Journal of Phytopathology and Pest Management 3(2): 85-93, 2016
pISSN:2356-8577 eISSN: 2356-6507
Journal homepage: http://ppmj.net/

Duration of different developmental stages, mortality rate and adult longevity of rice grain bug *Paraeucosmetus pallicornis* (Dallas) on rice *Oryza sativa* (L.) and string beans *Vigna sesquipedalis* (*L.*) under controlled condition

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Abstract

Paraeucosmetus pallicornis **Dallas, locally known as Rice grain bug (RGB) is considered a new pest of rice in the Philippines. Originally RGB is a pest attacking string beans which is commonly planted along the bunds of rice field. This study was conducted to be able to establish the effect of string beans and rice plant on the duration of each developmental stage and adult longevity *P. pallicornis* Dallas under controlled condition. The duration of egg incubation and adult longevity of RGB both on rice and string beans in laboratory and screenhouse were not significant. Although there were nymphal instars that were found to be significantly different, it does not affect the total developmental period of RGB on rice and string beans under laboratory conditions. In the screenhouse, the total development period of RGB was significant on rice and string beans wherein RGB reached adult stage on the average of 30.75 days on rice plants compared to an average of 43.59 days those on string beans. This suggests the possibility that a second generation of RGB will be produced by the new batch of RGB adults bred on rice plants. Considering that the reproductive to ripening phase of rice is about 65 days, the duration of this phase could accommodate a second generation of RGB nymphs and adults. Percent mortality of RGB in rice and string beans was 23.33% under laboratory condition while in screenhouse, 76.66% was recorded in rice and 55% in string beans.**

Key words: *Paraeucosmetus pallicornis*, rice grain bug, rice, string beans.

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Introduction

Rice (*Oryza sativa* L.) is one of the important cereal foods in the world and is the staple diet of approximately half of mankind (Chandler, 1979). In the Philippines, it is important to the economy and to the people at lower income levels. Palay production in the Philippines has tripled from 5.32 million tons in 1970 to a peak of 16.82 million tons in 2008 (Pinoyrkb, 2010). The country is the 8th largest rice producer in the world, accounting for 2.26% of global rice production (BAS, 2013). Although there is an increase in production, shortage of supply is still a problem since there is continues increase in population which consequently increases the rice consumption. In fact the country is also the world's largest rice importer in 2010 at an estimate of 400,000 tons of rice (BAS, 2011). Consumption increased from only 26,000 tons in 2003 to the national daily consumption of the grain at 33,000 tons in 2010. This accounted for 20 percent of the daily household budget with 5 family members, with an average of 11.5 kilograms daily consumption, or more than two sacks a year (Tibao, 2010). One of the reasons of rice shortage has been accounted to be due to insect pest. Problem in insect pest is further aggravated by the impending effect of climate change such as frequent rains that brought about flooding and typhoon which result to possible change in pest status of a particular pest or a shift of preferred host. The latter was the case of the Rice grain bug (*Paraeucosmetus pallicornis* Dallas). *P. pallicornis* was first recorded to attack rice plant in North and South Sulawesi, Indonesia as early as 1991 and the insect pest was commonly known as Black ladybug, it was only in 2008 when its population rises significantly in the Districk of Luwu, South Sulawesi wherein a total of 571 ha were attacked. In the Philippines the insect pest is locally known as Rice grain bug (RGB) is considered a new pest of rice in the Philippines. Originally RGB is a pest attacking string beans which is commonly planted along the bounds of rice field. It was first discovered in Bicol and Dimasalang, Masbate in early 2011 when it wreaked havoc on rice fields, in Ragay, Camarines Sur during the summer of the same year. To date, it has spread to Western Visayas, Central Visayas, Eastern Visayas, Zamboanga Peninsula and Caraga Region particularly in the municipalities of Kitcharao, Agusan Del Norte and Alegria, Surigao Del Norte. According to the Regional Crop Protection Center-DA in Camarines Sur, Rice Grain Bug is far more notorious and damaging than any other rice bugs (Calleja, 2012). This pest that threatens the rice granary of the country has a dirty-brown color and half the size of a rice bug with bigger forelegs making it more of a crawler than a flyer (PIA, 2012). Rice grains damaged by this pest appeared dark brown spots on the punctured marks around the ears are attacked, resulting in the rice becomes empty (Rahayu et al., 2015). It also causes cracked rice grains which taste bitter when cooked due to mold infection. According to PIA (2012), rice grain bug causes 40-80 percent reduction in rice yield. In 2012, reduction of yield reached up to 80% in the municipality of Ragay, Camarines Sur. Furthermore, the final milled product marked a reduction of at least 50% (Bravo, 2012). Since the insect is originally a pest on String beans, it is important to know the effect of the host to the developmental stages of the insect pest especially when the string beans are usually planted along the bunds in the rice field. This is vital information in designing a suitable management strategy hence the conduct of this study.

