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Yellow Pan Water Trap for Sampling the Small Brown Planthopper, *Laodelphax striatellus* (FALLÉN), a Vector of the Rice Stripe Virus

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For sampling the small brown planthopper, *Laodelphax striatellus* (FALLÉN), a vector of the rice stripe virus, pan water traps of various colors were tested. Yellow pans which were set at the crop level attracted three times as many planthoppers as green or white pans, and black pans attracted about one tenth of those by yellow pans. Catching efficiency per area of pan decreased with increase of size of pan and pan of 60 cm in diameter seemed to be highest in efficiency and also convenient for handling. Yellow pans set at 1.5m height above the ground caught one tenth to one fourth as few planthoppers as pans set at the crop level. Sampling by yellow pan water trap was compared with those by insect net sweeping and counting by eyes. At the beginning of the immigration season of the first generation or soon after the transplantation of rice plant, yellow pans showed higher efficiency than the other methods. Catching curves by yellow pan preceded those by counting. It was considered that yellow pan sampled planthoppers which were actively flying at the crop level and counting estimated the density of planthoppers settled down on rice plants. Level of catching by a yellow pan corresponded to that of 5 hills by counting as a general trend. Sampling by sweeping much depended on the growth stage of rice plant, not necessarily with the density of planthopper. Catching by yellow pans showed the diurnal periodicity, bimodal curve of high catching from 5.00 to 11.00 in the morning and 15.00 to 19.00 in the evening. In 1963 and 1965 high catches were obtained in the season of the first generation but much less catches in 1964. Catch curves were composed of several minor peaks, synchronized among several plots. Coincidence of attractive stage of rice plant, 10 days to 2 weeks after transplantation, with the peak of immigration of planthopper induced high catches, consequently the severe infection of the rice stripe virus.

INTRODUCTION

Attractiveness of yellow plate and water trap for aphids was reported by MOERICKE (1955). HEATHCOTE (1957) compared several traps for sampling aphids and found that water traps were almost as effective as suction trap in catching those species of aphids which were attracted to yellow, and when aphids were few, for example, at the beginning of the season, they were more effective than

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sticky traps.

Laodelphax striatellus (FALLÉN), a vector of the rice stripe virus, overwinters as diapausing nymphs among weeds on dikes, farm roadsides and fallow fields or forage crop fields. Main habitats for the insects of the first generation are wheat and barley fields and others with gramineous weeds. Adults of the first generation begin to migrate into rice seedling beds and paddy fields from the end of May to June. These immigrants play the most important part in transmission of the rice stripe virus, particularly in fields of early transplantation.

Estimation of density and time of immigration of *L. striatellus* has been made by insect net sweeping or sticky trap. But weather conditions, particularly rainfall prevailing in the season of adult emergence of the first generation, disturb the performance of sampling. Growth stage of the rice plant and skill of collector also remarkably affect the estimation by sweeping. As a simple and effective sampling method pan water traps of various colors were tested, expecting to catch particularly immigrants in the early stage of rice plants.

METHODS

Pans of tin plate, 60 cm in diameter and 7 cm in depth having a small overflowing outlet at a height of 5 cm from the bottom, were painted on the whole surface with yellow, green, white and black paints of Kansai Paint Co. Ltd. Each pan was set on a wooden stand at the level of crop height (Fig. 1). One third to a half volume of pan was filled with water containing about 0.1% of detergent. The water was renewed every few days. Insects caught were all taken out by a wire net spoon several times daily and sorted.

Spectrophotometric characteristic of paints used was kindly offered by Kansai Paint Co. Ltd., as shown in Fig. 2.

Fig. 1. Pan water trap set on a wooden stand at the crop level in paddy rice field.

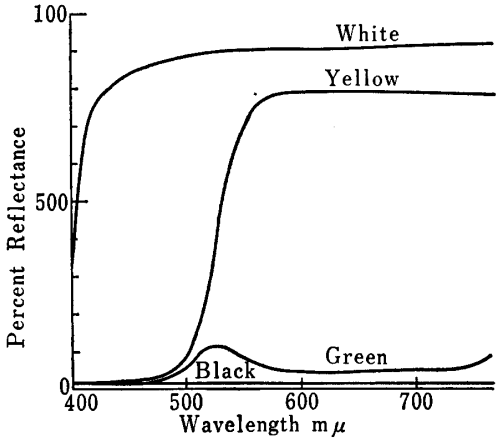

Fig. 2. Spectrophotometric characteristic of the colour paints used.
(By the courtesy of Kansai Paint Co. Ltd.)

