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Table 2. AVERAGE DURATION OF THE LARVAL INSTARS IN DAYS ON CR-1014 AND IR-8[a]

Instar	Variety	
	CR-1014	IR-8
I	3.3	3.3
II	2.5	2.7
III	2.6	2.7
IV	4.3	4.3
V	4.5	5.2
Total	18.3	18.2

[a] Data were based on the rearing of 30 individuals.

was noticed after 40th day. The oviposition continued for about 70 days. The hatchability of the eggs laid on CR-1014 reached 89.6% with a mean egg period of 3.2 days. On IR-8 90.0% of the eggs hatched with a mean egg period of 3.1 days. On both varieties the shortest egg period was 3 days and the longest 5 days.

The larval period involved 5 instars on both varieties. HOWE (1956) reported 4 larval instars on wheat flour. Average duration of larval instars is shown in Table 2.

On both varieties the larval period was completed in 18.2 days. The shortest larval period was 17 days while the longest period was 20 days. The larval period on rice flour was longer than that reported by HOWE (1956) of 15.4 days on wheat flour.

The larval mortality on IR-8 and CR-1014 was 8.6% and 7.4%, respectively. The average pupal period on IR-8 and CR-1014 was 6.1 and 6.2 days, respectively. No pupal mortality was noticed.

From the above results, it is considered that the flour of the rice varieties used was not unsuitable food materials for the insect, although somewhat unfavourable as compared with wheat flour.

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Received March 3, 1974

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Mating Signal of the Brown Planthopper, *Nilaparvata lugens* STÅL (Homoptera : Delphacidae) : Vibration of the Substrate[1]

Female abdominal vibration in Delphacid insects is believed to be related with mating along with the male songs (OSSIANNILSSON, 1949; STRÜBING, 1962; MCMILLIAN, 1963). The mechanism of the male response to the female abdominal vibration, however, has remained to be clarified. We found that vibration of the substrate caused by the female abdominal vibration in the brown plant hopper, *Nilaparvata lugens*, one of the serious insect pests of the rice plant, can elicite mating excitation and orientation from males.

In the present study, virgin females began intermittent vibration of their abdomens by the fifth day of adult emergence, and this behaviour continued through almost the entirety of their lives. Mated females, however, did not demonstrate this vibratory behaviour. The duration of the vibration was from less than 1 sec to more than 3 min, and in some cases the vibration was repeated more than 100 times in 1 hr. Furthermore, vibrations took place irrespective of the presence or absence of males. Males did not mate with mated females and immature virgin females, but did so only with sexually matured vibrating females. These observations suggest that the abdominal vibration is related to the mating behaviour of this insect. As seen in Fig. 1, the female inserts her stylet into a rice plant stem and vibrates finely her abdomen in

[1] Appl. Ent. Zool. **9** (3): 196—198 (1974)

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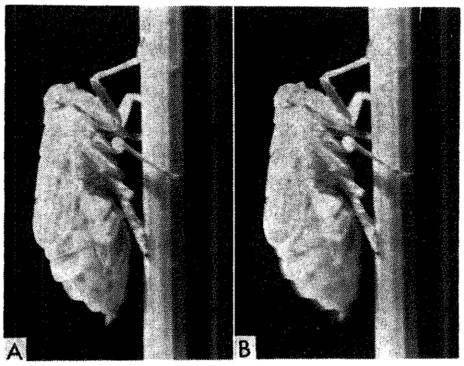

Fig. 1. Abdominal vibration in the brachypterous female of *N. lugens*. A: Not vibrating. B: Vibrating. Note the vibrating abdomen.

a dorso-ventral direction, without tapping the rice plant directly.

A sexually matured female and male was paired and confined in a glass tube (2 cm in diameter and 17 cm in height) into which a rice seedling was fixed to a piece of moistened polyurethane mat for the purpose of observing the mating behaviour. When the male was in the process of setting on the inside wall of the glass tube, it did not respond to the vibration of the female, even when both were in close proximity. After the male had settled on the rice seedling, however, it immediately responded to the vibration, and moved towards the female to mate. In order to clarify the mechanism involved in this response and movement to the vibrating female, the following experiments were conducted.

In one experiment, a single male was placed on a piece of thin paper disk (8 cm in diameter) which was in direct contact with a rice seedling onto which one virgin female was placed. The male immediately responded to the abdominal vibration of the female and ran about the paper until the vibration ceased. On the other hand, when the paper disk was separated by only a few millimeters from the rice seedling, the male did not show any response to the vibration, even when he was located at a distance of only about 2 cm from the female.

