Predation by Green Lynx Spider, *Peucetia viridans* (Araneae: Oxyopidae), Inhabiting Cotton and Woolly Croton Plants in East Texas

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ABSTRACT Predation by green lynx spider, *Peucetia viridans* (Hentz), was studied on cotton and woolly croton plants in East Texas. This species feeds both diurnally and nocturnally. *P. viridans* was observed feeding on insects of orders Diptera, Hymenoptera, Heteroptera, Homoptera, Coleoptera, Lepidoptera, Neuroptera, and Odonata, as well as on several spider species. Predaceous arthropods (e.g., *Hippodamia convergens* Guérin-Méneville, Coccinellidae; *Chrysoperla rufilabris* [Burmeister], Chrysopidae) constituted more than half of the spiders' diet. In cotton, *P. viridans* was found to be a predator of the pests *Heliothis zea* (Boddie) and *Alabama argillacea* (Hübner) (together 8% of the spiders' prey). Size of killed prey in cotton ranged between 0.14- and 1.3-fold the spiders' size (average prey length, 5.90 ± 0.99 mm). On woolly croton plants, *P. viridans* was often seen feeding on cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter) (numerically almost 30% of the spiders' prey), which is a key pest in cotton. It was estimated that on cotton and croton plants in East Texas, one *P. viridans* captured an average of less than one prey daily. Our results are compared with data in the literature on the diet of *P. viridans*.

KEY WORDS *Peucetia, Pseudatomoscelis,* cotton, croton, predation, diet

ONE OF THE most conspicuous American spiders is the green lynx, *Peucetia viridans* (Hentz). This vivid green species is armed with many black spines on its legs. Average length of adult females is 16 mm and that of adult males is 12 mm, making it the largest lynx spider north of Mexico (Brady 1964). *P. viridans* is a hunting spider that remains motionless on leaves in a characteristic prey-catching posture. This spider inhabits foliage of tall grass, weeds, and shrubs throughout the southern United States from coast to coast. *P. viridans* has been found in cotton fields in Arkansas (Whitcomb et al. 1963) and Texas (Dean et al. 1982), soybean fields in Arkansas (Whitcomb et al. 1966) and North Carolina (Deitz et al. 1980), and grasslands in Texas (Brady 1964).

Whitcomb et al. (1963) reported that *P. viridans* feeds on bollworm, *Heliothis zea* (Boddie), moths; cotton leafworm, *Alabama argillacea* (Hübner), moths; and cabbage looper, *Trichoplusia ni* (Hübner), moths. All are considered to be pests in cotton. Thus, a better understanding of the feeding ecology of this spider species is important to entomologists and ecologists interested in natural and biological control of cotton pests. Data on the feeding ecology of *P. viridans* on cotton and croton plants in East Texas are presented to add to the list of known prey species of this spider.

Materials and Methods

Part of this investigation was conducted in an unsprayed cotton field located 8 km west of Austonio, Tex., near Crockett in Houston County, during the summer of 1985 (June–mid-September). The cotton field bordered on extensive meadows (composed of various grasses and low-growing annual Dicotyledonae), which are considered to be predator reservoirs for colonization of the cotton fields by spiders (unpublished data). The cotton was planted on 27 May and emerged in the 1st wk of June. Observations were also made in an unsprayed cotton field near Huntsville, Tex., from 1978 to 1981.

Other studies were conducted in a plant community (ca. 0.1 ha) dominated by woolly croton, *Croton capitatus* Michaux, in late summer 1984 (August–September). Woolly croton is the primary host of the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter). The site was located next to a residential area.

