ECOLOGY OF THE LEAF FOOTED PLANT BUG, *Leptoglossus Australis* FABIRICIUS (HETEROPTERA : COREDIAE), IN THE SUB-TROPICAL REGION OF JAPAN

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ABSTRACT

Population surveys on the seasonal prevalence of occurrence, as well as the mortality factors in the egg and nymphal stages were conducted for the leaf-footed plant bug, *Leptoglossus australis*, mainly in two different host plants, a wild melon, *Bryonopsis laciniosa,* and the bitter gourd, *Momardica chranatia*. Overwintered adults utilized the fruits of *B. laciniosa* and bred there from May to June. In this season, the population density increased due to the lower occurrence of natural enemies such as an egg parasite, *Gryon pennsylvanicum*, and ant species. Adults also immigrated to oviposit on *M. chranatia* in this season, although no eggs hatched due to the regular application of insecticides to prevent injury by the melon fly, *Dacus cucurbitae*. From July to September, the population density of *L. australis* markedly decreased due to the outbreak of a herbivorous lady beetle, *Epilachna boisduval*, which was destroyed the host plant, *B. laciniosa*. Most of the eggs were unable to hatch due to the attacks of egg parasites and ants. After October, the population density of this species tended to increase again with the recovery of the host plant, *B. laciniosa*. The emerged adults were considered to form the overwintering population.

It was observed that caged male adults strongly attracted the conspecific adults of both sexes and the nymphs, suggesting that male adults release an aggregation pheromone.

Introduction

The leaf-footed plant bug, *Leptoglossus australis* FABRICIUS, is distributed in tropical regions of Africa and Asia. The main hosts of this plant bug are cucurbits, citrus, groundnuts and many legumes. Adults are sometimes found on oil palm in Malaysia, passion fruit in Kenya, and coffee, yam, sweet potato, cacao, and rice (Hill, 1974), tomato and guava in Japan (Yasuda, 1987). The adults and nymphs of *L. australis* cause serious damage to bitter gourd (Fig. 1), cucumber and loofah in Okinawa Prefecture (Yasuda, 1983 ; Tsurumachi *et al*., 1988). Only the adults injured citrus (Fig. 2).

Adults of *L. australis* have a high flying ability. Populations of this species depend on the fruits of several plants and they maintain successive generations by migrating to several host plants. Although this species is considered to undergo several generations per year, the precise seasonal prevalence of occurrence in each host is unknown.

This paper reports the estimation of the number of generations per year, the seasonal prevalence of occurrence, life tables in two different host plants, i. e. a wild melon, *Bryonopsis laciniosa*, and the bitter gourd, *Momardica chranatia*, as well as an attractant secreted by male adults.

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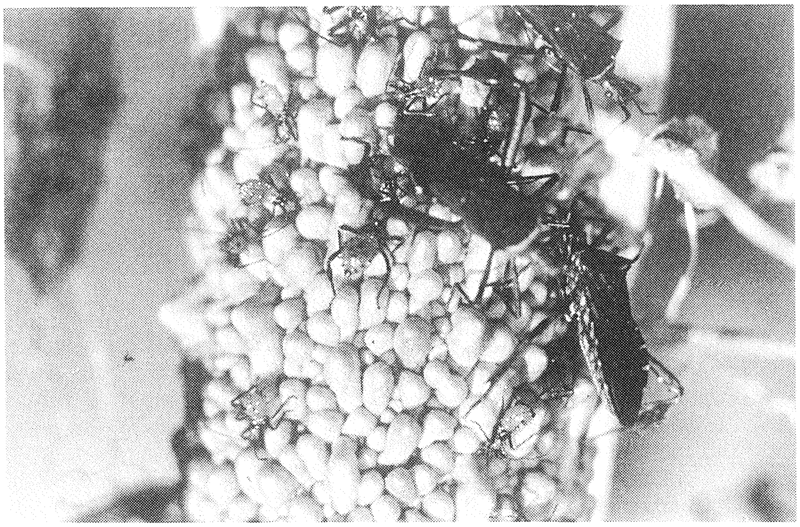

Fig. 1 Nymphs and adults of *L. australis* on the bitter gourd, *Momardica chranatia*

