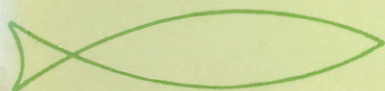
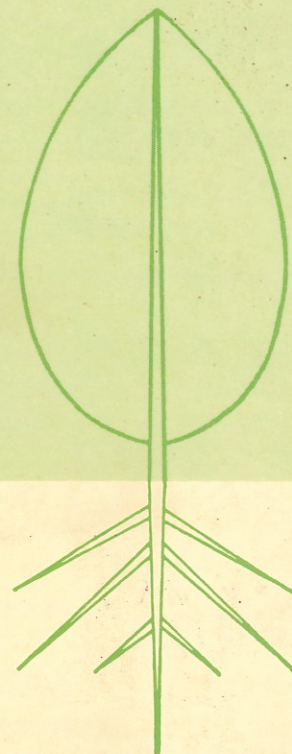


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Legume Host Impact on Performance of Adult *Piezodorus guildinii* (Westwood) (Hemiptera: Pentatomidae)

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ABSTRACT Laboratory studies of adult *Piezodorus guildinii* feeding on the seeds or pods of five legumes demonstrated that this polyphagous stink bug exhibits differences in reproductive parameters, survival, longevity and body weight depending on food source. Results of these laboratory studies, coupled with previous field observations, suggest that *Indigofera hirsuta* and *Crotalaria lanceolata* serve as important wild hosts in the seasonal phenology of *P. guildinii*.

Piezodorus guildinii (Westwood) is a neotropical pentatomid with numerous species of wild and cultivated plants reportedly serving as hosts; the fruiting structures of these plants are the primary feeding sites (Panizzi and Slansky 1985a). This stink bug is a serious pest of soybeans in South America; several studies have investigated the effect of its feeding on seed yield and quality, and economic thresholds have been determined (Panizzi and Slansky 1985a). However, little information is available on the host plants of *P. guildinii* in North America, or on the impact of various plants on its biology in either North or South America. Because *P. guildinii* apparently prefers to feed on various legumes, critical evaluation of the suitability of these plants is necessary to determine their potential as hosts, and in particular the role of various wild plants in serving as sources of stink bugs colonizing crop plants. The objective of our study was to determine the impact of certain legumes on reproduction, survival, longevity, and body weight of adult *P. guildinii*.

Materials and Methods

During November 1983, fourth and fifth instar nymphs of *P. guildinii* were collected from the wild legume hairy indigo (*Indigofera hirsuta* L.) growing near a field of mature soybeans in the University of Florida Agronomy Farm (Alachua County, north-central Florida). They were reared in the laboratory on *I. hirsuta* pods. Immediately after the imaginal molt, adults were sexed by visually examining the genitalia (McPherson 1982). Single female-male pairs were placed in glass rearing jars (17.0 by 6.5 cm) covered with filter paper. Ten pairs each were fed each of the following legumes: *I. hirsuta* green (immature) pods,

lanceleaf crotalaria (*Crotalaria lanceolata* E. Mey.) green pods, soybean (*Glycine max* [L.] Merrill var. 'Bedford') pods at full green bean stage (R6 of Fehr et al. [1971]), air-dried soybean seeds at harvest maturity (R8 of Fehr et al. [1971]), green bean (*Phaseolus vulgaris* L.) green pods, and raw, shelled peanuts, *Arachis hypogaea* L. (the latter two foods were commercially obtained and their varieties were unknown).

I. hirsuta and *C. lanceolata* were chosen to compare with soybean because they apparently are two important wild hosts of *P. guildinii* during autumn in this area of Florida (Panizzi and Slansky 1985b). Peanuts, if suitable as a food for *P. guildinii*, would be readily available commercially for use in laboratory rearing; green beans are commonly used as suitable laboratory food for another polyphagous stink bug, *Nezara viridula* L. (Harris and Todd 1981).

