Annual Variation in Stink Bug (Heteroptera: Pentatomidae) Seasonal Abundance and Species Composition in Georgia Soybean and Its Impact on Yield and Quality[1]

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ABSTRACT Six soybean fields in southwest, south central and southeast Georgia were sampled weekly, beginning in mid-June and continuing until mid-October 1987-1991, for the presence of stink bug pests. *Nezara viridula* (L.), *Acrosternum hilare* (Say), *Euschistus servus* (Say), and *Piezodorus guildinii* (Westwood) comprised over 98% of the stink bug complex during this period, although eight other pest species plus three predatory species also were encountered. Stink bug population densities began to steadily increase in mid-August as the pods began to fill with seeds and peaked in mid-September to early October. *Piezodorus guildinii* accounted for over 13% of the total stink bug complex in 1987, but was present at low densities (less than 1%) the next four seasons. The three years when stink bug pests caused economic losses to soybean (1988, 1989 and 1991), the high population levels were due to high numbers of *N. viridula*. The years with low seasonal stink bug populations (1987 and 1990) had near equal numbers of the major pest species. When the stink bug complex exceeded the current treatment threshold level of 9 per 25 sweeps, significant reductions in soybean yield and quality were documented.

KEY WORDS Stink bugs, soybean, *Nezara viridula*, *Acrosternum hilare*, *Euschistus servus*, *Piezodorus guildinii*.

The stink bug complex and the corn earworm, *Helicoverpa zea* (Boddie), are reportedly the most serious soybean, *Glycine max* (L.) Merrill, pod and seed feeders in the United States (Turnipseed and Kogan 1976). Stink bugs can cause significant yield and quality losses in soybeans (Jensen and Newsom 1972, McPherson et al. 1979b), particularly in the southern states. Stink bugs cost Georgia producers over $13 million in chemical controls and crop losses in some years (Douce and McPherson 1991). Soybeans are susceptible to stink bug damage from early pod-fill until maturity (Minor 1966), a period of about three months in Georgia.

In the southern states, the stink bug complex that occurs in soybean is primarily comprised of *Nezara viridula* (L.), *Acrosternum hilare* (Say), and *Euschistus servus* (Say) (Turnipseed and Kogan 1976); however, several other species are also found at low population densities (McPherson et al. 1979a).

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Recently, *Piezodorus guildinii* (Westwood) populations have been observed in Florida and Georgia soybeans, and this relatively new pest could become an economic problem in the future (Panizzi and Slansky 1985). Numerous studies have reported on the biology and damage of stink bugs on soybean and many of these are reviewed by Panizzi and Slansky (1985) and Todd (1989).

Most of the stink bug research on soybean has focused on the southern green stink bug, *N. viridula*, which is highly polyphagous with a cosmopolitan distribution (DeWitt and Godfrey 1972, Todd and Herzog 1980). Although this is usually the most abundant species in the soybean stink bug complex (Todd and Herzog 1980), information is needed on the population dynamics of the remaining species in the complex, especially how annual changes in species composition can impact soybean production. Therefore, this study was conducted from 1987-91 to survey the stink bug species in soybean produced in three areas of Georgia, and to examine the impact of the stink bug complex on soybean quality and yield.

Materials and Methods

Six soybean fields, one in Decatur County (Southwest), three in Tift County (Southcentral), and one in Burke County (Southeast), Georgia were sampled weekly for stink bugs beginning in early vegetative growth (V3-V4) (Fehr et al. 1971) and continuing until physiological maturity (R7) during 1987-1991. Sampling began in mid-June each season and continued until mid-October (16-17 wk). The three fields in Tift County were all located on land being maintained by the Georgia Coastal Plain Experiment Station. The field in Decatur County was located at the Attapulgus Research-Extension Center, and the field in Burke County was located at the Southeast Branch Experiment Station. The soybeans in Burke County were sampled on only three dates (mid-July, late July, mid-August) in 1990 and not at all in 1991 due to the distance from the home office (Tift Co.) and budgetary constraints. Each field was planted with c. v. Braxton (1987-89) or c. v. Gordon (90-91) soybeans, both maturity group VIII cultivars, in conventional seedbeds with rows spaced 91 cm apart. All fields were planted between 10 and 23 May. Field size ranged from 2.5-4.0 ha.