RESULTS

Comparison of the Attractiveness of Various Colours

Attractiveness of four colours, yellow, white, green and black, was compared in 1963. Four pans of different colours were set in square 5 m apart from each other in each plot of paddy field of 1 *a* transplanted on May 15, and three sets consisting of these four pans were replicated. Catching was started at 15.00 hr (Japan Standard Time) of June 6 and continued until 17.30 hr of June 9. The total number of *L. striatellus* caught throughout the period were shown in Table 1.

Table 1. Comparison of the Attractiveness of Pan Water Traps of Various Colors to the Small Brown Planthopper, *Laodelphax striatellus* (Fallén)

	Replicate No.	Yellow	White	Green	Black	Total
Female	1	238	63	80	32	413
	2	224	67	55	44	390
	3	196	52	67	18	333
	Average	219.3[a]	60.7[b]	67.3[b]	31.3[c]	1136
Male	1	291	102	112	24	529
	2	334	147	105	31	617
	3	260	104	60	17	441
	Average	295.0[a]	117.7[b]	92.3[b]	24.0[c]	1587

a, b and c.... Difference between different letters were significant at a level of 0.05. Original numbers were transformed into logarithmic scale for analysis of variance. Catching was made from June 6 to June 9, 1963.

Planthoppers captured in yellow pans were about three times as many as those captured in green or white ones and the attractiveness of black was the lowest. This trend was found to be consistent through all observation times as shown in Fig. 3.

Effect of Height of Pan-Setting on Catching Efficiency

Catches by yellow pans which were set at a height of 1.5 m above the ground were compared with those by pans set at the crop level. Catching was made from 9.00 hr of June 8 to 17.00 hr of June 17, 1963. Three sets of pans were used in fields transplanted on May 15. Results were shown in Fig. 4. It was found that pans of high level caught only about one tenth to one fourth of planthoppers of those caught by traps at the crop level. The difference was particularly large at a period of high catching at the crop level. It was suggested that the flight of planthoppers resulting in attractiveness of pans was densely found near the crop level. Ratio of male in captured planthoppers was high at the crop level, while that at a height of 1.5 m was nearly 50 %.

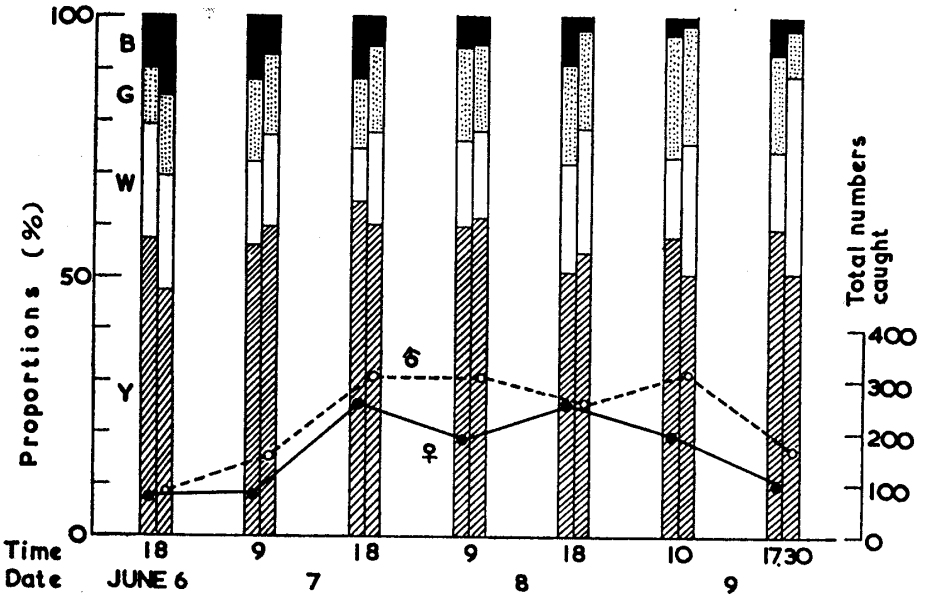

Fig. 3. Proportions in percentage of planthopper, *Laodelphax striatellus*, caught by pan water traps of yellow (Y), white (W), green (G) and black (B) at various observation times.

