts were planted on 10 May (2 fields), 11 May (2 fields), 14 May, 15 May, and 20 May. For each field, samples were obtained from 2 edge locations along each of the 4 sides of the field. The first edge location was 0-3.66 m from the outside edge of the field, and the second edge location was 3.66-7.31 m from the outside edge of the field. The interior of the field was subdivided into 9 equally-sized blocks. In each field, sweep samples were collected for each sampling date as follows: 6-10 samples from each side in the first edge location, 2 samples from each side in the second edge location, and 2 samples from the center of each of the 9 interior blocks.

In 2005, seven fields of GA Green peanuts were sampled. Peanuts were planted on 8 May (2 fields), 10 May (2 fields), 11 May, and 18 May (2 fields). On the side of the peanut field next to a cotton field, samples were obtained from 3 edge locations, rows 1, 5, and 9 from the outside edge of the field. For the other 3 sides of the field, samples were taken from 2 edge locations, rows 1 and 5 from the outside edge of the field. The interior of the field was subdivided into 9 equally-sized blocks. In each field, sweep samples were collected for each sampling date as follows: 9 samples from row 1 and 6 samples each from rows 5 and 9 for the side next to cotton, 3 samples each from rows 1 and 5 for the other 3 sides, and 1-3 samples from the center of each of the 9 interior blocks.

In 2006, seven peanut fields were sampled. One field was planted in the 02-C variety of peanuts on 18 May. Another field was planted in the C99R variety of peanuts on 23 May. The remaining fields were planted in GA Green peanuts on 10 May (3 fields), 20 May, and 22 May. In 2007, six peanut fields were sampled. Two fields were planted in the 02-C variety of peanuts on 29 May. The remaining fields were planted in GA Green peanuts on 21 May (2 fields), 22 May, and 29 May. In both 2006 and 2007, each field had 4 sides, A-D, with side A being the side next to a cotton field. On side A, samples were obtained from 3 edge locations, rows 1, 5, and 9 from the outside edge of the peanut field, and from 7 interior locations, rows 16, 33, 67, 100, 133, 167, and 233 from the outside edge of the field. For sides B-D, samples were taken from 2 edge locations, rows 1 and 5 from the outside edge of the field. In each field, sweep samples were collected for each sampling date as follows: 9 samples from rows 1, 5, and 9 for side A, 3 samples each from rows 1 and 5 for sides B-D, and 6 samples from each of the interior locations.

In 2004, some *N. viridula* adults in peanuts were marked to examine the propensity of adults of this pest to disperse from peanuts into cotton. A medium line, opaque, oil-based paint marker (Sanford Corp., Bellwood, IL) was used to paint a specific color on the prothorax of the captured insect. The color was used to designate the date the insect was found. Adults were marked on 23 July and 13 August in only one field as they were collected in peanuts during sampling.

Stink bug eggs were somewhat difficult to obtain because stink bug eggs are laid on peanut leaves, and we were not always able to collect leaves with eggs with a sweep net. Thus, sentinel eggs of *E. servus* and *N. viridula* were placed in peanut fields in 2004 and 2005 to determine rates of predation and parasitization of these eggs. To obtain egg masses, adults of both species of stink bugs were maintained in separate cages (29.85 × 29.85 × 29.85 cm) and held at 24-27°C and 40-50% RH in the laboratory. Insects were fed raw, shelled peanuts and pole beans. Stink bug females were allowed to oviposit on a large (9.92 cm^2) piece of stockinette sleeve material (Bioquip, Rancho Dominquez, CA) in these cages. For each egg mass deposited, a small section of the stockinette sleeve material with an egg mass was cut out of the cloth, and then each freshly laid ($\leq$ 16 h old) egg mass was quickly frozen in a freezer held at −77°C killing the stink bug eggs in the egg mass. Powell and Shepard (1982) previously determined that percent emergence for the stink bug egg parasitoid *Trissolcus basalis* (Wollaston) was approximately the same for freezer-stored (−75°C) and fresh stink bug eggs, and freezer-stored eggs were suitable hosts for a longer time. The cloth with the frozen egg mass was hung with a paperclip in a peanut plant for 48 h. At that time, the egg mass was brought into the laboratory, examined for predation, and then, if appropriate, held for emergence of adult parasitoids. In 2004 for *N. viridula*, 3 egg masses were hung in 7 peanut fields on 4 August, 3-4 egg masses were hung in 7 fields on 18 August, and 1 egg mass was hung in 6 fields on 27 August. For *E. servus*, 2 egg masses were hung in 7 peanut fields on 4 August, and 2 egg masses were hung in 6 fields on 27 August. In 2005 for *N. viridula*, 1-2 egg masses were hung in 5 peanut fields on 20 July, 3-4 egg masses were hung in 6 fields on 27 July, 3-4 egg masses were hung in 6 fields on 3 August, 3-5 egg masses were hung in 6 fields on 10 August, and 3 egg masses were hung in 6 fields on 31 August. For *E. servus*, 2-3 egg masses were hung in 5 peanut fields on 20 July, 2-3 egg masses were hung in 6 fields on 27 July, 1-2 egg masses were hung in 6 fields on 3 August, and 2-3 egg masses were hung in 6 fields on 10 August.

Overall means and standard errors associated with these means were obtained for eggs, nymphs, and adults for stink bugs and for their natural enemies using PROC MEANS (SAS Institute 2003). Also, means were obtained for total stink bug nymphs and adults per sampling date using PROC MEANS (SAS Institute 2003). Mortality data for hung stink bug eggs were analyzed using the PROC MIXED procedure of the Statistical Analysis System (SAS Institute 2003). The fixed effects were mortality factor, species, mortality factor by species, and year. Random effects were field within mortality factor and residual error. Least squares means were separated by least significant difference (LSD, $P > 0.05$) (SAS Institute 2003) where appropriate.