Food was replaced every 2 days and water (moistened cotton balls) was provided for adults feeding on the mature soybean seeds and peanuts. Rearing jars were randomly placed in an environmental chamber maintained at $25 \pm 2^\circ\text{C}$ and $70 \pm 10\%$ RH under a photoperiod of LD 14:10. Daily records were made of female oviposition and fecundity (number of egg masses and eggs per mass), egg fertility, and adult survival. Fresh body weight (mg) was measured weekly until death of the stink bugs, using a Mettler AC-100 electronic balance. Data were analyzed with analysis of variance and Duncan's multiple range test using the Statistical Analysis System (Ray 1982).

Results and Discussion

Reproduction. Most females feeding on *I. hirsuta* or *C. lanceolata* pods oviposited and laid their first eggs when ca. 13 to 14 days old, whereas on other foods tested many females failed to oviposit, and the timing of those that did was highly vari-

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Table 1. Reproductive performance of *P. guildinii* females feeding on six different foods in the laboratory

Food	Females ovipositing (no.)	Female age (days) at first oviposition ^a ($\bar{x} \pm SE$)	No. per female ^b		Egg fertility ^c (%) ($\bar{x} \pm SE$)
			Egg masses ($\bar{x} \pm SE$)	Eggs ($\bar{x} \pm SE$)	
<i>I. hirsuta</i> pods	90.0 (9)	12.9 (± 1.0)c	12.2 (± 2.2)a	204.8 (± 35.9)a	73.2 (± 3.5)a
<i>C. lanceolata</i> pods	90.0 (9)	14.1 (± 1.7)bc	5.2 (± 1.1)ab	58.2 (± 14.6)b	62.6 (± 12.6)a
Green beans	70.0 (7)	46.1 (± 16.4)a	4.0 (± 1.2)bc	45.0 (± 16.9)bc	67.4 (± 13.0)a
Soybean pods (R6)	40.0 (4)	31.2 (± 14.7)abc	2.2 (± 1.3)bc ^d	28.0 (± 16.0)bc	45.5 (± 26.4)a
Soybean seeds (R8)	30.0 (3)	33.7 (± 12.3)ab	2.0 (± 0.6)bc	9.3 (± 2.4)cd	41.1 (± 21.6)a
Peanuts	30.0 (3)	33.0 (± 10.8)abc	1.3 (± 0.3)c ^d	3.3 (± 1.2)d	30.0 (± 15.3)a

^a Data transformed to $\log(x + 0.1)$ for analysis. Means followed by the same letter are not significantly different ($P < 0.05$; Duncan's multiple range test).

^b Data from females ovipositing.

^c Data transformed to arc sine for analysis. Means followed by the same letter are not significantly different ($P < 0.05$; Duncan's multiple range test).

^d Data were included in the analysis, although not normally distributed.

able and greatly delayed (Table 1). Females feeding on *I. hirsuta* produced significantly more egg masses (2- to 10-fold more) than females on all other foods except *C. lanceolata*, and their fecundity was significantly greater than on any other food (Table 1). Fecundity of females feeding on mature soybean seeds or peanuts was <5% of that of females on *I. hirsuta*. Egg fertility varied from 73% for females feeding on *I. hirsuta* to 30% for females on peanuts, although these differences were not significant (Table 1).

Compared with females on *I. hirsuta*, the reduced reproductive performance of females on the other foods could have been caused either by reduced quality of these foods and/or by the switch from nymphal diet (*I. hirsuta*) to the different adult foods. We are unable to evaluate this because we did not raise nymphs on foods other than *I. hirsuta* and then switch them to different foods as adults. Fecundity in other species of seed-sucking insects is affected by both nymphal and adult foods (Al-Munshi et al. 1982, Ananthakrishnan et al. 1982, Kester and Smith 1984, Panizzi and Herzog 1984), but the impact of switching foods from nymph to adult has not been rigorously examined.

Survivorship and Longevity. Ninety percent or more of both sexes feeding on green beans and males on soybean pods survived up to 40 days (Fig. 1). Survival of adults on most of the other foods ranged from ca. 40 to 60%, but no males on mature soybean seeds survived to day 40. Survival and longevity of adults on *I. hirsuta* beyond 40 days and on *C. lanceolata* beyond 30 days could not be determined because of lack of pods. Males lived significantly longer when they fed on green beans or soybean pods than on peanuts or mature soybean seeds; for females, no significant differences in mean longevity among foods were ob-

served, although, like males, they tended to live longer on green beans (Fig. 1).