Materials and methods

Collection of Rice grain bug Adult and Mass Rearing: Rice grain bug (*Paraeucosmetus pallicornis*) adults were collected from rice fields in Inopacan, Leyte, Philippines. Adult RGB were placed in a container covered with nylon tulle and brought to the laboratory. All adults were transferred in a 12” x 12” rearing cage with chopped string beans pods as food. Moistened cotton was placed inside the container for water supply and also as site of egg deposition. Dates of collection and the durations of each developmental stage were recorded accordingly. Laboratory experiments were conducted using sliced string bean pods and rice panicle and results were confirmed in the screen house using a live string beans and rice plants.

Laboratory Experiment: The developmental stages of RGB were observed under ambient temperature ranges from 28-30^{0}C. Newly laid eggs were collected from the rearing cage of adult RGB. The eggs were placed individually in separate plastic cups and were labeled accordingly. A total of one hundred twenty (120) plastic cups were used. Sixty (60) cups were supplied with sliced ‘PSB-B#3’ string bean pods about one inch long as food for the developing nymphs. Moistened cotton wad was placed for water supply. The other sixty (60) plastic cups were supplied with ‘RC18’ rice grain, the end part of the stalk where the grains are attached were covered with wet cotton so it would not dry fast and it served as water supply for the developing nymphs. String beans and rice grains were replaced regularly. They were observed daily to record occurrence of molting until the adult stage. Dates and duration of egg incubation and each nymphal instar were recorded. In addition, adults were continually observed until death to record the mortality.

Screenhouse Experiment: A separate set-up was prepared in the screen house wherein a live potted sting beans and rice plants were used as host of the developing *P. pallicornis*. ‘PSB-Bs#3’ string beans were prepared using clean seedling tray (70 x 35 cm). The seedling trays were filled with sterilized mixture of soil, compost and burnt rice hull then placed in screen house. Two seeds of ‘PSB-Bs#3’ string beans were sown in every hole of the seedling tray. After four (4) days, the string beans were transplanted to pots filled with sterilized soil. Two seedlings of ‘PSB-Bs#3’ string beans were transplanted in every pot. Bamboo trellis was set up in each pot for climbing and additional support to the growing string beans. For the ‘RC18’ rice, the seeds were sown into the seedling tray with sterilized soil and regularly watered. After 20 days, pots (10” x 10”) were prepared containing sterilized soil and submerged with 2 inches of water above the soil. Four rice seedlings were transplanted from the seedling tray. When rice seedlings reach five to six inches, water level was increased to four inches deep. Rice plant and string beans were maintained by watering and fertilization following the standard water and fertilizer requirements of each plant. Rice plants were planted one month earlier than string beans in order to have the same time in bearing fruits. Six potted 'PSB-Bs#3' string beans and RC18 rice at reproductive stage were used. Ten (10) RGB eggs were introduced in each pot. To avoid the RGB nymphs and adults from escaping and facilitate easier observation of the development, string bean pods and rice grains were individually enclosed in improvised cylindrical cage. Cotton wad was also added to each pot inside the improvised cage for water supply. The eggs were checked regularly to record their development. The moistened cotton wads were replaced daily to avoid contamination. When eggs started to hatch, nymphs were allowed to develop in the same potted plants. Nymphs were checked regularly to monitor possible molting until adult. The presence of exuvium indicated that molting has occurred. Adult longevity was also recorded. In a separate set up, eggs were also introduced following the previous methods. When molting was observed; at least ten samples of nymphs of every instar and adult were collected in a vial with 70% ethyl alcohol. A representative of each life stage was mounted, preserved, and submitted to the VSU Natural History Museum. The duration (days) of different developmental stages and total development period, and percent mortality rate of *P. pallicornis* Dallas in string beans and rice plant were observed and recorded. This was computed following the formula below; the mean duration of each developmental stage of RGB in rice was compared to the mean duration of those reared in string beans using two independent samples t-test in SPSS 13.0 for windows.

Results

Rice grain bug originally feeds on string beans and was only recently recorded to feed on young rice grains. To be able to design a sound management tactics, information such as the duration of each developmental stage both in string beans and rice plant is a fundamental requirement.

Duration of different stages of RGB in Rice: The duration from egg laying to adult stage ranged from 43 to 61 days (Table 1). Out of 60 eggs observed, 58 were successfully hatched within 8-9 days. The nymphs underwent 5-6 instars. A total of 14 eggs did not developed into adult, while only 79% of the nymphs developed into adult stage. Among the 46 RGB that developed into adult, six underwent five nymphal instar while 40 underwent sixth nymphal instar. In the screenhouse, out of 60 eggs observed, 53 were successfully hatched within 8-9 days (Table 2). There were only 14 RGB that fully developed into adults. Unlike in the laboratory wherein there were six RGB that attained adult stage after the fifth instar, in screenhouse all 14 underwent sixth nymphal instar before adult stage. The total duration of development of RGB is 47-64 days.