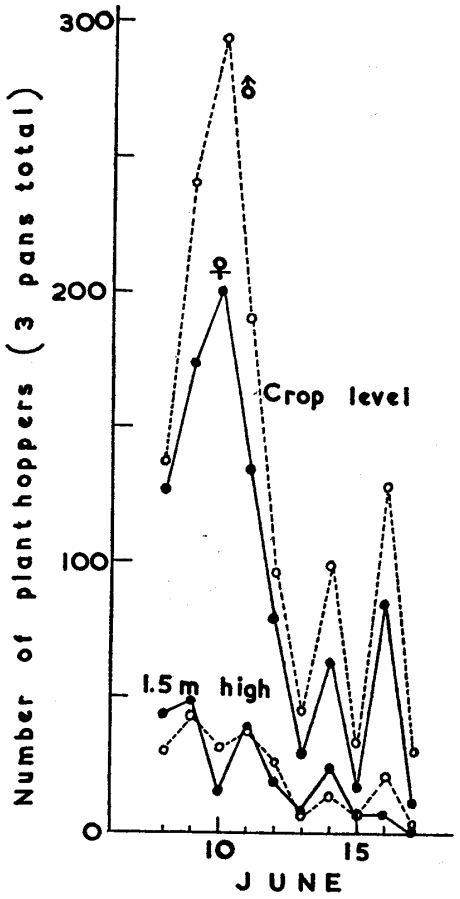

Fig. 4. Catches of *L. striatellus* by yellow pan water traps set at the crop level and 1.5m high above the ground. Three pans for each height were used.

Effect of Size of Pan

Pans of different sizes, 42.4 cm, 60 cm and 84.9 cm in diameter whose area were $^1/_2$, 1 and 2, respectively, were compared in their catching efficiency in 1964. Two sets of pans of different sizes were set in paddy fields transplanted on May 15, two in fields transplanted on June 3 and 1 set in a field sown directly on May 21. Pans were set at 12.00 hr of June 8 and catching was continued until 17.00 hr of June 12. Results were shown in Table 2.

Table 2. Comparison of Catching Efficiency of Yellow Pan Water Traps of Various Sizes

Size of pan (Diameter, cm)		Total number of planthoppers caught	Number per area of pan (100 cm^2)	Number per diameter (cm)
Small	(42.4 cm)	♀ 100	7.08	2.36
		♂ 120	8.50	2.83
Medium	(60.0 cm)	♀ 143	5.06	2.38
		♂ 175	6.19	2.92
Large	(84.9 cm)	♀ 173	3.05	2.04
		♂ 273	4.18	2.79

Catching was made from 12.00 of June 8 to 17.00 of June 12, 1964. Total number of planthoppers caught in 3 pans was shown.

Catching efficiency, shown by the number of planthoppers caught per area, decreased with increase of size, but number of planthopper per linear dimension, for example, diameter showed much less difference than in the former. Pans of large size were not easy to handle, in addition to the low catching efficiency, but medium ones seemed to be convenient.

Comparison of Pan Water Trap, Sweeping and Counting

Sampling by pan water trap, sweeping by insect net and counting by eyes was compared in 1964 and 1965. Thirty strokes, 15 each in two marches, were made by an insect net of 30cm in diameter in the early afternoon, except for days of rainy or windy weather. Fifty hills of rice plants were sampled systematically and planthoppers were counted by the author only to avoid personal fluctuation in counting efficiency. One yellow pan was set in the middle of the field. All samplings were carried out in each field of 1 *a*, transplanted on May 15 and June 3 in 1964 and on May 30 and June 4 in 1965. Results were shown in Fig. 5 and Fig. 6.

Peaks of catching by water trap tended to precede those by counting. Peaks by sweeping were found to two to three weeks after the transplantation, later than those by water trap and counting, particularly in plots of late transplantation. So, at the beginning of immigration period or soon after the transplantation the yellow pan water trap showed much higher sampling efficiency than the other methods. Counting by eye seems to be the best one among the three

