Host-Finding Behavior of the Rice Bug, *Leptocorisa chinensis* DALLAS (Hemiptera: Coreidae), with Special Reference to Diel Patterns of Aggregation and Feeding on Rice Plant

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Diel pattern of the aggregation on rice plants by the rice bug, *Leptocorisa chinensis* DALLAS, was evaluated by counting and sweeping methods in the paddy field and by field cage experiment to elucidate its host-finding behavior. Adult bugs were observed to feed in daytime and fly actively after sunset. Flight tunnel experiments in daytime showed their upwind orientation to the odor source of rice plants, though the response was not so high as to explain the aggregation of the rice bug on the rice plant in the flowering stage. It is postulated that the rice bug can detect the odor of rice plants in close to the rice field, but the aggregation on the ears of rice plants seemed to be caused mostly by the arresting effect of the ears in the flowering stage.

INTRODUCTION

The rice bug, *Leptocorisa chinensis* DALLAS, is one of the major pests of rice plants in Japan, which causes damage to rice grains by sucking the ears of the rice plant. This damage causes pecky rice which has become a serious problem since around 1970 (Iwata and Yoshihara, 1976).

This insect usually occurs in mountainous area or in fields close to mountains. More bugs can be found in weedy places in non-used paddy fields and footpaths among rice fields. In addition to the rice plant, they feed mostly on gramineous plants; e.g., crabgrass (*Digitaria adscendens* HENR.) and barnyard grass (*Echinochloa* spp.) (Iwata and Yoshihara, 1976).

In Chiba Pref., post diapause adult bugs migrate to the rice fields in the flowering stage from the middle of July to the beginning of August, and are seldom found to come flying to the rice field before the flowering time of the rice plant (Shimizu and Maru, unpublished). It has been suggested that some stimuli from the rice field cause the rice bug to aggregate on the rice plant, especially during the flowering period. In Miyazaki Pref., this species was found to have a host preference for the ears of gramineous plants, especially Italian ryegrass (*Lolium multiflorum* LAMARCK.), crabgrass

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and rice plant after earing in a field cage experiment (NAGAI and NONAKA, 1976). To analyze the host finding behavior of the rice bug, the diel pattern of the feeding behavior and the response to the odour of rice plant was investigated.

MATERIALS AND METHODS

Field observation. The active flying time of day of the rice bug was examined by means of counting and net-sweeping in rice fields. This field observation was performed at the rice field in Chiba Pref. from July 12 to 14 in 1978, when the rice plants were in the early stage of flowering. The counting was carried out every hour by walking along three footpaths, A, B and C, between rice fields. The number of adult rice bugs observed within 3 min on rice plants along footpaths, A and B, was recorded. Courses A and B were the opposite side of the same rice field. Course C had only thirty rice hills in the stage of flowering along a footpath. Observation on these thirty hills was not limited to 3 min. Twenty sweepings with a net (36 cm in dia.) were carried out every hour in a rice field by walking across the field, and the number of bugs caught was recorded.

Field cage experiment. Bugs were collected by sweeping on July 14, 1978 at the rice field in Chiba Pref. They had just come flying to this field. They were kept in a mesh cage (45×45×100 cm) with the rice plant. Twenty hills of rice plant in flowering stage were also collected from the same rice field, and immediately planted in flower pots. The ears were removed from 10 hills and the rest left intact. The two groups of intact hills and those without ears were arranged crosswise in a field cage (5.5×11×2 m) as shown in Fig. 3. Five hundred rice bugs (280 males and 220 females) were released at the center of the cage at 17:00 on July 15, and the bugs aggregating on ears and on leaves of rice plant were counted mostly every hour on each group of hills. Also, bugs on the ceiling and walls of the field cage were counted at arbitrary intervals. This experiment was continued till 16:00 on July 17.

