Performance of Southern Green Stink Bug (Heteroptera: Pentatomidae) Nymphs and Adults on a Novel Food Plant (Japanese Privet) and Other Hosts

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ABSTRACT Japanese privet, *Ligustrum japonicum* Thunb. (Oleaceae), was found to be a novel food plant of the southern green stink bug, *Nezara viridula* (L.), in the state of Paraná, Brazil. In the laboratory, nymphs performed better when fed on immature fruits of soybean, *Glycine max* (L.) Merrill (Leguminosae), than on immature fruits of Japanese privet. Female and male nymphs required 6.7 and 4.6 d more to complete development on Japanese privet than on soybean, and had greater mortality on the former (38.7%) than on the latter (20.0%) food plant. At emergence, adult fresh body weight was ≈31–40% greater on soybean than on Japanese privet. In contrast, adult *N. viridula* performed better on Japanese privet than on soybean; 62.5% of females oviposited on the 1st and 45.0% on the 2nd food. Fecundity was 2–3 times greater on Japanese privet [alone or supplemented with dried soybean seeds + shelled peanuts, *Arachis hypogaea* (L.) (Leguminosae)] than on soybean fruits or on vegetative soybean plants or water cress, *Nasturtium officinale* L. (Brassicaceae), leaves. These 2 last foods were supplemented with dried soybean seeds + peanuts. The amount of fresh body weight gain up to the 4th wk of adult life was ≈3 times greater on Japanese privet fruits than on soybean fruits. Total longevity was similar for females and males on Japanese privet or soybean fruits, but it was greater on Japanese privet + soybean seeds + peanuts than on water cress + soybean seeds + peanuts. These results indicate that *N. viridula* has expanded its host range to Japanese privet in Brazil, and that the berries of this plant are suitable food particularly for adults.

KEY WORDS southern green stink bug, *Ligustrum japonicum, Glycine max, Arachis hypogaea, Nasturtium officinale,* food effect

THE SOUTHERN GREEN stink bug, *Nezara viridula* (L.), is cosmopolitan and polyphagous. Several studies have listed host plants (cultivated and uncultivated) from many parts of the world (e.g., van Heerden 1934, Hoffmann 1940, Rizzo 1968, Silva et al. 1968, Lopes et al. 1974, Vélez 1974, Todd and Herzog 1980, Link and Grazia 1987, Jackai et al. 1990). Despite its wide range of host plants, *N. viridula* is not recorded on plants of the family Oleaceae, except for reports of its occurrence on *Ligustrum vulgare* L. and *L. ovalifolium* Hassk. in southern Brazil (Lopes et al. 1974, Link and Grazia 1987).

Recently, we observed *N. viridula* feeding and reproducing on Japanese privet, *Ligustrum japonicum* Thunb. (Oleaceae), in Londrina (latitude 23° 11' S, longitude 51° 11' W) and in Curitiba (latitude 25° 25' S, longitude 49° 15' W), in the state of Paraná. *L. japonicum* is abundant, particularly in Londrina, where it is used in the city as an ornamental. The stink bug originates on preferred hosts, such as soybean, *Glycine max* (L.) Merrill, which is widely cultivated in this area during summer. This abundance in food causes populations of *N. viridula* to increase dramatically, and the insect seeks alternate hosts when soybean is harvested. *L. japonicum,* abundant and perennial, with fruits (preferred feeding sites) during most of the year, is exploited as a food resource by this insect.

This investigation was conducted to test the suitability of immature fruits (berries) of *L. japonicum* for nymph (survivorship, developmental time, and body weight attained at adult emergence) and adult (longevity, reproduction, and weight gain) *N. viridula,* and to compare the results with insects feeding on immature fruits of a preferred food (i.e., soybean pods). In addition, we compared the reproductive performance of *N. viridula* on *L. japonicum,* on soybean plants (vegetative) mixed with dried seeds plus raw peanuts, *Arachis hypogaea* (L.) (Leguminosae), which is commonly used to mass rear this insect in the laboratory (Corrêa-Ferreira 1985), and on water cress, *Nasturtium of-*

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ficinale L. (Brassicaceae), which is colonized by *N. viridula* in Curitiba.