Ten to fifty 25-sweep sampling units were taken each week from each field, using a stratified random design. Each field was partitioned into 10 strata, with each stratum containing an equal number of rows and row length. When populations were low (less than 2 per sample average) five sampling units were taken from each stratum. A 38-cm diameter net was passed through the foliage of a single row (Kogan and Pitre 1980). In early season, the net was swept through the entire canopy, but as the soybeans grew taller, the net passed only through the upper third of the canopy. Each 25-sweep sampling unit was placed into a plastic bag, labeled, frozen and examined at a later date. Adults and nymphs of each stink bug species were identified and recorded. Voucher specimens were placed in the insect collection at the Coastal Plain Experiment Station.

Beginning in 1988, and continuing annually, a 0.25 ha area in one of the survey fields (two fields in 1989) was partitioned according to randomized block design with four replications. Two stink bug treatments were randomly arranged within each replication in plots measuring 9.1 m wide (10 rows) × 15.2

m long. These treatments included either cyfluthrin 2EC at 0.025 or 0.015 kg (AI)/ha (Mobay Corp., Kansas City, MO 64120), methyl parathion 4E at 0.56 kg(AI)/ha (Helena Chemical Co., Memphis, TN 38137) or acephate 75S at 0.84 kg(AI)/ha (Valent USA Corp., Walnut Creek, CA 94596), and an untreated control. Methyl parathion and acephate are currently labelled for stink bug control in soybeans, and cyfluthrin has been shown to be highly effective in screening tests (McPherson and Padgett 1988). These plots were sampled using a standard 38-cm net, taking 25 sweeps per plot prior to treatment and 3, 7, and 14 days after treatment (DAT). The insecticides were applied when the stink bug population reached nine per 25 sweeps which usually occurred in early September. A second insecticide application was made at the test site in 1988 because stink bugs exceeded the treatment threshold 14 days after the first application of cyfluthrin. Methyl parathion was applied in one field in 1990, even though the stink bug population never exceeded four per 25 sweeps.

Insecticides were applied with a CO_2-powered backpack sprayer calibrated to deliver 202 liters per hectare at 241.5 kPa (35 psi) through TeeJet no. 8002 nozzles. At maturity, all plots were harvested with a small plot combine, and yield and seed quality were determined. From the yield sample, four 100-seed samples were randomly obtained from each plot. The seeds from these samples were visually examined and categorized as having either light, moderate, heavy or no kernel damage due to stink bug feeding (McPherson et al. 1979b). The 100-seed weights also were determined. These data were analyzed with a paired t test ($P = 0.05$).

Results and Discussion

Over 51,000 stink bugs from four genera were collected and identified from the 2,000 to 2,500 sampling units (25-sweeps) taken from soybeans each season. The seasonal incidence of the primary pest species, *N. viridula, A. hilare, E. servus,* and *P. guildinii,* in each of the three sample areas of Georgia is presented in Table 1. Stink bugs were most numerous in southwest Georgia in 1987, averaging 3.6 per 25 sweeps for the season. In 1988, 1989, and 1991, stink bugs were abundant in all the sampling locations, with seasonal means per sample ranging from 3.3 to 10.6 per 25 sweeps. In 1990, stink bug populations were low throughout the season at all three sites.

The annual soybean production in Georgia, along with the total revenue losses attributed to insect pests and specific losses due to stink bug control costs and crop damage are recorded in Table 2. Soybean production steadily increased during the mid-1980's and peaked at 466,000 ha in 1989, then rapidly declined due to a drought in 1990 and a weakened economy (high production costs/low unit price) in 1991. Revenue losses in soybeans, as reported in the annual summary of losses from insect damage and cost of control in Georgia (Douce and McPherson 1991), varied greatly between years, ranging from $5.9 to $25.3 million. Losses due to stink bugs were very high in 1989 ($13.5 million). Losses due to this pest complex would have been higher in 1988 and 1990, except over 93,000 hectares in southern Georgia received an average of 2 insecticide applications for soybean looper control (Douce and McPherson 1989, 1992). These controls, applied during late August to mid-September, aided in controlling the stink bug populations.