Diet rhythm of feeding under laboratory conditions. Adult bugs were maintained at 27°C and 30-50% R.H. under 15L-9D conditions. They consisted of two groups, one was reared from egg stage to adult stage in the laboratory and the other was collected from a weedy place in Chiba Pref. on October 12, 1978. Bugs from the field seemed to have just entered into diapause. The observation was performed from December 21 to 22, 1978. They were given ears of rice plant as their diet before and during the observation. A rearing container (13 cm in dia., 12 cm high) made of two transparent plastic ice cream cups (SHIMIZU, 1976) was used for observation. The bugs were given a diet of frozen ears of rice plant and appropriate moisture. Their behavior in the container, either feeding or resting, can easily be seen from outside. Approximately 15 bugs comprised of a similar number of males and females were introduced into the chamber. Total number of bugs was 848 (421 males and 427 females) in 62 containers. Hourly changes in the number of bugs in feeding posture (extruding their proboscis on the ears) were observed by counting them in each container. This observation was carried out every hour for two days. In darkness, a small 2-watt red bulb for photographic darkroom was used for observation.

Laboratory experiments with a flight tunnel. In order to examine the attractiveness of the odour from rice plant, the response of the adult rice bug to wind-borne odour
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Fig. 1. Flight tunnel. A: fan. B: releasing hole. C: wire mesh. D: two or four hills of potted rice plant.

was examined with a cylindrical wind tunnel.

Bugs, which had been used in the field cage experiment, were collected on July 29, 1978, and kept in a plastic container (22 cm in dia., 12 cm high) having a lid with a nylon mesh window. Odour source was the rice plant in flowering stage which had been used in the field cage experiment. Both the intact hills of rice plant and those without ears were prepared.

The wind tunnel used was a cylindrical tube of 3 m long and 40 cm in dia., which consisted of six sections of transparent cylinder of 50 cm long (Fig. 1). Both ends of the tunnel were fixed with wire mesh. The air was drawn through the tunnel with an electric fan driven directly by a variable speed motor. Each section was numbered from the downwind end of the tunnel. A small opening (4.5 cm in dia.) was made at the first section to put insects through. At the upwind end of the tunnel, an additional transparent cylinder of 50 cm long and the same dia. was placed to draw the odour of rice plant effectively. Two or four hills of rice plant planted in flower pots were placed diagonally in the additional cylinder at the upwind end of the tunnel, when the response to the rice plant odour was examined. An empty cylinder was used as control. Also, moist wind was produced by hanging a wet cloth at the upwind end. Wind speed was fixed at 40 cm/sec throughout the experiment.

Initially, the bugs (counted but not sexed) were released at Section No. 1. The number of bugs in each section was counted after drawing the odour of rice plant, damp air, or clean air as control through the cylinder, for 10 minutes. The odour of rice plant was introduced every hour, and controls were performed before and after the odour flows.

These experiments were conducted under laboratory conditions from 3:00 to 17:30, the light of which was from outdoors through windowpanes. (sunrise:4:11, sunset:19:24). The temperature was almost the same as outdoors.

Expt. I was commenced at 3:00 on July 30, with 50 bugs which had been starved for 15 hrs, and was terminated at 7:20 on the day. The control flows before the odour flows proceeded for 30 or 40 minutes. At 6:00-6:10, damp air was drawn through a hanging wet cloth. The odour of rice plant was produced by placing two hills of rice plant with ears at the upwind end of the working section as in Fig. 1.

Expt. II was begun at 13:00 on the same day as the previous expt. with another group of 50 insects (not sexed) which had been starved for 25 hrs, and ended at 17:30. In the series with rice plant odour, the two hills without ears (15:00–15:10) and the four hills with ears (15:10–15:20) were examined. From 17:00 to 17:30, a different operation was performed. The bugs, which had been examined for response to the control flow at 16:10–16:20, were all collected and placed at Section No. 1. In this
experiment, the odour source was two hills of rice plant without ears.

RESULTS

Field observation

The result of the counting method in course A is shown in Fig. 2-A. The decrease in the number of counted bugs on rice plant at around 14:00 was caused by their behavior on the same rice hills. They walked down to the lower part of the hills from the ears and the upper part of the leaves. This behavior might be caused by their avoidance of the direct rays of the sun. In dark period, the number of bugs decreased abruptly. A similar pattern of curves was obtained in the other two courses, B and C.