Material and Methods

Nymphal Study. During December 1994 and January 1995, egg masses of *N. viridula* were obtained from a laboratory culture established in cages (50 by 50 by 70 cm) with potted soybean plants 'Paraná' plus mature soybean seeds and raw-shelled peanuts of unknown variety. Egg masses were collected on the day of oviposition and placed in petri dishes (9.0 by 1.5 cm) with moistened filter paper. On the 1st d of the 2nd stadium (1st instars do not feed), nymphs were removed and placed individually in petri dishes. Immature fruits of Japanese privet and soybean were offered. For each food, 80 nymphs (replicates) were used.

Petri dishes were placed at random in an environmental chamber maintained at 25 ± 1°C and 65 ± 5% RH with a photoperiod of 14:10 (L:D) h. Daily observations were made on molting and mortality, and food was replaced every 2 d. Nymphal development time and percentage of mortality of each instar (except the 1st) and from 2nd instar to adult, were calculated. Fresh body weight at adult emergence was taken using an electronic balance. Data were analyzed with *t*-test ($P < 0.05$).

Adult Study. During February 1995, *N. viridula* nymphs (mostly 3rd instars) were field collected on soybean plants growing in the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) Farm at Londrina County, northern Paraná. Nymphs were taken to the laboratory and separated into 2 groups in plastic rearing boxes (12.0 by 12.0 by 3.8 cm) covered with a lid; the 1st group was fed immature fruits of Japanese privet, and the 2nd group was fed immature fruits of soybean. Upon molting to adult, single female/male pairs were placed in a rearing plastic box with moistened filter paper, which was covered with a lid. Forty pairs were fed immature fruits of Japanese privet and 40 were fed immature fruits of soybean. Food was replaced every 2 d.

During February–April 1995, daily observations were made on adult survivorship and reproduction. Total longevity, percentage of females ovipositing, female age at 1st oviposition, mean number of egg masses and eggs per female, and percentage of egg hatch were calculated. Adult body weight gain (%) during the 1st, 2nd, and 4th wk of life was calculated. Data were analyzed with *t*-test ($P < 0.05$).

Two additional studies were done to compare adult reproductive performance. In the 1st study, *N. viridula* adults were field collected on 23 May 1995 on castor bean, *Ricinus communis* L. (Euphorbiaceae), at the EMBRAPA Farm and taken to a rearing room (25 ± 2°C, 65 ± 5% RH, and a photoperiod of 14:10 [L:D] h). One hundred pairs were put in each of 8 cages (50 by 50 by 70 cm). Adults from 4 cages were fed immature fruits of

Table 1. Mean ± SEM developmental time and fresh body weight of 1-d-old *N. viridula* feeding on immature fruits of Japanese privet or soybean in the laboratory

Food[a]	Stadium duration, d[b]				Total developmental time, d[c]		Fresh body wt, mg	
	2nd	3rd	4th	5th	Female	Male	Female	Male
Japanese privet	6.5 ± 0.21a [66]	6.0 ± 0.26a [64]	6.3 ± 0.14a [61]	9.9 ± 0.34a [49]	*30.1 ± 0.76a [27]	26.9 ± 0.65a [22]	*137.0 ± 6.40b [27]	104.8 ± 3.71b [22]
Soybean	5.1 ± 0.04b [75]	4.4 ± 0.13b [71]	5.2 ± 0.16a [71]	8.3 ± 0.15b [64]	*23.4 ± 0.49b [27]	22.3 ± 0.30b [37]	*180.1 ± 4.21a [27]	146.5 ± 2.34a [37]

Means followed by the same letter in each column do not differ significantly ($P < 0.05$) using *t*-test. *, Significant difference ($P < 0.05$) between sexes using *t*-test.

[a] Initial number of nymphs $n = 80$ on each food.

[b] Numbers surviving each stadium are given in brackets.

