The Damage of Rice Panicles Caused by Insect Pests in Sri Lanka*

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An analytical study on the damage of rice panicles caused by insect pests was carried out as a part of the cooperative research program, "Studies on factors influencing yield stability of early maturing rice varieties of Sri Lanka****", which was being undertaken by Mr. H. Morita (Tropical Agriculture Research Center) and Mr. M. P. Danapala.

The present study consisted of field observation to examine the actual situation of the damage on rice panicles, and field experiments to make clear the characteristics of insect incidence on panicles and the damage. The study was carried out during the period of four months from July to November, 1986 in the Central Rice Breeding Station (CRBS), Batalagoda.

Field observation

To obtain basic data to establish a key pest management strategy, species of key pests and arthropod fauna on rice panicles were investigated.

1) *Key pest*

The field observation was conducted in rice fields in various areas such as Kurunegala, Kandy, Kekirawa, Dambulla, Girandurukotte, Puttalam, Bombuwela, Angunakolapelessa, Amblantota, etc.

It was recognized that the majority of the damage of rice panicles was caused by rice

Plate 1. Adults of *Leptocorisa oratorius* and rice panicles damaged by them

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stink bugs, with a minor part of other insect pests, diseases, etc.. The paddy bug *Leptocorisa oratorius*, the main species of stink bugs, showed high population in most fields (Plate 1). In rice fields showing the paddy bug population more than ten individuals per m², severe damage which reduces rice yield by more than 50% was recognized (Plate 1). In addition the whorl maggot, *Hydrelia philippina*, was commonly recognized to cause panicle damage.

2) Insect and nematode pests on panicles

A tentative list of insect and nematode pests which directly attack or may attack rice panicles is given below.

1. Stink bugs
   1. *Leptocorisa oratorius* and others
   2. *Pigomenida bengalensis* and others
   3. *Eysarcoris ventralis*
   4. *Nezara viridula*
   5. *Cletus punctiger* and others
   6. *Paromius gracilis*
2. Whorl maggot — *Hydrelia philippina*
3. Thrips — *Haplothrips ganglbaueri*
4. Leafhoppers
   1. *Nephotettix virescens*
   2. *Tettigella* sp. and others
5. Planthoppers — *Sogatella furcifera*
6. Nematode — *Aphelenchoides besseyi*
7. Orthoptera — *Conocephalus* sp.

Table 1. Arthropod fauna found on rice panicles at the flowering stage

Species group	No. of individuals	Composition rate (%)	Food habits*
Heteroptera	30.3	11.8	Pp, O, E
Leptocorisa oratorius	13.5	5.2	Pp
Pigomenida bengalensis	3.0	1.2	Pp
Orius sp.	11.0	4.3	E
Homoptera	12.3	4.8	Pp, O
Nephotettix virescens	6.5	2.5	Pp
Sogatella furcifera	3.0	1.2	Pp
Thysanoptera	102.0	40.0	Pp
Haplothrips ganglbaueri	102.8	40.0	Pp
Diptera	22.4	8.7	Pp, O, E
Chironomidae	19.8	7.7	O
Lepidoptera	0.3	0.1	Pp
Coleoptera	1.4	0.5	O, E
Hymenoptera	85.4	33.2	E
Japania andoi	43.8	17.0	E
Micro Hymenoptera	41.0	15.9	E
Odonata	0.5	0.2	E
Araneae	0.5	0.2	E
Acarina	1.3	0.5	O
Total	257.2	100.0	

The collection was made on Aug. 18, 1986, in rice fields of var. Bg 400-1 in CRBS, by 4 replications of 10 sweepings.

* Pp=Paddy pest, E=Entomophagous, O=Others.

The fact that *Haplothrips ganglbaueri* and *Sogatella furcifera* damage rice spikelets was already reported in India[9] and Japan[7], respectively.

3) Arthropod fauna

In four rice fields, the arthropod fauna associated with rice panicles at the flowering stage was examined by means of ten times sweeping by an insect net.