Table 1. Yearly average numbers (and standard error of the mean) of four stink bug species collected from Georgia soybeans grown in three areas, 1987-1991.

Sampling area†	Total 25-sweep samples	Mean stink bugs per 25 sweeps*					Overall Yearly Average
		N.v.	A.h.	E.s.	P.g.	Total	
1987							
SW	740	1.03 (0.91)	0.97 (0.45)	1.03 (0.56)	0.57 (0.27)	3.60	
SC	1300	0.42 (0.80)	0.26 (0.35)	0.22 (0.20)	0.03 (0.10)	0.93	
SE	325	0.17 (0.33)	0.51 (0.61)	0.41 (0.38)	0.38 (0.44)	1.47	1.84
1988							
SW	370	5.55 (1.31)	2.31 (2.01)	0.85 (0.76)	0.23 (0.32)	8.94	
SC	1100	8.36 (3.15)	1.67 (1.85)	0.56 (0.45)	0.03 (0.05)	10.62	
SE	285	4.34 (2.88)	1.09 (1.11)	0.66 (0.76)	0.01 (0.03)	6.10	9.54
1989							
SW	460	4.75 (1.70)	0.57 (0.71)	0.40 (0.55)	0.17 (0.34)	5.89	
SC	1615	7.79 (2.89)	0.61 (0.42)	0.79 (1.10)	0.04 (0.12)	9.23	
SE	360	3.09 (1.47)	0.46 (0.56)	0.88 (1.17)	0.01 (0.03)	4.44	7.90
1990							
SW	370	0.12 (0.29)	1.29 (1.03)	0.16 (0.10)	0.003 (0.01)	1.57	
SC	1670	0.12 (0.35)	0.14 (0.29)	0.12 (0.13)	0.001 (0.01)	0.38	
SE	30	0.17 (0.44)	0.23 (0.18)	0.17 (0.20)	0.00 (0.00)	0.57	0.59
1991							
SW	340	2.15 (2.31)	0.44 (0.55)	0.66 (0.47)	0.02 (0.03)	3.27	
SC	1810	3.29 (2.77)	0.81 (0.43)	1.02 (0.91)	0.01 (0.02)	5.13	
SE	–	–	–	–			4.83
OVERALL	10775	3.40	0.74	0.60	0.08	4.82	

* Stink bug species include *N. viridula* (*N. v.*), *A. hilare* (*A. h.*), *E. servus* (*E. s.*), and *P. guildinii* (*P. g.*).

† Sampling conducted in southwest (SW), south central (SC), and southeast (SE) Georgia.

Table 2. Annual statewide soybean production and revenue losses due to all insect pests and stink bug pests in Georgia, 1987-1991.

Year	Soybean production (hectares)	Total insect losses (million $)	Losses due to stink bugs (million $)*		
			Control costs	Crop damage	Total losses
1987	336,000	5.92	0.27	0.41	0.68†
1988	377,000	7.33	0.42	0.38	0.80†
1989	466,000	25.27	7.59	5.89	13.48
1990	283,000	5.96	0.53	0.54	1.07†
1991	243,000	5.95	1.23	1.34	2.57

* Obtained from annual 'Summary of losses from insect damage and costs of control in Georgia' (Douce and McPherson 1989, 1991, 1992).
† The soybean looper was the number one insect pest in Georgia in 1987, 1988, 1990; insecticide controls directed at this pest aided in control of stink bug pests. The stink bug complex was the most costly soybean pest in 1989 and 1991.

The percentages of each species in the stink bug complex each season during the five year study are presented in Fig. 1. The years when stink bug population densities were low (1987 and 1990), the overall percentage of *N. viridula* was low. The years with economically damaging populations of stink bugs (1988, 1989, and 1991) had a high percentage of *N. viridula*. The *A. hilare* and *E. servus* population densities remained relatively constant between years, reaching population peaks of around 1-2.5 per 25 sweeps in late September. The only exception to this was when the *A. hilare* population in 1988 in South central Georgia peaked at 17.5 per 25 sweeps on 5 October. However, *N. viridula* peaked at 62.4 per 25 sweeps at this location on this sampling date. *P guildinii* were present in high numbers only in 1987, when they comprised over 13% of the annual stink bug complex. From 1988-1991, this species never accounted for more than 0.8% of the complex. Most of the *P. guildinii* were encountered in Southwest Georgia, although some were captured at all three sampling areas.