[c] From 2nd stadium to adult.

Table 2. Reproductive performance (mean ± SEM) of *N. viridula* females feeding on immature fruits of Japanese privet or soybean in the laboratory

Food	Females ovipositing, % (no.)	Female age (days) at 1st oviposition	No. per female[a]		Egg hatch, %[b]
			Egg masses	Eggs	
Japanese privet	62.5 (25)	21.5 ± 2.30a	3.8 ± 0.53a	256.5 ± 40.87a	97.8 ± 0.54a
Soybean	45.0 (18)	27.4 ± 2.30a	1.4 ± 0.14b	67.7 ± 10.57b	99.8 ± 0.19a

Means followed by the same letter in each column do not differ significantly ($P < 0.05$) using t-test.
[a] Data from female ovipositing.
[b] Data transformed to arcsine for analysis.

Japanese privet, and adults from the remaining 4 cages were fed soybean (potted plants plus dried Paraná seeds) plus raw shelled peanuts of unknown variety. Daily observations were made for 30 d and egg masses were collected. The number of egg masses and total eggs per cage, and the number of eggs per mass were calculated. Data were analyzed with t-test ($P < 0.05$).

In the 2nd study, egg masses of *N. viridula* were obtained in the laboratory from adults field collected on soybean near Curitiba, in southern Paraná. Colonies of nymphs were established in cylindrical cages (10 by 15 cm) with immature fruits of Japanese privet or green leaves of water cress. At adult emergence, females and males were paired, and each pair was put in a cage with fruits from Japanese privet ($n = 20$) or leaves of water cress ($n = 10$). In both cases, soybean seeds 'IAC 6' and raw peanuts of unknown variety were used as complementary diet. Cages were taken to a rearing room (25 ± 1°C, 60 ± 10% RH, and a photoperiod of 14:10 [L:D] h). Foods were replaced every 3 d. From April 1994 to February 1995, daily records were made of survivorship and oviposition. The number of egg masses and total eggs per female, the number of eggs per mass, and adult longevity were calculated. Data were analyzed with t-test ($P < 0.05$).

Results

Nymphal Study. Developmental time for each of the nymphal stadia (except the 4th) and for total nymphal period (stadia 2 through 5) was significantly longer on Japanese privet than on soybean (Table 1). Nymphs took from 1.1 to 1.6 d longer to complete the various stadia on Japanese privet than on soybean; female and male nymphs required 6.7 and 4.6 d longer on Japanese privet than on soybean to complete nymphal development (except 1st stadium). Mean developmental time was greater ($P < 0.05$) for females than for males on both foods (Table 1).

Total nymph mortality was greater on Japanese privet (38.7%) than on soybean (20.0%). On Japanese privet, mortality was particularly greater during the 2nd and 5th stadia (≈3- and 2-fold) than on soybean (Table 1).

Fresh body weights attained at adult emergence were significantly greater for females and males fed on soybean than fed on Japanese privet (Table 1). On soybean, adults were ≈31–40% heavier than on Japanese privet. Females were heavier than males on both foods.

Adult Study. Unlike the nymphs, adult *N. viridula* performed better in general on Japanese privet than on soybean. For instance, 62.5% of the females fed on Japanese privet oviposited, whereas on soybean this value was 45.0% (Table 2). Females tended to take longer (≈6 d more) to oviposit on soybean than on Japanese privet, although no significant difference was observed. Fecundity was ≈3 times greater in number of egg masses and ≈4 times greater in total number of eggs on Japanese privet than on soybean. Total longevity, however, was similar for females (40.4 ± 4.36 and 32.6 ± 2.25 d) and for males (31.1 ± 3.40 and 29.9 ± 2.24) on both foods; percentage of egg hatch was also similar between females fed on the 2 foods.