Males lived a mean of ca. 21 days longer than females on green beans and ca. 37 days longer on soybean pods, although only the difference on soybean pods was significant (Fig. 1). Reduced survival and longevity of reproductive females compared with males may be due to the great strain of egg production, which, by diverting energy and nutrients away from the maintenance of the female, shortens its life (Slansky 1980a,b). Males of two other hemipterans, *Oncopeltus fasciatus* (Dallas) and *Euschistus heros* (Fab.), live longer than females (Slansky 1980a, Villas Bôas and Panizzi 1980).

On peanuts and on mature soybean seeds, where egg production (and thus presumably reproductive strain) was very low, the longevity of female *P. guildinii* was similar to or greater than that of males, respectively (Fig. 1), apparently supporting the strain of reproduction hypothesis. However, substantial female mortality on these two foods, and on soybean pods, occurred prior to oviposition. Also, survival of the sexes was similar on *I. hirsuta* and *C. lanceolata* in spite of high egg production, and survival and longevity of *P. guildinii* females on the different foods was similar (Fig. 1) in spite of large differences in fecundity (and thus presumably large differences in reproductive strain; Table 1). Thus, these results, and the similar longevity of the sexes in several other hemipterans (Miner 1966, Panizzi and Smith 1977, Al-Munshi et al. 1982, Panizzi and Herzog 1984), suggest that reproduction is not a life-shortening strain on females of these species. In *P. guildinii*, differences in survival and longevity are apparently determined by food quality differences acting more directly on the physiology of these stink bugs.



Fig. 1. Survival of adults on *I. hirsuta*, *C. lanceolata*, and soybean pods in the field after 40 days. Mean longevity were similar for males and females on all foods.

Body Weight. Female body weight increased with age, sex, and food quality. Body weight increased for females and males on green beans and soybean pods, and for females on mature soybean seeds, but not for males on peanuts or mature soybean seeds. Body weight increased in certain hemipterans.

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 ($\bar{x} \pm SE$)
 3.2 (± 3.5)a
 2.6 (± 12.6)a
 7.4 (± 13.0)a
 5.5 (± 26.4)a
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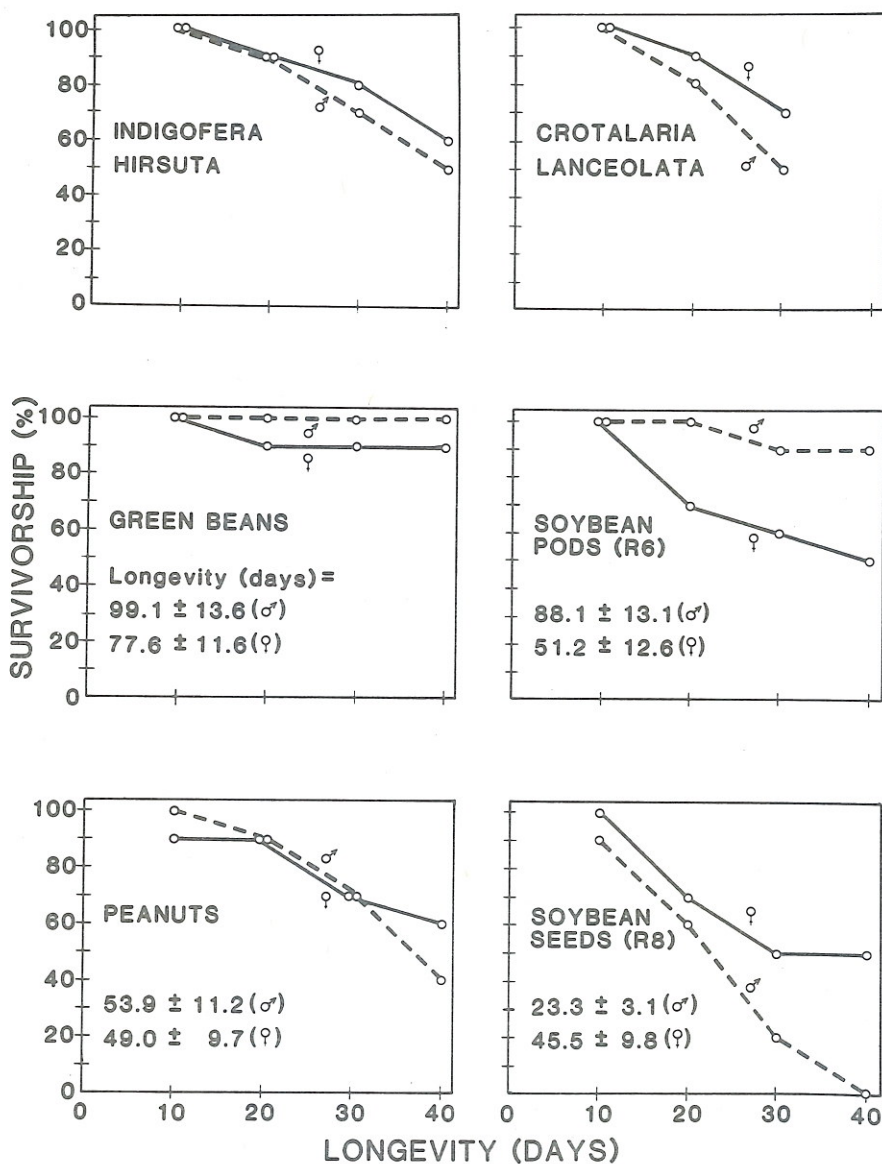