Results and Discussion

Eight species of phytophagous stink bugs were found in peanuts over the 5-yr on-farm study. The 4 predominant stink bug species were the southern green stink bug, *N. viridula*, the brown stink bug, *E. servus*, the dusky stink bug, *Euschistus quadrator* (Rolston), and the rice stink bug, *Oebalus pugnax pugnax* (F.) (Tables 1, 2). The green stink bug, *Acrosternum hilare* (Say), was found in relatively low numbers (Table 2). The 3 remaining stink bug species present in peanuts were *Euschistus tristigmus* (Say), *Euschistus ictericus* (L.), and *Thyanta custator accerra* McAtee.

All developmental stages of *N. viridula*, *E. servus*, *E. quadrator*, *O. p. pugnax*, and *A. hilare* were collected from peanuts at various times during the study (Tables 1, 2). With the exception of eggs in 2003, eggs, all nymphal stages, and adults of *N. viridula* were found in peanuts each year. Drake (1920) also found very young *N. viridula* nymphs on peanuts. Egg masses of *E. servus* were collected in 2005, 2006, and 2007. With the exception of 1^{st} instars in 2003, adults and all nymphal stages of *E. servus* were found in peanuts each year. Egg masses of *E. quadrator* were collected only in 2006, and the mean (± SE) number of egg masses per sweep sample over all sampling dates was 0.0001 (± 0.0001). All nymphal stages of *E. quadrator* were found in peanuts in 2006 and 2007. Egg masses of *O. p. pugnax* were collected in 2005, 2006, and 2007. Egg masses of *A. hilare* were collected only in 2007, and the mean (± SE) number of *A. hilare* egg masses per sweep sample over all sampling dates for that year was 0.0001 (± 0.0001). All nymphal stages of *O. p. pugnax* and *A. hilare* were found in peanuts over the study. However, because the nymphal data for these two stink bug species was variable over the years, only total nymphs for each species were lumped for analysis. These data on developmental stages of stink bugs in peanuts indicate that five species of stink bugs, *N. viridula*, *E. servus*, *E. quadrator*, *O. p. pugnax*, and *A. hilare*, develop on peanuts. To develop on peanuts, the immatures of these stink bugs species must be feeding on peanuts. Observations of *N. viridula* and *E. servus* nymphs and adults on peanuts in the field and laboratory have confirmed that these two species of stink bugs actually feed on peanuts (Tillman, unpubl. data).

Only adults of *T. accerra*, *E. tristigmus*, and *E. ictericus* were found in peanuts, and they occurred in very low numbers. The mean (± SE) number of *T. c. accerra* adults per sweep sample over all sampling dates was 0.0008 (± 0.0006) in 2004, 0.0001 (±

Table 1. Mean (± SE) number of *N. viridula* and *E. servus* for each development stage per sweep sample over all sampling dates in peanuts in 2003 through 2007

Species	Stage	2003	2004	2005	2006	2007
N. viridula	egg mass		0.0008 ± 0.0006	0.0006 ± 0.0006	0.0005 ± 0.0002	0.0008 ± 0.0002
	1st	0.0017 ± 0.0017	0.0199 ± 0.0145	0.0017 ± 0.0014	0.0065 ± 0.0026	0.0086 ± 0.0034
	2nd	0.0847 ± 0.0284	0.0573 ± 0.0096	0.0042 ± 0.0021	0.0122 ± 0.0019	0.0288 ± 0.0040
	3rd	0.0288 ± 0.0100	0.0738 ± 0.0106	0.0045 ± 0.0029	0.0082 ± 0.0013	0.0067 ± 0.0009
	4th	0.0085 ± 0.0045	0.0288 ± 0.0045	0.0014 ± 0.0006	0.0052 ± 0.0007	0.0024 ± 0.0006
	5th	0.0102 ± 0.0053	0.0467 ± 0.0053	0.0040 ± 0.0011	0.0035 ± 0.0005	0.0037 ± 0.0005
	adults	0.0797 ± 0.0147	0.0908 ± 0.0068	0.0082 ± 0.0018	0.0063 ± 0.0007	0.0149 ± 0.0012
E. servus	egg mass			0.0023 ± 0.0023	0.0003 ± 0.0001	0.0017 ± 0.0004
	1st		0.0017 ± 0.0008	0.0003 ± 0.0003	0.0024 ± 0.0011	0.0096 ± 0.0022
	2nd	0.0051 ± 0.0029	0.0162 ± 0.0037	0.0040 ± 0.0023	0.0057 ± 0.0011	0.0253 ± 0.0023
	3rd	0.0034 ± 0.0024	0.0153 ± 0.0032	0.0011 ± 0.0006	0.0041 ± 0.0006	0.0056 ± 0.0008
	4th	0.0034 ± 0.0024	0.0119 ± 0.0025	0.0011 ± 0.0006	0.0075 ± 0.0012	0.0028 ± 0.0006
	5th	0.0017 ± 0.0017	0.0259 ± 0.0044	0.0060 ± 0.0025	0.0052 ± 0.0008	0.0070 ± 0.0009
	adults	0.0593 ± 0.0103	0.0674 ± 0.0058	0.0105 ± 0.0017	0.0080 ± 0.0008	0.0171 ± 0.0013

Table 2. Mean (± SE) number of *E. quadrator*, *O. p. pugnax*, and *A. hilare* per sweep sample over all sampling dates in peanuts in 2004 through 2007

