23. STUDIES ON THE SEASONAL PREVALENCE, DAMAGE AND CONTROL OF THE BEANFLY, *OPHIOMYIA PHASEOLI* (TRYON) AS A PEST OF SOYBEAN

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ABSTRACT

Seasonal prevalence of the beanfly, *O. phaseoli* (Tryon), which is the most important insect pest of soybean in Indonesia, and the damage on soybean caused by the beanfly were surveyed on soybeans which were cultivated six times in a year, every two monthes. Each farm was divided into insecticide treated plot and control plot. And also the test on cultural control method to the beanfly was conducted. These experiments were carried out at the Muara Experiment Substation of the Central Research Institute for Food Crops, Bogor, Indonesia, in 1979 to 1980.

Occurrence of the beanfly was observed throughout the year. There was difference in the abundances of the beanfly in each sowing time. The abundance of the beanfly was higher in the dry season than in the wet season. The highest population density was observed in the begining of the dry season. The peaks in each population density of the adult beanfly were recognized from the germination to two weeks after sowing. And second peaks of those were found within four to five weeks after sowing.

The growth periods of soybeans in each planting were ranged 87 to 101 days in insecticide treated plots. In control plots (non-treated plots), they took more 1 to 4 days. In general view, soybean had shorter growth period in dry season than in wet season.

Withered or dead soybean seedlings were observed from 20 days after sowing and most of survived seedings were suppressed their growth in control plots of all plantings by the attack of the beanfly. Finally, the seedling rates in control plots showed large differences as compared with insecticide treated plots, and the ratios of these were ranged 70 % to 90 %. Also in the main stem length, shorter ones were recorded in the control plots by the attack of the beanfly. The rates of polished soybean grains in control plots to insecticide treated plots were ranged 78.6 % to 37.5 %.

As the cultural control method to the beanfly, in cases of soybean was cultivated under condition leaving the standing paddy stock after harvesting (ear plucking), and after soybean was sowed, the farm was mulched with paddy straw, a certain effect in disturbing the activity of the beanfly was recognized. Fewer damaged soybean stems, higher seedling rates, higher stem lengths and higher yields were recorded in those plots.

INTRODUCTION

There are many kinds of insect pests of soybean in Indonesia. The beanfly, *Ophiomyia phaseoli* (Tryon) (Diptera : Agromyzidae) is one of the most serious pests of soybean. The beanfly is a widely distributed seedling pest in Asia, Australia and Africa, and it attacks soybeans, cowpeas, lima beans, mung beans and winged beans (6).

The beanfly is a minute insect. Females are 2.2 mm and males are 1.9 mm in length, and they are shiny black in color, except for their legs, antennae, and wing veins, which are light brown. The fly oviposits mostly on the upper surface of the cotyledon and the primary leaf, and the hatched maggot then behaves like a leaf-miner, penetrating underneath the epidermis of the leaf until it reaches a vein. It then tunnels to the midrib and the leaf stalk, finally reaches to the stem near the ground surface. Pupation takes place in the stem and in the root zone. Infestation begins as soon as the

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plants appear above ground. Leaves of infested plants show the mines as pale, irregular lines; the plant becomes stunt and yellow and finally dies in case of seedling is infested seriously by the maggots.

Purpose of this study was ascertainment of the seasonal prevalence of the beanfly and realities of the damage caused by the beanfly. Accordingly, soybeans were cultivated six times in a year, every two monthes. The numbers of adult which immigrated to soybean were recorded. The growth of soybean and the influence on the yield of soybean caused by the beanfly were examined.

There are few reports on the control of the beanfly. At present, control of the beanfly is done by spraying Azodrin in the Central Research Institute for Food Crops.

But it is not easy to get an insecticide for farmers who are a little agricultural income. It is in hopes that the control method without insecticide for the beanfly is established. Therefore, we studied also the cultural control for this pest. We got some knowledges in this experiment. This report thus describes the seasonal prevalence of *Ophiomyia phaseoli*, the damage and yield loss caused by *O. phaseoli*, and the cultural control for *O. phaseoli*.

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MATERIALS AND METHODS

1. Test 1. Seasonal prevalence of the beanfly, *O. phaseoli*, and influence on the growth and yield of soybean caused by the beanfly

The test was carried out at the Muara Experiment Farm Field (alluvial soil) of the Central Research Institute for Food Crops, Bogor, Indonesia, in 1979 - 1980. Soybeans (variety; ORBA) were cultivated six times, every two monthes from July, 1979 to August, 1980 as mentioned below. Insecticide treated plot sprayed with Karphos or Azodrin which were effective for controlling the beanfly, and control plot (non-treated plot) were prepared in each planting.

1st planting was sowed on 23rd, July, 1979
2nd planting was sowed on 24th, September, 1979
3rd planting was sowed on 26th, November, 1979
4th planting was sowed on 23rd, January, 1980
5th planting was sowed on 31st, March, 1980
6th planting was sowed on 23rd, May, 1980

The area of one test plot in each planting was 80 m^2, and each planting had two replications. Each plot was divided into two treatment plots, one of them was insecticide treated plot and another was control plot. Karphos or Azodrin was sprayed in insecticide treated plot two times, after one week and two weeks from sowing, with 0.05 % active ingredient at the rate of 600 liter per hectare.

Soybean was sowed in sowing hole with three or four seeds per one hill after plowing. The width between ridges was 40 cm interval, the distance between hills was placed at interval of 20 cm, and sowing holes were made by dibble (it is called *tugal* in Indonesia).

As for fertilizer, CaO was broadcasted at the rate of 400 kg per hectare. 40 kg of urea, 130 kg of TSP and 60 kg of potassium sulfate per hectare were applied on every row as basic fertilizer.

Neighboring four fields were used for this experiment, but the background of previous crops in those fields was not uniform.

Survey : The numbers of adult beanfly, which immigrated to soybean, were recorded on 100 hills per one plot in each plot. This survey was conducted during 8 to 9 o'clock from just after germination through 35 days after sowing.

Besides, the growth of main stem length, yield and harvested crop were surveyed and the influence on soybean caused by the beanfly was calculated.

2. Test 2. Cultural control of the beanfly, *O. phaseoli*

The test was conducted at the Muara Experiment Farm Field (alluvial soil) of the Central Research Institute for Food Crops, Bogor, Indonesia. The field just after the paddy rice was harvested by the method of ear plucking (it is called *ani-ani* in Indonesia) was adopted for this test.

Soybean (variety : No. 1667) was sowed in the test plots on 9th of August, 1980, as mentioned below.

1st plot : After paddy stock was dug out and was released from the plot, plowing was done, and seed was dibbled.

2nd plot : Paddy stock was mowed from the surface of ground and was released from the plot. Seed was dibbled without plowing.

3rd plot : Paddy stock was mowed at 10 cm height from ground and paddy straw was released from the plot. Seed was dibbled without plowing.

4th plot : Ear of rice was harvested by the method of ear plucking. Seed was dibbled under that condition. (The growth of rice was poor and the weight of air-dried paddy straw was about 1.5 ton per hectare).

5th plot : After the same treatment with 2nd plot was done, ground was covered with paddy straw at the rate of about 2.5 ton (air-dried condition) per hectare, and paddy straw was left until harvesting time.

6th plot : After the same treatment with 5th plot was done, paddy straw had been scheduled to burned up, but it could not be done by the influence of a rainfall. Then, paddy straw was removed from the plot after one week from sowing.

7th plot : Same treatment with 1st plot was done and Furadan granule was applied on row at the rate of 30 kg per hectare, at the same time with fertilizer.

8th plot : Same treatment with 1st plot was done and Azodrin emulsion was sprayed with 0.05 % active ingredient at the rate of 600 liter per hectare after one week and two weeks from sowing.

The cultural conditions of soybeans in eight test plots were the same with test 1. The area of each plot was 14.4 m^2, and two replications were prepared.

Survey : The numbers of adult beanfly, which immigrated to soybean, were recorded on 100 hills per one plot in each plot. The observation was continued, during 8 to 9 o'clock, from just after germination through 35 days after sowing. 15 soybean plants per one plot were collected from every plot, and the number of plants attacked by the beanfly were surveyed. Beside the growth of main stem length, yield and harvested crop were examined and the influence on soybean caused by the beanfly was calculated.

RESULTS

Test 1. The rainy days, rainfall, maximum and minimum temperature in each month during test period were given in table 1. It was rain more than 100 mm in every month, the essential dry season was not recognized. But, July to August in 1979 and May to July in 1980 were the weather looked like dry season. The wet season was from September in 1979 to April in 1980, the peak of it was January.

There was difference of the climate condition as mentioned above, and moreover, the background of previous crop was not same in each planting. Accordingly, the considerable differences in the growth and yield of soybean were observed among each planting. Especially, in the soybean sowed in January, the germination ability was weak and the germination rate was low. But this experiment could be smoothly completed, in general view.

TABLE 1. Rainfall and temperature during experiment season

Month		Rainy days	Amount of rainfall	Max. temperature	Min. temperature
1979	Jul.	10	192 mm	30.8°C	21.3°C
	Aug.	9	146	31.1	21.3
	Sep.	15	315	31.3	22.0
	Oct.	14	352	31.1	22.1
	Nov.	24	575	30.9	22.0
	Dec.	23	221	30.3	20.8
1980	Jan.	26	407	28.9	21.8
	Feb.	19	252	29.8	21.2
	Mar.	25	402	30.6	21.4
	Apr.	21	372	30.6	21.5
	May	12	305	30.9	22.0
	Jun.	9	137	31.0	21.5
	Jul.	15	160	30.6	21.1

(1) *Seasonal prevalence of the beanfly, O. phaseoli*

Occurrence of the beanfly was observed throughout all plantings (Fig. 1). There were a little differences of its abundances in each planting. But in general view, the peaks in each population density of adult beanfly which immigrated to soybean were observed from the germination to two weeks after sowing. After that, the population densities of the beanfly decreased, and the second peaks of it were recognized within four to five weeks after sowing.

In the comparison of abundances of the beanfly among each planting, the highest population density was observed on the soybean sowed in May, and its peaks appeared on 6th day and 25th to 26th day after sowing. The second higher population density was found on the soybean sowed in July, and its peak was recognized from 7th to 11th day after sowing.

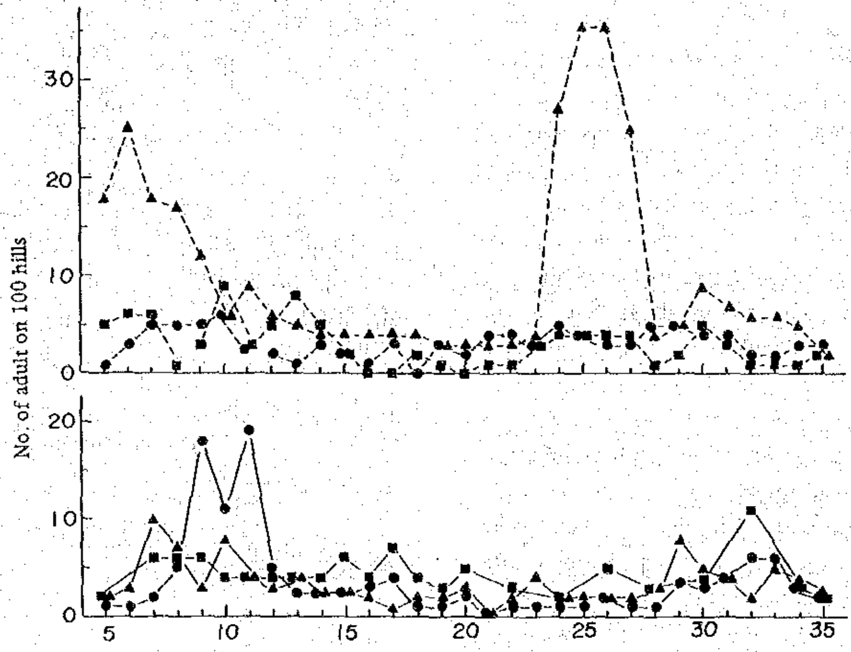

Fig. 1 Seasonal prevalence of adult beanfly, *O. phaseoli*

--●-- : sowed in Jan., --■-- : sowed in Mar.,
--▲-- : sowed in May, —●— : sowed in Jul.,
—■— : sowed in Sep., —▲— : sowed in Nov.

On the soybeans sowed in September, November, January and March, the population densities of the beanflies were remarkably lower than on the soybeans sowed in May and July. And the differences of the population densities among those were trifling, and also the peaks of the population densities were not apparent.

In the contrast with seasonal prevalence and meteorological phenomena table (table 1), the abundance of the beanfly was higher in the dry season than in the wet season and also the population density of the beanfly was higher on the soybean sowed in May than on the soybean sowed in July. The highest population density of the beanfly was in the begining of the dry season. Though abundances of the beanfly and the rainfall during two weeks after each sowing were shown in table 2, it was not clear that the relation between the abundance and rainfall.

TABLE 2. Abundance of beanfly, rainfall and rainy days during two weeks after sowing

Plot	Sowing time	Total number of beanfly	Total rainfall	Rainy days
I	Jul. 23	67	64	7
II	Sep. 24	44	247	9
III	Nov. 26	45	78	10
IV	Jan. 23	34	75	7
V	Mar. 31	51	200	9
VI	May. 23	120	102	8

(2) Influence of the beanfly, *O. phaseoli* to the growth and yield of soybean

Growth period : The growth period of soybean in insecticide treated plot was shortest in the plot sowed in March (87 days) and it was longest in the plot sowed in November (101 days). In the other planting, they were ranged within 91 to 96 days. In control plot, they took more 1 to 4 days and their delays were 0 to 2 days in the flowering time (Table 3).

Seedling rate : The seedling rates of each planting were ranged within 80 % to 90 %, but the germination ability of soybean sowed in January was weak and also its germination rate was poor as about 60 %. But in control plots of each planting, the withered soybean seedlings caused by the beanfly appeared from 20 days

TABLE 3. Growth period of soybean

Plot		Sowing time	Emergence time	Flowering time	Harvesting time
I	(A)	7. 23	7. 28	8. 30	10. 22
	(B)	〃	〃	〃	10. 23
II	(A)	9. 24	9. 29	11. 7	12. 27
	(B)	〃	〃	11. 9	1. 1
III	(A)	11. 26	12. 1	1. 2	3. 5
	(B)	〃	〃	1. 3	3. 7
IV	(A)	1. 23	1. 28	3. 7	4. 26
	(B)	〃	〃	3. 9	4. 28
V	(A)	3. 31	4. 7	5. 2	6. 25
	(B)	〃	〃	5. 4	6. 27
VI	(A)	5. 23	5. 27	6. 24	8. 22
	(B)	〃	〃	6. 25	8. 24

I : Seed was sowed on 23, July, II : Seed was sowed on 24, September, III : Seed was sowed on 26, November, IV : Seed was sowed on 23, January, V : Seed was sowed on 31, March, VI : Seed was sowed on 23, May, (A) : Insecticide treated plot, (B) : Control plot.

after sowing and finally, the number of plants at harvesting time in each planting showed large differences as compared with insecticide treated plots (Table 4).