Fig. 1. Survival up to 40 days and longevity of adult *P. guildinii* feeding on six different foods. Longevity data for adults on *I. hirsuta* and *C. lanceolata* were not obtained because pods of these plants were not available in the field after 40 days, necessitating termination of these two treatments. The only significant differences in mean longevity were between males and females on soybean pods, and between males on green beans and soybean pods versus males on peanuts and mature soybean seeds ($P < 0.05$; Duncan's multiple range test).

Body Weight. Fresh weight gain by *P. guildinii* varied with age, sex, and host plant (Table 2). Fresh body weight increased significantly up to day 8 or 15 for females and males fed *I. hirsuta* or soybean pods, and for females fed green beans or *C. lanceolata* pods, but not for females and males fed peanuts or mature soybean seeds, or males fed green beans or *C. lanceolata* pods. High food intake and increase in weight during the teneral period in certain hemipterans is associated with cu-

ticle, flight muscle and gonad formation, and nutrient storage in the fat body (Slansky 1980a, Kester and Smith 1984). Lipid content of newly molted female *P. guildinii* feeding on green beans doubled by day 4, after which it leveled off (unpublished data). Because body weight tended to level off after day 15, adults feeding on *I. hirsuta* pods, soybean pods or green beans tended to weigh more than adults on *C. lanceolata*, peanuts or soybean seeds throughout the rest of their lives. Fe-

Table 2. Fresh body weight (mean \pm SE) of adult female and male *P. guildinii* at different ages feeding on six different foods in the laboratory (no. of adults in parentheses below)