Species	Stage	2004	2005	2006	2007
E. quadrator	1st			0.0005 ± 0.0003	0.0008 ± 0.0006
	2nd			0.0028 ± 0.0028	0.0012 ± 0.0004
	3rd		0.0003 ± 0.0003	0.0025 ± 0.0004	0.0008 ± 0.0002
	4th		0.0003 ± 0.0003	0.0023 ± 0.0004	0.0013 ± 0.0003
	5th		0.0003 ± 0.0003	0.0049 ± 0.0006	0.0030 ± 0.0006
	adults	0.0471 ± 0.0050	0.0085 ± 0.0016	0.0132 ± 0.0010	0.0060 ± 0.0008
O. p. pugnax	egg mass		0.0006 ± 0.0006	0.0002 ± 0.0001	0.0003 ± 0.0001
	all nymphs*		0.0054 ± 0.0043	0.0044 ± 0.0008	0.0052 ± 0.0009
	adults	0.0195 ± 0.0031	0.0065 ± 0.0016	0.0083 ± 0.0012	0.0053 ± 0.0011
A. hilare	all nymphs*	0.0017 ± 0.0008		0.0024 ± 0.0005	0.0024 ± 0.0005
	adults	0.0038 ± 0.0014	0.0003 ± 0.0003	0.0010 ± 0.0003	0.0010 ± 0.0003

* Includes all nymphal stages over all years

0.0001) in 2006, and 0.0005 (± 0.0002) in 2007. For *E. tristigmus*, the mean (± SE) number of adults per sweep sample over all sampling dates was 0.0004 (± 0.0002) in 2006. The mean (± SE) number of *E. ictericus* adults per sweep sample over all sampling dates was 0.0003 (± 0.0001) in 2006. Adults of these 3 stink bug species were collected only along edges of peanut fields. These stink bug adults probably moved into peanuts from surrounding vegetation, and thus their occurrence in peanuts is likely only incidental.

Generally, for *N. viridula*, *E. servus*, and *A. hilare*, the percent of female stink bugs was higher than what would be expected for a 1 female:1 male sex ratio (Table 3). The percent of *E. quadrator* females was somewhat lower than that for the other 3 stink bug species, but females of this species remained prevalent in peanuts. These data indicate that these species of stink bugs in peanuts are reproductive populations and not there just by chance.

Seasonal abundance of nymphs and adults of *N. viridula* and *E. servus* for each of the 5 yrs of the study provide further support that these stink bug species developed on peanuts. In 2003, *N. viridula* adults migrated into peanuts early in the growing season, and nymphs soon appeared in the crop (Fig. 1). Young nymphs along with adults were present in peanuts on 9 July. Over the following 2 wks late instars were present in this crop. Therefore, adults probably began moving into peanuts at least a week before sweep samples were obtained. The peak for the *N. viridula* population occurred on 6 August and consisted mostly of adults that had developed in peanuts and young instars. At this time adults occurred in cotton bordering peanuts, and so some stink bugs apparently dispersed from peanuts into cotton. The nymphs, though, stayed in peanuts and developed into adults. In this same year, *E. servus* adults began to move into peanuts in early July, but the peak number of nymphs occurred on 20 August, a couple of weeks later than the peak for *N. viridula* nymphs. On 3 September, new adults of both stink bug species were found in cotton bordering the peanuts, and so some stink bugs apparently dispersed from peanuts into cotton at this time. Some of the new adults, however, apparently laid eggs on peanuts, for on this same date the *N. viridula* population consisted mostly of adults and another generation of 2nd and 3rd instars. On 17 September, the population of *E. servus* consisted mainly of adults and 2nd and 3rd instars, and so a second generation of nymphs of this pest began developing in this crop in mid-September just before peanuts were harvested.

In the second year of the study, *N. viridula* adults migrated into peanuts and laid eggs on leaflets of peanuts early season (Fig. 2). Young nymphs along with adults

Table 3. Overall percent females and percent parasitization of stink bug adults in peanuts in 2003 through 2007

	% Females					% Parasitized adults				
Species	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
N. viridula	57.6	63.8	76.5	81.6	80.0	51.5	22.9	3.4	12.6	15.0
E. servus	71.4	56.5	67.4	56.3	73.6	—	2.5	—	0.9	0
E. quadrator	—	—	40.0	52.8	46.0	—	—	—	0.6	0
A. hilare	—	66.7	—	57.1	50.0	—	—	—	7.1	25.0