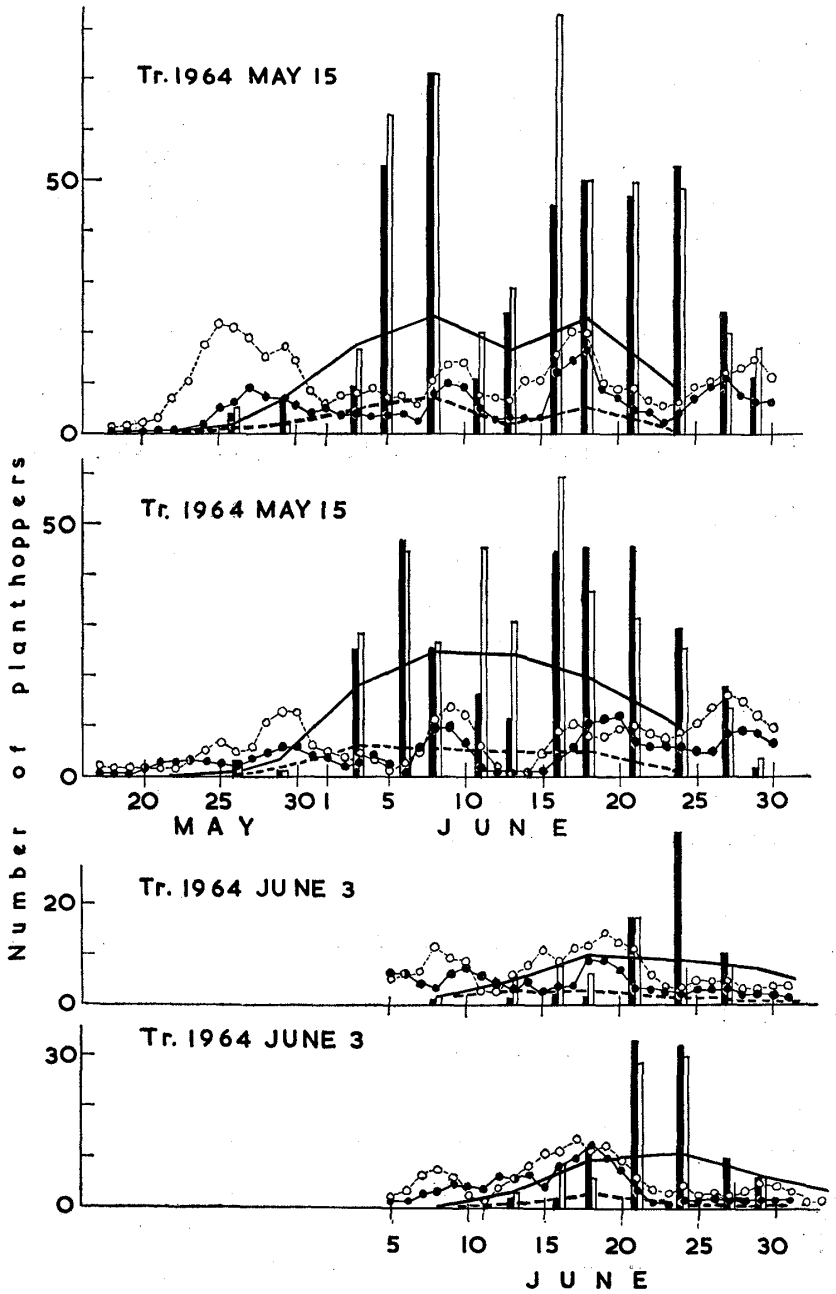

Fig. 5. Comparison of catch curves of *L. striatellus* by yellow pan water trap, sweeping by insect net and counting by eyes in fields of various transplantation time (Tr.) in 1964. Legend is shown in Fig. 6.

methods used in the present study, but it has several disadvantages, for example, active planthoppers tend to be underestimated and rice plants of many tillers disturb precise counting, etc. Higher counts of female than male shown in Fig. 5 and 6 seem to reflect these disadvantages. As a rule, counting seems to estimate the density of planthoppers settled down and yellow pan water trap depends on that of voluntarily flying planthoppers. Efficiency of sweeping