Food	\bar{x} (\pm SE) fresh body weight (mg) ^a					
	Day 1	Day 8	Day 15	Day 22	Day 29	Day 36
<i>I. hirsuta</i> pods	49.7 (\pm 1.1)abC (10)	58.9 (\pm 2.2)abB (10)	Females 68.1 (\pm 3.8) ^a aA (10)	72.1 (\pm 3.3) ^a aA (9)	72.5 (\pm 5.0) ^a aA (8)	71.7 (\pm 5.0)aA (6)
	46.9 (\pm 1.8)bc (10)	50.1 (\pm 2.8)bbB (10)	60.0 (\pm 3.7) ^a abcA (10)	58.0 (\pm 3.4)bcAB (9)	53.3 (\pm 3.1)bcAB (7)	— (0)
<i>C. lanceolata</i> pods	48.1 (\pm 2.8)abB (10)	62.7 (\pm 3.5) ^a aA (10)	58.6 (\pm 5.1)bcA (10)	63.3 (\pm 2.5) ^a abA (9)	62.1 (\pm 2.4)bcA (9)	57.5 (\pm 2.7)bcA (9)
	56.3 (\pm 2.9) ^a aB (10)	64.4 (\pm 2.7)aAB (10)	66.8 (\pm 3.9) ^a abA (9)	64.8 (\pm 4.0) ^a abAB (7)	65.9 (\pm 4.3)abAB (6)	64.9 (\pm 4.2)abAB (5)
Green beans	47.6 (\pm 1.9)abAB (10)	42.4 (\pm 4.1)bbB (10)	46.2 (\pm 4.2)dAB (9)	49.5 (\pm 3.9)cbAB (7)	56.1 (\pm 4.7)bcA (5)	54.9 (\pm 1.9)bcA (5)
Soybean pods (R6)	48.5 (\pm 2.3)aba (10)	47.3 (\pm 3.3)ba (10)	54.7 (\pm 2.3)cA (9)	52.5 (\pm 3.4)cA (9)	52.9 (\pm 3.4)cA (7)	51.8(\pm 3.4)cA (7)
Soybean seeds (R8)	47.7 (\pm 1.3)abB (10)	54.1 (\pm 2.6)aA (10)	Males 54.1 (\pm 2.7)aA (10)	56.0 (\pm 2.8)aA (9)	57.2 (\pm 3.7)aba (7)	62.1 (\pm 2.4)aA (6)
	45.3 (\pm 1.6)aA (10)	48.4 (\pm 2.2)aA (10)	49.1 (\pm 2.0)abA (9)	53.7 (\pm 2.5)abA (6)	47.3 (\pm 4.2)bcA (5)	— (0)
Green beans	45.6 (\pm 1.6)aA (10)	53.6 (\pm 3.1)aA (10)	54.9 (\pm 2.7)aA (10)	53.8 (\pm 2.5)abA (10)	56.8 (\pm 2.7)aba (10)	55.4 (\pm 2.6)aA (10)
	46.6 (\pm 1.9)abB (10)	57.0 (\pm 1.1)aA (10)	52.7 (\pm 2.2)abA (10)	51.8 (\pm 2.0)abA (10)	59.6 (\pm 3.0)aA (9)	55.6 (\pm 2.0)aA (9)
Soybean pods (R6)	44.9 (\pm 2.5)aA (10)	38.1 (\pm 3.2)ba (9)	44.5 (\pm 2.1)ba (8)	46.1 (\pm 3.1)abA (6)	44.0 (\pm 4.3)cA (3)	— (0)
Soybean seeds (R8)	43.2 (\pm 2.2)aA (10)	48.5 (\pm 2.7)aA (10)	46.7 (\pm 2.1)abA (10)	44.6 (\pm 1.7)ba (8)	47.4 (\pm 2.2)bcA (7)	45.0 (\pm 1.2)ba (6)

^a Means (within each sex) followed by the same upper case letter in each row, or the same lower case letter in each column, are not significantly different ($P < 0.05$; Duncan's multiple range test).

* Female value significantly greater than male value ($P < 0.05$; Duncan's multiple range test).

Table 3. Fresh body weight of *P. guildinii* on the day of oviposition. The range in parentheses indicates the range in weight measured weekly, this is the range in weight at oviposition

Food (no. female)	Weight (mg)
<i>I. hirsuta</i> (9)	71.7 (\pm 5.0)
<i>C. lanceolata</i> (8)	57.5 (\pm 2.7)
Green beans (7)	54.9 (\pm 1.9)
Soybean pods (4)	51.8 (\pm 3.4)
Soybean seeds (3)	51.8 (\pm 3.4)
Peanuts (3)	51.8 (\pm 3.4)

There were no significant differences between means of variance).