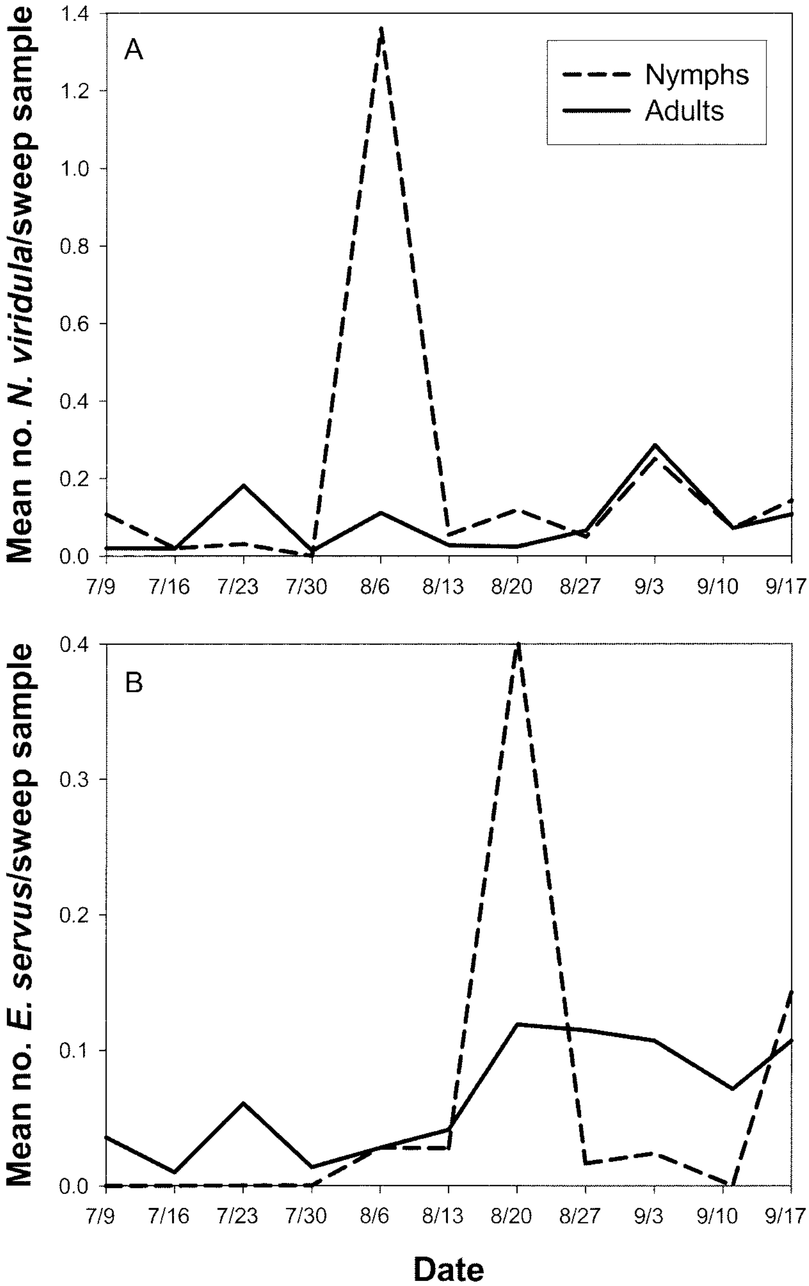

Fig. 1. Seasonal abundance of *N. viridula* (A) and *E. servus* (B) in Irwin Co., Georgia in 2003

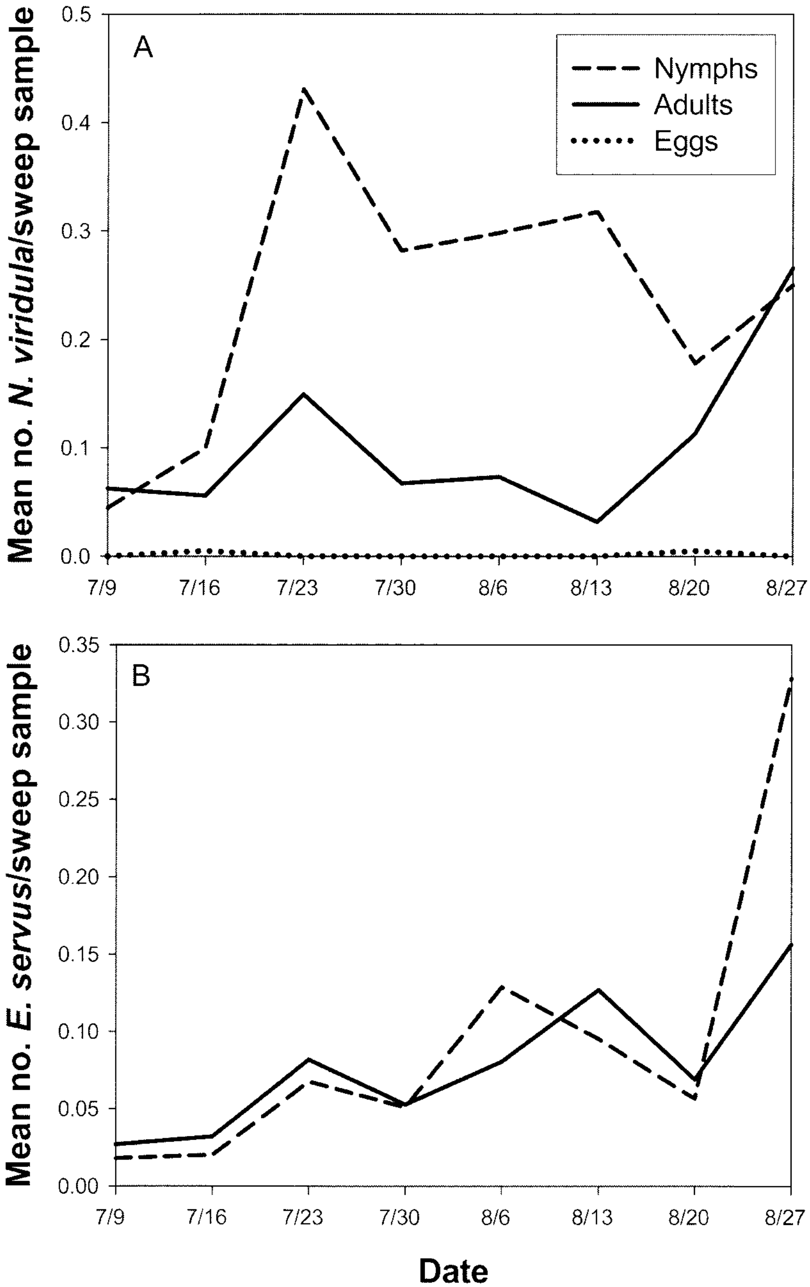

Fig. 2. Seasonal abundance of *N. viridula* (A) and *E. servus* (B) in Irwin Co., Georgia in 2004

were present in peanuts on 9 July. The following week, 3rd instars were present in this crop. Therefore, stink bug adults probably began moving into peanuts at least a week before samples were collected. The peak population of *N. viridula* nymphs occurred on 23 July and consisted of 2nd through 5th instars. Some new adults were also present in peanuts and cotton at this time. First instars appeared in peanuts on 30 July, and egg masses were found in cotton on 23 July. One adult female that had been marked with paint in peanuts on 23 July was found in cotton adjacent to the peanuts on 30 July. Therefore, some of the new adults in peanuts dispersed into cotton on these dates. The nymphs in peanuts, though, developed into adults which began to increase in peanuts after mid-August. Some of these new adults stayed in peanuts and oviposited on leaflets of this plant producing another generation of nymphs. New adults were present in cotton on 20 August, and 2 females that had been marked with paint in peanuts on 13 August were found in cotton on the following week so some adults moved from peanuts into cotton in mid-August. For *E. servus*, apparently 2 discrete generations developed in peanuts in July and August, and by the end of August another generation began developing in this crop just before peanuts were harvested. On 30 July, adults and eggs of *E. servus* were found in cotton, and on 20 August, adults were present in cotton indicating that these stink bugs dispersed from peanuts into cotton at these times.