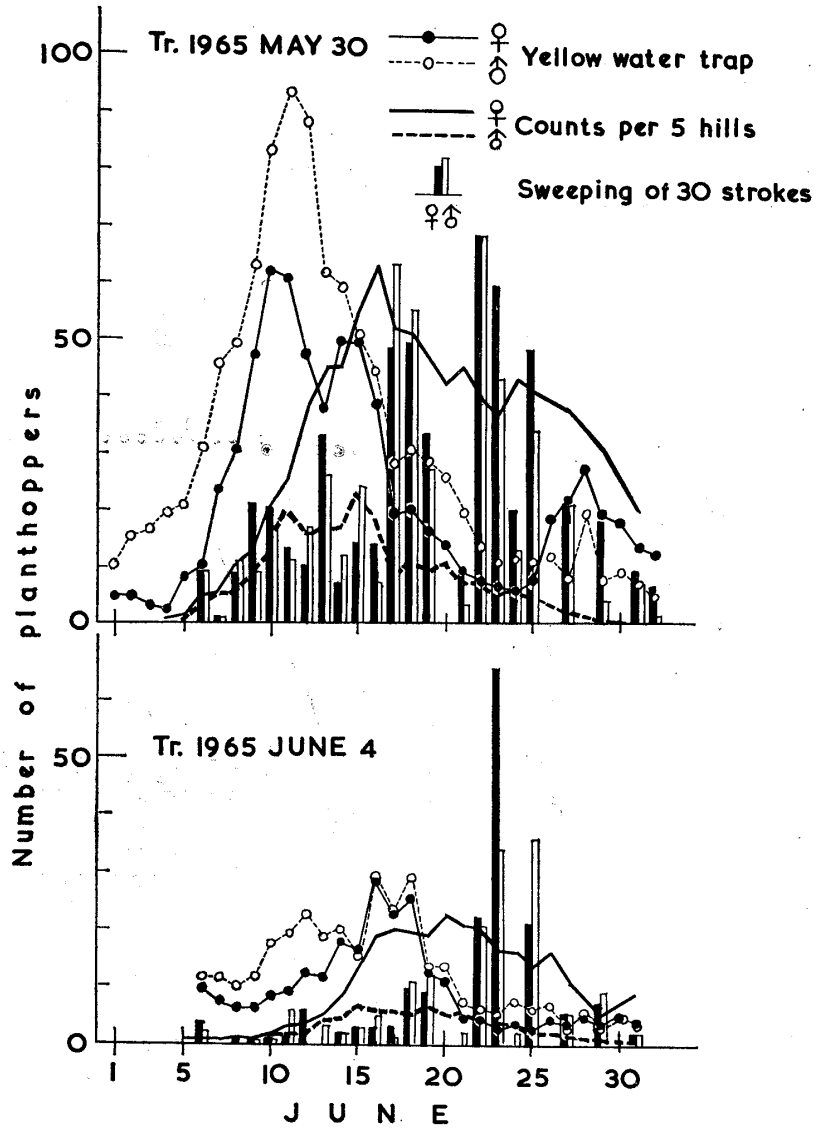

Fig. 6. Comparison of catch curves of *L. striatellus* by yellow pan water trap, sweeping by insect net and counting by eyes in fields of various transplantation time (Tr.) in 1965.

depends largely on the growth stage of rice plants. It is often experienced that the sweeping on rice plants is much easier 2 to 3 weeks after transplantation than younger or older ones. Levels of density estimated by a water trap were equal to those of females per 5 hills estimated by counting.

Daily Periodicity of Catching

Catches were recorded one or two hours intervals early in June of 1963, 1965 and 1966. Three pans were used in 1963 in fields transplanted on May 15, 5 pans in 1965 one in each field transplanted on the 10th, 15th, 20th, 25th and 30th of May and 6 pans in 1966 two in each of the fields transplanted on the 6th, 16th and 26th of May. Temperature at the crop level was measured at the time of collection of the caught insects. Results were shown in Fig. 7. Two periods of high

catching, from 5.00 to 11.00 in the morning and 15.00 to 19.00 in the late afternoon, were noticed. Clearly high catches were sometimes found just before sunset. Sunrise is about 4.50 and sunset is about 19.15 at Zentsuji early in June. Effect of temperature on the catching was not clear but large catches were usually obtained at 20 to 25°C. Rainfall did not necessarily inhibit catching but in many cases high catches were obtained during cloudy weather.