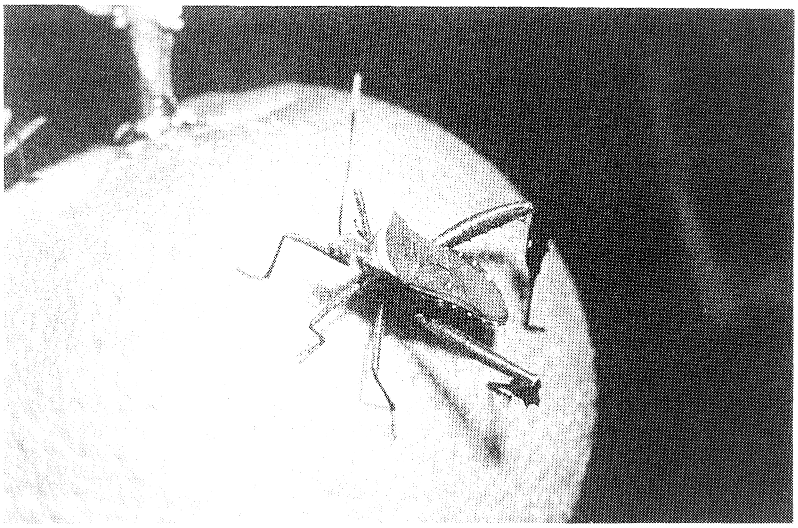

Fig. 2 An adult of *L. australis* on a Tankan fruit, *Citrus tankan*

Materials and methods

1 Relationship between temperature and development of eggs and nymphs : Eggs and nymphs were reared in the laboratory at 21, 26, 28, and 30°C.
2 Age structure in each host plant : Field surveys on the age structure were conducted in three plots cultivated with a wild melon, *B. laciniosa*, in four plots planted with the bitter gourd, *M. chranatia*, in three plots planted with the loofah, *Luffa acutangula*, and a wild host, *Trichosanthes bracteata*, from June to October, 1985 on Ishigaki island. Application of insecticides and damage of the melon fly, *Dacus cucurbitae*, were also examined.
3 Seasonal prevalence of occurrence of adults and nymphs : Census for nymphs and adults were conducted at two to five day intervals in a plot with a wild melon, *B. laciniosa*, in two fields with the bitter gourd, *M. chranatia*, from May to September, 1985. Insecticides were applied to the bitter gourd field.
4 Life table of eggs and nymphs : Egg-masses which were laid on a 15 cm string of in the laboratory were set in each host plant. The number of eggs and nymphs was counted and mortality factors were examined at one or two day intervals from June to September, 1985, in two plots with wild melon, *B. laciniosa*, and in five plots planted with the bitter gourd, *M. chranatia*.
5 Attractant of male adults : Traps baited with 10 males, 10 females, and 4th or 5th-instar nymphs, respectively were tested for their attractiveness to conspecific adults or nymphs. The traps consisted of a half-cylinder-shaped cage (12×20cm) made of nylon cloth. The number of attracted conspecific insects was counted for 17 days in the field with the bitter gourd.

Results

The developmental rate of eggs and nymphs decreased with the decrease of the temperature. The effective accumulative temperature and the threshold temperature for eggs were 81.1 day-degrees and 15.4°C, respectively. For nymphs, the corresponding figures were 450.6 day-degrees and 17.3°C, respectively (Table 1).

Age structure in several host plants is shown in Table 2. The ratio of nymphs in *B. laciniosa* ranged from 91.9 to 96.0 % in the T-1 and T-2 plots in July and Y-3 in October. However, the ratio of nymphs in the bitter gourd, *M. chranatia*, ranged from 0 to 93.0%. The difference in the nymphal ratio depending on the fields may be ascribed to the fact that eggs and nymphs were killed by the application of insecticides in some fields and to the existence of interspecific competition with the melon fly, *D. cucurbitae*, in fruits (Yasuda, 1989). The damage caused by the melon fly was especially severe in the bitter gourd compared with other hosts. When the eggs of both species were laid on the same fruit at the same time, the fruit rotted and dropped before eggs of *L. australis* were hatched. This phenomenon may be due to the fact that the duration from oviposition to

Table 1 Effective accumulative temperature and threshold temperature of eggs and nymphs

	Egg	Nymph
Regression formulae[a)]	$y=0.190+0.012x$ ($r=0.99^{**}$)	$y=-0.039+0.002x$ ($r=0.88^{*}$)
Effective accumulative temperature (day-degrees)	81.1	450.6
Threshold temperature for development (°C)	15.4	17.3