In Southwest Georgia in 1987, stink bug population densities were very low until mid-August when pods began filling with seeds. They began to steadily increase in late August, reaching the seasonal peak on 14 September of 7.1 per 25 sweeps (Fig. 2). Although *N. viridula* was the most abundant species at this location, each week throughout the season it accounted for less than half of the total pest species captured. The population trend for *P. guildinii* was similar to *N. viridula*, except population densities were higher in the early season and the population peaked at 1.6 per 25 sweeps. Stink bug populations were much higher in 1988, due primarily to the rapid increase of *N. viridula* from mid-September to mid-October (Fig. 3). The seasonal peak in 1988 in the SC Georgia field was attained on 5 October at 82.3 per 25 sweeps, and *N. viridula* accounted for 62.4 of these. *A. hilare* also were abundant in 1988 and peaked at 17.5 per 25 sweeps on 5 October. Population trends in 1989 were similar to 1988, except peak populations were much lower and more *E. servus* and fewer *A. hilare* were captured (Fig. 4). In 1990, a year with very low stink bug population densities, the overall stink bug population peaked only at 1.6 per 25 sweeps on 18 September (Fig. 5). *A. hilare* was the most commonly encountered species on seven of the 13 sampling dates in which some stink bugs were captured (no stink bugs captured on three dates). Stink bug populations in 1991 peaked on 27 September at 17.2 per 25 sweeps (Fig. 6); *N. viridula* was the primary species of this economically damaging population.

Yields and percent kernels with no stink bug damage were significantly increased at the five test sites where insecticide applications were made to control stink bug populations above nine per 25 sweeps (one per 0.3 row-m), the established treatment threshold (Adams 1990) (Table 3). Four of these tests also had significantly fewer moderate or heavy (or both) damaged seeds when insecticides were applied. The 100-seed weights also were significantly higher in the treated plots in two of the tests. In the 1990 test, where stink bug numbers reached only about one-third the treatment threshold, there were no differences in yield, quality, or 100-seed weights.

Several other pentatomid species were encountered in Georgia soybeans during this five year study. Their numbers were very low, so they were not included in the tabular data and population curves. These species included, *Euschistus ictericus* (L.), *E. obscurus* (Palisot de Beauvois), *E. quadrator* Rolston, *E. tristigmus* (Say),

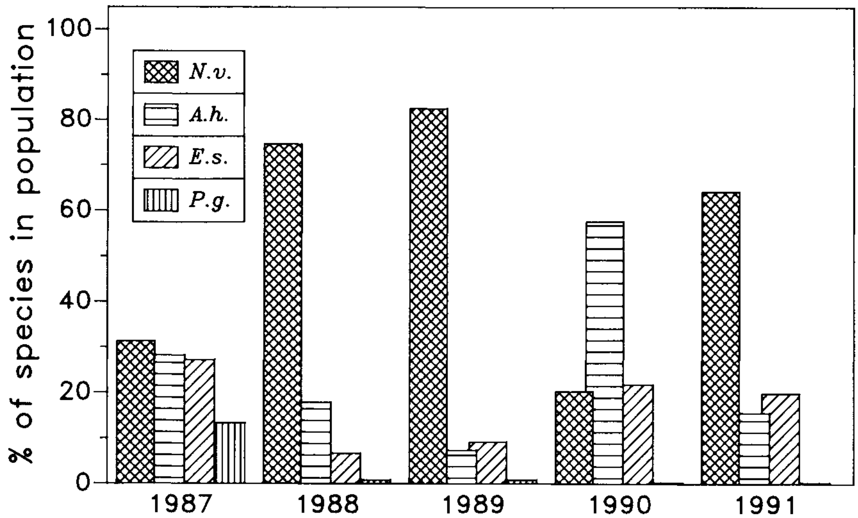

Fig. 1. The percentage of four stink bug species comprising the stink bug pest complex in Georgia soybeans, 1987-1991; *N. viridula* (*N. v.*), *A. hilare* (*A. h.*), *E. servus* (*E. s.*), and *P. guildinii* (*P. g.*).