TABLE 4. Number of plant* at harvesting time

Plot	Insecticide treated plot (A)	Control plot (B)	A/B × 100
I	362	328	90.6%
II	416	300	71.8
III	402	300	74.6
IV	202	190	94.1
V	320	284	88.8
VI	372	270	72.6

* Numbers of plants were recorded in 10 m^2.
Plot I to VI are the same sowing time with table 3.

Though the ratios of seedling number in control plots to insecticide treated plots showed 90 % in soybeans sowed in January and July, those in the soybeans sowed in the other months were ranged from 70 % to 90 %, and it in the plot sowed in September was 28.2% decrease as 71.8 %.

Main stem length : Main stem lengths of soybean in the early stage, in the middle stage of growth period and in the harvesting time were given in table 5. Though, there was not difference between insecticide treated plot and control plot in the soybean sowed in March, the shorter stem lengths were observed in control plots as compared with insecticide treated plots in the other plantings. And they showed the same tendency through the whole growth periods. Especially, in the soybeans sowed in September, November and January when the elongation of main stem length was higher, ten cm differences were observed. The coefficient of variation of main stem length among the hills in the soybean sowed in May was as follows, and it was also recognized that the variation among the hills in control plot was larger than in insecticide treated plot.

Plot	Early stage of growth period	Middle stage of growth period	Harvesting time
Insecticide treated plot	8.0%	10.0%	12.6%
Control plot	14.0	18.0	19.5

TABLE 5. Stem length of soybean

Plot	Date of survey	Days after sowing	Stem length	
			Insecticide treated plot	Control plot
Early stage of growth period				
I	Aug. 21	29	13.0 cm	11.9 cm
II	Act. 23	29	15.0	12.2
III	Dec. 27	31	21.3	19.6
IV	Feb. 16	24	13.5	12.0
V	Apr. 21	21	13.4	13.2
VI	Jun. 24	32	19.9	15.7
Middle stage of growth period				
I	Sep. 13	52	30.8	29.1
II	Nov. 6	43	31.8	23.7
III	Jan. 8	43	42.8	38.7
IV	Mar. 11	47	40.7	35.2
V	May. 10	40	33.7	33.8
VI	Jul. 4	42	31.7	24.2
Harvesting time				
I	Oct. 22*	91*	34.6	33.3
II	Dec. 27	94	52.1	41.5
III	Mar. 5	99	65.4	55.9
IV	Apr. 26	93	50.9	41.6
V	Jun. 25	86	40.9	42.0
VI	Aug. 22	91	33.9	26.2

* Records in insecticide treated plots.
Plot I to VI are the same sowing time with table 3.

Number of root nodule : Numbers of root nodules of 15 soybean plants in each plot were calculated (Table 6). The control plots had fewer root nodules per one soybean stem as compared with the insecticide treated plots through every planting.

TABLE 6. Number of root nodule of soybean

Plot	Date of survey	Days after sowing	No. of nodule	
			Insecticide treated plot	Control plot
I	Sep. 2	41 days	20.3	18.3
II	Nov. 12	49	29.5	28.2
III	Jan. 5	40	73.6	55.5
IV	Mar. 17	53	48.9	36.8
V	May 2	31	40.7	30.8
VI	Jun. 30	38	21.8	20.5

Plot I to VI are the same sowing time with table 3.

Yield : The yields were vary in each planting by the influence of the different weather conditions in each planting, and further, by ununiform background of previous crops in each test plot as mentioned before. Though the yield was good in the soybean sowed in November, the growth of soybean was generally poor in the other plantings, especially the yield of soybean sowed in May was lower. But in spite of those circumstances, the considerable different yields were got between insecticide treated plot and control plot (Table 7). Namely, though the weights of cleaned grains in control plots were about 75 % as compared with insecticide treated plots in the soybeans sowed in July and in March, they were lower than 50 % in the other plantings, especially in the soybean sowed in November, it was 37.5 %.

Test 2. The germination and growth of soybean were normal. But as the soil fertilities were not uniform in each plot, the difference of the influence to soybeans caused by the beanfly among each treatment could not be cleared.

Number of damaged soybean plant caused by the beanfly : Fifteen plants per one plot were randomly collected in each plot, and the number of plants attacked by the beanfly was surveyed (Table 8). In the consideration among each treatment, percentages of the damaged plants caused by the beanfly were more than 97 % in the 1st and 2nd plots which paddy stock was released from those plots regardless of plowing.

The 3rd plot which paddy stock was left at 10 cm height above ground had 87 % damaged plants. The

TABLE 7. Yield of soybean

Plot		Wt. of total grain (C)	Wt. of cleaned grain (D)	D/C x 100	Percentage of cleaned to (A) plot
I	(A)	730*	550*	75.3%	100%
	(B)	575	410	71.3	74.5
II	(A)	417	288	69.1	100
	(B)	198	127	64.1	44.1
III	(A)	1.013	800	79.0	100
	(B)	600	300	50.0	37.5
IV	(A)	420	400	95.2	100
	(B)	221	200	90.5	50.0
V	(A)	482	388	80.5	100
	(B)	455	305	67.0	78.6
VI	(A)	248	213	85.9	100
	(B)	114	102	89.5	47.9

* show yield (gram) in 10 m^2.

Plot I(A) to VI(B) are the same sowing time and treatment with table 3.

TABLE 8. Distinction in number of damaged soybean plants caused by *O. phaseoli* under different cultural condition

Plot	No of plants used	No of plants attacked by O. phaseoli
1	30	30
2	30	29
3	30	26
4	30	21
5	30	22
6	30	22
7	30	13
8	30	2

1 : Plowing, paddy stock was released from plot, 2 : Without plowing, paddy stock was released from plot, 3 : Without plowing, paddy stock was mowed at 10 cm height and was released, 4 : Without plowing, ear of rice only was harvested and paddy stock was left, 5 : Without plowing, ground was mulched with paddy straw, 6 : Without plowing, ground was mulched with paddy straw, for one week after sowing, after that paddy straw was removed, 7 : Plowing, applied Furadan granule, 8 : Plowing, sprayed Azodrin emultion.

4th plot harvested the ear of rice only and, the 5th and 6th plots covered the ground with paddy straw had fewer damaged plants as 70 % to 73 %. The damage of the 7th plot treated with Furadan was 47 % and it of the 8th plot treated with Azodrin was 7 %. The effect of Furadan was considerably lower than Azodrin. Though the 1st to 6th plots had more damaged plants as compared with the Azodrin treated plot, the 4th to 6th plots which paddy stock or paddy straw were left in the plots had fewer damaged plants as compared with the plots which paddy straw was released.

Growth and yield : The seedling rates were surveyed in the flowering time as the withered soybean seedlings caused by the beanfly were observed from 20 days after sowing (Table 9). The highest seedling rate was observed in the Azodrin treated plot, and the 2nd higher seedling rate was found in the 4th plot harvested the ear of rice only and left the paddy stock in the plot. But the significant differences were not recognized among each plot, because of the large differences of the seedling rates were observed generally among each plot.

TABLE 9. Number of plants per 10m² in the flowering time

Plot	No of plant per 10 m²
1	298
2	282
3	258
4	300
5	262
6	280
7	282
8	314

Plot 1 to 8 are the same treatments with table 8.

were found among each plot.

DISCUSSION

1. Seasonal prevalence of the beanfly, *O. phaseoli*

It is known that three species resembled closely, *Ophiomyia phaseoli*, *Melanagromyza sojae* and *M. dolichostigma* attacking to soybean occur in Java Island and attack on the different parts of the soybean plant.

TABLE 10. Main stem length* of soybean

Date of survey	Plot 1	2	3	4	5	6	7	8
Sep. 12	22.0	23.0	19.2	21.4	25.2	23.0	20.6	23.5
Sep. 26	29.9	24.4	27.5	30.9	37.4	33.8	29.1	34.0
Oct. 10	30.2	33.7	27.0	32.3	37.4	33.1	29.1	35.2
Nov. 8	30.1	32.9	26.2	31.1	37.9	32.0	28.9	34.7

* cm., Plot 1 to 8 are the same treatments with table 8.

The main stem length showed the superior trend in the plots mulched with paddy straw and in the plot treated with Azodrin as compared with the other plots, and its tendency was continued to the harvesting time (Table 10). The yields of 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th plots were 10.26, 8.96, 5.13, 9.39, 11.39, 8.17, 10.43 and 12.00 kg per 100m² respectively. Though the yield also showed the higher trend in the plot covered with paddy straw and in the plot treated with Azodrin as compared with the other plots, the significant differences were not recognized among each plot because the large differences of the yields

They have caused enoumuos lossess annually to soybean.

The attack of *M. sojae* starts as soon as the seedling emarge, with eggs laid singly on the lower surface of the leaf. The larvae tunnel through the leaf petiole and pupate in the stem at ground level (6). *M. dolichostigma* larvae attack and feed on the growing tip of the soybean stem at most stage of plant development (6). Among these pests, the beanfly, *O. phaseoli* is the most serious soybean pest in Indonesia (10). *M. dolichostigma* is less destructive than *M. sojae (6)*.

For the purpose of securing the seasonal prevalence of the beanfly, soybeans were cultivated six times in a year, every two months, from July in 1979 to August in 1980. The numbers of adult beanfly on soybean were recorded from just after germination through 35 days after sowing. It was very difficult to found up *O. phaseoli* only from three species mentioned above in a field. But regarding the differences in the population densities of three species, it was supposed that most of the number recorded in this experiment were the adult of *O. phaseoli*.

The peaks in each population density of the adult beanfly were observed from germination to two weeks after sowing. After that, the population densities of the beanfly decreased and the second peaks of those were recognized within four to five weeks after sowing.

From the result, it is found that the adult beanfly immigrates and oviposits to soybean from germination to two weeks after sowing, namely from 5 days to 14 days after sowing, and the eggs hatch, the adults emerge pass through larvae and pupae, from four to five weeks after sowing. It takes about three to four weeks. According to Prasadja and Supriadi, the egg stage takes 2 to 4 days, the larval stage occupies about 10 days and the pupal stage requires a further 9 to 10 days (4). So the total is about 23 days. The occurrence of two peaks in each seasonal prevalence of the adult beanfly almost coincide with above life cycle. Accordingly, in the control of this pest, the measure for control should be taken for ten days from germination, and as the second peak exists, it is important to make uniform the sowing time in an area. It is reported that the most damaging time of the beanfly infestation is within only one week after crop emergence (1, 9).

In this experiment, Karphos or Azodrin was sprayed twice, after one week and two weeks from sowing in each planting and it was effective for controlling the beanfly.

Difference in the adult abundance between the insecticide treated plot and control plot was not observed during three weeks after sowing. The result was considered to be due to the small area of each plot arranged in adjoining position. But in the second peak, difference of the adult abundance was recognized, namely a few adults were counted in the insecticide treated plot owing to the effect of insecticide and many adults were recorded in the control plot.

Occurrence of the beanfly was observed in the whole sowing times. But differences in the abundance of the beanfly were recognized in each sowing time, regardless of a rainfall during two weeks after sowing. The highest population density of the beanfly was observed on soybean sowed in May in this experiment. The second higher population density was found on soybean sowed in July. The low population densities were recorded in the other plantings, especially the lowest density was on soybean sowed in January. As it has been related that abundance of the beanfly is more in the dry season than in the wet season (11), the result of this experiment could support it. But because the highest population density of the beanfly was recognized on soybean sowed in May, it was considered that the highest population density of it was in the begining of the dry season. In the consideration between the abundance of the beanfly and the rainfall during two weeks after sowing (Table 2), the relation between the abundance and rainfall was not clear. Namely, it was seemed that the change of weather, which is called dry season and wet season, worked severely on the seasonal prevalence of the beanfly during a year. There is a lot of rain in Bogor, the distinction between dry season and wet season is not so apparent as it is in the central and east Java where is main producing area of soybean. Accordingly, it is necessary to reexamine whether the highest population density is in the whole dry season or only in the bigining of the dry season, in the area where the difference between dry season and wet season is clear.

2. Influence of the beanfly, *O. phaseoli* to the growth and yield of soybean

Considerable difference was recognized on the growth of soybeans between insecticide treated plots and control plots throughout all plantings. The withered or dead soybean seedlings caused by the beanfly appeared from about 20 days after sowing in control plots of each planting. Finally, the seedling rates in control plots showed large difference as compared with insecticide treated plots. Also the main stem length of soybeans escaped death was lower in control plots, and the coefficient of variation among the stumps was larger in control plots. Soybean in control plots had fewer root nodules and also in the growth period, they took delay. Consequently, the yield of soybeans showed great decrease in control plots as compared with insecticide treated plots. It was considered that the differences in the growth and yield of soybeans, as mentioned above, between insecticide treated plot and control plot were to be due to the difference of the damage caused by the beanfly. But it was not recognized that the relation between the abundance of the beanfly, and influence on the growth and yield of soybeans. The rates of cleaned grain-weight in control plots against insecticide treated plots in soybeans sowed in May and July, when the higher population densities of the beanfly were recorded, were 78.6 % and 74.5 % respectively. On the other side, the rate of it was 52.6 % in soybean sowed in January, when the population density of the beanfly was lowest. These reasons are not apparent. The farms used test were arranged into neighboring four farms. The plots sowed in July, September and November, had not been interfered until soybeans were sowed after paddy rice was harvested in June, 1979. The plots sowed in January and March had been cultivated peanut, and in the plot sowed in May, peanut was cultivated two times before soybean was sowed. It was supposed that the different background of previous crops as mentioned above, had larger influence on the growth and yield of soybeans than the influence of the beanfly. Anyhow, it had showed heavy damage by the beanfly that the rates of cleaned grain-weight in control plots to insecticide treated plots were ranged 78.6 % to 37.5 %. We had observed the farms where most of soybeans were withered or died by the attack of the beanfly. It was considered to be due to the restriction of soil moisture in dried farms and the obstacle of meristem caused by the attack of the beanfly. This experiment was carried out in Bogor, where was a lot of rain, and the limitation of soil moisture was not found after soybean was sowed. Accordingly, in soybean cultivated in the dry season, it is supposed that larger injury may be caused than the damage in this experiment. It was reported that the ORBA variety was suffered about 85 % dead plants during dry season (8).