As shown in Table 1, the population density of rice stink bugs, leafhoppers, planthoppers and *Haplothrips* was comparatively high.

According to Table 2, the composition rate of rice pests which was about 50% in fields was a little lower than that in Japan, which is about 60% or more[4]. On the other hand the composition rate of entomophagous arthropods which was nearly 40% in the field was conspicuously higher than that in Japan, which is about 8% or less[4].

As natural enemies are one of the extremely beneficial resources, we have to take care to reserve them by means of integrated pest control, as we recommend later.

Table. 2 Composition rates of paddy pests and entomophagous insects associated with rice panicles

Food habits	No. of individuals	Composition rate (%)
Paddy pest (Pp)	132.9	51.7
Entomophagous (E)	99.7	38.8
Others (O)	24.6	9.5
Total	257.2	100.0

Analytical field experiment

Field experiments to analyze the damage of rice panicles due to insect pests were conducted in a rice field where two varieties, Bg 380 and Bg 400–1, were planted. The experimental design is shown in Table 3. In general, two panicles (1–3 panicles) were covered with 15, 22 or about 130 mesh viny-

Table 3. Experimental designs employed to analyse the characteristics and the amount of damage caused by *Leptocorisa oratorius*, *Nephotettix virescens* and *Haplothrips ganglbaueri* to rice panicles at different developmental stages

	Developmental stage of the panicle									
	Flowering(anthesis) and early grain development stage				Milk grain stage			Dough grain stage		
	Treatment no.	No. adult per cage	No. of replications Expt. 1	No. of replications Expt. 2	Treatment no.	No. adult per cage	No. of replications	Treatment no.	No. adult per cage	No. of replications
Leptocorisa oratorius	1	0	7	10	1	0	10	1	0	10
	2	1♂	5	5	2	1♂	5	2	1♂	5
	3	1♀	5	5	3	1♀	5	3	1♀	5
	4	2♂	5	5	4	2♂	5	4	2♂	5
	5	2♀	5	5	5	2♀	5	5	2♀	5
	6	4♂	5	5	6	4♂	5	6	4♂	5
	7	4♀	5	5	7	4♀	5	7	4♀	5
Nephotettix virescens	1	0	10							
	2	5	10							
	3	10	10							
	4	20	10							
Haplothrips ganglbaueri	1	0	8							
	2	5	6							
	3	10	7							
	4	20	7							

The experiment on *Haplothrips* was conducted in a screen house, while others were done in the field.

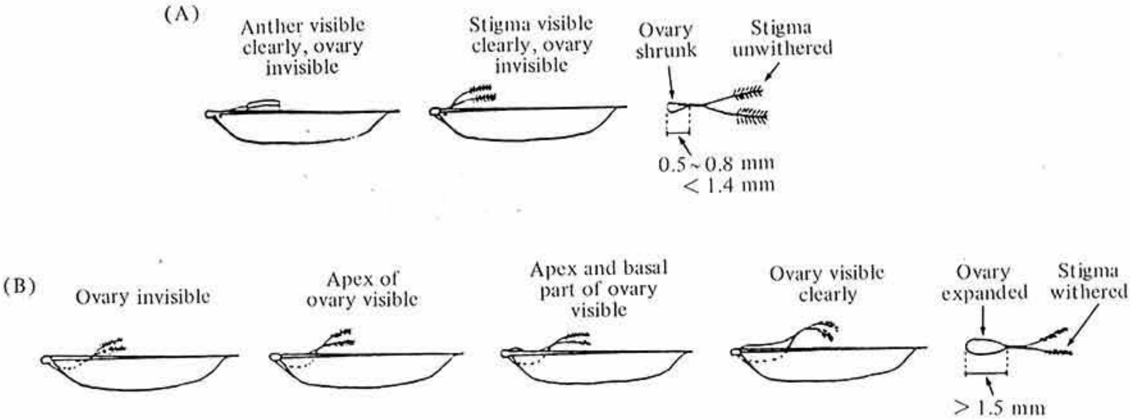

Fig. 1. Visible symptoms of ovary and stigma before and after fertilization
(A): Unfertilized, (B): Fertilized.

lon or tetron cloth to cage the paddy bug, the green leafhopper or the *Haplothrips*, respectively. The insect individuals were caged in the cover to feed on the test panicles for five days. Prior to caging the insects, all spikelets younger or older than the prescribed developmental stages (three stages shown in Table 3) were removed from the panicles. Dead individuals were replaced with living ones in the morning and afternoon throughout the 5-day period.