[a)]y : developmental velocity ; x : temperature (°C)

Table 2 Ratio of nymphs and adults on different host plants and conditions

Host plants	Places	No. nymphs	No. adults	Ratio of nymphs(%)	Application of insecticide	Damage by the melon fly(%)
Bryonopsis laciniosa	T-1	1,092	96	91.9	no	<5
	T-2	1,696	71	96.0	no	<5
	Y-3	51	4	92.2	no	<5
Momardica chranatia	T-2	0	154	0	Every five days	0
	H-1	37	219	17.4	no	90.5
	H-2	0	30	0	no	76.0
	I-1	494	37	0	Once a few weeks ago	27.5
Luffa acutangula	H-3	0	25	0	no	0
	Y-2	49	4	92.5	no	0
Trichosanthes bracteata	Y-3	0	362	0	no	0

pupation in *D. cucurbitae*, (8 days) was shorter than the egg period of the plant bug (9 days).The ratios of nymphs were 0 and 92.5% in loofah, *Luffa acutangula* mainly in male flowers. All the insects were adults in *Trichosanthes bracteata* and they were considered to have migrated from other hosts.

Figure 3 shows the seasonal prevalence of occurrence of adults and nymphs in each host plant. Insecticides such as CYAP were applied to the bitter gourd field at intervals of four or five days. Fruits of the bitter gourd had developed from the start of the investigation from May to August. Since only adults were found, they were considered to be immigrants. A marked peak of occurrence was recognized in early June, and small peaks were observed in late May and early August. The number of eggs oviposited was 42 with 2 egg-masses, but no eggs hatched due to the application of insecticides. Fruits were present in the field without application of insecticides from early June to late November. As the insects which were usually observed on each day were almost adults, it was considered that they had been flying from other areas as in the case of the field with application of insecticides. Nymphs were observed on a few days in August and November. It was considered that the fruits of *B. laciniosa* had been produced from early April. The fruits had already matured before the investigation started in the middle of May. Most of the insects observed were nymphs, and a peak of occurrence was recognized in the middle of June. However, the ratio of adults was high in the middle of May. In late June to July, the plants withered as most of the leaves were damaged by a herbivorous lady beetle, *Epilachna boisduval*, In this case, a large number of 5th-instar nymphs emerged to adults, but the ratio of adults was low due to immediate emigration to other areas. This emigration occurred in spite of the presence of large quantities of hosts.

Tables 3, 4, and 5 show the life tables of eggs and nymphs in the bitter gourd. Eggs oviposited in June were parasitized (15.8%) mainly by *Gryon pennsylvanicum* (Fig. 4) and a few individuals of *Anastatus japonicus*. Predation caused by *Reduviidae* spp. (Heteroptera), was diagnosed by direct observation and sucking marks. Death by parasitism and predation always occurred in the form of egg-masses. In the 1st or 2nd-instar, main mortality factors consisted of predation by a spider, *Neoscona theisi*. In the 3rd and 4th-instars, nymphs died by predation of a mantis, *Hierodulam patellifea*, and by dropping with rotted fruits which were damaged by the melon fly. The mortality rate at the nymphal stage which was 63.2%, and mainly involved 2nd-instar nymphs, was higher than that at the egg-stage (30.7%).

In August and September, none of the eggs hatched in *M. chranatia* (Tables 4, 5). An egg parasite, *G. pennsylvanicum* accounted for the main mortality factor (71.1% and 66.