3. Cultural control of the beanfly, *O. phaseoli*

The measure for controlling the beanfly should be taken within two weeks after sowing, in considerating the result of survey on the seasonal prevalence of the beanfly as mentioned above. For the purpose of finding the cultural control method which could avoid the damage of the beanfly, the differences in the injury caused by the beanfly were examined among plowing-plot, rice stubble managements-plots, Azodrin treated-plot sowing applied after one week and two weeks from sowing, Furadan treated-plot which applied at the same time with fertilizer and control plot. Soybean plants were randomly collected in each plot after 23 days from sowing and number of damaged soybean plants caused by the beanfly were surveyed. The lowest damage was observed in Azodrin treated-plot. Second lower damage was recorded in the plot harvested the ear of rice only by ear plucking and Furadan treated-plot. Comparatively light damage was found in the plots covered with paddy straw regardless of plowing as compared with the plot left 10 cm height-paddy stock and the plot removed paddy stock. Above result showed that the lower damage caused by the beanfly was obtained in case of soybean was sowed in the farm left paddy stock after harvested the ear only, and in the farm mulched with paddy straw after sowing. It is supposed as the reason that paddy stock and paddy straw mulch are useful for physical prevention to immigration of the beanfly. The growth of rice of previous crop was poor and the weight of air-dried paddy stock was about 1.5 ton per hectare in the plot where the ear of rice only was harvested by ear plucking, and soybean was sowed under that condition. Therefore, if the growth of rice was average and the weight of air-dried paddy stock was about 2.5 ton, it was supposed that standing paddy stock was more useful for preventing to immigration of the beanfly. But there is a report, in case of soybean was cultivated in the farm where left paddy stock after harvested the ear only, paddy stock resulted yield losses on soybean due to the shading effect (4). This can be attributed to the shading effect on soybean, caused the plant to etiolate (5).

The highest seedling rate was observed in the Azodrin treated-plot and second was found in the plot harvested the ear of rice only and left the paddy stock in the plot. But no significant difference was observed among each plot, because of the large differences of the seedling rates were recognized among each plot. Also on the growth and yield, higher growth and yield were recorded in the plot treated with Azodrin and in the plot mulched with paddy straw. According to Prasadja and Supriadi (4), paddy straw mulch always gave a lower percentage of germination compared to no stubble-plot, standing paddy stock-plot and other plots, but nevertheless it still produced high yield. This can be attributed to better soil conditions for plant growth. Lal (3) mentioned that mulching with crop residue at the rate of 4-6 tons/ha decreases soil temperature and maintains favorable soil structure by more intensive soil flora and fauna activity. In addition, Dadson and Boateng (2) stated that soil moisture conservation and reduced crusting are more crucial to emergence of soybean than decreased soil temperature. Furthermore, mulching increases the plant height, the number of nodes on the main stem and the number of pods per plant (4). High yield in rice straw mulch can be attributed to the high number of pods produced per plant (4). Therefore, poor germination may be compensated for by profuse branching and increased yield per plant (7).

CONCLUSION

Occurrence of the beanfly, *Ophiomyia phaseoli* (Tryon), which is the most serious insect pest of soybean in Indonesia, and influence to soybean caused by the beanfly were examined, and also a few tests on control method of the beanfly were carried out.

1. The peak in the population density of adult beanfly which immigrated to soybean were observed from germination to two weeks after sowing. After that the population density decreased and the second peak of it was recognized within four to five weeks after sowing. The more abundance of the adult beanfly was found in the dry season than in the wet season. And the most abundance of the adult was recorded in the begining of the dry season.

2. Withered or dead soybean seedlings were observed and most of survived seedlings were suppressed their growth in control plot, by the attack of the beanfly. The rates of cleaned soybean grain in control plots to insecticide treated plots were ranged 78.6-37.5 %.

3. As cultural control method to the beanfly, the method sowed soybean in the farm left the standing paddy stock after harvested the ear of rice only, and the method mulched the farm with paddy straw after sowed soybean, showed a certain effect in disturbing the activity of the beanfly.

REFERENCES

1. ASIAN VEGETABLES RESEARCH and DEVELOPMENT CENTER. 1978. Progress report for 1977. Shanhua, *Tainan, Republic of China.*

2. DADSON, R. B., and K. B. BOAKYE-BOATENG. 1975. The influences of *Glycine max* L. Merill. In soybean production, protection and utilization. *Intsoy Series Number 6, Univ. of Illinois, Urbana.*

3. LAL, R. 1975. Role of mulching techniques in tropical soil and water management. *Technical Bulletin* 1. *International Institute of Tropical Agriculture, Ibadan, Nigeria,* 38 p.

4. PRASADJA I. and H. SUPRIADI. 1980. Effect of rice stubble management on beanfly infestation of soybean cultivated after transplanted rice. *Internal Seminar* 123. *Division of Pest and Diseases, Cent. Res. INST. AGR., INDONESIA,* 12 p.

5. SHAUMAGASUNDARAM, S. 1976. Soybean cropping system in the tropics. In : Expanding the use of soybeans. *Proc. of a Conf. for Asia and Oceania. International Soybean Program Series* 10, *Univ. of Illinois, Urbana.*

6. SINGH, S. R. and H. F. VAN EMDEN. 1979. Insect pests of grain legumes. *Ann. Rev. Ent.,* 24 : 255-278.

7. SINGH, B. B. 1976. Breeding soybean varieties for the tropics. In : Expanding the use of soybeans.
Proc. of a Conf. for Asia and Oceania. International Soybean Program Series 10. *Univ. of Illinois, Urbana.*

8. TENGKANO, W. 1977. Screening of soybean varieties for resistance to *Agromyza phaseoli* Coq. *Pests and Diseases Research Report* 10 : 42-58. *CRIA, Bogor. In Indonesia.*

9. ————————., 1979. Relation of bean fly *Agromyza phaseoli* Coq. Infestation with the growth stages of soybean plants. *First Indonesian Ent. Cong., Jakarta, Jan.* 9-11, 7 p.

10. ————————., and HARNOTO. 1977. Insect pests of grain legumes including soybeans in Indonesia and their control measures. *Pests and Diseases Research Report* 10 : 75-82. *CRIA, Bogor, in Indonesia.*

11. ————————., D. SOEKARNA, E. SURACHMAN and M. ROOVERS. 1977. Fluctuation of infestation by important pests on the growing stages of soybean Orba variety 1973 dry season - 1974/1975 wet season. *Pests and Diseases Research Report* 10 : 8-29. *CRIA, Bogor in Indonesia.*

摘　　　要

大豆害虫としてのマメモグリバエの発生消長，被害及び防除に関する研究

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インドネシアには多種類の大豆害虫が分布している。このうち最も重要な害虫はマメモグリバエ（*Ophiomyia phaseoli* Tryon, Diptera：Agromyzidae）である。マメモグリバエは東南アジア，オーストラリア，アフリカなどに広く分布する大豆の稚苗期の害虫である。大豆のほか，ササゲ，インゲンマメなどを加害する。

成虫は大豆の出芽直後から大豆圃場に飛来し，子葉及び第1葉の表面に産卵する。ふ化幼虫は直ちに表皮下に潜入して食害し，葉脈，中肋及び葉柄内を潜行して茎に食入する。茎の表皮下を下方へ食害し，最後には地際に達し，表皮を残して周皮，篩管部を食害する。茎の表皮下及び根の間で蛹化する。1世代を約23日で経過する。本種に加害された大豆の葉は色あせて，子葉及び第1葉に幼虫が潜行した不規則な線がみられる。植物の生長は阻害され，幼虫の加害が激しい場合には大豆は枯死する。

試験1．マメモグリバエの発生消長及びマメモグリバエの加害による大豆の生育と収穫量に及ぼす影響

マメモグリバエの発生消長及び被害の実態を調査するため，ボゴール市内のインドネシア食糧研究所ムアラ実験農場において1979年7月から1980年8月まで，大豆（品種：OR-BA）を2か月間隔で6回栽培した。播種日は第1回目の栽培が1979年7月23日，第2回目は9月24日，第3回目は11月26日，第4回目は1980年1月23日，第5回目は3月31日及び第6回目は5月23日であった。各播種日とも1区面積は80m²で，2反復とした。各区とも2分し，その1つは殺虫剤散布区，他を無散布区とした。殺虫剤散布区は播種1週間後と2週間後にカルホス乳剤あるいはアゾドリン乳剤の0.05％液（有効成分）をヘクタール当り600 *l* の割合で散布した。

大豆の栽培は前記研究所の奨励する栽培方法を採用し，耕起後播種穴に大豆を3～4粒宛播種し，後日2本立てとした。畝幅は40cm，株間は20cmとした。元肥としてヘクタール当り石灰を400kg，尿素40kg，重過石130g，硫酸カリ60kgを施用した。この実験には隣接した4圃場が供試されたが，各試験区の前作物の種類，栽培経緯は同一でなかった。

マメモグリバエの発生消長調査は大豆の出芽（播種5日後）と同時に開始し，播種後35日まで毎日8時から9時の間に，各区において1区当り100株上の成虫数を記録した。一方，大豆の主茎長の生育推移，収穫量及び収穫物を調査し，マメモグリバエの加害による大豆への影響を検討した。

マメモグリバエの発生は年間を通して観察された。発生量は6回の各栽培において異なり，乾期に発生量が多く，雨期は少なかった。最大の発生量は5月播種の大豆で記録されたことから，乾期の初めに発生量が最も多いものと考えられた。各播種期におけるマメモグリバエ成虫の発生量は，大豆の出芽から播種2週間後までに1回目のピークがあり，2回目のピークは播種4週間後から5週間後の間にみられた。

各栽培期の殺虫剤散布区における大豆の生育期間は87日から99日の開きがあり，3月播種の大豆の生育が最も速やかであった。無散布区の大豆は殺虫剤散布区の大豆と比較して，開花期で0日～2日，収穫期で1日～4日遅れた。

成苗率は80％～90％であった。各播種期とも無散布区においてはマメモグリバエの加害によって播種20日後頃から萎凋あるいは枯死した大豆がみられた。収穫期における無散布区の殺虫剤散布区に対する健全茎率は72％～94％であった。特に9月及び5月播種の大豆では約30％が枯死した。

主茎長の推移について生育初期（播種20日～30日後），生育中期（播種40日～50日後）及び収穫期に調査した。殺虫剤散布区及び無散布区における主茎長を比較すると，3月播種の大豆では差はみられなかったが，他の播種期においては生育初期から差がみられ，特に5月播種の大豆では殺虫剤散布区が19.9cm，無散布区15.7cmで，殺虫剤散布区の方が4cm高かった。生育中期では殺虫剤散布区が32cm，無散布区は24cmで，8cmの差があった。収穫期においては差がさらに大きくなった。9月播種の無散布区の主茎長（41.5cm）は殺虫剤散布区の主茎長（52.1cm）の80％，11月播種は86％（55.9cmと65.4cm），1月播種は82％（41.6cmと50.9cm），5月播種は77％（26.2cmと33.9cm）であった。

根粒菌の数について播種30日～50日後に殺虫剤散布区と無散布区で調査したところ，無散布区の大豆では根粒菌の数が少なかった。

収穫量は各栽培期間の天候の相異及び供試圃場における前作物の栽培経緯の相異によって大差であった。各播種期別に殺虫剤散布区と無散布区を比較すると，9月播種の無散布区の収穫量（198g／10m²）は殺虫剤散布区の収穫量（417g／10m²）の47％，11月播種は59％（600g／10m²と1,013g／10m²），1月播種は53％（221g／10m²と420g／10m²），5月播種は46％（114g／10m²と248g／10

m^2）であった。

以上，成苗率，主茎長，収穫量で記述された殺虫剤散布区と無散布区における差の多くはマメモグリバエの加害によって生じたものであり，マメモグリバエによる被害の大きいことが理解できる。

試験2．マメモグリバエに対する栽培的防除

大豆の栽培方法とマメモグリバエによる被害との関係について，インドネシア食糧研究所ムアラ実験農場において1980年8月から11月に行った。稲穂のみをつみ取った収穫直後の水田圃場を供試した。1区面積は14.4m^2，2反覆とした。大豆品種はNo.1667を供試し，栽培方歩の概要は試験1と同様とした。

試験区の構成は次のとおりであった。

第1区：稲株堀取り，除去，耕起，種子を播種穴に播種。

第2区：稲株刈取り，不耕起，種子を播種穴に播種。

第3区：稲を高さ10cmで刈取り，除去，不耕起，種子を播種穴に播種。

第4区：稲のみ収穫，稲株が立残っている状態で種子を播種穴に播種（前作稲の生育不良，稲わらの風乾重は1.5トン／ha）。

第5区：稲株刈取り，不耕起，種子を播種穴に播種。風乾稲わら（2.5トン／ha）で地表面をマルチ，収穫期まで稲わら放置。

第6区：稲株刈取り，不耕起，種子を播種穴に播種。風乾稲わら（2.5トン／ha）で地表面をマルチ，稲わらは播種3日後に焼却する計画であったが，降雨のため不可，播種1週間後に除去。

第7区：稲株堀取り，除去，耕起，種子を播種穴に播種，フラダン粒剤30kg／ha施用。

第8区：稲株堀取り，除去，耕起，種子を播種穴に播種，アゾドリン乳剤（0.05％）600l／ha散布。

マメモグリバエの発生消長，マメモグリバエによる被害茎率，主茎長の生育推移，収穫量及び収穫物を調査した。

マメモグリバエによる大豆の被害茎率は，稲株，稲わらが除去された第1区及び第2区では97％で最も高く，稲穂のみ収穫し，稲株が立残っていた第4区及び稲わらでマルチした第5区ならびに第6区は約70％で若干低かった。フラダン粒剤施用区の被害茎率は47％で，アゾドリン乳剤散布区の7％と比較して劣った。

開花期における単位面積当りの大豆本数は，アゾドリン乳剤散布区で最も多く（314本／10m^2），つづいて稲穂のみ収穫した第4区（300本／10m^2）であった。しかし試験区間に有意差はなかった。

主茎長は稲わらでマルチした第5区及びアゾドリン乳剤散布区の第8区ですぐれた傾向がみられ，この傾向は収穫期まで継続した。収穫期における主茎長は第5区で38cm，第8区で35cmであり，他区の26cm～32cmと比較してすぐれていた。

収穫量はアゾドリン乳剤散布区で最も高く，100m^2当り12.0kg，次は稲わらでマルチした第5区で11.4kgであった。

これらの結果から稲穂のみを収穫し，稲株が立残っている圃場に大豆を栽培した場合，及び大豆を播種後に稲わらでマルチし栽培した場合は，マメモグリバエの被害を回避するうえである程度有効であるように思われた。

24. COMPARATIVE REARING TEST OF THE COMMON ARMYWORM, *LEUCANIA SEPARATA* WALKER ON ARTIFICIAL DIET AND HOST PLANT, AND PATHOGENICITY OF *LEUCANIA SEPARATA* NUCLEAR POLYHEDROSIS VIRUS TO THE COMMON ARMYWORM, *LEUCANIA SEPARATA* WALKER

Muneo Okada* and Muhammad Arifin**

ABSTRACT

Two kinds of artificial diet have been developed and handling procedures have been devised to facilitate the continuous maintenance of laboratory colony of the common armyworm, *Leucania separata* Walker. The diets, composed of pinto bean powder, wheat bran powder, dried yeast powder, L-ascorbic acid, agar, water, and three mold inhibitors, satisfactorily supported the development of the common armyworm. The diets were evaluated by comparing the development of the diet-reared worm and host plant-reared worm. Biological studies covering egg stage, larval and pupal duration, development and body weight, adult emergence, longevity and oviposition are also included.