Mean percentage of increase in fresh body weight of female *N. viridula* was 3 times greater on Japanese privet than on soybean during the 1st wk of adult life, 2 times during the 2nd wk, and 3 times during the 4th wk, with a range of ≈14–42%

Table 3. Mean ± SEM percentage of fresh body weight gain of *N. viridula* feeding on immature fruits of Japanese privet or soybean in the laboratory (number of adults in brackets)

Food	Female			Male		
	Week 1	Week 2	Week 4	Week 1	Week 2	Week 4
Japanese privet	17.8 ± 4.28a [40]	14.3 ± 3.73a [29]	42.2 ± 3.93a [27]	14.3 ± 3.09a [37]	3.4 ± 1.81a [30]	27.7 ± 3.88a [20]
Soybean	5.4 ± 2.97b [39]	6.2 ± 3.08a [37]	13.2 ± 5.18b [23]	7.2 ± 1.85a [38]	3.8 ± 2.09a [36]	15.0 ± 3.14b [21]

Means followed by the same letter in each column do not differ significantly ($P < 0.05$) using t-test.

Table 4. Reproductive performance (mean ± SEM) of *N. viridula* feeding on immature fruits of Japanese privet or soybean plus peanuts, in rearing room (n = 4 cages)

Food	No./cage		No. eggs/mass
	Egg masses	Eggs	
Japanese privet	22.3 ± 1.98a	1,280.0 ± 148.82a	57.3 ± 3.63a [89][c]
Soybean[a] + Peanut[b]	8.0 ± 0.93b	390.0 ± 74.88b	47.0 ± 4.56a [32]

Means followed by the same letter in each column do not differ significantly ($P < 0.05$) using t-test.
[a] Vegetative plants plus dried seeds.
[b] Shelled peanuts.
[c] Total number of egg masses obtained.

body weight increase (Table 3). For males, a similar trend was observed: 2 times more fresh body weight gain during the 2nd and 4th wk on Japanese privet than on soybean (range, ≈7–15% weight increase); during the 2nd wk no difference was observed, and there was relatively little weight gain (≈4%) on each food.

Data from the rearing room (in Londrina) indicated a better reproductive performance of *N. viridula* on Japanese privet than on soybean (vegetative plants and dried seeds) plus peanuts. For example, total numbers of egg masses and eggs per cage were ≈3 times greater on the former food than on the latter (Table 4). The number of eggs per mass tended to be greater on Japanese privet than on soybean + peanuts, although not significantly so ($P > 0.05$).

Data from the rearing room (Curitiba) showed a greater (>2 times) adult longevity of *N. viridula* on Japanese privet plus soybean seeds and peanuts than on water cress plus soybean seeds and peanuts (Table 5). Adult fecundity was also greater (>2 times the number of egg masses per female and >3 times the number of eggs per female) on Japanese privet than on water cress, supplemented with soybean seeds and peanuts. There were also more eggs per mass on the former than on the latter food.

Discussion

These results demonstrate that the performance of the highly polyphagous *N. viridula* is influenced by food. The fact that nymphs showed greater survivorship, faster developmental time, and attained greater weight at adult emergence on immature fruits of soybean than on immature fruits of Japanese privet may be explained, not only by the greater preference of this bug for legumes in general (Todd 1989), but by the greater suitability of this food for nymphs. Most studies carried out with *N. viridula* nymphs feeding on soybean indicate a relatively low (<30%) nymph mortality, whereas on other host plants, uncultivated and some perennial like the Japanese privet, nymph mortality was >40% (e.g., Jones 1979, Panizzi and Rossini 1987, Panizzi and Meneguim 1989, Panizzi and Slansky 1991, Velasco and Walter 1992, Panizzi and Saraiva 1993), which is more in agreement with the ≈40% mortality found here for nymphs on Japanese privet. In addition, it is interesting that mostly adult *N. viridula* are found on Japanese privet, and nymphs are found only occasionally (A.R.P., unpublished data). This may indicate that this plant is not a preferred oviposition site, despite the abundance of fruiting structures; these are used for feeding during most of the year, particularly in northern Paraná. Perhaps this may be because during the peak of reproduction, *N. viridula* mainly colonizes the preferred host, soybean; and when Japanese privet is invaded, there is a reduction in reproduction because of lower temperatures and shorter days. However, the behavior of a *N. viridula* population on Japanese privet has not been monitored, which needs to be done to understand this interaction better.