Feeding by *P. viridans* was observed along cotton rows or across the croton field at different times of the day and year, and the numbers of spiders with and without prey were recorded. To test if the frequency of feeding in *P. viridans* depends on time of day or season, we applied the χ^2-test for contingency tables to our data. A total of 85 h was spent observing *P. viridans* in cotton and 25.5 h in croton. Additional data were gathered while we observed the feeding habits of other spider species. Between 1978 and 1984 the observed cases of predation were recorded directly in a field book. In 1985, spiders with prey were captured by hand in a plastic cup (7 cm diameter), killed, and preserved in 70% ethyl alcohol. Later, the prey were

Table 1. Striped and green lynx spiders as a percentage of all hunting spiders[a] on cotton foliage

Date	Total no. foliage-hunting spiders observed[a]	Striped lynx (%)	Green lynx (%)	Both lynx species (%)
22–28 July	170	74.7	19.4	94.1
29 July–4 Aug.	400	68.8	20.5	89.3
5–11 Aug.	479	79.1	12.3	91.4
12–18 Aug.	548	70.8	19.7	90.5
19–25 Aug.	305	75.7	11.5	87.2
26 Aug.–3 Sept.	395	84.3	11.1	95.4
4–8 Sept.	124	83.1	12.1	95.2
$\bar{x}$	—	76.6	15.2	91.8

[a] All spiders found on cotton plants that capture prey without a web.

identified in the laboratory under a microscope. Night observations were carried out with a head lamp.

An important parameter in the evaluation of the spiders' potential as biological control agents is the prey capture rate (no. of prey/spider/day), because the impact of spiders on prey populations is, among others, a function of this value. The prey capture rate (b) of *P. viridans* was calculated according to Edgar's (1970) method developed for wolf spiders, modified by us as follows:

$$b = (T_f \cdot 60 \cdot w)/(1 \cdot T_h \cdot 100),$$

where T_f is the time (hours per day) available for prey capture and feeding in the field, w is the percentage of spiders with prey in a sample, and T_h is the average handling time (in minutes). The handling time is the period between the initiation of an attack and the cessation of feeding. To assess T_f and w, collections were made in the field at different times of the day, and the numbers of spiders with and without prey were recorded (see above). T_h was evaluated in feeding experiments.

Results

During the summer of 1985, the green lynx constituted 11–20% of the hunting-spider fauna observed on the foliage in an East Texas cotton agroecosystem (Table 1). In the same agroecosystem, the striped lynx, *Oxyopes salticus* Hentz, constituted 70–84% of the observed hunting spiders on foliage (Table 1). Studies on the feeding ecology of *O. salticus* are described in Nyffeler et al. (1987). Together, these oxyopids constituted >85% of the entire hunting-spider fauna on foliage, suggesting that based on abundance they are the dominant spiders in East Texas cotton fields.

P. viridans is univoltine in East Texas (Killebrew & Ford 1985), and according to a study by Whitcomb et al. (1966) in Arkansas cotton fields, late instars of *P. viridans* occur in late May and early June, and adults are present in late June and thereafter. A similar seasonal trend was observed in East Texas. In the cotton agroecosystem at Austonio, the green lynx spiders observed feeding had an average body length of 10.96 ± 0.41 mm ($\bar{x}$ ± SE; range, 8.2–12.7 mm). The early instars of this spider were not found in this cotton agroecosystem. Thus, all *P. viridans* observed in cotton were late instars or adults. In cotton, *P. viridans* killed prey of a size between 0.14- and 1.3-fold its own size. Prey had an average body length of 5.90 ± 0.99 mm ($\bar{x}$ ± SE; range, 1.6–16.5 mm).

Twenty-five predation events by *P. viridans* on

Table 2. Prey of *P. viridans* in unsprayed cotton fields

Prey			No. prey	Location[a]	Stage[b]	% prey
Diptera			2	A	a	8.0
Hymenoptera	Apidae	*Apis mellifera* L.	1	H	a	4.0
	Wasps		1	H	a	4.0
	Unidentified		1	A	a	4.0
Heteroptera	Reduviidae	*Zelus cervicalus* Stål	1	A	a	4.0
	Miridae	*Spanagonicus albofasciatus* (Reuter)	1	A	a	4.0
	Nabidae	*Tropiconabis capsiformis* (Germar)	1	A	a	4.0
Coleoptera	Coccinellidae	*H. convergens*	1	A	a	4.0
Lepidoptera	Noctuidae	*A. argillacea*	1	H	i	4.0
	Noctuidae	*H. zea*	1	H	a	4.0
Neuroptera	Chrysopidae	*C. rufilabris* (Burmeister)	2	A	a	8.0
Araneae	Araneidae	*A. stellata*	2	A	a, i	8.0
	Linyphiidae	*Eperigone* sp.	1	A	a	8.0
	Oxyopidae	*O. salticus*	2	A	a	8.0
	Oxyopidae	*P. viridans*	1	A	a	4.0
	Clubionidae	*C. inclusum*	2	A	a	8.0
	Lycosidae		1	A	i	4.0
	Salticidae		1	H	i	4.0
Unidentified arthropods			2	A		8.0
Total			25			100