The larval development and pupal body weight of the common armyworm reared on the artificial diets were not different from those reared on host plants which were favourable for development of the common armyworm. The adult reared on the artificial diet laid as many eggs as those reared on the favourite host plants. Methyl p-hydroxy benzoate added to the artificial diet as a mold inhibitor was not suitable for the first instar larvae just after hatching. Sorbic acid in the artificial diet caused pupal deformity and the remarkable low rate of emergence.

The pathogenicity of *L. separata* nuclear polyhedrosis virus was examined to the common armyworm larvae. During the 1st to 3rd instar larvae, the common armyworm larvae were relatively susceptible to the virus. But after the 4th instar larvae, susceptibility of the common armyworm larvae to the virus became decrease with larval instars.

INTRODUCTION

The common armyworm, *Leucania separata* Walker is one of the serious agricultural pests in Indonesia. This insect species is widely distributed in Asian countries. The larvae attack more than 70 species of host plants, including important gramineous crops and other crops. It is not rare case that numerous armyworm flare up unforeseenly and eat up all leaves of gramineous crops.

In order to support the insect material used tests, larvae are usually reared on fresh leaves of a host plant in laboratory. The maintenance of experimental insect on this method requires considerable space, time, money and continuous cultivation of a host plant. Therefore some entomologists have conducted experiments on rearing method using artificial diets (1, 5, 6, 8, 9). One of the advantages of this method is that homogenous insects can be obtained easily at minimum cost. The purpose of this experiment is to develop a simple artificial diet and to evaluate it by comparing the development of *L. separata* reared on an artificial diet and on some host plants.

The other side, insect pest control by chemical insecticide may cause problems in future from the view point of environment conservation, health control and disturbance of fauna. Then, study of future pest control should intend to integrated control. It is examined that the possibility of control of the common armyworm by a nuclear polyhedrosis virus.

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MATERIALS AND METHODS

1. Comparative rearing test of the common armyworm, *Leucania separata* Walker on artificial diet and host plant

Preparation of the artificial diet

Two substances were used in the artificial diet as the basic ingredient. One of them was pinto bean powder, which was ground through a 1-mm diameter sieve, and another was wheat bran powder, which was ground through a 2-mm diameter sieve. The composition of an artificial diet discussed herein is shown in Table 1.

TABLE 1. The composition of the artificial diet for *L. separata*

Ingredient	Diet	
	Young larvae	Mature larvae
Pinto bean powder	100g	100g
Wheat bran powder	100	100
Ebios (dried yeast powder)	40	40
L-ascorbic acid	4	4
Methyl p-hydroxy benzoate	–	3
Sorbic acid	1.5	–
Sodium propionate	4	4
Agar	13	13
Water	700 m*l*	700 m*l*

The general method of preparation of the artificial diet is almost the same as that described by Okada (1977) on the tobacco cutworm, *Spodoptera litura* Fabricius. Formaline was omitted from the artificial diet for the common armyworm because of a harmful influence to a person who prepares the diet. In this experiment, sodium propionate was used as a substitute for formaline, though antiseptic ability was inferior to formaline.

Each of the diet ingredients with exception of agar, was blended with 300 m*l* water. The agar was separately boiled in 400 m*l* water. The hot agar solution was mixed with the other blended ingredients. The diet was kept at 5°C in a refrigerator.

General rearing

The common armyworms were collected as larvae from corn field of Cikeumeuh Experiment Substation of CRIFC in Bogor city in 1979. Insects of the second generation reared on corn leaves in an laboratory were used in this experiment.

The common armyworm larvae just after hatching were reared separately in plastic petri dishes (9 cm in diameter and 2 cm in depth, with a filter paper at the bottom) containing individually leaf cuttings of corn, sorghum, sugarcane, rice, wheat, grass I (*Axonopus compressus*), grass II (*Imperala cylindrica*), soybean, and peanut or a slice of the artificial diet. The number of larvae was ten individuals per diet. A little water was dropped on a filter paper in petri dish in order to prevent it from drying. The host plants were renewed daily, and the artificial diet was renewed every two days.

Newly emerged adults were paired in a bottle (9 cm in diameter and 18 cm in depth) and supplied with 10 % honey solution and a folded rough paper to lay eggs.

All the rearing experiments were carried out at between 26.5°C and 31°C. Relative humidity was not controlled.

Larval duration, number of larval instars, larval mortality, area of leaf eaten by larva, maximum larval weight, maximum larval head capsule width, rate of pupation, pupal duration, pupal mortality, pupal weight, rate of emergence, adult longevity, preoviposition and oviposition period, and number of eggs laid per female were observed.

The area of leaf eaten by larva was measured by graphic paper method. The larval head capsule width was measured by Nikon-Profile Projector 6L-2, 50X magnified.

The experimental design used was Completely Randomized Design (CRD) with an unequral number of replications.

2. Pathogenicity of *Leucania separata* nuclear polyhedrosis virus to the common armyworm, *Leucania separata* Walker

All larvae of the common armyworm used were from a stock culture which was collected as larvae from corn field of Cikeumeuh Experiment substation of CRIFC in Bogor city in 1980. The armyworms were successively reared on the artificial diet for some generations. The culture was maintained in an laboratory at between 25°C and 30°C. 1st to 5th instar larvae of the culture were used in this test.

Leucania separata nuclear polyhedrosis virus used was collected in Hiroshima Prefecture, Japan, in 1975. The virus was inoculated perorally to the larvae of the common armyworm, and was propagated. The virus dead larvae were homogenized with ion-exchanged water and passed through a layer of 100 mesh filter. Crude polyhedral suspension was centrifuged at 1,000 g, for 15 minutes and sedimental polyhedra were washed 3 times with ion-exchanged water. Washed polyhedra was suspended in 0.1 % triton x-100 solution. The meter.

Serial ten fold dilutions of the polyhedral suspension were made by using 0.1 % triton x-100 solution, and 10^8-10^2 (PIBs)/mℓ of those were inoculated perorally to the larvae. The fixed quanities of each polyhedral solution were applied on the grass leaves (*Axonopus compressus*). Immediately, after the leaves were made air-dried, the leaves with polyhedra were fed to the fixed numbers of larvae in glass test tube (diameter 2.5 cm, depth 10 cm) covered with parafilm bored minute holes for 48 hours. After the inoculation, the larvae were reared individually in the cotton plugged glass test tube (diameter 2 cm, depth 10 cm) with artificial diet for 13 days.

Dead larvae were observed through a microscope at 600X magnified, and the existence of polyhedra was judged. Infective titer (–log. LD_{50}) was calculated by the method of Reed and Muench (7).

RESULTS

1. Comparative rearing test of the common armyworm, *Leucania separata* Walker on artificial diet and host plant.

Larval duration, number of larval instars, larval mortality, leaf area fed by larva, maximum larval weight and maximum larval head capsule width are given in Table 2.

There were significant differences among each average larval duration of the larvae reared separately on different foods. Fastest larval development was observed when the larvae were reared on sorghum. Both larvae reared separately on wheat and artificial diet had relatively short larval duration. The durations of larvae reared separately on the other host plants were longer.

The number of larval instars showed susceptible response to each diet and they had significant difference among each diet. The larvae reared separately on sorghum, wheat, soybean and artificial diet elapsed six instars, whereas the larvae fed on the other host plants took more than six instars.

The larval death was not observed in the plots that the larvae were reared separately on corn, sorghum, and wheat. The mortality of the larvae reared on

TABLE 2. Larval duration, number of larval instars, larval mortality, leaf area fed by larva, maximum larval weight and maximum larval head capsule width of *L. separata* on the host plants and the artificial diet.

Diet	Number used	Larval duration (days)	Number of larval instars ⊕⊕	Larval mortality (%)	Leaf area fed by larva(cm^2) ⊕	Max. larval weight (mg)		Max. larval head capsule width (μ)
						Female	Male	
Corn	10–10	17.6**	6.8**	0	256.7^b	763.3^{ns}	696.5^{ns}	2663*
Sorghum	10–10	13.8^{ns}	6.0^{ns}	0	270.0^b	790.0^{ns}	716.3^{ns}	2495^{ns}
Sugarcane	35– 6	21.5**	6.8**	82.9	202.2^c	775.3^{ns}	751.3^{ns}	2564^{ns}
Rice	22– 9	21.0**	7.8**	59.1	166.2^d	743.0^{ns}	704.4^{ns}	2759**
Wheat	10–10	14.6^{ns}	6.0^{ns}	0	155.0^d	778.3^{ns}	706.4^{ns}	2479^{ns}
Grass I	19–10	19.2**	7.0**	47.4	319.2^a	827.5^{ns}	776.3^{ns}	2688**
Grass II	38– 3	25.7**	7.3**	92.1	228.3^c	725.0^{ns}	705.0^{ns}	2714*
Soybean	15–10	15.7 *	6.0^{ns}	33.3	171.3^d	744.0^{ns}	695.5^{ns}	2502^{ns}
Peanut	18– 8	19.1**	6.7**	55.6	105.0^e	746.0^{ns}	672.0^{ns}	2505^{ns}
Art. diet	10– 9	14.3	6.0	10	–	809.3	741.3	2673

** = Significant at 1% level of the LSD value

* = Significant at 5% level of the LSD value

ns = not significant

⊕ = Values followed by the same leter are not significantly different at 5% level of the DMRT value

⊕⊕ = Data are transformed by logarithmic transformation, log (x + 1) artificial diet was relatively small, whereas in the case of larvae reared on the other host plants, mortalities were higher.

The average leaf area fed by larvae reached to 319-105 cm^2. The results also showed significant differences among each host plant. The largest leaf area fed by larva was observed when the larva was reared on the grass I, and areas became smaller in the order given: sorghum, corn, grass II, sugarcane, soybean, rice, wheat and peanut.

There was no significant difference among the larvae reared separately on the different host plants and artificial diet in the weights of the larvae both males and females. However in calculating, the heaviest larval weight was produced when the larva was reared on the grass I. Comparative heavy larval weight was recorded in the case of larvae reared separately on corn, sorghum and artificial diet.

There were significant differences among the larvae reared separately on the different host plants and artificial diet in the average of maximum larval head capsule width. Those of the larvae reared separately on sorghum, sugarcane, wheat, soybean and peanut were narrower than the larvae reared separately on rice, grass I and grass II.

Pupation rate, pupal duration, pupal weight, adult longevity, preoviposition and oviposition period, and number of eggs per female are given in table 3.

The pupation rate of the larvae reared separately on corn and sorghum reached to 100 %, whereas in each plot of larvae reared on both wheat and artificial diet it was 90 % and on the other host plants they were less.

The average pupal duration was almost the same among the larvae reared separately on different diets. However in calculating, the pupal durations that the larvae were reared separately on sorghum, wheat, soybean, peanut, and artificial diet were more rapid than in the case of larvae reared on the other host plants.

Sexual difference was observed in pupal weight. Generally, the pupal weight in female was heavier than in male pupa. For instance, average pupal weight in females that reared separately on sorghum and artificial diet was 361 mg and 352 mg respectively. Otherwise in males it was 352 mg and 347 mg respectively. The result also showed that the pupal weights in both females and males reared separately on corn, sorghum, sugarcane, grass I and artificial diet were significantly heavier than those on the other host plants. All pupae reared separately on the every host plants and artificial diet

TABLE 3. Pupation rate, pupal duration, pupal weight, adult longevity, preoviposition and oviposition period and number of eggs per female of *L. separata* on the host plants and the artificial diet.

Diet	Number used	Pupation rate (%)	Pupal dulation (days)	Pupal weight (mg)		Adult longevity (days)		Pre ovi-position period (days)	Oviposition period (days)	Number of eggs per Female
				Female	Male	Female	Male			
			⊕			⊕	⊕	⊕	⊕	
Corn	10–10	100	8.5**	333.1^{ns}	326.3^{ns}	10.8^{ns}	8^{ns}	1.5^{ns}	8.0^{ns}	1084.8^{ns}
Sorghum	10–10	100	8.2^{ns}	361.4^{ns}	351.7^{ns}	8.6^{ns}	9.6^{ns}	1.4^{ns}	7.2^{ns}	1260.4^{ns}
Sugarcane	35– 6	17.1	8.7**	351.8^{ns}	334.2^{ns}	12.5^{ns}	6.7^{ns}	2.7^{ns}	9.5^{ns}	1103.0^{ns}
Rice	22– 9	40.9	8.9**	309.0*	316.5^{ns}	11.0^{ns}	6.7^{ns}	1.7^{ns}	9.0^{ns}	1097.7^{ns}
Wheat	10– 9	90	8.3^{ns}	337.8^{ns}	309.2**	10.0^{ns}	7.5^{ns}	1.5^{ns}	8.0^{ns}	1162.0^{ns}
Grass I	19–10	52.6	8.8**	332.8^{ns}	317.1^{ns}	8.5^{ns}	6.8^{ns}	2.0^{ns}	6.5^{ns}	1032.5^{ns}
Grass II	38– 3	7.9	9.0**	303.4^{ns}	274.7^{ns}	8.0^{ns}	7.0^{ns}	2.0^{ns}	6.0^{ns}	1291.0^{ns}
Soybean	15– 8	53.3	8.0^{ns}	309.9*	294.5**	8.0^{ns}	7.3^{ns}	1.8^{ns}	6.0^{ns}	1150.3^{ns}
Peanut	18– 8	44.4	8.3^{ns}	294.1**	272.3**	8.7^{ns}	5.3^{ns}	2.0^{ns}	7.3^{ns}	773.5^{ns}
Art. diet	10– 9	90	8.0	351.9	346.6	9.5	7.5^{ns}	1.5	8.5	1229.5

** = Significant at 1% level of the LSD value

* = Significant at 5% level of the LSD value

ns = Not significant

⊕ = Data are transformed by logarithmic transformation, log (x + 1) emerged normally and the emergence rates reached to 100 % in each rearing test plot.

There was no significant difference among the armyworm adults emerged from pupae reared separately on each host plant and artificial diet in preoviposition and oviposition period, number of eggs per female and adult longevities both in females and males. However in calculating, the armyworm adults reared separately on sorghum, grass II and artificial diet laid more eggs than those reared separately on the other host plants. Sexual difference in adult longevity was also found. Generally, the adult female longevity was longer than male. For instance, the average adult longevity in females emerged from pupae reared on the artificial diet was 9.5 days, whereas in male it was 7.5 days. There was a correlation between the number of larval instars and the larval duration (r = 0.850) and also correlation between the pupal weight and the number of eggs laid by adult female (r = 0.842).