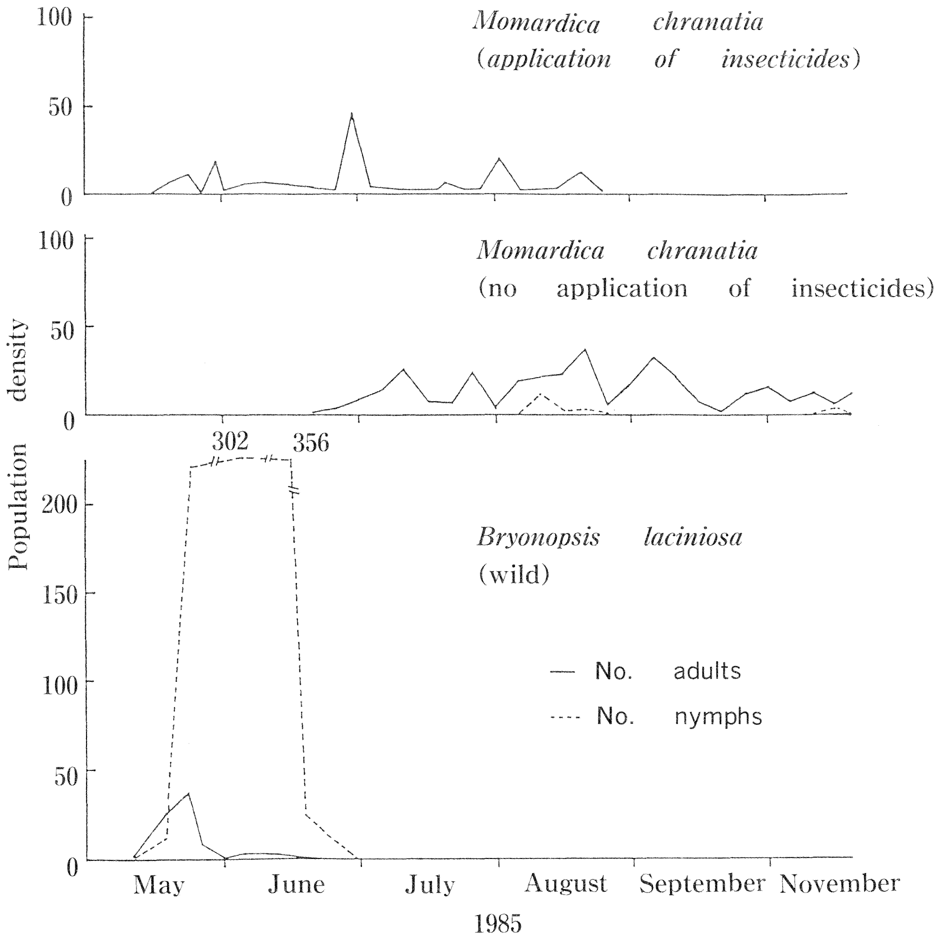

Fig. 3 Seasonal prevalence of occurrence of adults and nymphs in different host plants

0%). Mortality rate by predation was 28.4% and 32.3%, respectively. The predation was caused by ants, although the species were not determined. Mortality factors of eggs changed with the progression of the season from July to September. The percentage parasitism of eggs increased from July (Fig. 5) onward. Most of the eggs did not hatch due to parasitism and predation in August and September. Consequently, the population density of *L. australis* decreased with the progression of the season.

Table 6 shows the life table for the eggs oviposited in June in *B. laciniosa*. Parasitism by *G. pennsylvanicum* accounted for the main mortality factor in the egg stage. The percentage of parasitism was 15.7%. A total of 78 nymphs in the 1st-instar were observed. Attempts were made to remove the eggs and nymphs which were already present in the field. As the removal was incomplete, these nymphs could not be distinguished from wild nymphs and the investigation was discontinued. The life table for the eggs oviposited in August in *B. laciniosa* is shown in Table 7. Many eggs disappeared within two or three days after the start of the investigation. Although the mortality factors were largely unknown, predation by ants was suspected.

The results of the field experiment on the attractiveness of adults or nymphs to

Table 3 Life table for eggs oviposited in June in *Momardica chranatia*

Age l(x)	Duration in days	No. of eggs or nymphs at the beginning of l(x) (16 egg-masses)	Factors responsible for dxF	No. of individuals who died during x	dx as % of lx	Accumulated mortality as %
Egg	9	323	Parasite (*Gryon*)	51	15.3	
			Predation (Reduviidae)	43	13.3	
			Embryonic death	5	1.5	
			Total	99	30.1	30.1
N-1	4	224	Spider	32	14.3	
			Unknown	26	8.6	
			Total	58	22.9	48.6
N-2	5	166	Spider	34	20.5	
			Unknown	42	25.3	
			Total	76	45.8	72.1
N-3	4	90	Predation (*Mantis*)	4	4.4	
			Emigration	15	16.7	
			Unknown	24	26.7	
			Total	43	47.8	85.4
N-4	5	47	Predation (*Mantis*)	7	14.9	
			Unknown	7	14.9	
			Total	14	29.8	89.9
N-5	7	33	Emigration	4	12.1	
			Unknown	9	27.3	
			Total	13	39.4	93.8
Adult	20					