1) Characteristics of the damage

A tentative key to identify the damage of the ovary and grain of rice is given below.

1(2) Ovary undeveloped, shorter than 1.4 mm length (Fig. 1-A).
Ovary and stamen uninfected. Spikelets colored normally ....
Ovary undeveloped (Plate 2–1).
Ovary and stamen severely infected with pathogens. Spikelets dark brownish wholly or basally ....
Ovary undeveloped and the development arrested by unknown factor (2) (Plate 2–4).

2(1) Ovary developed, longer than 1.5 mm length (Fig. 1-B).

3(4) Ovary development arrested before it rech full length and width.
Ovary expanded, empty, sometimes or often with small scabs and brownish tinge on the surface ....
Ovary development arrested by insect (Plate 2–2).
Ovary shrunk or flat, colored uniformely without scabs on the surface ....
Ovary development arrested by unknown factor (1) (Plate 2–3).
Ovary shrunk or flat severely infected with pathogens.
Ovary and spikelets dark brownish wholly or partially changed color gradually ....
Ovary undeveloped and the development arrested by unknown factor (2) (Plate 2–4).

4(3) Ovary reached full length and width.

5(6) Grain filled completely, without abnormal shape and color.

6(5) Grain unfilled or filled with abnormal shape and/or color.
Grain unfilled, sometimes sharpened apically, whitish or greenish uniformly or normal color ....
Incomplete by an unknown factor (1) (Plate 2–3).
Grain particularly tinted with light red or dark wholly or basally, or dull white, often with brownish stripe on unfilled grain ....
Damaged by an unknown factor (2) (Plate 2–5).