2. Pathogenicity of *Leucania separata* nuclear polyhedrosis virus to the common armyworm, *Leucania separata* Walker

Five larval instars, 1st to 5th instar larvae of *L. separata* were used for the test on the pathogenicity of LsNPV to the common armyworm larvae. The test was conducted with ten larvae per one plot and three replications. LD_{50} of 1st, 2nd, 3rd, 4th and 5th instar larvae were 4 x 10^3 (PIBs)/mℓ, 4 x 10^3 (PIBs)/mℓ, 8 x 10^3 (PIBs)/mℓ, 4 x 10^4 (PIBs)/mℓ and 4 x 10^5/(PIBs)/mℓ respectively.

During the 1st to 3rd instar larvae, the common armyworm larvae were relatively susceptible to the virus. After 4th instar larvae, the common armyworm developed resistance against higher dosages of the polyhedra, and 5th instar larvae showed 100 times-resistance of 1st instar larvae.

DISCUSSIONS

1. Comparative rearing test of the common armyworm, *Leucania separata* Walker on artificial diet and host plant

The average larval durations of the common armyworms reared separately on sorghum, wheat and artificial diet were shorter than the larvae reared on the other host plants. The difference of the larval duration was considered to depend on the number of larval instars. Larvae with a small number of instars had a short period. All larvae reared separately on sorghum, soybean, wheat and artificial diet had six instars, whereas on the other host plants, the larvae had more than six instars. Moreover, the larvae reared on rice had seven to nine instars. This species usually had six instars, but when the larvae were reared on unfavourable host plants and diets or under adverse conditions, there maybe possibility that the larvae had more than six instars (1).

In addition, the average leaf areas eaten by larvae reared separately on peanut, rice, soybean and wheat were smaller than those reared on the other host plants. This evidence showed that these diets above can be used for rearing the larvae more efficiently. However, by consideration that the larvae reared on both peanut and rice had more than six instars, thus, soybean and wheat can be considered as diets for rearing the larvae of common armyworm. In the other word, the number of larval instars can be used as a criterion to decide the kind of diet for rearing the larvae especially the artificial diet.

The correlation between the pupal body weight and the number of eggs per adult female showed that there was a strong evidence that in the different foods, pupae with heavy weight had the number of eggs more. In the other word, the more weight the pupae, the more number of eggs.

The pupation rate of larvae reared on artificial diet was 90 %, whereas on both corn and sorghum they were 100 %. Although it was 90 % in artificial diet plot, the rate of emergence of the pupae reared on artificial diet was 100 %. The larval death on the artificial diet was not be known certainly. Preliminary test on the preference of newly hatched larvae to some kinds of artificial diet containing each mold inhibitor and on the preservative ability of each mold inhibitor was conducted (Table 4). Newly hatched larvae crowed willingly on the diet C containing sorbic acid, diet D containing sodium propionate, and diet H containing hormalin. The other side, the preservative abilities of sodium propionate, streptomycin and hormalin in diets were inferior.

As it seems that formalin has a harmful influence to a parson who prepare the diet, sorbic acid and sodium propionate were used as mold inhibitors in the artificial fiet for rearing younger larvae. The younger larvae of the common armyworm grew well on the diet containing sorbic acid and sodium propionate. It is known that sorbic acid cause deformity of pupa and adult in

TABLE 4. Composition of artificial diets for comparing the effect of anticeptics, preference of newly hatched larvae to diets and preservative ability of anticeptics

Ingredient	Diet								
	A	B	C	D	E	F	G	H	I
Pinto bean powder	25	25	25	25	25	25	25	25	25
Wheat bran powder	25	25	25	25	25	25	25	25	25
Ebios (dried yeast powder)	10	10	10	10	10	10	10	10	10
L-ascorbic acid	1	1	1	1	1	1	1	1	1
Methyl p-hydroxy benzoate	1								
Sorbic acid		1	0.5						
Sodium propionate				1					
Sodium dehydroacetata					1				
Salicylic acid						1			
Streptomycin							1		
Hormalin (37%)									
Agar powder	3	3	3	3	3	3	3	3	3
Water	175	175	175	175	175	175	175	175	175
* No of newly hatched larvae on each diet	37	29	63	219	5	35	47	115	18
Days until fungi occurr	>5	>5	>5	2	>5	3	2	2	1

rearing the common armyworm (1). Also in our simple rearing test, when the common armyworm was reared on the diet including sorbic acid, deformed pupae were produced. Therefore, methyl p-hydroxy benzoate and sodium propionate were employed as mold inhibitor in the artificial diet for rearing mature larvae, normal pupae could be obtained from the common armyworm reared on that diet.

2. Pathogenicity of *Leucania separata* nuclear polyhedrosis virus to the common armyworm, *Leucania separata* Walker

Result obtained in this test was almost the same with the pathogenicity of *S. litura* nuclear polyhedrosis virus to the larvae of *Spodoptera litura* Fabricius (5) and also the same with the results of *Trichoplusia ni* NPV (4), *Spodoptera exigua* NPV (3), *Heliothis zea* NPV (2), and *H. virecens* NPV (2). As it is judged that the practical use of these NPV is every possibility, it is supposed that the practical use of nuclear polyhedrosis virus isolated from *Leucania separata* Walker is possible in the control of the common armyworm.

CONCLUSIONS

1. The larval development and pupal body weight of the common armyworm on the artificial diet were not different from those reared on the host plants which were favourable for development of the armyworm.
2. The adults reared on the artificial diet laid as many eggs as those reared on the favourite host plants.
3. Pathogenicity of *Leucania separata* nuclear polyhedrosis virus to *Leucania separata* larvae was almost the same infective titer with nuclear polyhedrosis viruses of the other worms, such as *Spodoptera litura*.

REFERENCES

1. Hirai, K. 1976. A simple artificial diet for mass rearing of the armyworm, *Leucania separata* Walker (Lipidoptera, Noctuidae). *Jap. Journ. App. Ent. Zool.* 11 (4) : 278-283.

2. Ignoffo, C. M. 1966. Susceptibility of the first-instar of the bolloworm, *Heltothis zea,* and the tobacco budworm, *Heliothis virescens* to *Heliothis* nuclear-polyhedrosis virus. *J. Invertebr. Pathol.* 8 : 531-536.

3. Ignoffo, C. M. and Garcia, C. 1969. Relative susceptibility of four noctuids to their respective nucleopolyhedrosis virus. *J. Invertebr.* Pathol. 14 : 282-283.

4. Mcewen, F. L. and Hervey, E. S. 1958. Control of the cabbage looper with a virus diseases. *J. Econ. Ent.* 51 : 626-631.

5. Okada, M. 1977. Studies on the utilization and mass production of *Spodoptera litura* nuclear polyhedrosis virus for control of the tobacco cutworm, *Spodoptera litura* Fabricus. *Review of Plant Protection Research.* 10 : 102-128.

6. Okamoto, D. and Okada, M. 1968. Studies on the tobacco cutworm, *Prodenia litura* Fabricius, as an insect pest of the forage crops. *Bull. Chugoku Nat. Agr. Exp. Sta.* E-2, 111-144.

7. Reed, L. J. and Muench, H. A. 1938. A simple method of estimating fifth per cent and point. *Am. J. Hyg.* 27, 493-501.

8. Sato, Y. 1965. The artificial diet for mass rearing of the tobacco cutworm, *Prodenia litura* Fabricus and the common armyworm, *Leucania separata* Walker. *Jap. Journ. App. Ent. Zool.* 9(2): 99-105.

9. Shorey, H. H. and R. L. Hole. 1965. Mass rearing of the larva of nine nuctuid species on a simple artificial medium *J. Econ. Ent.* 58(3): 522-524.

摘　　要

人工飼料と寄主植物を食餌としたアワヨトウの比較飼育試験，及びアワヨトウ核多角体病ウイルスのアワヨトウに対する病原性

岡田斉夫・Muhammad Arifin

各種の実験に供試する昆虫材料を常時大量に確保する必要がある。食葉性昆虫，特にヨトウムシ類の累代飼育に当って食餌として食草を用いた場合，年間を通してその植物の確保以外に昆虫の飼育管理に多大の労力と時間が必要である。そこでアワヨトウを材料として，人工飼料の開発と，それによる大量累代飼育法の確立を目的として研究を行った。

アワヨトウはインドネシアにおいて重要な農業害虫で，水稲，とうもろこしのほか約70種類の植物を加害する。アワヨトウはアジア諸国に広く分布しており，特発的に大発生して作物を食いつくすことも珍らしくない。インドネシアにおける2年間（1979年－1980年）の観察では，乾期の初め，即ち4月から6月に水稲及びとうもろこしなどで大発生した。

アワヨトウの人工飼料はウズラマメ粉末（100g）及びフスマ粉末（100g）を主材として，エビオス（40g），L－アスコルビン酸（4g），寒天末（13g），水（700mℓ）及び3種の防腐剤，即ちパラヒドロキシ安息香酸メチル（3g），ソルビン酸（1.5g）及びプロピオン酸ソーダ（4g）であった。3種の防腐剤のうち，パラヒドロキシ安息香酸メチルを含有する人工飼料に対してはアワヨトウ若齢幼虫の嗜好性が悪いため，若齢幼虫用飼料の防腐剤にはソルビン酸及びプロピオン酸ソーダを用いた。また，ソルビン酸を含有する飼料でアワヨトウ老齢幼虫を飼育した場合は，奇形蛹あるいは成虫の羽化異常が発生したため，老齢幼虫用飼料にはパラヒドロキシ安息香酸メチル及びプロピオン酸ソーダを防腐剤として用いた。

比較飼育試験に用いた食草はとうもろこし，ソルガム，さとうきび，いね，こむぎ，いね科雑草Ⅰ（*Axonopus compressus*），いね科雑草Ⅱ（*Imperala cylindrica*），大豆及び落花生の9種であった。

アワヨトウはボゴール市内のとうもろこし圃場で採集した幼虫を，実験室内でとうもろこし葉を食草として1世代飼育した室内第2世代幼虫を供試した。

ふ化直後のアワヨトウ幼虫をプラスチックシャーレ（径9cm，深さ2cm，底にろ紙を裏打ち）に1頭ずつ収容し，各食草の切葉及び人工飼料の小片を給与した。食草は毎日新鮮葉と交換し，人工飼料は2日に1回更新した。供試虫数は1食草当り10頭以上とした。飼育温度は26.5℃～31℃であった。

幼虫期間，幼虫齢数，幼虫の食葉面積，幼虫の死亡率，蛹化率，蛹期間，蛹体重，蛹の死亡率，羽化率，成虫寿命，1雌当りの産卵数を調査し，人工飼料育及び各食草育間の比較を行った。

アワヨトウの食餌別幼虫期間の平均は13.8日～25.7日であった。幼虫の発育はソルガム，人工飼料及び小麦育区で速やかであった。幼虫齢数はソルガム，小麦，大豆及び人工飼料育の幼虫が6齢で経過し，他の食草育区の幼虫は6齢以上を経過した。

とうもろこし，ソルガム及び小麦育区では幼虫の死亡はみられなかった。人工飼料育区では10頭中1頭が死亡した。他の食草育区の死亡率は33～92％であった。人工飼料育区での死亡原因は不明であった。

食草別に飼育した各幼虫の最大体重の平均は672.0mg～827.5mgで，*Axonopus compressus* 育区で最も重く，つづいて人工飼料育区，ソルガム育区であった。

蛹期間は8.0日～9.0日で幼虫の飼料の違いによる差は小さかった。蛹体重は361mg～270mgでソルガム，人工飼料及びさとうきび育区で重かった。また雌の方が雄より体重が重かった。

成虫の寿命は5日～12日，産卵期間は6日～10日であった。1雌当りの平均産卵数は770粒～1300粒で，*Imperala cylindrica*，ソルガム，人工飼料及び小麦育区で多く，一般に蛹体重の重い区で産卵数が多かった。

以上の結果から，この試験で開発された2種の人工飼料，即ち若齢幼虫用飼料と老齢幼虫用飼料によるアワヨトウの飼育は，幼虫の発育は速やかで，通常の齢数，即ち6齢で幼虫期間を経過し，幼虫期間中の死亡率は低く，幼虫体重及び蛹体重は重く，1雌当りの産卵数が多かった。アワヨトウの好適な寄主植物であるソルガム，小麦等による飼育結果と比較して劣らなかった。

この試験で用いられた人工飼料は組成が簡単で，調製も容易であり，食草による飼育と比較して飼育労力面でも著しく軽減された。

化学殺虫剤による害虫防除は人間の健康管理，環境汚染，生物相の攪乱などの点で将来に問題を引き越す恐れがある。将来の害虫防除は総合防除を指向すべきであり，天敵微生物利用はその有力な1素材である。そこで昆虫病原ウイルス利用によるアワヨトウ防除の可能性を検討した。

広島県福山市で1975年に採集したアワヨトウ核多角体病ウイルス（以下ウイルスと略す）をアワヨトウ幼虫に添食し，ウイルスに感染し死亡した幼虫から精製した核多角体病ウイルス封入体を供試した。

このウイルスの $10^8 \sim 10^2$（多角体）／mlを食草（*Axonopus compressus*）の葉に塗末し，アワヨトウの1齢～5齢幼虫に48時間添食した。添食後は人工飼料を与えて飼育し，13日間感染死亡状況を観察した。

この結果，1齢及び2齢幼虫の LD_{50} はともに 4×10^3（多角体）ml，3齢は 8×10^3（多角体）／ml，4齢は 4×10^4（多角体）／ml及び5齢は 4×10^5（多角体）／mlであった。このウイルスの病原性は米国においてすでに実用的に使用されている *Heliothis virescens* 及び *H. zea* のウイルスの病原性ならびに量産さえできれば実用化が可能である日本のハスモンヨトウのウイルスの病原性と同等であり，将来，研究を進めれば実際の防除に使用可能と考えられる。

25. インドネシアにおける水田加害鼠(アゼネズミ，*Rattus argentiventer*)の防除に関する研究

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緒　　言

インドネシア共和国には110種のネズミ科(Muridae)に属するネズミ類が生息する。そのうちクマネズミ属(*Rattus*)は52種，ハツカネズミ属(*Mus*)は4種類である(Van der Zon, 1979)。これらのうち，水田加害鼠として最も重要な種はアゼネズミ *Rattus argentiventer* であり，大津(1979)によると，同国における米の全収穫量の約3割は本種によって食害されるという。

筆者は国際協力事業団の委嘱により，短期専門家(任期3カ月)として「熱帯野鼠駆除に関する研究」に従事した。すなわち，インドネシア側の要望もあり，水田加害鼠アゼネズミの個体群動態調査のための基礎的な実験を若干試みた。言語，習慣の相違や不十分な研究資材など多くの障害を克服して成果を挙げるには，3カ月という滞在期間は余りに短く，満足できる研究を行えなかったが，以下にその大要を報告する。