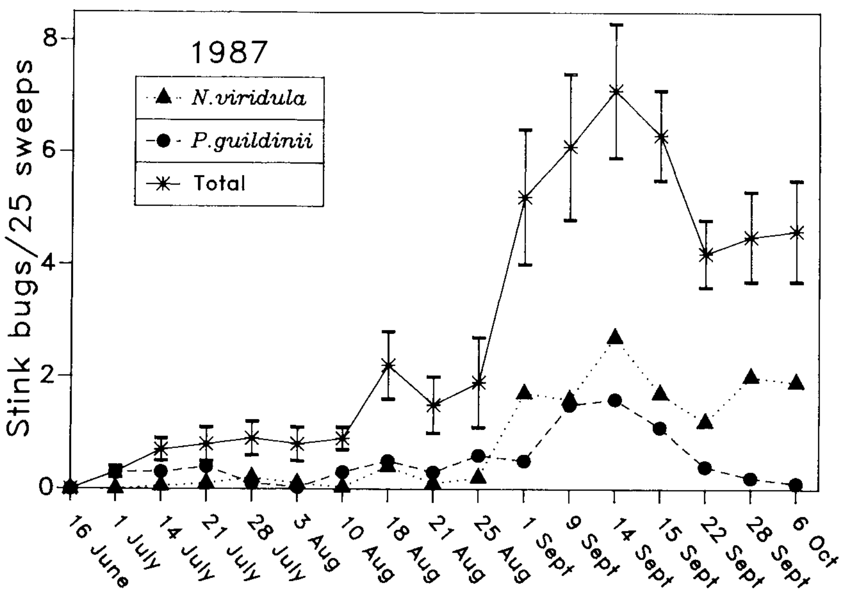

Fig. 2. Seasonal abundance of the soybean stink bug pest complex, and *N. viridula* and *P. guildinii*, in southwest Georgia, 1987. Error bars represent standard error.

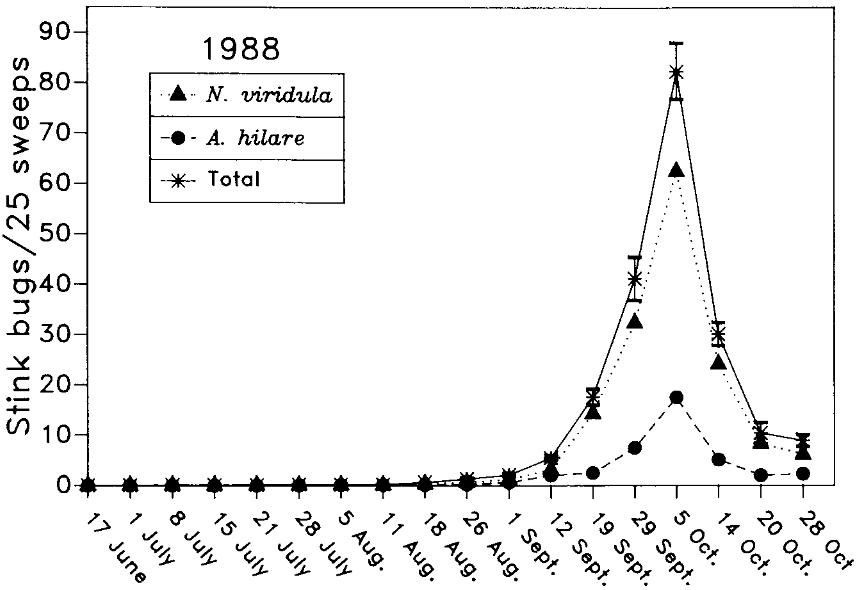

Fig. 3. Seasonal abundance of the soybean stink bug pest complex, and *N. viridula* and *A. hilare,* in south central Georgia, 1988. Error bars represent standard error.