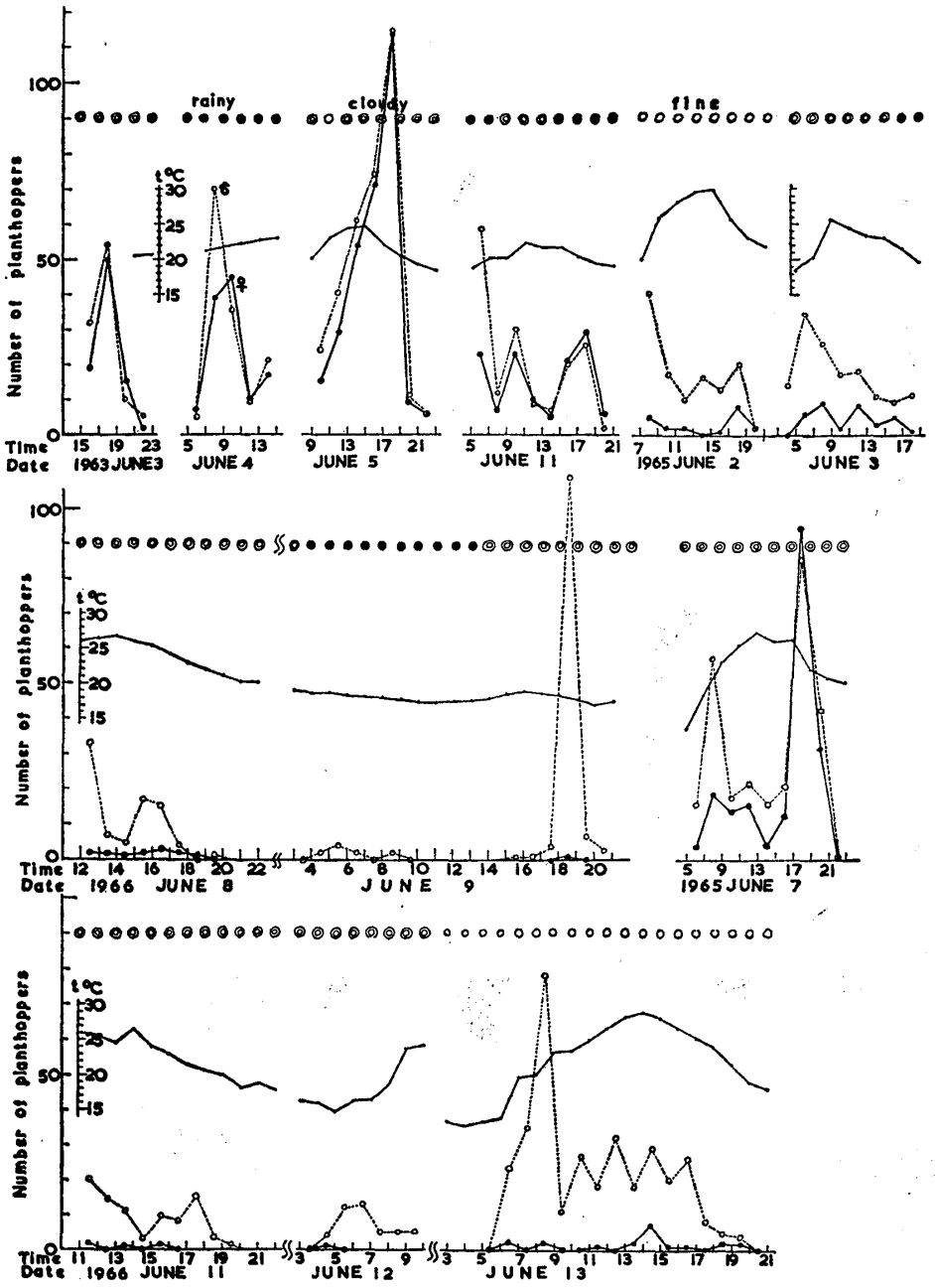

Fig. 7. Daily periodicity in catching *L. striatellus* by yellow pan water trap.

Catches by Yellow Pan Water Trap through Several Years

Records by yellow pan water traps set in paddy fields transplanted at various times were shown in Fig. 5, 8 and 9. Time of collection of captures was 17.00 hr. Three days' smoothing of catches was made to avoid fluctuation due to daily periodicity of catching. In 1963, pans were set on June 3 and the other years pans were set on the day of transplantation.

Levels of catch curve differed from each other with year and time of transplantation of rice plant. Catch curves covering the first generation were shown to be composed of two or more minor peaks. In 1963, two clear peaks were shown, though no records before June 2 were obtained. In 1964, a clear peak was already found in the later part of May as shown in Fig. 5 because of unusually early emergence of adults comparing to the other years. Catches kept a low level throughout the period forming three peaks of low level. In that year densities estimated by counting also kept much lower levels throughout the period than those in 1963 and 1965.