In contrast to what was observed for nymphs, reproductive performance of *N. viridula* adults was

Table 5. Total longevity of adults and reproductive performance (mean ± SEM) of *N. viridula* feeding on immature fruits of Japanese privet or leaves of water cress, in rearing room (n = number of pairs)

Food	Longevity, d[a]	No./female		No. eggs/mass
		Egg masses	Eggs	
Japanese privet[b] (20)	114.9 ± 16.2a	7.2 ± 0.69a	630.9 ± 40.06a	87.6 ± 5.36a [144][c]
Water cress[b] (10)	52.3 ± 8.74b	3.4 ± 0.48b	183.0 ± 28.30b	53.7 ± 3.56b [34]

Means followed by the same letter in each column do not differ significantly ($P < 0.05$) using t-test.
[a] Mean ± SEM longevity of females and males.
[b] Plus dried soybean seeds and shelled peanuts.
[c] Total number of egg masses obtained.

much higher on Japanese privet than on soybean pods, or on soybean plants plus soybean seeds and peanuts, or on water cress plus soybean seeds and peanuts in the environmental chamber and in the rearing rooms. These results are surprising, because there is no record of *N. viridula* breeding on Japanese privet, except in southern Brazil on the congeners *L. vulgare* and *L. ovalifolium* (Lopes et al. 1974, Link and Grazia 1987). Japanese privet was introduced into Brazil from Asia (probably from Japan), primarily as rootstock in grafting of olive, *Olea europaea* L., probably by Japanese emigrants at the beginning of this century (Joly 1975, V. C. Souza, personal communication to A.R.P.). It became extremely abundant particularly in urban areas, where it is used as an ornamental tree. It is surprising that although *N. viridula* occurs in several areas of Asia (e.g., Japan) where *L. japonicum* is present, no mention of its occurrence on this plant was found in the literature. Apparently, it can exploit this plant as a food resource with great success, particularly in northern Paraná, where an insect–plant interaction seems to be occurring, despite the relatively short period of coexistence in this area. The fact that *N. viridula* (particularly females), at the end of the 4th wk of adult life, increased 2–3 times more in fresh weight on Japanese privet than on soybean is another indication of its greater suitability as the 1st rather than the 2nd choice of food for adult life. This better performance of adult *N. viridula* on Japanese privet is similar to that observed for this insect on sesame, *Sesamum indicum* L. (Pedaliaceae), in northern Paraná (Panizzi and Hirose 1995).

Ours is the 1st record of *N. viridula* on water cress. An egg mass was collected in Curitiba on this plant in 1992. A colony of water cress was established in the field in Curitiba in 1993 from where nymphs were recovered later. Another pentatomid, *Thyanta perditor* (F.) has been recorded on this plant (Link and Grazia 1987). Despite these records, it seems that this plant is used by pentatomids only occasionally.

Despite its extreme polyphagy and wide range of distribution (see references in Todd 1989), *N. viridula* has not been recorded on oleaceous plants, and no reference to it colonizing Japanese privet was found in the literature. Perhaps this association of *N. viridula* with Japanese privet is unique for the species in Paraná. Local populations of insects show different preferences and actually act as mono- or oligophages rather than polyphages depending on host availability and time of exposure to restricted hosts (Fox and Morrow 1981). As a result, local populations may be well adapted to a plant usually not considered a host. In Japan, *L. japonicum* is colonized by the heteropteran *Eurystylus coelestialium* (Kirkaldy) (Tomokuni et al. 1993).

In conclusion, our results demonstrate the suitability of immature fruits of Japanese privet for *N. viridula,* particularly for reproduction. Several other species of pentatomids were found colonizing Japanese privet in northern Paraná (A.R.P., unpublished data). The abundance of fruits (berries) during most of the year in this area may be the main reason that insects use this host, but additional studies are needed to fully characterize this association.

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