In another experiment, three young rice plants which had been individually cultured in three pots were arranged in a row as shown in Fig. 2. One sexually matured virgin female was placed on either of the outer rice plants and a male was then placed on the lower part of the stem of the rice plant set in the center. This test was repeated with 10 males. The males failed to show any response or movement if the leaf blade was not in contact with that of the adjacent rice plant where the female was vibrating her abdomen. However, when the leaf blades were in direct contact, most of the males immediately responded to the abdominal vibration and ran upward and

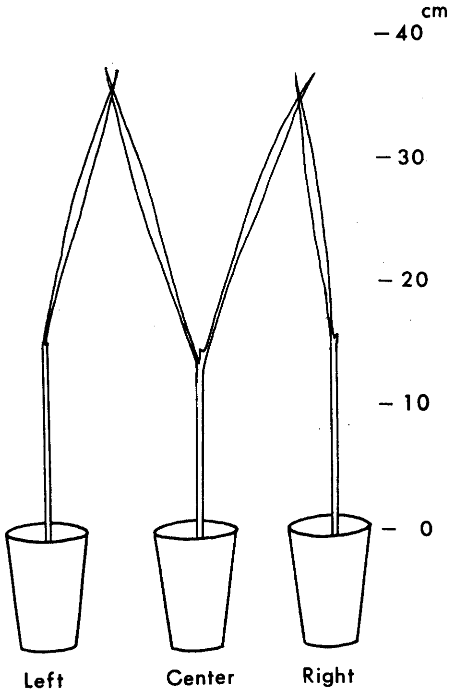

Fig. 2. A method to clarify the excitation and attraction of males by the female abdominal vibration on rice plants. A male was placed on the rice plant set in the center, and one virgin female was placed on either of the outer plants.

Table 1. Exciation and Attraction of Males by the Female Abdominal Vibration in *N. lugens*

Female placement on rice plant	Number of males[a] and direction of movement		
	Left	Right	Not moved
Left	9	0	1
Right	0	10	0

[a] Male was placed on the rice plant set in the center. See Fig. 2 and refer to the text.

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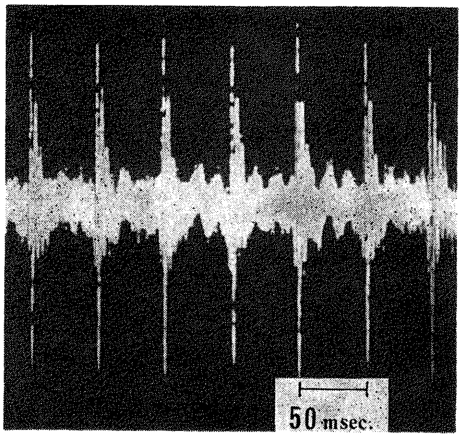

Fig. 3. Pulse repetition frequency of the vibration of rice plant caused by the female abdominal vibration.

across the contacted leaves, then down the stem to the female. Males were observed to respond and properly orient even from a distance of about 70 cm, eventually arriving at the side of the female and displayed copulatory behaviour. Results of this experiment are given in Table 1.

The vibration of the rice plant caused by the abdominal vibration was detected by means of a cartridge (M-2100, Micro Sound Co. Ltd.) and recorded on a sound recording tape (Scotch magnetic tape) following electrical amplification. The recording was then reproduced from a sound speaker and transmitted as the vibration through a piece of thin paper onto which males were placed. The males clearly responded to the vibration and ran about the paper until it ceased in a manner similar to that observed in the previous experiment using the rice seedling. As shown in Fig. 3, the pulse repetition frequency analysed with an oscilloscope (Model 181 A, Hewlett Packard) was revealed to be 20 cycles per sec., and at least three damped waves were found in each pulse. This experimental evidence and observation of the mating behaviour indicated that vibration of the substrate caused by the abdominal vibration of the females was the mating signal for the males.

Females of two other species of planthoppers, *Laodelphax striatellus* and *Sogatella furcifera*, aslo communicated with respective species of males in the same manner as the brown planthopper but at different pulse repetition frequencies. Further details will be presented in a subsequent paper.

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Received May 9, 1974

[1] The authors wish to express appreciation to Mr. M. Sakuma for his technical assistance in the recording and reproduction of vibrations.

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