稿を進めるに当たり，筆者の出発前から帰国まで，連絡調整などに終始ご高配下さった国際協力事業団(含ジャカルタ事務所)の関係者各位，ジャワ島滞在中絶えずご協力と激励を賜った「作物体系に係る豆類研究強化プロジェクト」チーム(団長　戸田節郎博士)の日本人研究者各位に心からお礼申し上げる。また，筆者の派遣を全面的に支援し，数々の助言と関連文献を下さった熱帯野鼠対策委員会の上田明一委員長以下の委員各位および同事務局の職員各位と九州大学農学部動物学教室の内田照章教授に厚く謝意を表する。

現地での調査・実験に際しては，中央農業研究所(Central Research Institute for Agriculture, CRIA, 現在はCentral Research and Development Institute for Food Crops，略してFood Crop Research Institute, FCRIと改称)の昆虫・薬剤科長D. Soekarna氏，カウンターパートを務めてくれた同野鼠研究室のRochman氏ほか研究室員諸氏，ならびに中央農業研究所スカマンディ(Sukamandi)支所長B. H. Siwi博士に大変お世話になった。これらの諸氏にも厚くお礼申し上げる。

1. アゼネズミの生息数推定法に関する基礎実験

目　　的

わが国の林野では，ハジキ罠により採集された野鼠の個体数を基に，地域野鼠個体群の生息数を推定する除去法が広く採用されている。その他に生け捕りした個体に標識を付けて放し，一定時間後に捕獲された試料中の標識個体数の割合から，もとの個体数を推定する記号放逐法がある。筆者はこの除去法と記号放逐法の両法をアゼネズミへも適用すべく，本種の餌への嗜好性と罠への反応について検討した。

方　　法

1. 実　験　A

中央農業研究所があるボゴール(Bogor)市の北東約160km，ジャワ海に面した平坦な地域に造られた同研究所スカマンディ支所内にある水田と休耕地において罠かけを試みた。この実験を行った1981年1月の水田には約15cmの深さに水が張られ，稲丈は約60cmに伸長していた。諸所に本種により加害された株が認められた(第1図版，第1図)。他方，休耕田はあちこちに小さな沼沢のある雑草地と化していた(第1図版，第2図)。

水田ではインドネシア製カゴ罠100個を10m間隔で10行×10列の格子状に配置した。それぞれのカゴ罠は板(縦18cm×横50cm×厚さ1.3cm)に保定して水面に浮かべられた。各板は移動せぬように，罠番号を記入した小さな目印の旗をつけた竹へビニール紐で結びつけられた(第1図版，第3図)。餌としては針で多数の小孔をうがった小形ビニール袋(縦12cm×横8cm)の中へ米を15gずつ入れたものを罠の吊鈎にかけて用いた。罠かけ期間は1981年1月14日から17日までの4日3晩とした。なお，餌は毎日新しい米袋と交換した。

休耕田では100個のインドネシア製ハジキ罠を15m間隔で10行×10列の格子状に配置した。餌としては10種類(軽く焼いたサワガニ *Parathelphusa* (*Parathelphusa*) *convexa*，エビの練りものを塗布したキャサバ，生のキャサバ，ビニール袋に入れた米，ピーナッツ・バターを塗ったキャサバ，輪切にしたトウモロコシ，軽く焼いたタラシ，

軽く焼いた椰子の実，甘藷およびソーセージ）を第1図に示す通り罠に付けた。餌は毎日新しいものと付け替えた。この場合の罠かけ期間は1981年1月13日から17日までの5日4晩であった。なお，タラシ（Terasi）とは現地の人が食欲増進のために米飯と一緒に食べる，極めて悪臭の強い魚肉製品である。

2. 実　験　B

この実験は実験Aと同じ水田で行われた。イネは既に完熟期にあり，収穫も間近と思われた。餌としては市場から買って来た生きたウナギを輪切りにしたもの1種に限り，罠を5種類用いた。つまり，インドネシア製カゴ罠（前回使用），インドネシア製ハジキ罠（前回使用），日本製カゴ罠（カマボコ型のいわゆる千匹捕り），日本製プラスチック・ハジキ罠（Easy trap）および米国製ハジキ罠（Victor）を第2図に示すように10m間隔の5行×10列に配置した。罠をそれぞれ前回と同じ大きさの板に保定し，この板には割竹で作った脚を釘で打ちつけた（第1図版，第4図）。この4本の脚を水田の底土に差し込み，水面から罠の底面までの距離が4～5cmになるように罠を固定した。餌は毎日新鮮なものと取り替え，1981年2月23日から26日までの4日3晩罠かけをした。

結果および考察

1. 実　験　A

水田における4日3晩の罠かけで採集されたのはヒメクイナの1種マミジロクイナ，*Porzana cinerea* だけで，それぞれ2日目と3日目に1羽ずつ得られた。アゼネズミは1頭も採集されなかった。また本種が罠を訪れた形跡も見られなかった。同様に休耕田において5日4晩行われた罠かけでもアゼネズミは全く採集されなかった。得られたのは5日目にサワガニを餌としたハジキ罠で採集された食虫類のジャコウネズミ *Suncus murinus* 1頭（雄）だけであった（第1図版，第5，6図）。

第1表　淡水棲ヘビ類の採集結果

日	*Natrix vittata*	*Natrix piscator*	*Homalopsis buccata*	計
1	4	1	1	6
2	3	0	1	4
3	2	0	0	2
計	9	1	2	12

罠かけ期間，1981年2月23日～2月26日の4日3晩

2. 実　験　B

輪切りのウナギを餌とし，5種類の罠を使ったこの捕鼠実験においても，アゼネズミは1頭も採集されなかった。代わりに背側に細い縦縞の走る *Natrix vittata* 9頭，体表に大きな黒褐色の斑紋が散在する *N. piscator* 1頭および太い黒褐色の横帯がある *Homalopsis buccata* 2頭，合計3種12頭のヘビが採集された（第2図版，第1，2図，第1表）。罠の種類別では日本製プラスチック・ハジキ罠で6頭（*N. vittata* 4頭，*N. piscator* 1頭および *H. buccata* 1頭），日本製カゴ罠で *N. vittata* 4頭およびインドネシア製ハジキ罠で *N. vittata* と *H. buccata* がそれぞれ1頭採集された。インドネシア製カゴ罠と米国製ハジキ罠ではヘビ類も採集されなかった。*N. vittata* と *N. piscator*（和名ソウカダ）はいずれもヘビ科Colubridaeのユウダ（游蛇）亜科Natricinae，ユウダ属 *Natrix* に属することから知られるように，游泳が巧みで魚類や両生類の無尾類（カエル類）などを捕食する。また *H. buccata* はディプサス科Dipsadidae ホマロプシス亜科（カワヘビ亜科）Homalopsinae，カワヘビ属 *Homalopsis* に属し，淡水棲で魚類を常食としている。

この実験で生魚を用いたのは，タイ国におけるアゼネズミの捕獲成功例（関，1981）に倣ったものであるが，ジャワ島の水田では生魚を餌として捕鼠を試みても成功しないことが知られた。アゼネズミが生魚を好食するか否かは今後とも検討を要する問題であるが，仮にそうだとしても，本種よりも先にこれらの水棲ヘビ類が罠へかかり，多くの罠を無効罠化してしまう恐れがある。これらのヘビ類は冷血動物を常食とし，恒温動物である小形哺乳類を捕食しないので，アゼネズミなどの水田加害鼠の天敵としての効果は期待できない。

以上の通り，スカマンディ支所の水田と休耕田で行った捕獲実験では，目的のアゼネズミを1頭も捕獲できなかった。しかし，水田では本種に嚙み切られて倒伏した被害株が諸所に見られ，かつ畦や灌漑溝の土手には鼠穴が散見された。また，後述するように，これらの鼠穴を掘さくして繁殖状況を知るための材料を相当数入手し得た事実から，水田やその周辺に本種が生息していたことは疑いない。休耕田でも本種の通路（run way）と糞を確認した。大津（1979）はインドネシア中央農業研究所のムアラ（Muara）試験用水田で13種の餌に対するアゼネズミの嗜好性に関する試験を行い，同種の食痕や臭いをつけた餌はその種類によってはかなり摂食されたが，無処理のものはほとんど摂食されなかったこと，および供試した13種類の餌の中では軽く火で焼いた塩漬けの魚が最もよく食われたことを報告している。Wood（1971）はマレーシアにおいてカゴ罠で捕獲した本種に指切り法によって標識を施し，リンカーン指数法（Lincoln index）により，その生息数を推定している。

此処で考慮すべきことは罠かけ時期の問題である。上記Wood（1971）もアゼネズミの罠へのかかりかたは本種が利用できる食物の存在の多寡に左右され，食物の豊富な時期であるイネの成熟後期（late ripening period，すなわち完熟期と枯熟期）には，ネズミは生息しているのに全く採集されなかったと述べている。逆に食物の乏しい時期には再捕獲も容易で，3晩連続してカゴ罠へ入った個体もあった

という。筆者が捕鼠実験を試みたのは雨季で，イネの成長段階からすると成熟後期に当たる。乾季，あるいは水田耕起時期～分けつ期など水田に餌が少ない時期ならば，罠に対する本種の反応も異なったかも知れない。個体群動態を調査するには材料を捕獲することが先決であるが，その第1段階である捕鼠法についてさえ，今後逐一検討すべき問題が山積されているのが現状である。

Ⅱ．アゼネズミの繁殖状況調査

材料および方法

本種のイネの成熟後期における繁殖状況を知ることを目的に，1981年2月24日～25日の2日間，上記した捕獲法の実験を行ったスカマンディ支所の水田周辺の畦と灌漑溝の土手に作られた鼠穴を掘さくし，雄3頭と雌14頭を捕獲した。得られた材料については体重と外部形質（全長，頭胴長，尾長，後足長および耳長）を測定後，剖検した。雄では精巣下降の有無を調べたのち，精巣（左側）の長径と短径を計測した。雌では膣開口の有無，乳頭の発達度および左，右の子宮角に認められた胎児数を記録した。

結果および考察

第2表に示す通り，2月下旬の雌はすべて妊娠していた（妊娠率100％）。胎児数は平均 11.6（範囲は7～14）であった。本種の乳頭は胸部に3対，腹部から鼠けい部にかけて3対，合計6対あり，得られた平均胎児数 11.6 に見合うだけの乳頭数を持つことが知られた。Soekarna *et al.*（1978）は本種の妊娠期間を1カ月とし，雨季における米の収穫前10～14日に平均11頭（範囲は3～17頭）の仔を出産すると述べている。また，約84％は2回目の出産を行い，第1回目と同じ数の仔を産む。米の収穫が長びく地方では3回目の出産が見られることもあるという。筆者の調査はイネの完熟期に行われたから，彼らの結果と一致する値が得られたことになる。草野（1980）によるとタイ国のアゼネズミの雌は6週令（雄は8週令）で性成熟に達し，22～24日の妊娠期間を経て，1腹7～10頭の仔を出産する。妊娠期間については，筆者は飼育実験を行っていないので明言はできないが，一般に *Rattus* 属のそれは21～24日とされている事実から，上記 Soekarna *et al.*（1978）の

第2表　アゼネズミの体重，外部形質の測定値および剖検結果

個体番号	性	B.W.（g）	T.L.（mm）	H.B.（mm）	T.（mm）	T./H.B.（％）	H.F.（mm）	E.（mm）	胎児数 左	胎児数 右	胎児数 計	膣開口	精巣（左） 長径（mm）	精巣（左） 短径（mm）
1	♀	180	354.0	175.0	179.0	102.3	33.5	20.0	3	10	13	+		
2	♀	173	295+α*	176.0	119+α*	−	34.0	20.0	5	8	13	+		
3	♀	155	336.0	162.0	174.0	107.4	31.7	19.0	3	6	9	+		
4	♀	150	338.0	174.5	163.5	93.7	33.0	19.2	3	10	13	+†		
5	♀	117	302.0	152.0	150.0	98.7	32.0	20.0	5	6	11	+		
6	♀	130	320.0	161.0	159.0	98.8	32.0	19.0	4	7	11	+		
7	♀	170	352.0	187.0	165.0	88.2	36.5	19.5	8	5	13	+		
8	♀	170	344.0	185.0	159.0	85.9	34.0	20.0	5	8	13	+		
9	♀	195	353.0	198.0	155.0	78.3	34.0	20.0	8	6	14	+		
10	♂	145	333.0	180.0	153.0	85.0	34.0	19.0					23.0	12.0
11	♂	118	304.0	160.5	143.5	89.4	32.0	19.0					21.0	11.5
12	♀	150	305.0	161.0	144.0	89.4	33.0	19.0	7	3	10	+		
13	♀	195	360.0	183.0	177.0	96.7	35.0	19.2	8	6	14	+		
14	♀	142	328.0	165.0	163.0	98.8	34.0	20.0	7	3	10	+		
15	♀	170	330.0	172.0	158.0	91.9	32.5	18.7	4	3	7	+		
16	♀	133	325.0	160.0	165.0	103.1	32.0	18.0	5	6	11	+		
17	♂	147	337.0	175.0	162.0	92.6	36.5	18.0					22.0	12.0

B.W.，体重；T.L.，全長；H.B.，頭胴長；T.，尾長；T./H.B.，尾率；H.F.，後足長；E.，耳長；
*，尾の先端切断；†，出血；上段は1981年2月24日採集，下段は1981年2月25日採集

値は長過ぎるように思う。タイ国のアゼネズミにおける例のように22~24日ではないかと考える。

雄3頭はいずれも陰嚢内へ下降した大きな精巣を持ち，その長径×短径はそれぞれ23×12mm，21×11.5mmおよび22×12mmであり，繁殖期にあることが裏付けられた。池田（1979）は本種の繁殖期を雨季および乾季米の収穫期であるとしているが，今回の調査でもその事実が一部確認された。本種がイネの成熟に繁殖を同調させている事実は極めて興味深いことである。

Ⅱ．色素糞による行動圏調査のための室内実験

目　　的

記号標識個体の再捕が容易であれば，アゼネズミのレンジ長や行動圏を推定することも可能となるが，罠で捕獲すること自体容易でないことから，色素糞法によりレンジ長や行動圏を調査することにした。色素糞法とは色素を動物体内へ摂取させて消化管内容物を染色し，結果的に体外へ排泄される着色糞を野外で探索し，その発見地点を地図上にマッピングしたのち，レンジ長や行動圏を知る方法である。

野外で動物に色素を摂取させるには，餌と混合したり，餌そのものを染色して間接的に色素を摂取させる方法が考えられる。また使用される色素の具備すべき条件としては，1）手軽に入手できること，2）対象動物に忌避されないこと，3）対象動物に生理的な悪影響を与えぬこと，4）糞の染色性が高いこと，5）糞の染色効果が持続すること，6）野外において染色糞の発見が容易であること，および7）正常糞と染色糞との識別が簡単にできることなどが挙げられる。本報告は色素糞法の野外適用の可能性を検討するために行った一連の室内実験に関するものである。