[a] A, Austonio (1985); H, Huntsville (1978–81).
[b] a, adult; i, immature.

Table 3. Diel change of percentage of feeding spiders in a *P. viridans* population in a cotton agroecosystem

Time (hours; CST)	No. h spent observing (x)	No. spiders observed (y)	No. spiders observed/h (y/x)	No. spiders with prey[a] (z)	% spiders with prey ($100z/y$)
0800–1155	25	140	5.6	7	5.0
1200–1555	17	69	4.1	4	5.8
1600–1955	19	94	4.9	4	4.3
2000–2355	13	53	4.1	0	0
2400–0355	3.5	12	3.4	1	8.3
0400–0755	7.5	29	3.9	4	13.8

[a] $P > 0.05$; χ^2-test for contingency tables.

cotton arthropods were recorded (Table 2). Food of *P. viridans* consisted exclusively of arthropods (Insecta or Arachnida). Forty percent of the prey items were spiders. Events of inter- and intraspecific predation were observed. Among the insects captured by *P. viridans* were species of the orders Hymenoptera, Heteroptera, Coleoptera, Diptera, Lepidoptera, and Neuroptera. More than half of these 25 prey were predaceous arthropods (e.g., *Chrysoperla rufilabris* [Burmeister] and *Hippodamia convergens* Guérin-Méneville); and two cotton pests, *H. zea* and *A. argillacea*, were observed as prey. One reason for the low incidence of predation by spiders on pests in the cotton fields near Austonio is that the pests were relatively rare during the period of this study; however, pests were more abundant at Huntsville (D.A.D., unpublished data).

The proportion of *P. viridans* with prey at different times of the day (Table 3) suggests that this species feeds both day (0800–2000 hours CST) and night (2400–0800 hours). The number of spiders with prey did not depend on the time of day ($P > 0.05$; χ^2-test for contingency tables). The percentage of feeding spiders was <10% throughout the 1985 season (Table 4); no dependence of the number of spiders with prey upon the time of the year was found ($P > 0.05$; χ^2-test for contingency tables).

Edgar's (1970) formula for calculation of b of *P. viridans* was used as previously described. Values used were as follows: $T_f = 20$ (see Table 3), $w = 5.35$ (mean from Table 4), and $T_h = 270$ (based on our observations). On this basis it was estimated that one spider captured about one prey every 4 d.

Table 5. Prey of *P. viridans* on croton plants

Prey		No. prey	% prey
Diptera	Muscidae	1	1.5
	Asilidae	1	1.5
Hymenoptera	Ants	1	1.5
	Wasps (medium-sized)	8	11.8
	Apis mellifera	9	13.2
	Bumble bees	1	1.5
Heteroptera	Cotton fleahoppers[a]	20	29.4
Homoptera	Leafhoppers	1	1.5
Coleoptera		5	7.3
Neuroptera	Chrysopidae	3	4.4
Lepidoptera	Moths	6	8.8
Odonata		1	1.5
Araneae			
Araneidae	*Neoscona arabesca* (Walckenaer)	1	1.5
Oxyopidae	*O. salticus*	3	4.4
Oxyopidae	*P. viridans*	2	2.9
Lycosidae	*Pardosa* sp.	1	1.5
Thomisidae	*Misumenops* sp.	2	2.9
Salticidae	*Hentzia palmarum* (Hentz)	1	1.5
Salticidae	*P. audax*	1	1.5
Total		68	100

[a] All adults except one.