Males tended to be heavier than females. Differences between sexes were not significant for some of the particular amount of food consumed at particular level of stimulus consumption. Endocrine levels of *O. fasciatus* (Shaw) were similar to those of *P. guildinii* (mean values) on days 6 and 8 after oviposition. Although the mean body weight of the different foods were no significant differences, the weight measurements of oviposition (Table 2) may have been delayed on soybean pods similar to weight gain on *C. lanceolata* and the influence the food has on *P. guildinii* depending on the food. *I. hirsuta* were the most preferred food of females exhibiting high fecundity was mature soybean pods, although causing delay in oviposition. The natural food, e.g., protein

Table 3. Fresh body weight (mg) of adult female *P. guildinii* on the day nearest to first oviposition (mean \pm SE, range in parentheses below). Because weights were measured weekly, this day ranges from 1 to 7 days before oviposition

Food (no. females)	Body weight
<i>I. hirsuta</i> (9)	64.4 (\pm 3.4) (51.7-79.5)
<i>C. lanceolata</i> (8)	58.7 (\pm 4.8) (41.9-77.4)
Green beans (7)	66.0 (\pm 2.8) (52.1-74.2)
Soybean pods (R6) (4)	71.1 (\pm 6.3) (61.0-88.4)
Soybean seeds (R8) (3)	58.7 (\pm 1.8) (56.5-62.2)
Peanuts (3)	68.2 (\pm 5.8) (59.5-79.3)

There were no significant differences among means ($P > 0.05$; analysis of variance).

males tended to weigh more than males, although differences between the sexes were significant on only some of the foods at certain ages (Table 2).

It has been proposed that consumption of a particular amount of suitable food or the storage of a particular level of nutrients may serve as an internal stimulus contributing to the initiation of neuroendocrine events leading to egg production in *O. fasciatus* (Slansky 1980b). In our study, age at first oviposition was quite variable (see Table 1 for mean values); for individual females, it ranged from 6 days on *I. hirsuta* to 134 days on green beans. Although there were significant differences in mean body weight among females feeding on the different foods at each age (Table 2), there were no significant differences in their mean body weight measured on the day nearest to the onset of oviposition (Table 3). Thus, the slowed weight gain of females on soybean seeds and peanuts (Table 2) may have contributed to their delayed oviposition (Table 1). However, oviposition was also delayed on soybean pods and green beans in spite of weight gain by females on these two foods being similar to weight gain by females on *I. hirsuta* and on *C. lanceolata*. Thus, it appears that both weight gain and the quality of the food being consumed influence the timing of oviposition in *P. guildinii*.

In conclusion, the results demonstrate that adults of *P. guildinii* exhibit differences in performance depending on the food source utilized. Pods of *I. hirsuta* were the most suitable food, followed by pods of *C. lanceolata*, on which a high percentage of females exhibited early oviposition, although fecundity was reduced. Green beans, soybean pods, mature soybean seeds and peanuts were less suitable foods, allowing fewer females to oviposit and causing delayed oviposition and reduced fecundity. The nature of the differences in food quality (e.g., protein levels, amino acid composition of

proteins, and presence and concentration of allelochemicals) contributing to these differences requires further investigation.

The abundance of *P. guildinii* eggs, nymphs, and adults on *I. hirsuta* and *C. lanceolata* plants growing near soybean fields in north-central Florida (Panizzi and Slansky 1985b), when coupled with the suitability of *I. hirsuta* and *C. lanceolata* for adults, strongly suggests that these two plants serve as important wild hosts, maintaining populations of this stink bug when cultivated plants are unavailable. In Colombia, *I. hirsuta* and *Crotalaria pallida* Aiton apparently provide sources of *P. guildinii* that infest soybeans (Hallman 1979). Fruiting structures of *I. hirsuta* and *C. lanceolata* are present only in late summer and autumn in north-central Florida. Thus, *P. guildinii* undoubtedly must exhibit seasonal shifts in host-plant use, but the extent to which individual stink bugs exhibit polyphagous feeding habits is unknown. Although soybean pods do not appear to be a highly suitable food source (Panizzi and Smith 1977), *P. guildinii* is commonly found in soybean fields in South America (Panizzi and Slansky 1985a) and seems to be increasing in abundance on soybeans in north-central Florida (Menezes 1981). Pods in earlier stages than those used here may be more suitable foods for *P. guildinii*, or these later-stage pods may be suitable foods if adult stink bugs are able to feed occasionally on other foods as well. Further research on food-switching behavior of *P. guildinii* is necessary to resolve these questions.

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