In Fig. 2-B, the first sweeping seemed to eliminate and scatter most of the bugs on that field. So, the number of bugs caught in the first dark period did not indicate the real number of bugs that came flying into this field. The peak of the number

![Graph A](image1)

![Graph B](image2)

Fig. 2. Hourly changes in the number of adult rice bugs on rice plants. A: The bugs were counted over in 3 min. by walking along a footpath in the rice field. B: The bugs were caught by 20 sweeps in the rice field.
of bugs in the second dark period shows the increase in the number of bugs that came flying to this field.

**Field cage experiment**

Hourly changes in the number of bugs in a field cage experiment is shown in Fig. 3. Just after sunset on the first day, approx. 70% of released bugs could be seen on the ceiling. This behavior was also repeated on the second day. The bugs on the rice plant with ears increased gradually after sunset and approximately one fourth of the released bugs were aggregated on them during daytime. And approximately two thirds of the bugs on intact rice plants were restricted to the ears. The number

![Figure 3](image-url)

**Fig. 3.** Diel pattern of aggregation of adult rice bugs on rice plant in a field cage. Approximately 500 bugs were released and the number on the ceiling (A), on ten hills of intact rice plant (B) and on ten hills of rice plant without ears (C), was counted. The arrangement of 20 hills of potted rice plants in the field cage was shown above the curves. ●: a hill of potted rice plant with ears. ○: the same without ears. ×: releasing point.

![Figure 4](image-url)

**Fig. 4.** Diel pattern of feeding activity of adult rice bugs under laboratory conditions. Approximately 850 bugs were observed in containers described by SHIMIZU (1976).
Fig. 5. Upwind movement of adult rice bugs in a flight tunnel with or without rice plant odour. Left: Expt. I in the morning. Right: Expt. II in the afternoon. Displacement of 50 bugs between 6 sections, after flowing clean air as control (the upper and lower row), odour of rice plants (middle) and damp air (6:00-6:10), is shown in the number of increase (solid arrow) and decrease (open arrow) in each section. Continual time of experiments is shown above each graph by the time of day. The last column shows the results of repeated trials by collecting the dispersed bugs at Section No. 1 at 16:30.

of bugs on the rice plants without ears remained at a low level of less than 30 bugs. Another experiment, in which the rotation of arrangement of potted rice plants was conducted, showed the same pattern of curves.

Diel rhythm of feeding under laboratory conditions

The results of the observation on feeding behavior are shown in Fig. 4. Among 848 bugs, maximum number of about 200 feeding bugs was reached at the middle of the second light period. A few hours before light-off, the number of bugs feeding began decreasing abruptly, and the minimum number of bugs in feeding was observed an hr after light-off. They increased to around 100 during dark periods and began increasing again just after light-on. Daily change in feeding activity shown in this graph was similar to that in the number of bugs in field observation (Fig. 2-A), except for the appearance of temporary decrease in the number of bugs in the daytime (around 14:00) in the field. The bugs were observed to be very active just after light-off. This also coincides with the results from field observation (Fig. 2) and from the field cage
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experiment (Fig. 3).

Laboratory experiments with a flight tunnel

Just after sunset, the bugs moved actively in a preliminary experiment with a flight tunnel, but no apparent difference was observed in their upwind movements with or without plant odour.

The results of Expt. I and II are shown in Fig. 5. It is clear that the bugs moved upwind toward the odour source mostly when the odour of rice plant was streamed. Visual stimuli could be excluded because they could not see the rice plant through the wire mesh at the upwind end of the arena. Although a wet cloth would provide enough water vapor compared with the rice plant, water vapor did not elicit clear upwind movement of the bugs (6:00–6:10). A few bugs went upwind in control flows (3:20–4:00, 5:20–6:00, 6:20–7:00), but these flows lasted for 40 minutes. The bugs tended to move downwind in response to the clean air (4:20–4:30, 4:30–5:00, 5:10–5:20, 6:10–6:20, 7:10–7:20) and damp air (6:00–6:10). The response of bugs to the odour of rice plants was characterized by an increase in the number of bugs which jumped up and flew upwind resulting in an increase of bugs in the upwind sections.