Table 4 Life table for eggs oviposited in August in *Momardica chranatia*

Age l(x)	Duration in days	No. of eggs at the beginning of l(x) (19 egg-masses)	Factors responsible for dxF	No. of individuals who died during x	dx as % of lx	Accumulated mortality as %
Egg	9	370	Parasite (*Gryon*)	263	71.1	
			Predation (Reduviidae)	105	28.4	
			Embryonic death	2	0.5	
			Total	370	100.0	100.0

Table 5 Life table for eggs oviposited in September in *Momardica chranatia*

Age 1(x)	Duration in days	No. of eggs at the beginning of 1(x)(16 egg-masses)	Factors responsible for dxF	No. of individuals who died during x	dx as % of lx	Accumulated mortality as %
Egg	9	285	Parasite (*Gryon*)	188	66.0	
			Predation (Reduviidae)	92	32.3	
			Embryonic death	5	1.7	
			Total	285	100.0	100.0

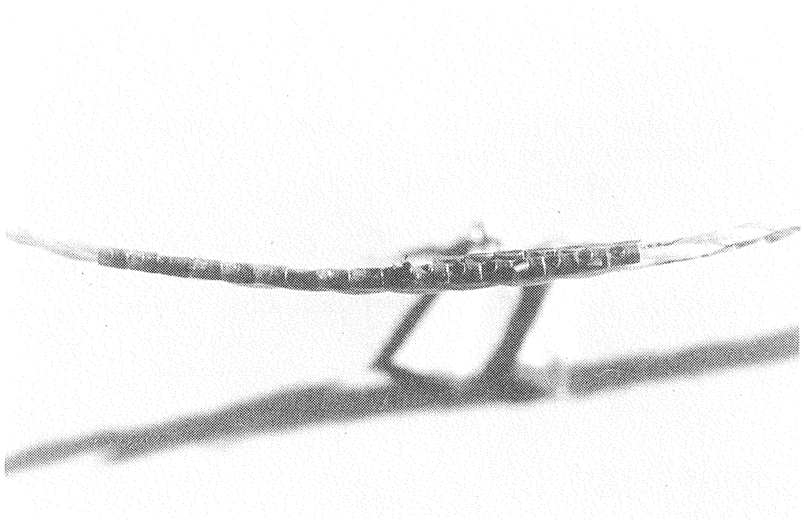

Fig. 4 Eggs parasitized by *Gryon pennsylvanicum*.

conspecific insects are shown in Table 8. It was observed that traps with caged male adults strongly attracted conspecific adults of both sexes and nymphs (Fig. 6). The caged female adults attracted only a few males and female adults. The caged nymphs did not attract any adults and nymphs.

Discussion

Based on the results of rearing experiments (Table 1), the effective accumulative temperature was estimated to be 81.1 day-degrees and 450.6 day-degrees for the eggs and nymphs, respectively. The threshold temperature was 15.4°C and 17.3°C for the eggs and nymphs, respectively. Therefore, it was estimated that *L. australis* underwent at least four generations per year. The immigration of the adult bugs from the wild host plants to cultivated hosts such as the bitter gourd is likely to occur and it is assumed that at least one or two generations occur on the cultivated hosts (Fig. 1).

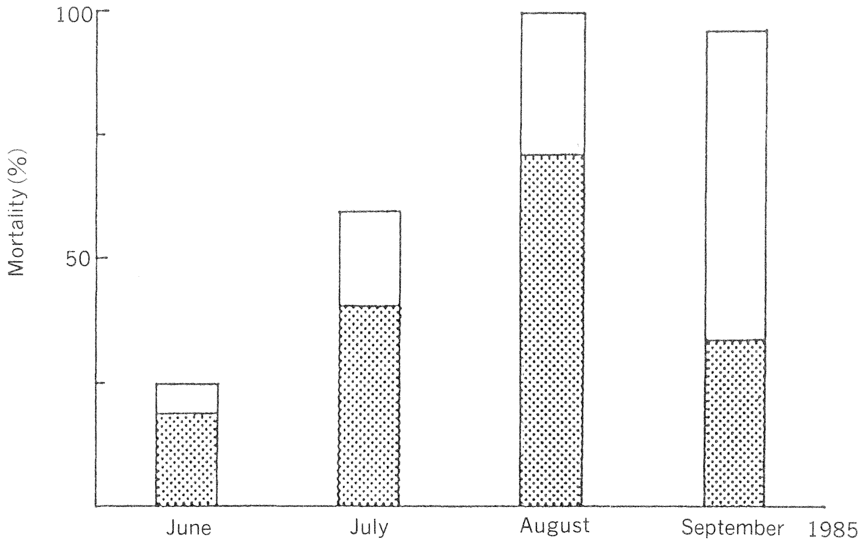

Fig. 5 Seasonal change of mortality factors of eggs in *Momardica chranatia*
☐ : predator ▒ : parasite