A total of 68 instances of prey capture was observed on woolly croton during late summer in 1984 near College Station (Table 5). As in cotton, the food of *P. viridans* consisted exclusively of Insecta and Arachnida. Sixteen percent of the prey were spiders (inter- and intraspecific predation). Among the insects killed by *P. viridans* on croton plants were species of the orders Diptera, Hymenoptera, Heteroptera, Homoptera, Coleoptera, Neuroptera, Lepidoptera, and Odonata. Half of the prey were entomophagous arthropods or pollinators. Twenty-nine percent of the prey of *P. viridans* were cotton fleahoppers, considered to be key pests in cotton in East Texas.

A total of 668 *P. viridans* was encountered on woolly croton with 68 observed cases of predation

Table 4. Seasonal change of percentage of feeding spiders in a *P. viridans* population and estimated prey capture rates

Date	No. h spent observing (x)	No. spiders observed (y)	No. spiders observed/h (y/x)	No. spiders with prey[a] (z)	% spiders with prey ($w = 100z/y$)	No. prey/spider/d ($b = 0.0444w$)
22–28 July	4.5	33	7.33	2	6.1	0.22
29 July–4 Aug.	14	76	5.43	5	6.6	0.29
5–11 Aug.	17	65	3.82	3	4.6	0.20
12–18 Aug.	18.5	108	5.84	3	2.8	0.12
19–25 Aug.	9	35	3.89	1	2.9	0.13
26 Aug.–3 Sept.	10	44	4.40	4	9.1	0.40
4–8 Sept.	4.5	15	3.33	0	[b]	[b]
$\bar{x}$	—	—	4.86	—	5.35	0.23

[a] $P > 0.05$; χ^2-test for contingency tables.
[b] Sample size too small for calculation of w and b.

(10.2%). Using this w value, and under the assumption that the T_h is about the same in cotton and croton, we calculated $b = 0.5$, indicating that on woolly croton plants a spider captures an average of one prey every 2nd d.

Discussion

On shrubs in California, Turner (1979) collected 189 prey of *P. viridans* and reported this spider feeding on Hymenoptera (41%), Diptera (15%), Lepidoptera (15%), Heteroptera (9%), Orthoptera (8%), Araneae (7%), and Coleoptera (4%).

In Florida, Randall (1982) collected 66 prey of *P. viridans*, which belonged to the insect orders Hymenoptera (41%), Diptera (27%), Heteroptera (21%), Lepidoptera (8%), and Coleoptera (3%). In Arkansas, Whitcomb et al. (1963, 1966) reported *P. viridans* feeding on moths of the families Noctuidae, Geometridae, and Pyralidae, as well as on dipterans (syrphid and tachinid flies), and hymenopterans (honey bees, sphecid and vespid wasps).

In our study, a considerable proportion of the prey of *P. viridans* was spiders. Eighteen cases of interspecific predation and three cases of cannibalism were observed. This result is contrary to the observations of Whitcomb et al. (1963), Turner (1979), and Randall (1982), who reported either no or few cases of interspecific predation between *P. viridans* and other spiders. Among those spiders captured by the green lynx, *O. salticus*, *Phidippus audax* (Hentz), *Misumenops* sp., *Chiracanthium inclusum* (Hentz), and *Acanthepeira stellata* (Walckenaer) are abundant spiders in East Texas cotton fields (Dean et al. 1982). *P. viridans* killed orb-weavers and irregular-web-building spiders, as well as hunting spiders. It is interesting that *P. viridans* even preyed on a large orb-weaver (adult *A. stellata*). During interspecific encounters, the green lynx probably has an advantage over most other spiders in cotton because of its large size. In the field we never found another species of spider feeding on a green lynx. Because birds are fairly minor predators in these cotton fields (W.L.S., unpublished data), the green lynx may be considered a top predator in cotton fields.

Our data concerning the prey of *P. viridans* confirm the findings of Turner (1979) and Randall (1982) that this spider has a diverse diet and, therefore, must be characterized as a food generalist. Another oxyopid spider occurring in this East Texas cotton agroecosystem, which was also observed to be a generalist predator, is *O. salticus* (Nyffeler et al., 1987).The striped lynx has a body length of <50% of that of *P. viridans*. The average prey length of the striped lynx was only 44% of that of the green lynx. This means that the striped lynx and the green lynx complement each other in their predatory activities; the striped lynx kills mainly small prey and the green lynx kills in addition medium- and larger-sized prey.