In 2005, *N. viridula* adults began moving into peanuts on 29 June, and nymphs were present the following week (Fig. 3). On 20 July, some late instars were present in peanuts. For the following 2 wks, mostly late instars and new adults were present in peanuts indicating that 1 generation of *N. viridula* developed in peanuts in July. The next generation of nymphs peaked on 10 August and included mainly 2nd and 3rd instars. Eggs were present in peanuts on 17 August and on cotton on 24 August. These eggs were probably laid by the 1st generation of females that developed in peanuts. For *E. servus*, 2 distinct generations were present in peanuts over the growing season. Adults of this pest migrated into peanuts and laid eggs on leaflets of peanuts early season. The first peak in the population occurred on 27 July and consisted mainly of 5th instars and new adults. The peak number of second generation nymphs occurred on 17 August a week later than the peak for *N. viridula*. These nymphs continued to develop into adults in peanuts. Adults of both stink bug species began appearing in cotton in late July to mid-August. In addition, *E. servus* egg masses were found on cotton 10 August, and *N. viridula* egg masses were observed in cotton on 24 August. These observations indicate that some stink bug adults of both species dispersed from peanuts into adjacent cotton.

In 2006, *N. viridula* and *E. servus* adults began migrating into peanuts early in the growing season (Fig. 4). For *N. viridula*, 1st through 3rd instars along with adults were present in peanuts on 13 July. Therefore, stink bug adults probably began moving into peanuts at least 2 wks earlier. Adults that developed from the 1st generation of nymphs were present by 27 July, and a second generation of nymphs was produced by these adults. The second generation of adults began ovipositing on peanuts on 17 August. The third generation of nymphs peaked the last couple of weeks of August and consisted of mostly 1st instars at this time. The third generation of adults was present by 14 September, and nymphs began to build up in peanuts the following week. By 13 July, adults and 3rd and 4th instars of *E. servus* were present in peanuts again indicating that stink bug adults had already migrated into the crop by this time. New adults occurred in peanuts by 3 August and produced a second generation of nymphs which peaked on 17 August. Adults from this generation of nymphs produced

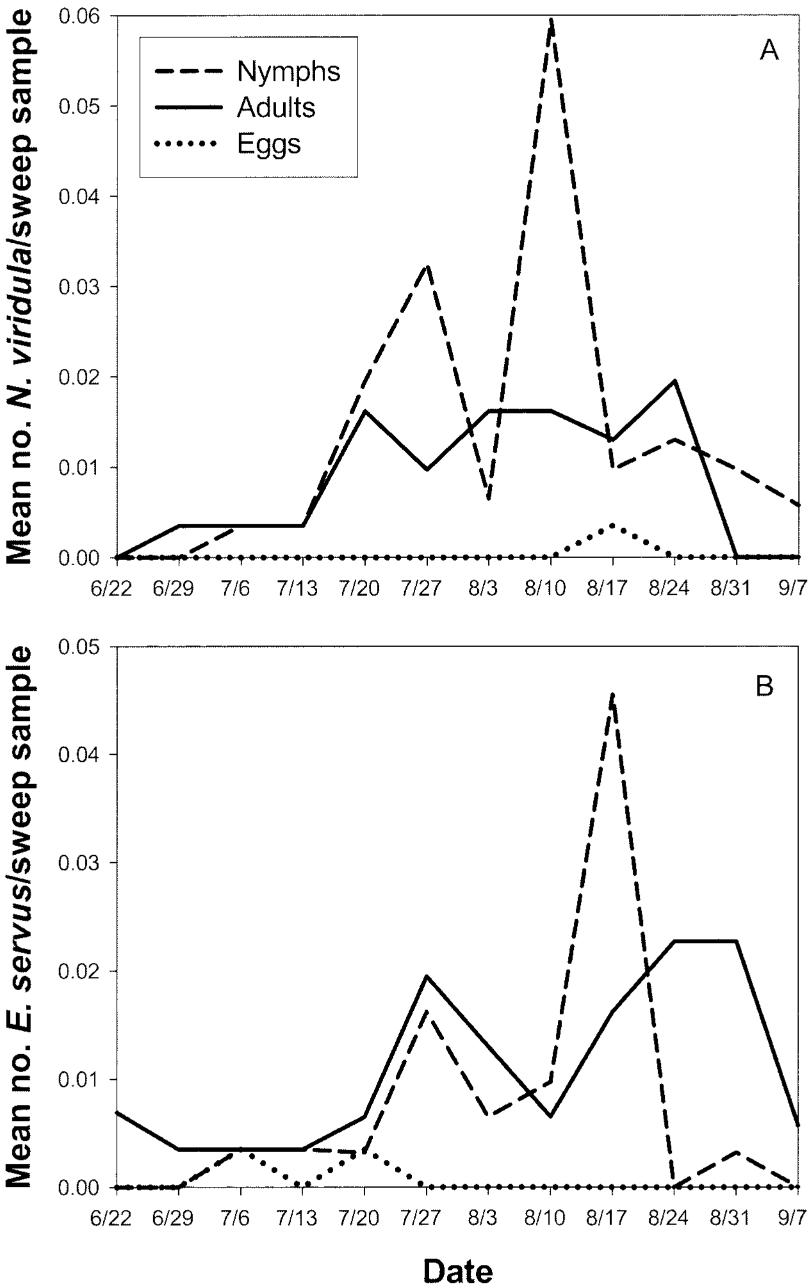

Fig. 3. Seasonal abundance of *N. viridula* (A) and *E. servus* (B) in Irwin Co., Georgia in 2005