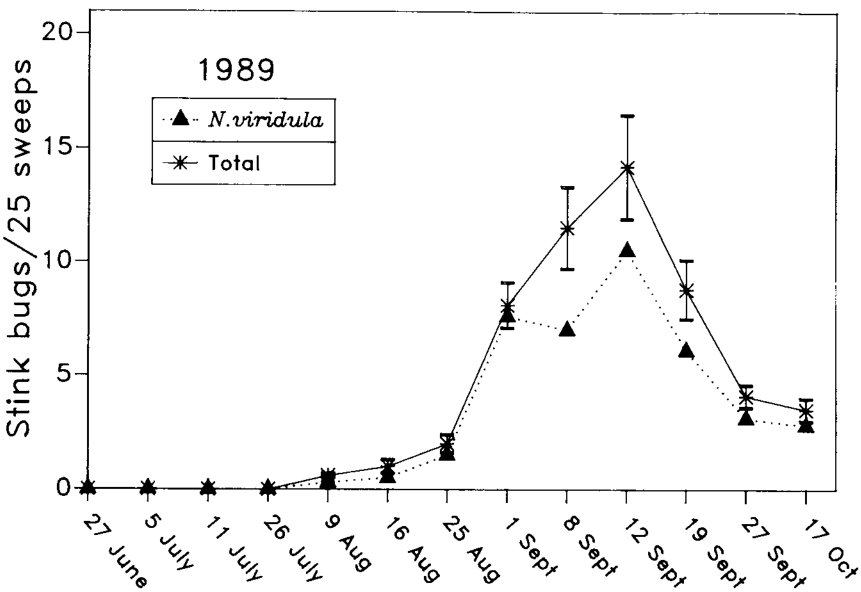

Fig. 4. Seasonal abundance of the soybean stink bug pest complex and *N. viridula* in south central Georgia, 1989. Error bars represent standard error.

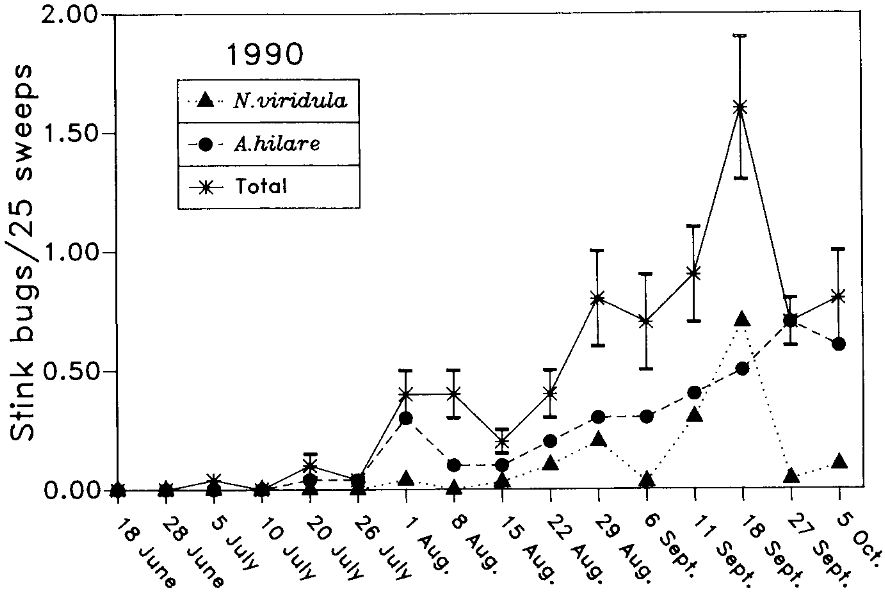

Fig. 5. Seasonal abundance of the soybean stink bug pest complex and *N. viridula* in south central Georgia, 1990. Error bars represent standard error.