材料および方法

(1) 色　素

ボゴール市内の市場で購入した建材用色素（赤，緑，青および黄の4色，以下それぞれRWL，GWL，BWLおよびYWLと記す，いずれも粉末），染織用色素（赤，緑，青，黄およびクリームの5色,以下RWT，GWT，BWT，YWTおよびCWTと記す，いずれも粉末，商標Wantex），食用色素（赤，緑および黄の3色，以下RFD，GFDおよびYFDと記す，いずれも粉末,商標Srikaya），日本製食用色素（赤，青および黄の3色，以下JRF，JBFおよびJYFと記す，いずれも粉末，商標キリヤ）ならびに組織学用のエオシン・イエロー（Eosine yellow,以下EYWと略記，Merck社）の16種類を供試した。

(2) 色素米の調製

実　験　A

上記した16種類の色素各1gをそれぞれ100mlの70％エチル・アルコールに溶かした溶液中に米を200gずつ浸漬（1昼夜）したのち，茶こしで染色された米と溶液を分離した。こうして染色された米を大型ガラス・シャーレ（直径18cm）の中へ移し，平らに広げて恒温器の中で1昼夜乾燥した。対照としては70％エチル・アルコールに浸漬して乾燥した米を準備した。

実　験　B

この実験では70％エチル・アルコールを使用せずに，色素1gと米200gを直接に混合したのち，十分に攪拌して色素米を作った。実験AとBで使用した色素米を区別するために，以下では前者を染色米，後者を色素混合米と呼ぶことにする。対照としては無処理米を用いた。

(3) 供試アゼネズミ

スカマンディ支所から東へ約15km離れたスカサリ（Sukasari）において畦を掘さくして生け捕りしたのち，ボゴールの中央農業研究所の野鼠飼育室で飼育していた個体を用いた（第2図版，第3図）。これら供試したアゼネズミの性および体重を第3表にまとめた。

(4) 色素に対する嗜好性の判定

アゼネズミを1頭ずつ収容した4連ケージの中へ，ブリキ製の給餌箱（縦7cm×横27.5cm×高さ3.2cm）に染色米（または色素混合米）と対照米を入れたものを与えて24時間自由に摂食させた。翌日，給餌箱に残っているそれぞれの米の量を秤量して1日の摂食量を求めた。この実験を5日間繰り返した。なおアゼネズミが摂食する際に，容器の外側へはじき飛ばした米粒なども完全に回収して秤量した。この給餌箱は5区劃に仕切られており，端から2番目の区劃へ染色米（色素混合米）または対照米をそれぞれ10gずつ入れて組とした（第2図版，第4図）。実験Aと実験Bにおいては同じ色素に対しては同一個体を使用し，両実験において体重1g当たりの摂食された染色米（または色素混合米）の重量％（この百分率を以下摂食率と呼ぶ）を算出し，嗜好順位をつけた。

(5) 糞の染色性および色素糞の排出期間

嗜好順位が高かった5種類の色素混合米をブリキ製給餌器（縦7cm×横14cm×高さ3.2cm）に20gずつ入れ，2日間自由に摂食させた。そののち餌を対象米と切り替え，染色された糞が何日間排出されるかを調べた。この5種類の色素の他に，日本製の食用色素（JBF）が摂食率は低くても顕著に排泄物を染色することが明らかだったので，この色素も対象とした。糞の着色は日数の経過とともに弱くなり，外観からは正常糞との識別が難しくなる。このような場合には，透明な水を入れたガラス・ビーカーの中へ糞を投入すると，糞粒から色素が溶脱して水を着色するので，着色，非着色の判定が可能であった（第2図版，第5図）。

結果および考察

1. 摂食率

実験Aでは染色米と対象の70％エチル・アルコール浸漬

第 3 表　染色米（または色素混合米）の摂食率と嗜好順位

供試	供試アゼネズミ		実験A					実験B				
			1日の平均摂食量*			染色米の摂食率	嗜好	1日の平均摂食量†			混合米の摂食率	嗜好
色素	性	体重(g)	染色米(g)	対照米(g)	合計(g)	(%)	順位	混合米(g)	対照米(g)	合計(g)	(%)	順位
RWL	♂	66.4	1.80	0.90	2.70	2.7	4‡	3.75	0.80	4.55	5.6	4‡
GWL	♂	222.2	4.72	3.46	8.18	2.1	6‡	1.70	7.45	9.15	0.8	9
BWL	♀	64.0	0.14	3.92	4.06	0.2	12	1.00	6.10	7.10	1.6	8‡
YWL	♂	77.7	2.78	3.56	6.34	3.6	2‡	4.85	1.10	5.95	6.2	2‡
RWT	♀	75.8	2.02	7.14	9.16	2.7	4‡	1.60	3.95	5.55	2.1	7‡
GWT	♂	99.2	0.26	8.28	8.54	0.3	10	5.95	8.65	14.60	6.0	3‡
BWT	♂	90.0	2.88	3.42	6.30	3.2	3‡	2.75	3.05	5.80	3.1	6‡
YWT	♀	114.5	0.14	4.90	5.04	0.1	15	0.55	7.35	7.90	0.5	12
CWT	♂	87.2	0.14	8.10	8.24	0.2	12	0.35	3.95	4.30	0.4	13
RFD	♀	71.3	0.62	2.58	3.20	0.9	7‡	6.20	0.85	7.05	8.7	1‡
GFD	♀	79.0	3.20	3.10	6.30	4.1	1‡	0.65	5.45	6.10	0.8	9
YFD	♀	78.2	0.12	4.98	5.10	0.2	12	0.45	5.00	5.45	0.6	11
JRF	♀	138.9	0.52	8.40	8.92	0.4	9	0.40	7.60	8.00	0.3	14
JBF	♂	103.9	0.80	4.12	4.92	0.8	8‡	0.35	7.80	8.15	0.3	14
JYF	♂	142.7	0.08	5.16	5.24	0.1	15	6.25	6.40	12.65	4.4	5‡
EYW	♀	85.8	0.26	5.00	5.26	0.3	10	0.30	8.45	8.75	0.3	14

*，実験期間は１９８１年1月２８日～２月２日の５日間；　†，実験期間は１９８１年２月２日～２月４日の２日間；
‡，嗜好順位が第１位～第８位の色素

米を１０ｇずつ同時に給与し，毎日それらの残量を秤量して１日の摂食量を求めた。結果は第３表に示されているが，一般に染色米よりも対照米の方がよく摂食され，色素米は好まれぬ傾向が知られた。しかし，RWLやGWLのように染色米における摂食量の方が多い例もあった。次に体重１ｇ当たりの染色米の摂食量を算出し，この値を１００倍した摂食率に基づき染色米に対する嗜好順位を決定した。同様に実験Ｂ（色素混合米と無処理の正常米を各１０ｇずつ同時給与）においても，無処理米が処理米よりも多食される傾向が知られた。処理米の方がより多く摂食されたのはRWL，YWLおよびRFDであった。また，実験ＡとＢにおける摂食率の順位（嗜好順位）は必ずしも一致せず，前者における順位は高いのに後者のそれは低い例（例えばGFD）や，その逆の例（例えばRFDやJYF）も見られ，単純には嗜好性の高い色素を決定することができなかった。そこで使用した１６種類の色素の半数に当たる嗜好順位１～８までの色素をそれぞれＡおよびＢ実験の結果から選び出し，両実験においてともに選出された色素を嗜好性の高い色素とみなした。それらはRWL，YWL，RWT，BWTおよびRFDの５種となった（第３表）。

2.　糞の染色性および色素糞の排出期間

上記５種類の色素にＪＢＦを加えた６種類の色素混合米を２日間アゼネズミに自由に摂食させ，その後は餌を正常米に切り替えて，先に摂取した色素がどれだけ長く糞中に出現するかを調べた結果を第４表に示した。約１日後には６種類の色素のうち４種類は既に糞中に認められず，ＢＷＴとＪＢＦの２種類だけが糞を染めていた。２日後にはＢＷＴも消失し，ＪＢＦだけが糞を青緑色に染めていた。この色素は８日後まで検出され，９日以降は対照糞との識別が困難になった。以上から，日本製の食用青色素はアゼネズミの嗜好性は低いが糞中に長く出現し，レンジ長や行動圏を測定するための色素糞法に最適と判断されたので，次に野外（水田）での適用試験を行うことにした。色素糞法はNew（１９５８）によって種々に実験され，比較的新しい報告としてはTemme（１９７３）が挙げられる。彼はフィリッピンのミンドロ（Mindoro）島のサン

第４表　色素糞の排出期間

供試色素	色素糞の持続日数（日）									
	1	2	3	4	5	6	7	8	9	10
RWL	−	−	±	−	−	−	−	−	−	−
YWL	−	−	−	−	−	−	−	−	−	−
RWT	−	−	−	−	−	−	−	−	−	−
BWT	+	−	−	−	−	−	−	−	−	−
RFD	−	−	−	−	−	−	−	−	−	−
JBF	⧻	⧻	⧻	⧺	+	+	+	+	±	±

色素混合米の給与期間，1981年2月14日～2月16日の2日間；正常米と切替え，1981年2月16日；糞の観察期間，1981年2月16日～2月26日の10日間；⧻，極めて強く染色；⧺，強く染色；＋，弱く染色，±，正常糞との識別困難；－，色素は検出されなかった

ホセ（San José）にある水田で，エオシン1：米170の割合で混合した色素混合米を使用し，本種の行動圏を調査することに成功している。筆者の色素混合米はすべて色素1：米200の割合で調整されたが，色素の配合割合も摂食率に大きく影響するから，この点についての検討も今後必要と思われる。

Ⅳ．色素糞法の野外実験

方　法

本種の生息数推定法に関する基礎実験（捕獲法に関する実験）を行ったスカマンディ支所の水田を実験地として，1981年2月22日～26日の5日間簡単な試験を試みた。アゼネズミへ摂食させる色素米はJBF1：米200の割合で混合して調製した。餌容器としては現地でよく使われている椰子の実の殻（coconut husk）を用い，これを水田のほぼ中央に100m間隔で5カ所に配置した（第2図版，第6図）。この手製容器に色素混合米を50gずつ入れ，毎日，田の畦を調査した。

結果および考察

実験期間中には色素混合米がアゼネズミによって摂食された痕跡は遂に見られなかった。また，色素糞も採取されなかった。5日間の調査期間のうち2日の降雨があったが，色素混合米は全く褪色せず，長期の使用に耐えることが裏付けられた。この実験で色素混合米が全く摂食されなかった理由としては，罠かけ実験で1頭のアゼネズミも採集されなかったのと同じく，時期の問題が考えられる。すなわち，収穫間近の水田には豊富な食物が満ちており，人為的な餌には惹きつけられなかったのであろう。もう1つの理由としては，本種の警戒心の強いことが考えられる。先にも述べたTemme（1973）の実験（1971年5月～8月，3.5カ月）では，本種が1夜に少なくとも平均30m半径内を動き回わること，2例では50m以上，1例では少なくとも93m行動したことが明らかにされている。その最も大きい行動半径は120mであったという。Harrison（1958）は記号放逐法により，マラヤにおける本種の行動範囲を調査して，標識個体の50%は半径25.5mの範囲内で採集され，ほとんどすべて（99%）は109mまでの行動半径内で再捕されたことを記している。日本製の食用青色素（JBF）を使用する筆者の色素糞法も，更に長期にわたって観察すれば，ある程度の成果が得られたと思われる。しかし，任期が終了する直前の実験であったため，短期間で打ち切らなければならなかったのは残念である。この種の調査は今後とも追試する価値のある課題の1つと考える。

要　約

インドネシア中央農業研究所野鼠研究室と同スカマンディ支所の水田および休耕田において，水田加害鼠アゼネズミ *Rattus argentiventer* の個体群動態を調査するための基礎的な実験と調査を行った。結果は以下の通りである。

1）水田において1981年1月14日から17日までの4日3晩，インドネシア製の100個のカゴ罠と米を餌として用いた捕鼠実験では，ヒメクイナの1種（マミジロクイナ，*Porzana cinerea*）2羽以外には何も採集されなかった。

2）休耕田において1981年1月13日から17日までの5日4晩，100個のインドネシア製ハジキ罠と10種類の餌を用いて行った捕鼠実験でも，食虫類のジャコウネズミ（*Suncus murinus*）1頭（雄）以外何も採集されなかった。

3）水田において5種類の罠50個（各種類10個ずつ）と輪切りにしたウナギを餌として使用し，1981年2月23日から26日までの4日3晩行った罠かけでは，3種の淡水棲ヘビが12頭（*Natrix vittata* 9頭，*N. piscator* 1頭および *Homalopsis buccata* 2頭）採集されたが，アゼネズミは全く採集されなかった。

4）捕鼠実験を行った水田の畦および周辺灌漑溝の土手を掘さくして生け捕りした14頭の雌はすべて妊娠していた（妊娠率100%）。平均可視胎児数は11.6（範囲7～14）で，高い妊性が示された。他方，雄は3頭採集されたが，いずれの精巣も陰のう内へ下降し，かつ大きく，雌雄ともに高い繁殖活動を示していた。この調査は1981年2月24日～25日の2日間行われたが，水田のイネは完熟期にあり，本種の繁殖がイネの収穫に同調して行われることが裏付けられた。

5）色素糞法による行動圏調査を試みるための基礎実験として，16種類の色素（建材用4種，染織用5種，食用6種および組織学用1種）と16頭のアゼネズミを用いて，色素に対する嗜好性，糞の染色性および染色能の持続性などについて検討した結果，日本製の食用青色素を最適と判定した。

6）水田５カ所において1981年2月22日～２６日の５日間，日本製食用青色素１：米２００の割合で調製した色素混合米と椰子の実の殻で作った容器を用いて，野外における色素米の摂食状況を調査した。しかし，この期間中にはアゼネズミによる摂食は確認されなかった。

文　献

Harrison, J.L. (1958) Range of movement of some Malayan rats. J.Mammal., 39:190~206.

池田安之助（1979）マレーシアおよびインドネシアのネズミ・害・防除．海外農業開発（56）：12~15．

草野忠治（1980）タイにおける最近のネズミ防除．海外農業開発（58）：1~10．

New, J.G. (1958) Dyes for studying the movements of small mammals. J.Mammal., 39:416~429.

大津正英（1979）インドネシアにおけるノネズミ *Rattus argentiventer* の嗜好性とわな餌の検討．応動昆．23：207~211．

関　勝（1981）カンボジア，台湾およびタイで使用した捕鼠罠と餌について（2月4日付私信）．

Soekarna, D., Partoatmodjo, S., Wirjosuhardjo, S. and Boeadi (1978) Problems and management of small mammals in Indonesia with special reference to rats. Symposium on small mammal problems and control, Los Baños, Philippines :1~31.

Temme, von M. (1973) Zum Aktivitätsraum von *Rattus argentiventer* ; beeinflußt durch eine Köderstation. Z. Angew. Zool., 60:269~281.