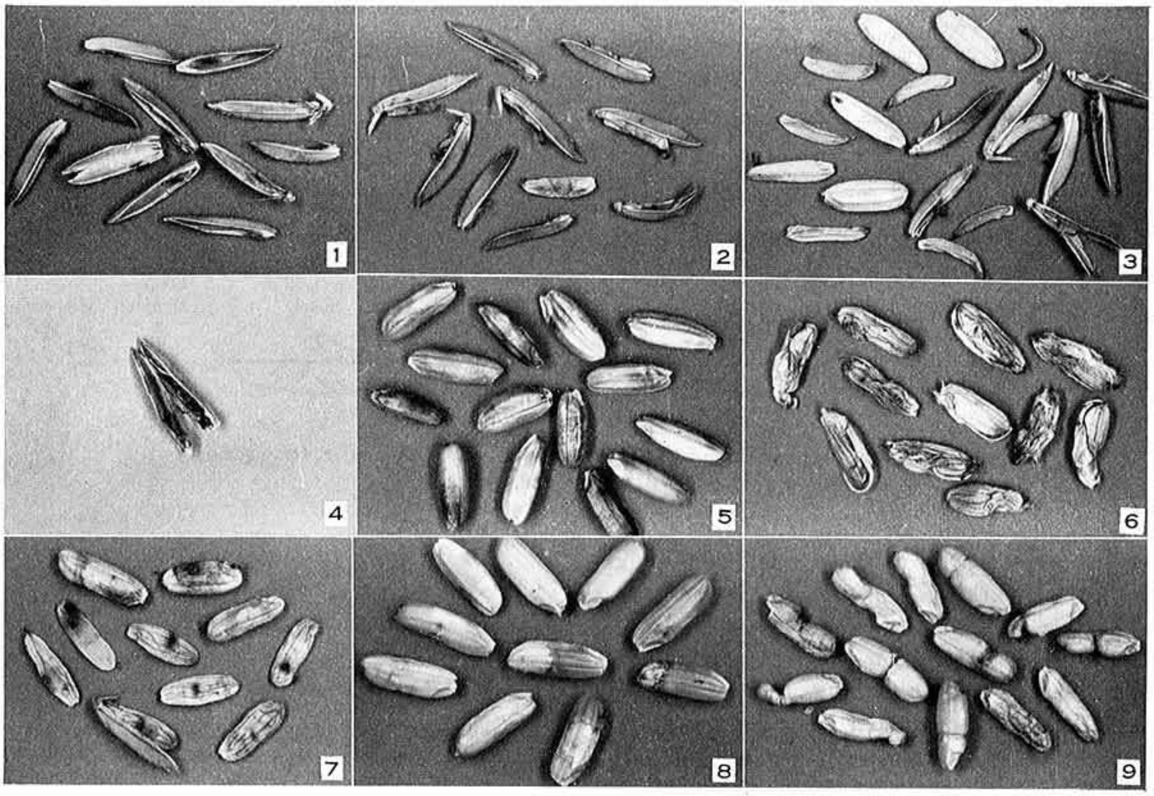

Plate 2. Rice ovaries and grains damaged by insects, fungi and others
1: Ovaries undeveloped, 2: Ovary development arrested by stink bug, 3: Ovary and grain development arrested by the unknown factor (1), 4: Ovary development arrested by the unknown factor (2), 5: Grains damaged by the unknown factor (2), 6: Viviparity by stink bug, 7: Grains damaged severely by stink bug, 8: Grains damaged slightly by stink bug, 9: Grains damaged by the unknown factor (3).

Grain unfilled, root (and bud) developed ...... Viviparity (Plate 2–6).
Grain unfilled, blackish wholly, sometimes or often with brown or black spot on the central part of light brownish grain surface ....
Damaged severely by stink bug (Plate 2–7).
Grain unfilled or filled, sometimes somewhat concaved, whitish, brownish or blackish at about a half part of the grain ....
Damaged medially by stink bug.
Grain filled, partially whitish, brownish or blackish, sometimes a little concaved at a part of grain ....
Damaged slightly by stink bug (Plate 2–8).
Grain with characters other than that described above, sometimes or often grain constricted at a part ...
Damaged by an unknown factor (3) (Plate 2–9).

Remarks: Unknown factors (1), (2) and (3) may be mainly physiological, phyto-pathological and nematological, respectively.

2) Analysis of different degree of damage caused by insect pests

The results of the experiment are summarized Fig. 2 and Table 4.

According to Fig. 2, rice ovary development was arrested, rice grains were severely dam-