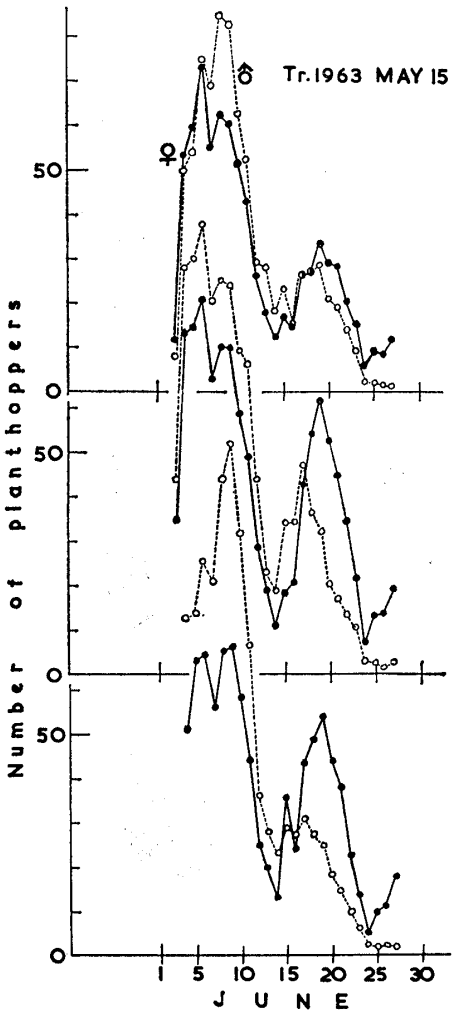

Fig. 8. Catch curves of *L. striatellus* by yellow pan water traps in paddy fields transplanted on May 15, 1963. Three days smoothing.

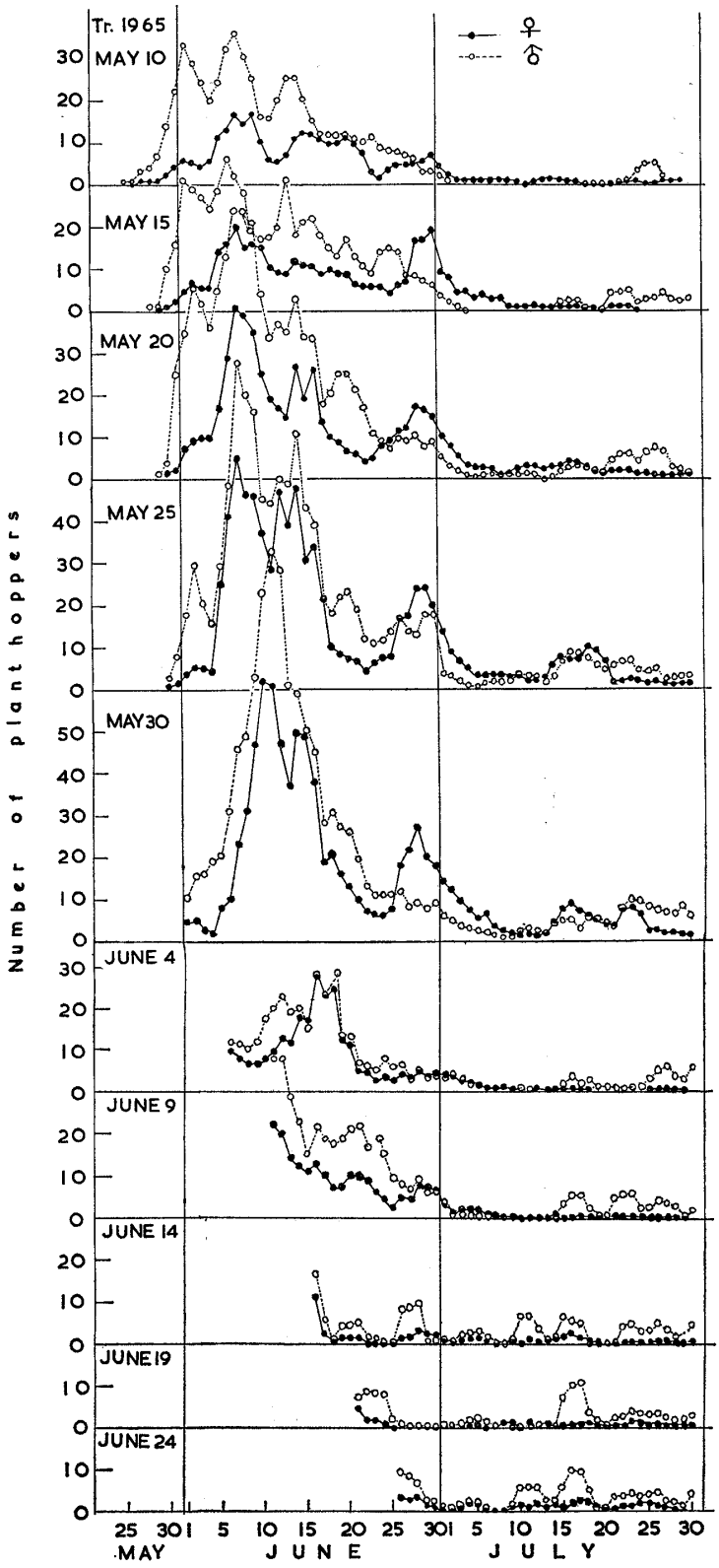

Fig. 9. Catch curves of *L. striatellus* by yellow pan water traps in paddy fields transplanted at various dates (Tr.) in 1965. Three days smoothing.

