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Function of the Male Pheromone of the Leaf-Footed Plant Bug, *Leptoglossus australis* (Fabricius) (Heteroptera: Coreidae) and Its Kairomonal Effect

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Abstract

A function of the male pheromone of *Leptoglossus australis* (Fabricius) in its migration process was investigated on Ishigaki Is., the southernmost part of Japan. It was observed that the immigration of adults into particular fields of bitter gourd or loofah occurred suddenly within a short period of time. Immigrants landed mostly on a male-baited cage placed in a cucurbit field (a host plant of the bug) rather than on crop plants themselves without males, suggesting that cues inducing landing of immigrants are not their host plants, but the pheromone emitted by males. Moreover, an egg parasitoid, *Gryon pennsylvanicum* (Ashmead) (Hymenoptera: Scelionidae), was attracted to the male pheromone of L. australis, which may act as a kairomone for host searching of the parasitoid.

Discipline: **Insect pest**
Additional key words: attraction, *Gryon pennsylvanicum*, immigration, parasitoid

Introduction

It is well known that male adults in some Heteroptera emit a pheromone that attracts conspecific adults of both sexes[1,2,4,8,12]. Another remarkable performance of Heteroptera is that adult bugs suddenly invade crop fields, including orchards[6,7,9] and they gregariously attack crops, often causing severe damage. However, it remains to be determined whether flying adults are attracted to pheromone-emitting males or to the cue of host plants.

The leaf-footed plant bug, *Leptoglossus australis* (Fabricius), is a serious pest of a limited kind of cucurbits and various fruits in the tropics and subtropics[3]. Outbreaks of adults have been reported from Sri Lanka and Papua New Guinea[5,11]. On Ishigaki Island, the southernmost part of Japan, the bug breeds mainly on a wild melon, *Diplocyclos palmatus* C. Jefferey, in spring, and ensuing adults disperse in seeking fruits appropriate as food, but scarcely visit cucurbit fields. From late June to July when the wild melon has decayed, substantial immigration of adults to cucurbit fields often occurs[13,14].

In order to clarify the role of adult males of *L. australis* in the induction of landing of immigrants, a number of host plant fields were investigated for the relation between the previous presence of males in the field and ensuing adult immigration.

In addition, the attractiveness of male or female *L. australis* to its egg parasitoid, *Gryon pennsylvanicum* (Ashmead), was examined, since a preliminary experiment suggested that the host-searching behavior of the parasitoid is elicited by the presence of *L. australis* adults.

Materials and methods

1) Detection of immigrants in cucurbit fields

To detect the immigration of *L. australis*, adults were visually counted in 17 fields of bitter gourd or loofah, both being host plants of the bug. These fields were located within an experimental area 2 km

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in diameter on Ishigaki Is. and each had enough fruits for bug's food. The census was conducted from June 15 to July 11, 1987 at intervals of 1 – 3 days after the onset of immigration.

2) Influence of male attraction on immigrants

A cage containing 5 *L. australis* males (male-baited cage) was placed in each crop field (Nos. 14, 16 and 17) on July 4, 1987. Another one was also set on June 15, 1987 in a shrubbery surrounded by non-host plants, i.e. sugarcane, in the experimental area. Adults attracted to the male-baited cages were counted until July 11.

The cage consisted of a plastic basket (21 cm in diameter and 9 cm in height) and a plywood cover, and the confined males were supplied with water and bitter gourd seeds in the basket (Fig. 1 – B).

3) Ovarian development of females attracted by male-baited cages and of those from crop plants

Some of the adults settling on male-baited cages or on crop plants were collected and all the females were dissected to examine the status of ovarian development. A female which showed fully developed eggs with a chorion or eggs of almost the same size was recorded as a mature one.

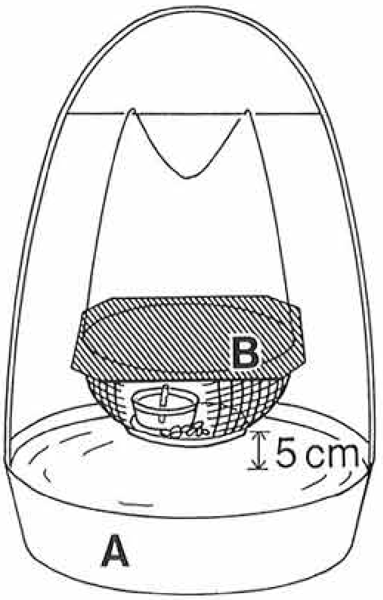

Fig. 1. Design of trap
Cage (B) used in the experiment of male attraction of immigrants, contained a water container and bitter gourd seeds. A trap in the experiment of attraction of *Gryon pennsylvanicum* consisted of a water pan (A) and the cage (B).