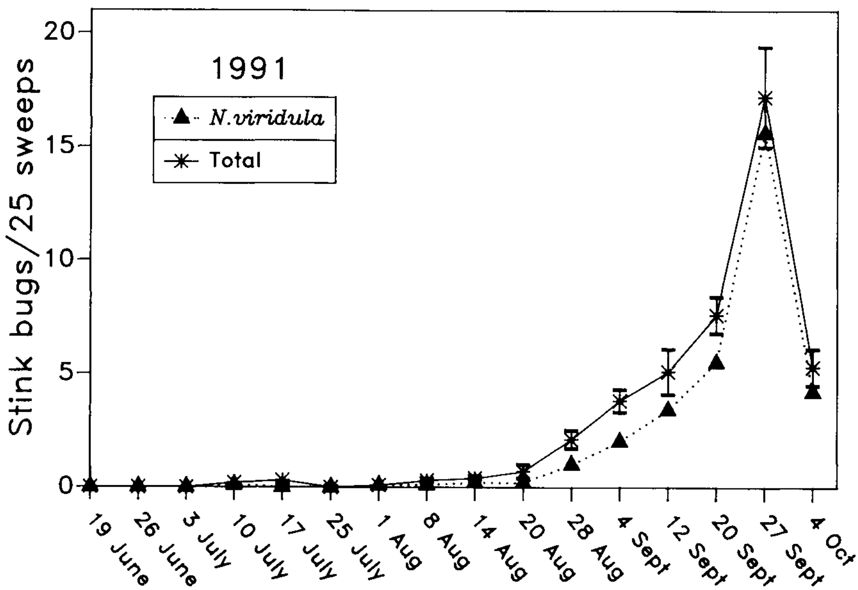

Fig. 6. Seasonal abundance of the soybean stink bug pest complex and *N. viridula* in south central Georgia, 1991. Error bars represent standard error.

Table 3. Effects of stink bug control on the quality (percent stink bug damaged kernels) seed weight, and yield of soybeans in Georgia, 1988-91.

Treatment and kg(AI)/ha		Peak popu. No./25 sweeps	% seeds in damage category: None	Light	Mod.	Heavy	100-seed wt (gm)	Yield kg/ha
			1988 (SW)					
Cyfluthrin 2EC	0.028	39.1	36.3*	39.0	16.6	8.2	15.2*	1845*
Untreated		77.8	11.0	41.1	22.1	25.9*	13.9	1502
			1989 (SW)					
Cyfluthrin 2EC	0.017	10.0	58.3*	38.5	2.8	0.5	18.9	1280*
Untreated		26.0	32.0	50.5	16.3*	1.3	17.4	822
			1989 (SC)					
Cyfluthrin 2EC	0.017	15.5	54.7*	27.7	12.0	5.7	13.8	1644*
Untreated		27.8	21.7	26.3	35.7*	16.3*	13.3	1051
			1990 (SC)					
M. parathion 4E	0.56	3.0	91.8	6.3	0.3	1.7	15.1	1180
Untreated		3.8	89.1	8.2	2.4	0.3	16.0	1212
			1991 (SC)					
M. parathion 4E	0.56	15.0	31.4*	39.4	24.9	4.2	14.9*	1785*
Untreated		26.7	13.1	24.5	47.2*	15.2*	13.4	1145
			1991 (SC)					
Acephate 75S	0.84	15.4	30.6*	37.7	26.9	4.8	14.8	1886*
Untreated		16.5	16.5	38.8	35.9	8.7	14.7	1482

Significant difference in variable tested between the treated and untreated plots, paired t test, $P = 0.05$.

Oebalus pugnax torridus (Sailer), *Perillus bioculatus* Clanda, *Proxys punctulatus* (Palisot de Beauvois), and *Thyanta* spp. Three predatory species of pentatomids also were collected: *Alcaeorrhynchus grandis* (Dallas), *Podisus maculiventris* (Say), and *Stiretrus anchorago* (F.).

In conclusion, numerous pentatomid species were observed in Georgia soybean, but three of these species, *N. viridula*, *A. hilare,* and *E. servus*, made up the vast percentage (over 98% every year except 1987) of the complex. *P. guildinii* also was abundant in 1987 but present at low densities for the next four growing seasons. Thus, this species does not appear to be the economic threat that was suspected after the 1987 season. In the years when economically damaging populations of stink bugs occurred (1988, 1989, 1991), the high stink bug populations were due to the high numbers of *N. viridula*. In the years with low seasonal stink bug densities (1987 and 1990), all three of the major species comprised a near equal percentage of the complex, or *N. viridula* was the least abundant. When the stink bug complex did exceed the treatment threshold level of nine per 25 sweeps, significant reductions were observed in soybean yield and quality if insecticidal controls were not applied.

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