In 1965, catches were made in 10 plots transplanted at various times from May 10 to June 24 in 5 days interval. Planthoppers began to be caught from the end of May, forming 4 to 5 minor peaks by around June 25. In the first peak the highest catch among the plots was obtained in plot of transplantation on May 20 but in the second and third peaks plots of later transplantation showed the highest catches. Synchronization in minor peaks among various plots was clear. The plot of rice plant of certain growth stages, 10 days to 2 weeks after transplantation tended to show high catches among the synchronized peaks. So the coincidence of the attractive growth stage of rice plant with the peak of immigration of planthopper following to the adult emergence in the environs induced high catches. In those plots transplanted during May which showed large catches were suffering from severe infection of the rice stripe virus.

Table 3. Total Number of Female and Male Planthoppers of *Laodelphax striatellus* (Fallén) Caught by Yellow Pan Water Traps Set at the Crop Level in Rice Fields of Various Transplantation Times within the First Generation

Year	Date of transplantation	Limiting date of the first generation	Female	Male	Percentage of female (%)
1963	May 15	June 28	1086	1101	49.7
	〃	〃	964	1043	48.0
	〃	〃	785	808	49.3
	May 21 (Direct sowing)	〃	140	159	46.9
	〃	〃	126	122	50.8
1964	May 15	June 23	187	391	32.4
	〃	〃	154	218	41.4
	June 3	〃	93	157	37.2
	〃	〃	102	136	42.9
	May 20 (Direct sowing)	〃	278	238	53.9
	〃	〃	230	225	50.5
	June 5 (Direct sowing)	〃	83	99	45.6
	〃	〃	275	249	52.5
1965	May 10	June 24	229	543	29.7
	May 15	〃	247	528	31.9
	May 20	〃	416	875	32.2
	May 25	〃	567	861	39.7
	May 30	〃	583	928	38.6
	June 4	〃	232	303	43.4
	June 9	〃	181	358	33.6
	June 14	〃	38	67	36.2
	June 19	〃	15	42	26.3

Sex Ratio of Planthoppers Captured

As shown in Fig. 5, 8 and 9, more males were caught by the trap than females, particularly in early minor peaks. Sex ratio in the total planthoppers caught within the first generation was shown in Table 3. In 1963, the ratio of female in various plots was about 50 %, while in 1965 the ratio was much lower than that in 1963. The ratio showed no clear correlation with the total catches in each year, which suggested that the ratio generally did not depend on the time of catching. Reasons of diversity of the ratio with year regarding the remains to be analysed.

DISCUSSION

Attractiveness of yellow colour has been found in aphids (MOERICKE 1955), the cereal leaf beetle, *Oulema melanopus* (L.) and the meadow spittlebug, *Philaemus spumarius* (L.) (WILSON and SHADE, 1967) and others. The attractiveness of yellow pans also proved itself regarding the small brown planthopper. Yellow pan water trap showed efficient catching for immigrants of the first generation, particularly at the beginning of the season and soon after transplantation.

Catches by water trap seem to represent the activity of planthopper. Daily periodicity of catching and formation of minor peaks showed not necessarily the fluctuation of density of planthopper on rice plants but they showed that of active flying at the crop level affected by meteorological conditions. But the population of planthoppers of this period is primarily formed by immigrants into paddy fields, which means that the increase of population density should be preceded by that of flying insects, as shown in Fig. 5 and 6.

Catch curves by the trap seem to be integrated curves of density fluctuation of immigrants and continuation trend of flying ability after immigration. The former seems to be much influenced by the adult emergence in source habitats. All the processes are considered to be under profound influence of meteorological conditions.

Yellow pan water trap has several advantages as a sampling method. Handling of trap is simple and it is of use even during rainfall. Fauna of planthopper caught in the trap is simple and specimens are in good condition for identification.

Brown planthopper, *Nilaparvata lugens* STÅL, and white-backed planthopper, *Sogata furcifera* HORVÁTH, were also found to be attracted to the yellow pan water trap, particularly in the immigration period in June and July. But very few green rice leafhopper, *Nephotettix cincticeps* UHLER, were attracted. Bees and wasps, and flies were attracted.

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