Previous reports described *P. viridans* as a diurnal species (e.g., Weems & Whitcomb 1977). But as our study revealed, this species is active diurnally and nocturnally. Nocturnal feeding in this species probably was overlooked because few investigators conducted night observations.

During the summer of 1985, only 20 instances of feeding in *P. viridans* were observed. This number of observed cases of predation seems to be very low. We found in cotton 4.86 green lynx spiders per hour on the average (Table 4), but in a California shrub habitat 15–25 green lynx spiders per hour were observed from July to September (Turner & Polis 1979), indicating that in California the population density was ca. 4-fold higher. In our study, the proportion of feeding spiders was ca. 3–9% (Table 4), but in the California shrub habitat 4-fold as many green lynx spiders (21.4%) were observed feeding (Turner 1979). Thus, in the California study the probability of encountering a feeding green lynx spider was ca. 16-fold higher than in our study. If the density of feeding spiders had been as high in the Texas agroecosystem as in the California shrub habitat, then we would have expected to find ca. 320 prey items during the summer of 1985.

Whitcomb et al. (1966) in Arkansas based their prey analysis on the collection of the dry carcasses of insects that were found below green lynx spiders and were considered to have been prey dropped by the spiders after the meal. This method of prey analysis is much less time-consuming than our method of direct observation. But in parts of the southern United States (e.g., in East Texas), the method of Whitcomb et al. can no longer be applied because these areas are now colonized by red imported fire ants, *Solenopsis invicta* Buren, scavengers that remove the carcasses.

It was estimated that on cotton and croton plants in East Texas less than one prey per green lynx spider per day was killed. If we put Turner's value of $w = 21.4$ into Edgar's (1970) formula and if we assume that on shrubs in California the T_h was the same as in our study in Texas, then we calculate $b = 0.95$, which indicates that on shrubs in California about one prey per spider per day was killed by *P. viridans* females. Also, in other hunting spiders it was found that not more than one prey per spider was killed daily (Edgar 1970, Schaefer 1974, Nyffeler & Benz 1981). In Europe, Edgar (1970) found that frequency of feeding in the wolf spider *Pardosa amentata* (Clerck) was affected by the time of day and by weather conditions. In our study we tested to see if frequency of feeding of *P. viridans* depended on the time of day or season, but no such dependence was found.

The previous work on *P. viridans* in Arkansas, California, and Florida led to the conclusion that this spider species captures numerous beneficial arthropods (predators or pollinators, or both). Weems & Whitcomb (1977, 1) stated that these spiders' ". . . usefulness in control of insect pests is counteracted by their willingness to prey also upon beneficial insects." The same authors wrote that *P. viridans* killed large numbers of honey bees and sphecid and vespid wasps, as well as syrphid and tachinid flies. In Turner's (1979) study, honey bees constituted the single most important prey taxon in the diet of *P. viridans* in California. Also, Randall (1982, 20) came to the conclusion that *P. viridans* "is counterproductive as a predator of economically important insects since it takes beneficial insects as prey more often than it takes harmful insects." According to Randall the ratio of "beneficial prey : harmful prey" in Florida was 44:12.

Our work confirms the observations of these previous workers that the diet of larger *P. viridans* may consist of a high percentage of beneficial arthropods (in our study more than half of *P. viridans*'s prey were beneficial). However, more data about the prey of these spiders and the mortality of the prey in cotton and other crops are needed before we can draw conclusions about the overall positive, neutral, or negative effect of the green lynx as a biological control agent. On the basis of our experience, we estimated that 425 h would have to be spent in cotton fields comparable with those in Austonio to be able to collect just 100 specimens of *P. viridans* with prey. On croton plants, 50% of the green lynx's diet consisted of predaceous arthropods and 10% of pollinators, but at the same time numerous economic pests (ca. 30% cotton fleahoppers) were killed by the green lynx. It would be of interest to conduct a similar study on green lynx spider predation in cotton in a year when the injurious pests are common.

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