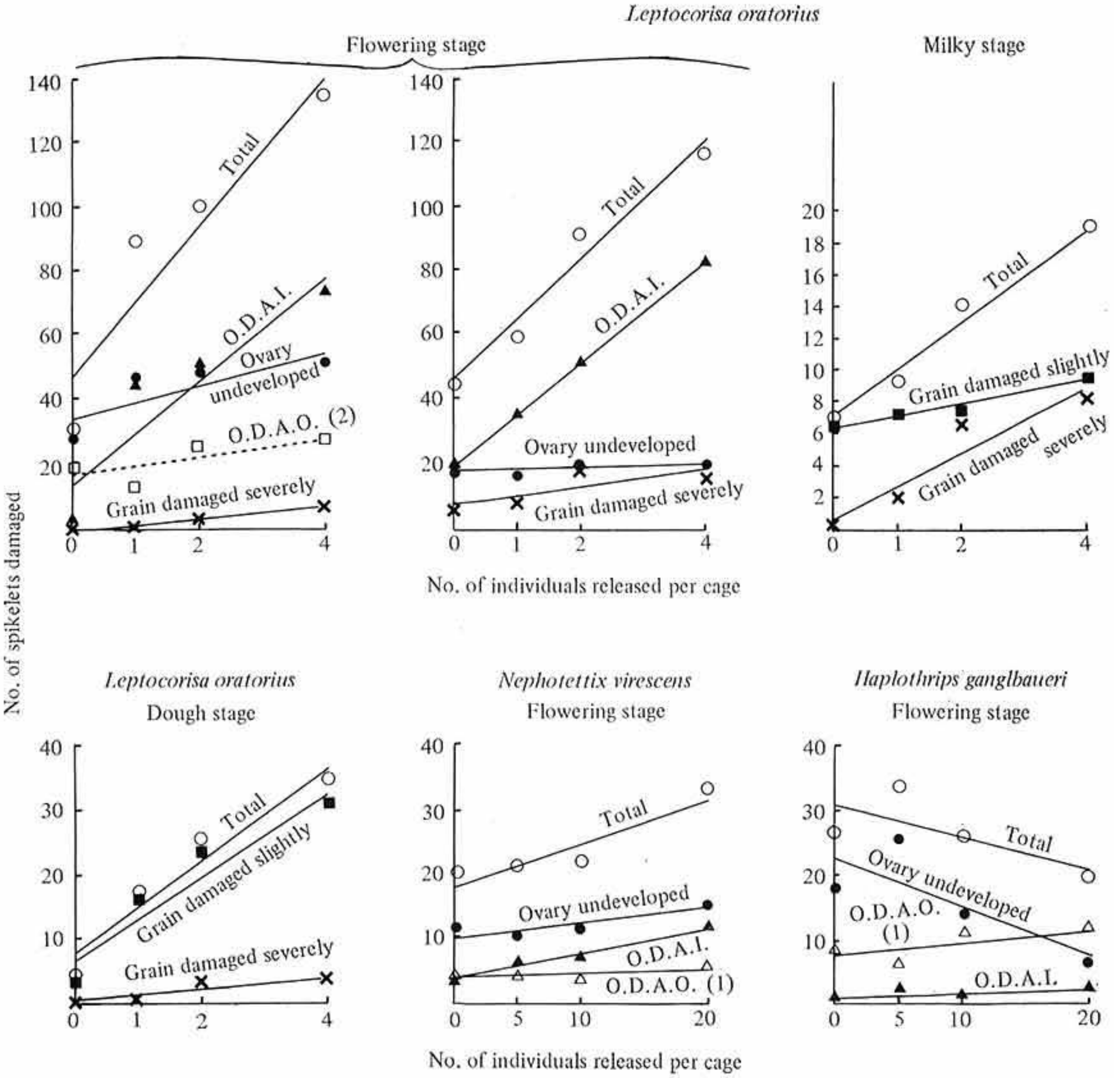

Fig. 2. Correlation between the number of insects released and the number of spikelets (ovaries and grains) damaged at each developmental stage of the panicle
O. D. A. I.: Ovary devlopment arrested by insects.
O. D. A. O (1) or (2): Ovary development arrested by other factors (1) or (2).

aged, and also undeveloped ovary, namely rice sterility was caused by attack of the paddy bug, *Leptocorisa oratorius*, at the flowering stage. By the attack of the paddy bug at the milky stage and dough stage, rice grains were damaged severely and slightly, respectively.

The attack of the green leafhopper, *Nephotettix virescens* at the flowering stage caused undeveloped ovary and also arrested ovary development.

From the linear regressions (equations) shown in Fig. 2, the number of ovary and grain damaged by one individual of the paddy bug per day at the flowering, milky and dough stages was estimated at 5.74, 0.57 and 0.47, respectively. On the contrary, that damaged by one individual of the green leafhopper per day was estimated at only 0.14.