Table 6 Life table for eggs oviposited in June in *Bryonopsis Laciniosa*

Age l(x)	Duration in days	No. of eggs at the beginning of l(x) (15 egg-masses)	Factors responsible for dxF	No. of individuals who died during x	dx as % of lx	Accumulated mortality as %
Egg	9	115	Parasite (*Gryon*)	18	15.7	
			Predation (Reduviidae)	0	0	
			Unknown	1	0.8	
			Total	19	16.50	16.5
N-1	4	78				

Table 7 Life table for eggs oviposited in August in *Bryonopsis laciniosa*

Age l(x)	Duration in days	No. of eggs at the beginning of l(x) (17 egg-masses)	Factors responsible for dxF	No. of individuals who died during x	dx as % of lx	Accumulated mortality as %
Egg	9	154	Predation (Reduviidae)	18	11.7	
			Parasite (*Gryon*)	5	3.2	
			Unknown	131	85.1	
			Total	154	100.0	100.0

Table 8 Number of adults and nymphs attracted by the traps which contained 10 male adults, 10 female ones, and 10 nymphs, respectively

Trap	No. attracted		
	Male adults	Female adults	Nymphs
Male adults	116.2	86.1	119.9
Female adults	0.4	0.2	0
4th or 5th instar nymphs	0	0	0

Fig. 6 Adults attracted by a male adult trap

Overwintered adults utilized the fruits of a wild melon, *B. laciniosa*, and bred there from May to June (Table 2). In this season, the population density increased due to the lower occurrence of natural enemies such as an egg parasite, *G. pennsylvanicum*, and ant species. In this case, a large number of adults emerged, although the ratio of adults was low due to immediate emigration to cultivated host plants such as bitter gourd, cucumber, loofah, guava and wild host plants such as *B. laciniosa*, and *Trichosanthes bracteata*. However, the development of nymphs was possible only on the bitter gourd, cucumber, loofah, and *B. laciniosa*. For the control of the melon fly, insecticides were regularly applied at four or five-day intervals in the bitter gourd fields. In these fields the nymphal ratio of the population was lower than that in *B. laciniosa*, as most of the eggs died before hatching.

In July, *B. laciniosa* withered and the number of fruits decreased suddenly due to the severe injury caused by a herbivorous lady beetle *Epilachna boisduval*. Even if the host plants were able to avoid the attacks of the beetle, the eggs were unable to hatch due to the activity of the egg parasites and ant species. In this season, the populations on the bitter gourd consisted mostly of migrated adults, because the oviposited eggs died by the application of insecticides. In the fields without insecticide application, such as gardens, egg hatching was difficult due to parasitism and predation as well as the interspecific competition with the melonfly, *D. cucurbitae*.

After October, the population density of this species tended to increase again with the recovery of a wild host plant, *B, laciniosa*. The damage caused by the melon fly to *B. laciniosa* was less severe than in the case of the bitter gourd (Table 2). Moreover, no insecticides were applied as *B. laciniosa* is not a cultivated plant. Survival rate of eggs and nymphs was higher, in this season than in summer. It is considered that the generation from October to November was likely to account for the second peak of nymphs in a year (Yasuda, 1983). Besides, the emerged adults which infested *Citrus* (Fig. 2) were considered to form the overwintering population.

From December onward, the temperature in Okinawa decreases to a level where the development of young nymphs of *L. australis* is difficult and the bitter gourd withers. Therefore, only adults or 5th-instar nymphs are able to overwinter in the wild host plant *B. laciniosa*.

The population of *L. australis* persists at least for more than 4 generations per year by migrating to several host plants throughout a year. As the main host, *B. laciniosa*, is frequently destroyed by outbreaks of a herbivorous lady beetle or typhoon, plant bugs can not use it as a source of food throughout the year. Therefore as they must search for other host plants and migrate there as soon as possible, the male adults release an aggregation pheromone.

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