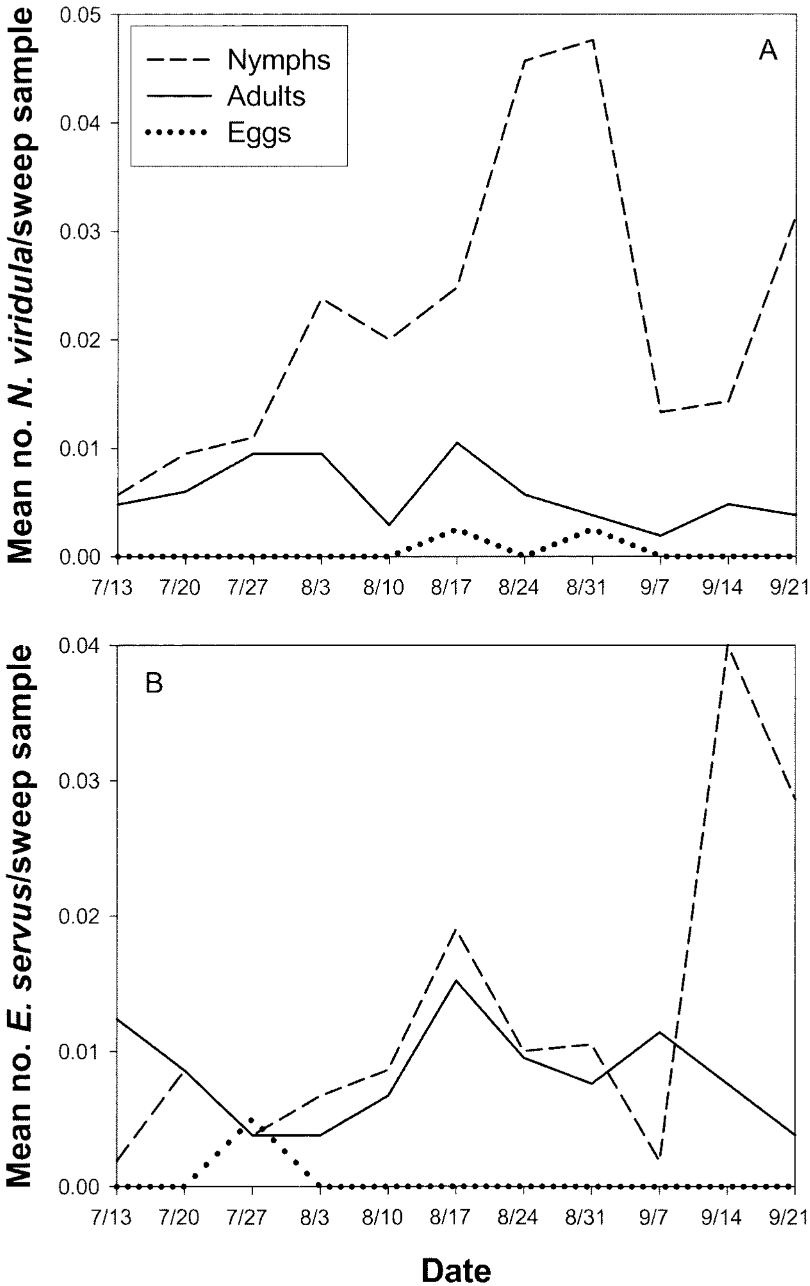

Fig. 4. Seasonal abundance of *N. viridula* (A) and *E. servus* (B) in Irwin Co., Georgia in 2006

a third generation of nymphs which peaked on 14 September. Based on the presence of new adults in cotton, both stink bug species began dispersing from peanuts into cotton in early to mid-August.

In the last year of the study, *N. viridula* adults began moving into peanuts in mid-July and females laid eggs on peanut leaflets soon thereafter (Fig. 5). Adults that developed from the 1st generation of nymphs were present by 15 August, and a second generation of nymphs was produced by these adults. A second generation of adults occurred in peanuts by 5 September. Eggs were not found on peanuts over the next 2 wks, and there was a decrease in adults on 12 September. Adults were observed in cotton over these 2 wks. Altogether, these observations indicate that *N. viridula* adults dispersed from peanuts over this period of time. Mark-recapture studies conducted in these fields demonstrated that adults of this stink bug species actually did disperse from peanut fields into cotton fields at the common boundary between the two crops (Tillman, unpubl. data). The third generation of nymphs peaked on 12 September. The third generation of adults was present by 3 October, and nymphs began to increase in peanuts the following week. The occurrence of the egg parasitoid, *T. basalis*, generally was related to the presence of young nymphs in peanuts. Adults of *E. servus* also moved into peanuts early in the season, but *E. servus* nymphs were present a couple of weeks later than *N. viridula* nymphs. New adults occurred in peanuts by 5 September, but apparently some of these adults dispersed into cotton, for adults were found in cotton on this date and on 12 September. The nymphal population continued to increase late season and peaked on 10 October.

Overall, for each year *N. viridula* and *E. servus* adults moved early season into peanuts. Female stink bugs began to oviposit on peanuts leaflets, and then populations of these pests developed and increased in peanuts. At least 1 generation of *N. viridula* and *E. servus* occurred in peanuts each year. Generally, some of the females that developed on peanuts oviposited on peanuts producing another generation of nymphs in this crop whereas some of the adults that developed on peanuts dispersed into cotton.