The fact which the present authors wish to emphasize is the importance of the flower-

Table 4. Economic injury levels to be used for paddy bug control

Insect density (x) (number of insect/m²)		Total grain loss* (number/m²)	Yield loss** (kg/ha)	Yield loss when one insecticide application is made*** (kg/ha)	Profit due to one insecticide application**** (Rs/ha)
Flowering stage					
Basis of calculation:	Flowering (spikelets)	120.50			
	Milk grains	43.89			
	Dough grains	255.68			
	Total	420.07			
0.5		210.03	54.6	10.92	− 98.64
1.0		420.07	109.2	21.84	− 87.92
1.5		630.10	163.5	32.70	− 42.40
2.0		840.14	218.4	43.68	+172.6
4.0		1680.28	436.8	87.36	+698.0
Milk grain stage					
Basis of calculation:	Milk grains	11.97			
	Dough grains	150.40			
	Total	162.37			
1.0		162.37	42.2	8.44	− 248.7
2.0		324.74	84.4	16.88	− 147.4
3.0		487.11	126.6	25.32	− 46.16
4.0		649.48	168.8	33.76	+ 55.12
8.0		1298.96	337.6	67.52	+460.2
Dough grain stage					
Basis of calculation:	Dough grains	60.16			
1.0		60.16	15.6	3.12	−312.56
2.0		120.32	31.2	6.24	−275.12
4.0		240.64	62.4	12.48	−200.2
8.0		481.28	124.8	24.96	− 50.48
10.0		601.60	156.0	31.20	+ 25.40
16.0		962.56	249.6	49.92	+249.4

* Total grain loss was calculated on the assumptions that:

(a) Population growth $N_t = N_0 \times 0.5$(sex ratio)$\times 300$(fecundity)$\times 0.6$(egg survival)$\times 0.6$(nymph survival), for a generation period of 30 days.

(b) No. of grains damaged is 5.74/insect · day at flowering, 0.57/insect · day at milk grain stage and 0.47/insect · day at dough grain stage.

(c) Basis of calculation: When x=1 at the beginning of the flowering stage, the insect multiplies and causes the total loss, 420.07 grains, composed of spikelet loss, milk grain loss, and dough grain loss.

** 1000 grain weight=26 g.

*** One application of insecticide can save 80% of the loss.

**** Insecticide application cost=350 Rs/ha (cost of paddy @ 3 Rs/kg).

ing stage for the damage by the paddy bug.

Attacking potential of the paddy bug was a little different between sexes as follows: male : female=1 : 1.56, 1 : 1.20 and 1 : 1.22 at the flowering stage, the milky stage and the dough stage, respectively.

3) Economic injury levels

Based on the experimental results shown above, an economic injury level of the paddy bug population of adults was tentatively calculated (Table 4). It was about 1.5, 3.5 and 9.5 individuals per m² at the beginning of the flowering stage, the milky stage and the dough stage, respectively.

The economic injury level of the paddy bug population was reported to be two bugs per m^2 in Sri Lanka by Nair[5] and two to four bugs per m^2 in the Philippines by Dyke[2]. These values are consistent with the values indicated above. On the other hand, the value, one bug per hill, was reported in India[1], one bug per two hills or one bug per 20 tillers in Thailand[8], two adults per hill in Malaysia[6] and eight bugs per m^2 in the Philippines[3]. These values appear extremely large, because they were obtained from the experiment not including the flowering stage.

Control strategies

In order to establish a technique to obtain stable high yields at a low cost, an integrated control method is recommended as follows.

(1) Environmental management: Removal of weeds before they bear seeds in areas from which the insect can fly into rice fields is effective to prevent the multiplication of stink bugs which attack rice panicles.

(2) Genetic control: It is desirable to promote the breeding of rice for resistance or tolerance to the whorl maggot, planthoppers, leafhoppers and the white-tip nematode.

(3) Agronomic control: To adjust the planting time of rice varieties in certain areas, so as to confine their flowering time within a period as short as possible is effective in escaping from the damage by stink bugs and preventing their multiplication.

Adequate fertilization is necessary to grow healthy rice plants. A sufficient amount of organic matters, and a moderate amount of chemical fertilizers are desirable, but too much fertilizers, especially nitrogen should be avoided.

(4) Insecticidal control: Minimal insecticide application should be made, only when the key pest population is going to increase beyond the economic injury level, in order to save natural enemies of insect pests as well as the expense.

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