Van der Zon, A.P.M. (1979) Mammals of Indonesia. Food and Agriculture Organization of the United Nations. pp. 152.

Wood, B.J. (1971) Investigations of rats in ricefields demonstrating an effective control method giving substantial yield increase. PANS, 17:180~193.

A	B	C	D	E	F	G	H	I	J	15 m
J	A	B	C	D	E	F	G	H	I	
I	J	A	B	C	D	E	F	G	H	
H	I	J	A	B	C	D	E	F	G	
G	H	I	J	A	B	C	D	E	F	
F	G	H	I	J	A	B	C	D	E	
E	F	G	H	I	J	A	B	C	D	
D	E	F	G	H	I	J	A	B	C	
C	D	E	F	G	H	I	J	A	B	
B	C	D	E	F	G	H	I	J	A	

第１図　１０種類の餌とハジキ罠（インドネシア製）による捕鼠実験

実験期間，１９８１年１月１３日～１月１７日の５日４晩；

Ａ，軽く火で焼いたサワガニ（Yuyu bakar）；

Ｂ，エビの練物を塗布したキャサバ（Ubi kayu＋Petis udang）；

Ｃ，キャサバ（Ubi kayu）；

Ｄ，米（Beras）；

Ｅ，ピーナッツ・バターを塗布したキャサバ（Ubi kayu＋Mentega kacang）；

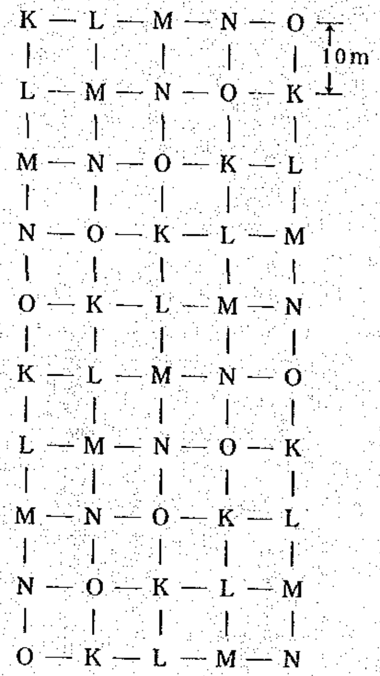
Ｆ，トウモロコシの輪切り（Jagung muda）；

Ｇ，軽く火で焼いたタラシ（Terasi bakar）；

Ｈ，軽く火で焼いた椰子の実（Kelapa bakar）；

Ｉ，甘藷の輪切り（Ubi jalar）；

Ｊ，ソーセージの輪切り（Sosis sapi）



第２図　５種類の罠と輪切りのウナギによる捕鼠実験
実験期間，１９８１年２月２３日～２月２６日の４日３晩；
K，カゴ罠（インドネシア製）；　L，カゴ罠（日本製）；
M，ハジキ罠（インドネシア製）；　N，ハジキ罠（米国製）；
O，プラスチック・ハジキ罠（日本製）

SOME PRELIMINARY EXPERIMENTS FOR THE STUDIES ON THE POPULATION DYNAMICS OF THE RICEFIELD RAT, *RATTUS ARGENTIVENTER*, IN INDONESIA

*Satoshi SHIRAISHI**

The author stayed in Java island, Indonesia, as a short term expert from December 8, 1980 to March 6, 1981 and engaged in a few preliminary experiments for the studies on the population dynamics of the ricefield rat, *Rattus argentiventer*, both at Rat Research Laboratory, Division of Pest and Plant Pathology, CRIA-Bogor and in the paddy field involving the fallow paddy field of CRIA-Sukamandi. The results obtained are summarized as follows:

1) In the trial to capture the rat in the paddy field with 100 Indonesian live traps and rice as bait from January 14 to 17, 1981, no rat was collected except two individuals of Ashy crake, *Porzana cinerea*.

2) In the trapping experiment in the fallow paddy field with 100 Indonesian snap traps and ten kinds of bait (roasted fresh water crab, *Parathelphusa (Parathelphusa) convexa* , cassava with shrimp paste, cassava, rice, cassava with peanut butter, sweet corn, roasted terasi, roasted coconut, sweet potato and beef sausage) for four consecutive nights (January 13 to 17, 1981), no animal was obtained but single male of the musk shrew, *Suncus murinus*.

3) From February 23 to 26, 1981, a third trial to trap the animal was carried out in the same paddy field with five kinds of traps (Indonesian live trap, Japanese live trap, Indonesian snap trap, Japanese plastic snap trap and U.S.A. snap trap) and chopped fresh slices of eel as bait. The sum total of 12 individuals of water snakes consisting of three species (*Natrix vittata, N. piscator and Homalopsis buccata*) were captured instead of the ricefield rat.

4) Fourteen adult females and three adult males collected by digging their burrows on the dikes of the rice paddy and the small irrigation channel adjacent to it were examined by dissection. The embryos were found in the uterine horns of all females, i.e., pregnancy rate was 100 %, and their number averaged 11.6 (7 ~ 14). In all males, the large testes descending into the scrota were recognized (the size of the left one was 23 x 12, 21 x 11.5, and 22 x 12 mm, respectively). It was confirmed that both sexes were in high breeding activity and their reproduction was synchronized with the ripening of rice in the paddy field.

5) In Rat Research Laboratory, 16 kinds of dye (four for wall painting, five for dying textile, six for foods and Eosine yellow for histological study) were tested as to the preference and lasting effect after ingestion by the rat. Throughout a serial test there was no sign of abnormal behaviour or toxicity in any animals. As the result of these experiments, the Japanese blue food dye (KIRIYA, brilliant blue) was selected as the most suitable one for the purpose of tracking the movements of the rat in the field.

6) In another paddy field of CRIA-Sukamandi, five coconut husks baited with dyed rice (the blue dye 1 : rice 200) were placed in a line 100 m apart each other. In order to find out a sign of visit and measure the amount of consumed blue rice by the rat, each bait station was checked everyday but neither sign of visitation nor consumption was recorded at all. Nevertheless, the author believes that this dying technique is worth while to be tried again in other time, when the food for the rat is scarce in the field.

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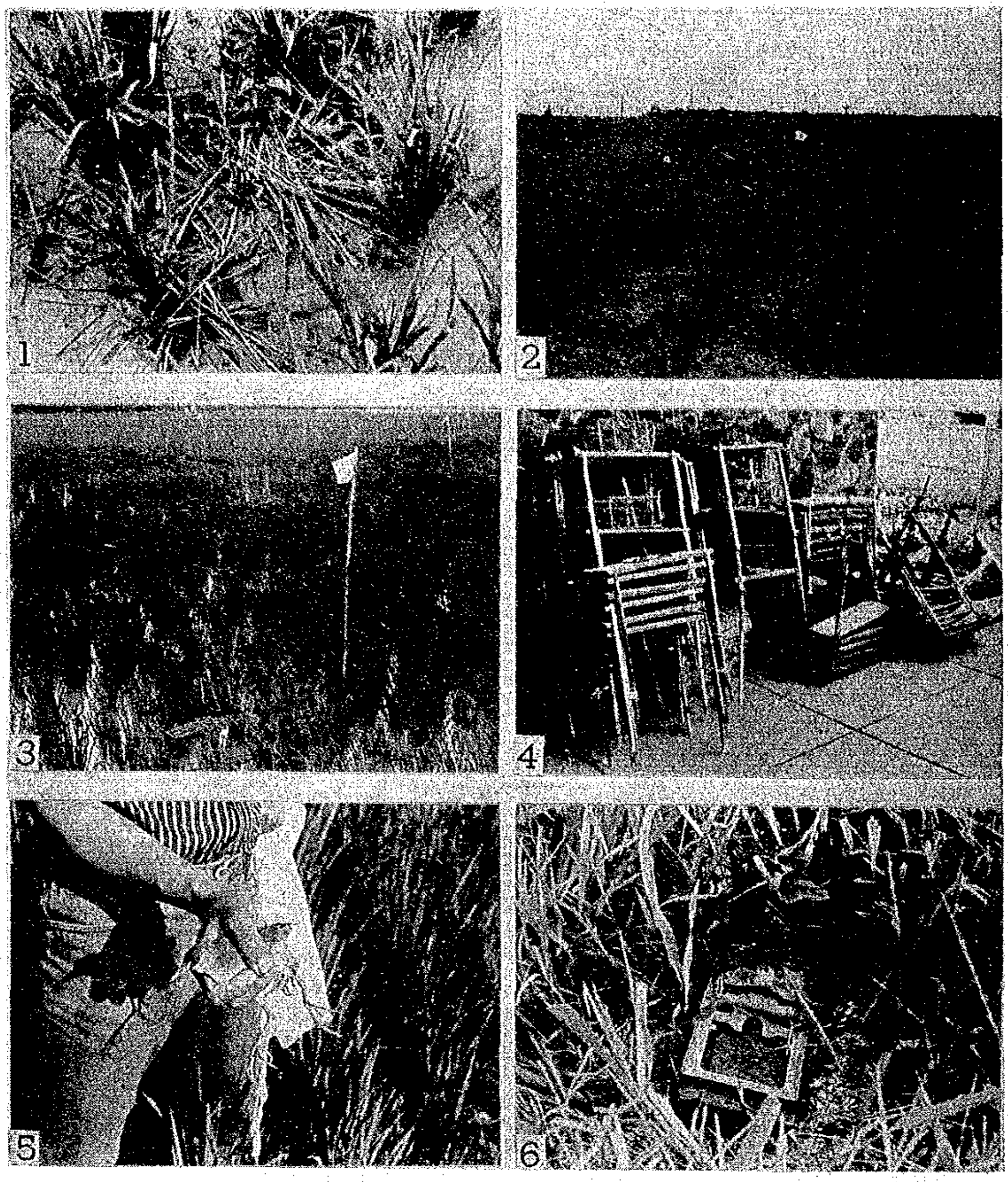
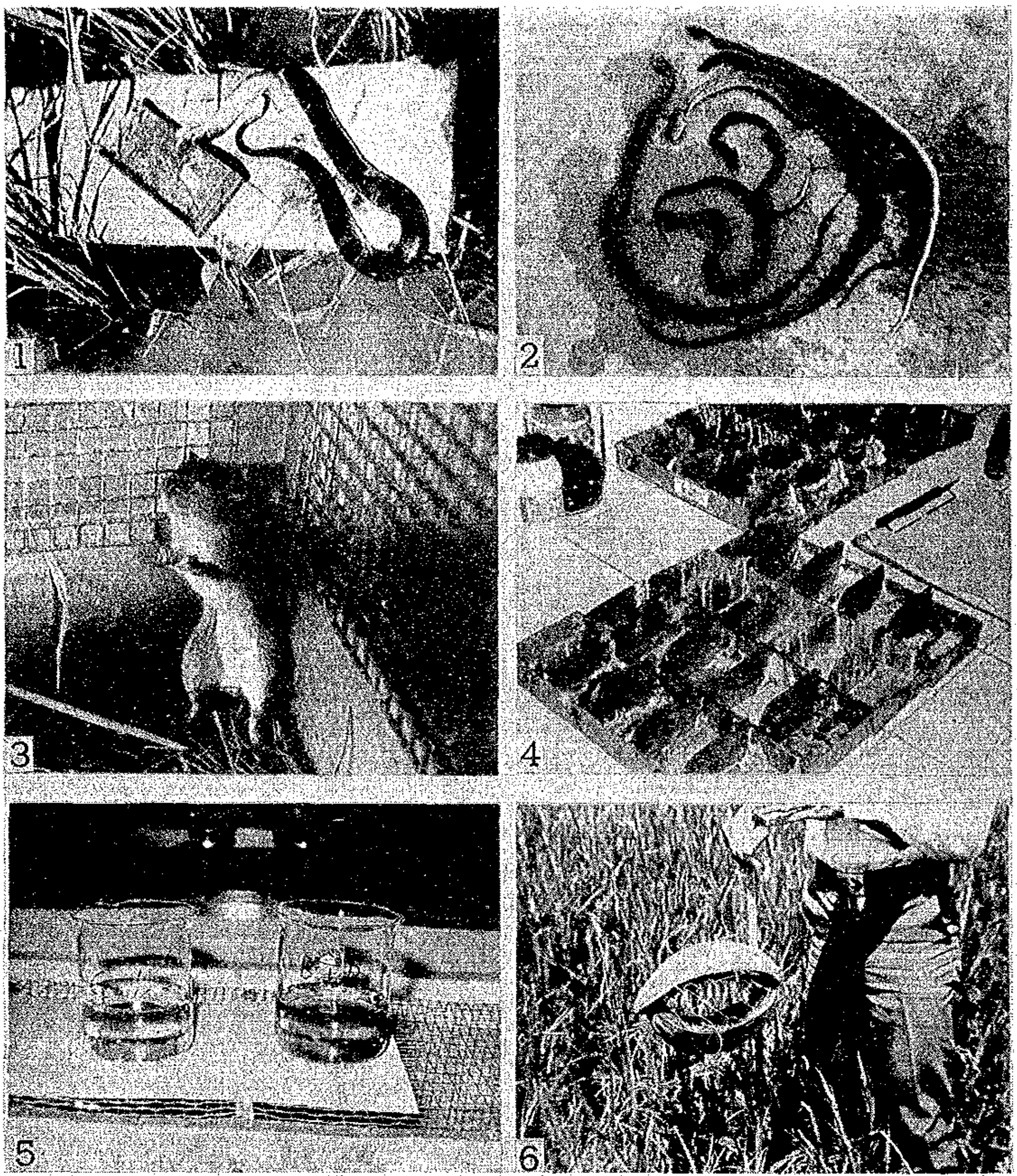


第 1 図版説明

第 1 図　アゼネズミに加害されたイネ株（スカマンディ支所）
第 2 図　捕鼠実験を行った休耕田，手前は沼沢（スカマンディ支所）
第 3 図　捕鼠実験を行った水田（スカマンディ支所）
第 4 図　テーブル型の板の上に保定されたカゴ罠（インドネシア製）
第 5 図　カゴ罠で捕獲された　マミジロクイナ *Porzana cinerea*
第 6 図　ハジキ罠（インドネシア製）で捕獲された食虫類のジャコウネズミ *Suncus murinus*



第 2 図 版 説 明

第 1 図　プラスチック・ハジキ罠（日本製）で捕獲されたカワヘビの1種 *Homalopsis buccata*

第 2 図　罠かけで捕獲された淡水棲ヘビ3種と宿舎の入口で捕殺されたツバハキコブラ *Naja naja sputatrix*（中央の小さい個体）

第 3 図　飼育中のアゼネズミ

第 4 図　染色米（または色素混合米）の摂食率を調べるために使用した給餌箱

第 5 図　色素嚢から溶脱中の日本製食用青色素（JBF，右側），左側は建材用緑色素（GWL）

第 6 図　水田に設置された給餌器（ coconut husk ）と色素混合米

JICA