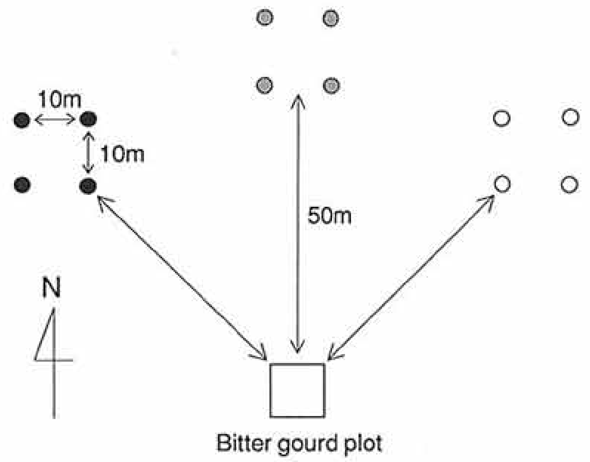

Fig. 2. Layout of 3 different traps (male-baited, female-baited and control)
The same marks indicate the same type of traps.

4) Attraction of G. pennsylvanicum *by* L. australis *adults*

A trap baited with male or female bugs was used to examine the attractiveness of *L. australis* adults to *G. pennsylvanicum*. The trap consisted of a water pan (35 cm in diameter × 8.5 cm in height) filled with water and of the same type of cage as that used in the male attraction experiment (see the section *2)* previously), which was kept ca. at 5 cm above the water surface (Fig. 1). Three different types of traps were used: a male-baited trap with 5 males in the cage, a female-baited trap with 5 females, and a control trap without bugs. Each cage was provided with a water container and bitter gourd seeds.

A group of 4 traps was placed in each of the 3 plots separated by ca. 50 m from a field of bitter gourd where *L. australis* naturally occurred. The traps of each plot were arranged in a square with a spacing of 10 m. Trap type was the same in all the 4 traps in each plot, but different among plots. The arrangement of the traps is shown in Fig. 2. The trap types were rotated among the plots every day. *L. australis* adults and *G. pennsylvanicum* caught by the traps were collected and their number counted daily during 7 days in September 1989.

Results

1) Detection of immigrants in cucurbit fields

In some fields, *L. australis* adults already appeared in mid-June when censuses had started, but there

Table 1. Number of *L. australis* adults in cucurbit fields on Ishigaki Is. in July 1987

Field No.	Crop[a)]	July										
		1	2	3	4	5	6	7	8	9	10	11
1	L		18		8			8				
2	L				0	0	0	1		0		0
3	L		0		0	0	1	10		8		2
4	L		0		1	2	12	31		92		175
5	L		0		1	13	50	40		42		23
6	L		0		38(6)	16	30			18		
7	L		0		0	0	0	0	0	0	0	0
8	B, L			1	65	48			544			
9	L		0	8	3	12	16		3	17		17
10	B, L	2		0	1	2	45(21)		386↓	20↓	0	
11	B. L	0	9	78(22)	40↓	18	100(20)		248	↓	15	
12	B, L		11		59	41	52	10	20		25	
13	B, L		1		31	60	67	45	30	68	55	30
14	B, L		0		0*	21	45(7)	30	36	51	24(15)	8
15	B, L		0		0	0		0	0	0		
16	B, L				1*	1	28	29	103	81	25(17)	13
17	L	0		7	11(7)*	7	10	24	66	77	43(32)	13

a): B: Bitter gourd, L: Loofah. *: Setting of mail-baited cage in field.
Figures in parentheses indicate the number of adults collected after the census.

was no substantial increase in number until the beginning of July. Hence, only the number of adults in the census fields from July 1 to 11 is shown in Table 1. Numerical figures in parentheses indicate the number of adults removed from the field for the examination of ovarian development.

During the period from July 1 to 8, conspicuous immigration was observed. Average number of adults per census field was 2.9 on July 1–2, then 96.3 on July 7–8. Only 36% (5/14) of the census fields were inhabited by adults on July 1–2, but the proportion of census fields suddenly increased to 88% (14/16) on July 7–8.

There were differences in the number of immigrants among the fields and the immigration occurred within a short period of time to some particular fields. For instance, a sudden increase in number was found in field 8 from July 3–4, whereas no concomitant increase was observed in field 9 which was only 200–300 m apart from field 8. A similar difference in the extent of immigration was observed between fields 10 and 11, 200–300 m apart from each other, in 2 days from July 1–3.

Sex ratio of adults during the census period was about 0.45. Nymphs were hardly observed in any fields.