Stink bug predators were collected from peanuts during the 5-yr study (Table 4). Adults of 3 predators, *Geocoris punctipes* (Say), *Geocoris uliginosus* (Say), and *Orius insidiosus* (Say), were observed feeding on stink bug egg masses. The spined soldier bug, *Podisus maculiventris* (Say), was seen attacking and consuming nymphs of pest stink bugs. The presence of all developmental stages of *P. maculiventris* in peanuts indicates that this predator was developing on prey in this crop. Spiders collected in peanuts included the green lynx spider, *Oxyopes salticus* Hentz, the brown lynx spider, *Oxyopes scalaris* Hentz, and spiders in the Salticidae and Thomisidae families. Many unknown families of spiders also were counted and recorded. Except in 2004 when only green lynx spiders were recorded, all these groupings of spiders were combined. Spiders were observed attacking and consuming nymphs of stink bugs. Lady beetles including the convergent lady beetle, *Hippodamia convergens* Guérin-Méneville, the seven-spotted lady beetle, *Coccinella septempunctata* (L.), the pink lady beetle, *Coleomegilla maculata* (De Geer), and the multicolored Asian lady beetle, *Harmonia axyridis* (Pallas), were observed feeding on stink bug eggs in peanuts. Red imported fire ants, *Solenopsis invicta* Buren, were present in peanut sweep samples in 2006 and 2007. They were observed feeding on eggs, nymphs, and adults of stink bugs in peanuts. *Nabid* spp. were only recorded for peanuts in 2005, 2006, and 2007. *Zelus* app. and *Sinea* spp. were only recorded for peanuts in 2005 and 2007. These

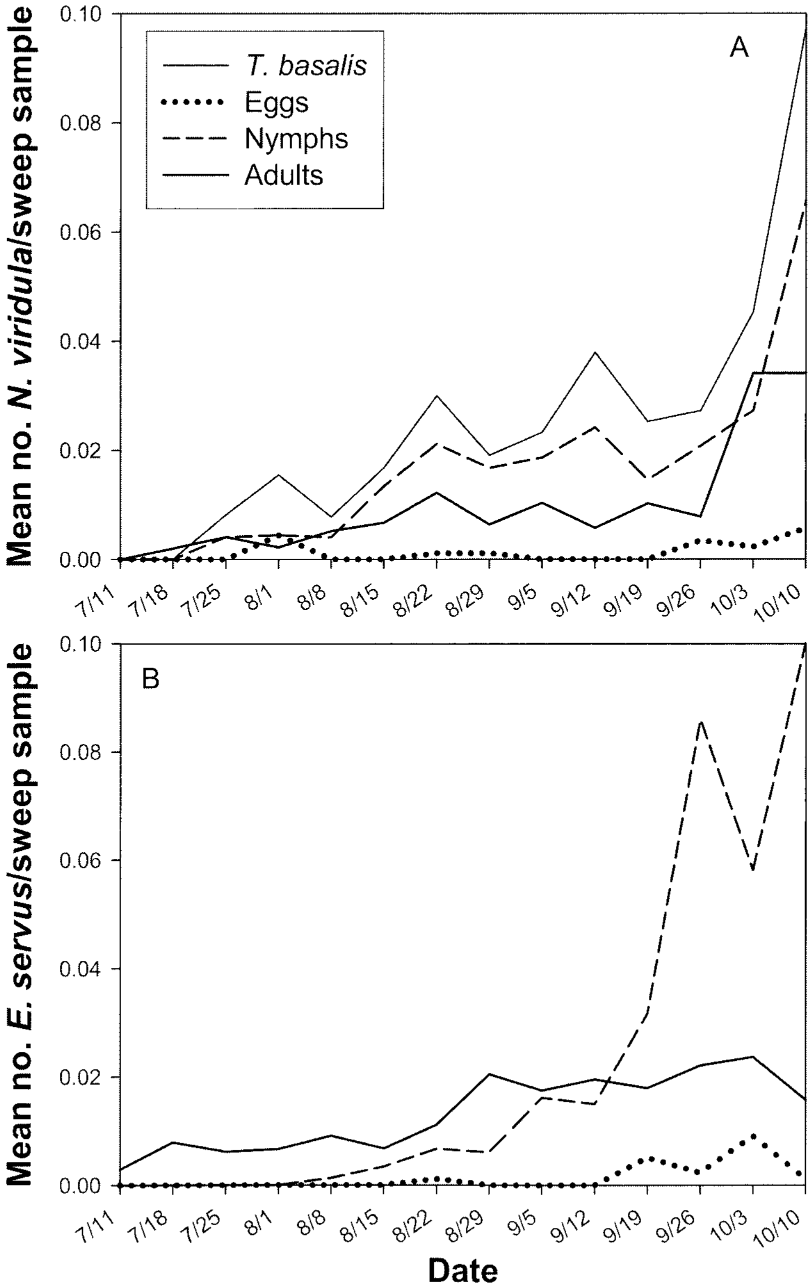

Fig. 5. Seasonal abundance of *N. viridula* (A) and *E. servus* (B) in Irwin Co., Georgia in 2007

Table 4. Mean (± SE) number of stink bug insect predators per sweep sample over all sampling dates in peanuts in 2003 through 2007

Species	Stage	2003	2004	2005	2006	2007
P. maculiventris	egg mass			0.0006 ± 0.0004	0.0002 ± 0.0001	0.0001 ± 0.0001
	1sts		0.0004 ± 0.0004			0.0005 ± 0.0003
	2nds	0.0102 ± 0.0086	0.0034 ± 0.0026		0.0013 ± 0.0004	0.0010 ± 0.0003
	3rds	0.0017 ± 0.0017	0.0038 ± 0.0013	0.0009 ± 0.0005	0.0009 ± 0.0003	0.0026 ± 0.0005
	4ths	0.0017 ± 0.0017	0.0068 ± 0.0017	0.0003 ± 0.0003	0.0011 ± 0.0003	0.0011 ± 0.0003
	5ths	0.0017 ± 0.0017	0.0034 ± 0.0012	0.0011 ± 0.0006	0.0013 ± 0.0003	0.0014 ± 0.0003
	adults	0.0746 ± 0.0156	0.0271 ± 0.0037	0.0204 ± 0.0025	0.0075 ± 0.0008	0.0054 ± 0.0007
O. insidiosus	adults	0.2678 ± 0.0240	0.6175 ± 0.0312	0.1067 ± 0.0082	0.2480 ± 0.0075	0.2278 ± 0.0067
Geocoris spp.*	adults	0.1390 ± 0.0210	0.3825 ± 0.0206	0.0416 ± 0.0045	0.3702 ± 0.0090	0.2205 ± 0.0053
Spiders**	adults	0.1983 ± 0.0258	0.1260 ± 0.0093	1.0411 ± 0.0425	0.9129 ± 0.0104	1.1267 ± 0.0133
Nabid spp.	adults			0.0230 ± 0.0034	0.0225 ± 0.0014	0.1041 ± 0.0040
Other***	adults			0.0244 ± 0.0044	0.0659 ± 0.0032	0.1465 ± 0.0047
Lady beetles****	adults			0.0062 ± 0.0013	0.3449 ± 0.0083	0.2538 ± 0.0076