The same upwind movement in response to the rice plant odour was also observed in Expt. II in the afternoon. This behavior, however, was not restricted to the odour of intact rice plants. They moved upwind, responding to the odour of only leaves (15:00–15:10, 17:10–17:20). The doubled quantity of odour of intact rice plants did not increase their upwind movement (15:10–15:20).

DISCUSSION

From the results of field observation and field cage experiment, the flying time of day is thought to be just after sunset. This conjectured behavior can be summarized as follows: The adult bugs feed on rice ears in the daytime except for a few hours during midday. Just after sunset, the bugs begin flying and move on and around the rice field. They stop flying and begin aggregating on rice plant as day breaks. From the results of experiments on diel feeding rhythm, it is concluded that more bugs feed in daytime than at night, and they move actively after sunset.

We had postulated that the overwintering bugs came flying into to the rice field, where the rice plant was flowering, with the aid of flower odour. Results of the flight tunnel experiment did not disprove the attractiveness of the flower odour, because the flower of rice plant and bugs used in these experiments may not be in the best state. The odour of only the leaves of rice plant could be said to play an important role in the orientation to rice plant under the laboratory conditions, to say the least. The responsiveness of the bugs to the rice plant odour did not correlate with the active flying time of day or just after sunset.

These observations and experiments were restricted to rice plants and to rice fields. Therefore, only their behavior after migration to the rice field was dealt with. How they come flying to the rice field from their overwintering place cannot be analogized from these hypothetical behaviors in a restricted range.

There are some reports about the orientation of insects to the odour source of their host plant using wind tunnels (Kennedy and Moorhouse, 1969; de Wilde,
1976; Visser and Nielsen, 1977). Russ (1976) and Mirsch and Mitchell (1966) suggested that the different stages of host plant have different attractiveness in odour. Also, Sarinigera (1976) proved by using an olfactometer that the scent of flowers attracts the female but the scent of leaves did not. In the rice field, when bugs come flying, the rice plant is in the stage in which the ears have flowers. The odour of rice plants in this stage can be thought to have effective attractiveness compared with other stages, though we could not demonstrate it.

Visual stimuli from a host plant are very important for insects in host finding. Moerike (1969) reported on host-plant's specific colour and behavior of Hyalopterus pruni (Aphididae). Also, optical stimuli are said to be related to the host plant detection in walking Colorado potato beetle, Leptinotarsa decemlineata (Say) (De Wilde, 1976). The visual response of the rice bug to the leaves and/or flowers of rice plants has not yet been examined.

The aggregation of adult rice bugs on ears of rice plants, when they alight to feed on the ears of rice plant after random flying about the rice fields, can be explained by the effect of 'arrestant' from the definition of Dethier et al. (1960). Sinigrin, which occurs in an undamaged rape plant, was reported to have an arrestant effect on females of Dasyneura brassicae Winn (Diptera) (Pettersson, 1976). And de Wilde (1976) observed that adult Colorado potato beetles apparently arrested their flight when they were above or near potato plants. If the odour of rice plants, e.g., the odour of flower and/or leaves, had such a function, it would be difficult to demonstrate; a wind tunnel is not suitable for verifying this phenomenon. Kennedy et al. (1959) on the host finding behavior of the green peach aphid, Myzus persicae (Sulzer), proved that much heavier accumulation of migrants on the peach, the specific overwintering host, was evidently due, not to their differential alightment, but to their differential departure, with a longer average stay on the peach. He did not use the term, 'arrestant', but it can be applied to this case if their stay was caused by a chemical or chemicals. To understand the mechanism of host-finding by the rice bug, more detailed analysis is required in both the field and the laboratory.

REFERENCES


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