Table 2. Comparison in the number of *L. australis* adults on a male-baited cage and on plants in cucurbit fields

Site[a)]	Male-baited cage or cucurbit crop	June		July										
		15	23	1	2	3	4	5	6	7	8	9	10	11
Shrubbery	Male-baited cage	*	0		1	7(7)	25(23)	35	30(22)	20	5	5	0	
Field 14	Male-baited cage						*	20	20(7)	6	10	22	14(11)	1
	Cucurbit crop	0			0		0	1	25	24	26	29	10(4)	7
Field 16	Male-baited cage						*	0	25	4	23	24	13(13)	1
	Cucurbit crop						1	1	3	25	80	57	12(4)	12
Field 17	Male-baited cage						*	0	0	0	20	39	33(28)	10
	Cucurbit crop	0	0	0		7	11(7)	7	10	24	46	38	10(4)	3

a): Refer to Table 1. *: Setting of male-baited cage in field.
Figures in parentheses indicate the number of adults collected after the census.

2) Influence of male attraction on immigrants

The number of adults settling on male-baited cages is given in Table 2, with reference to the number of adults on the crop where the cage was placed. Numerical figures in parentheses indicate the number of adults removed from the fields for the examination of ovarian development.

The male-baited cage set in the shrubbery on June 15 displayed a distinct increase in the number of adults on July 3–5, when immigration simultaneously occurred in other census fields.

On July 4 when male-baited cages were placed in fields 14, 16 and 17, no bugs, 1 female and 11 adults of both sexes were recorded, respectively. In fields 14 and 16 where no males were present, immigrants initially gathered on the male-baited cages and a few on the crop plant. In field 17 with both sexes, immigrants preferred the crop plant to the male-baited cage.

3) Ovarian development of females attracted by male-baited cages and of those from crop plants

Sampling sites were divided into 3 groups, that is, crop plants, male-baited cages in crop fields and male-baited cages in the shrubbery. Percentages of mature females in each group were 37, 24 and 9%, respectively. Most of the females seemed to be immature.

4) Attraction of G. pennsylvanicum *by* L. australis *adults*

G. pennsylvanicum was primarily caught in male-baited traps, and no wasps were caught in female-baited traps (Table 3). The control trap (without bugs) captured 2 individuals once, but no bugs on the other 6 days. All the parasitoids trapped were females. *L. australis* adults (15 females and 7 males) were caught only in male-baited traps.

Table 3. Number of *G. pennsylvanicum* and *L. australis* individuals in traps baited with 5 *L. australis* males and those with females

Trap	No. of insects[a]	
	G. pennsylvanicum	*L. australis*
Male-baited	5.6 ± 4.1**	3.1 ± 1.8*
Female-baited	0.0 ± 0.0	0.0 ± 0.0
Control	0.3 ± 0.7	0.0 ± 0.0

*, **: A significant difference from control at $P<0.05$ and $P<0.01$, respectively, by the randomization test.
a): Values are means (insects/4 traps/day) with SD ($n = 7$).

Discussion

Male-baited cage was apparently selected by immigrants as a landing place when the crop plants in the surroundings were not inhabited by males, suggesting that the male pheromone emitted from caged males stimulated the landing of flying adults. Therefore concentrated immigration was likely to be induced by a male pheromone released from certain fields. However, this fact does not necessarily imply that immigrants disregard host plants. Pioneer individuals seeking host plants must depend on other materials than male bugs as a cue for landing and host plants may be one of the candidates.

Consequently, the male pheromone of *L. australis* attracts both sexes to develop an adult population on the host plant. However the ecological significance of the male attraction remains to be elucidated. In the case of the brown-winged green bug, *Plautia stali* Scott, one of the fruit-piercing stink bugs in Japan, which exhibits male attraction to the conspecific adults of both sexes, adults attracted to caged males were mostly underfed, sexually immature[10] and did not mate between them[8]. Accordingly, the male attraction in *P. stali* was considered to be effective in the exploitation of temporally and spatially limited food resources rather than in mate-finding[10]. Indeed, adults may be able to save their energy and time for searching host plants by using an easily detectable sign which indicates the location of host plants. However the benefit which a pheromone-emitting male on a host plant can obtain by informing the location of the plant to other individuals remains unknown.

Another hypothesis is that a male on a host plant emits its pheromone to call females and simultaneously the other males aggregate to mate with the females attracted to the male pheromone[2]. In *L. australis*, mating was occasionally observed between the attracted adults (Yasuda, unpublished), suggesting that the male pheromone plays a role in mate-finding. More detailed studies should be conducted to confirm this assumption.

L. australis males attracted the egg parasitoid *Gryon pennsylvanicum*. It was reported that the attracted parasitoids attacked host eggs in the vicinity and eventually caused a high parasitism of eggs[15]. When adult bugs concentrate in particular host plant fields, the presence of male bugs rather than host plants may effectively indicate the area where host eggs probably occur.

Some of the chemicals emitted from male bugs certainly function as a kairomone for the parasitoid in its host-searching process. The chemicals may be related to the male pheromone of the bug, although this assumption should be confirmed by experiments using a synthetic pheromone. If so, the development of the synthetic pheromone may enable the effective control of *L. australis* through the manipulation of the host-searching behavior of the parasitoid.

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