* *G. punctipes* and *G. uliginosus*.
** Only *O. salticus* in 2004; *O. salticus*, *O. scalaris*, spiders in the Salticidae and Thomisidae families, and unknown spiders in 2003, 2005, 2006, and 2007.
*** *Zelus* spp. and *Sinea* spp. in 2005 and 2007; *S. invicta* in 2006 and 2007.
**** *H. convergens*, *C. septempunctata*, *C. maculata*, and *H. axyridis*.

3 predator species were observed feeding on nymphs and adults of stink bugs. Adults and older nymphs of phytophagous stink bugs were observed to prey on nymphs of the same stink bug species, but only occasionally.

Five species of parasitoids emerged from the *E. servus*, *N. viridula*, *O. p. pugnax*, and *P. maculiventris* egg masses collected from peanuts. These included the scelionids, *T. basalis*, *Trissolcus thyantae* Ashmead, *Trissolcus brochymenae* (Ashmead), and *Telenomus podisi* Ashmead, and an unknown encyrtid species. Because only a few *E. servus*, *N. viridula*, *O. p. pugnax*, and *P. maculiventris* egg masses were collected each year from 2004-2007, data on percentage of parasitized stink bug egg masses was combined over these 4 yrs. Only *E. servus* egg masses were parasitized by all five species of parasitoids. Of the 42 *E. servus* egg masses collected ~30% of them were parasitized. *Nezara viridula* egg masses were parasitized by only *T. basalis*. During the study, 23 *N. viridula* egg masses were collected and ~40% of them were parasitized. *Oebalus p. pugnax* egg masses were parasitized exclusively by *T. podisi*. For this stink bug species, 25% of the 12 collected egg masses were parasitized. An unknown encyrtid species and *T. podisi* emerged from egg masses of a stink bug predator, the spined soldier bug, *Podisus maculiventris* (Say). Seven egg masses of this predator were collected and 42% of them were parasitized. None of these host records were new for these parasitoids, for they were reported previously by Jones (1988). The few *A. hilare* and *E. quadrator* egg masses collected in this study were not parasitized.

Sentinel egg masses of *N. viridula* and *E. servus* in peanut plants were parasitized by the scelionids, *T. basalis*, *T. podisi*, *T. thyantae*, and *Gryon obesum* Masner, and an unknown encyrtid species. Factorial analysis revealed that there was a significant mortality factor effect ($F = 15.22$; df = 2, 42.1; $P = 0.0001$), species effect ($F = 28.04$; df = 1, 633; $P = 0.0001$), and mortality factor and species interaction ($F = 3.88$; df = 2, 634; $P = 0.0212$). Year effect was not significant ($F = 0.09$; df = 1, 39.9; $P = 0.7657$). Predation was significantly higher than parasitization for sentinel egg masses of both species of stink bugs in peanuts (Table 5). Also, predation and total mortality was

Table 5. Least squares means for percent morality for sentinel stink bug eggs in peanuts

Stink bug species	Mortality factor	% Mortality
N. viridula	Parasitization*	6.62b1
	Predation	28.99a2
	Total	35.56a2
E. servus	Parasitization**	10.64b1
	Predation	47.02a1
	Total	57.63a1

Least squares means within a column followed by the same lowercase letter are not significantly different between mortality factors for a species, and least squares means within a column followed by the same number are not significantly different between species for a mortality factor (PROC MIXED, LSD, $P > 0.05$, $n = 672$, SE = 7.45, df = 634).

* *T. basalis*, *T. thyantae*, *T. podisi*, *G. obesum*, unknown encyrtid.

** *T. basalis*, *T. podisi*, *G. obesum*.

significantly higher for *E. servus* than for *N. viridula*. Parasitization was similar for the 2 stink bug species. Diversity of egg parasitoids emerging from sentinel egg masses was greater than that observed for collected eggs. *Nezara viridula* egg masses were parasitized not only by *T. basalis*, but also by *T. thyantae*, *T. podisi*, *G. obesum*, and the unknown encyrtid species. *Euschistus servus* egg masses were parasitized by *T. podisi* in addition to 2 other parasitoid species, *T. basalis* and *G. obesum*.

Adults of 4 stink bug species, *N. viridula*, *E. servus*, *E. quadrator*, and *A. hilare*, were parasitized by tachinids in peanuts. The tachinid, *Trichopoda pennipes* (F.), emerged from adults of all 4 species, but percent parasitization by this parasitoid was generally higher for *N. viridula* than for the other 3 stink bug species (Table 3). This tachinid has been previously reported to be one of the most successful parasitoids of *N. viridula* adults (McPherson et al. 1982, Jones 1988). In 2004, only the tachinid *Cylindromyia* spp. emerged from the *E. servus* adults collected from peanuts. *Cylindromyia* spp. have previously been reported to parasitize *E. servus* adults in soybeans (McPherson et al. 1982, Jones et al. 1996). These data on natural enemies of stink bugs in peanuts indicate that populations of natural enemies had some impact on natural biological control of these pests in this crop.

In conclusion, peanuts harbor populations of stink bugs and their natural enemies. The data also indicate that peanuts are a reproductive host for the more common stink bug pests, *N. viridula* and *E. servus*. Therefore, the role of peanuts in the landscape ecology of stink bugs needs to be ascertained to better understand how to manage stink bug populations in landscapes in which peanuts are associated with other crops.

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