Duration of the different stages of RGB in String beans: Table 3 shows the duration (in days) of RGB in string beans under laboratory condition. A total of 60 eggs were observed. There were 58 eggs that successfully hatched to first instar within 8-9 days and 40 nymphs developed into adult. The total development period of RGB ranged between 47 -66 days.

Table 1. Duration (in days) of the different development stages of *Paraeucosmetus palicornis* on rice under laboratory condition.

Stages	Mean	Std. Dev.	Range	# of individuals examined
Egg	8.36	± 0.48	8-9	60
1st instar	5.71	± 1.28	4-8	58
2nd instar	5.85	± 0.90	5-8	56
3rd instar	4.52	± 0.96	3-6	54
4th instar	3.8	± 1.71	1-7	52
5th instar	5.33	± 1.63	3-10	50
6th instar	7.40	± 1.13	6-9	40
Total development period	45.72	±13.44	43-61	

Table 2. Duration (in days) of the development stages of *Paraeucosmetus palicornis* on rice under screenhouse condition.

Stages	Mean	Std. Dev.	Range	# of individuals examined
Egg	8.49	± 0.50	8-9	60
1st instar	5.49	± 1.56	3-8	53
2nd instar	6.28	± 0.85	5-8	47
3rd instar	3.74	± 1.31	1-6	43
4th instar	3.25	± 1.37	1-6	38
5th instar	5.43	± 1.75	3-9	32
6th instar	7.21	± 0.89	6-9	14
Total development period	30.75	±15.94	47-64	

Table 3. Duration (in days) of the development stages of *Paraeucosmetus palicornis* on string beans under laboratory condition.

Stages	Mean	Std. Dev.	Range	# of individuals examined
Egg	8.36	± 0.48	8-9	60
1st instar	7.7	± 1.31	5-10	58
2nd instar	5.78	± 1.10	4-8	56
3rd instar	5.04	± 1.69	3-9	54
4th instar	4.46	± 1.33	2-7	52
5th instar	5.36	± 1.25	4-10	50
6th instar	8.1	± 0.93	7-10	40
Total development period	49.36	±13.98	47-66	

Table 4. Duration (in days) of the development stages of *Paraeucosmetus palicornis* on string beans under screenhouse condition.

Stages	Mean	Std. Dev.	Range	# of individuals examined
Egg	8.45	± 0.50	8-9	60
1st instar	7.51	± 1.42	5-10	56
2nd instar	6.44	± 1.51	4-9	53
3rd instar	5.67	± 1.72	3-9	48
4th instar	4.67	± 1.37	3-7	45
5th instar	5.37	± 1.07	4-10	40
6th instar	8.37	± 1.04	7-10	27
Total development period	43.59	±19.19	54-68	

In the screenhouse, there were 60 eggs introduced and only 56 were successfully hatched after 8-9 days (Table 4). Twenty seven samples were able to fully develop into adult. The total development period ranged from 54-68 days. In the laboratory, both nymphs and adults fed on the sides of the sliced string bean pods while in the screenhouse, the nymphs and adults fed on the surface of the pods. The feeding behavior could be attributed to the texture of the tissue of the available food hence, in the laboratory the insect fed on the softer tissues afforded by the sliced pods which was not available in screenhouse. It was also observed that both nymphs and adults in screenhouse fed on the pods of the plant parts opposite to the direction of the sunlight.

Adult Longevity of *P. pallicornis* Dallas: RGB adults live longer in screen house condition on string beans and rice plants compared in the laboratory condition. The state and quality of the host likely affect the longevity of the insect since in screen house, host were live and potted thus, appropriate nutrition and care were maintained (Table 5).

Table 5. Adult longevity of *P. pallicornis* (days) on string beans and rice plant under controlled condition.

Host	Laboratory Condition		Screen house Condition	
	Mean	Range	Mean	Range
String Beans	11.83	10-14	13.5	10-16
Rice	11.67	10-14	12.86	10-14

Table 6. Two independent samples t-test analysis between the duration (in days) of the different stages of RGB *P. pallicornis* on rice and string beans under laboratory condition.

Stages	Rice		String beans		P value
	Mean	Std. Dev.	Mean	Std. Dev.	
Eggs	8.36	±0.48	8.36	±0.48	1^{ns}
1^{st} instar	5.71	±1.28	7.7	±1.31	0.0000^{*}
2^{nd} instar	5.85	±0.90	5.78	±1.10	0.9238^{ns}
3^{rd} instar	4.52	±0.96	5.04	±1.69	0.0577^{*}
4^{th} instar	3.8	±1.71	4.46	±1.33	0.0338^{*}
5^{th} instar	5.33	±1.63	5.36	±1.25	0.9403^{ns}
6^{th} instar	7.40	±1.13	8.1	±0.93	0.4506^{ns}
Adult longevity	11.67	±1.10	11.83	±1.47	0.5742^{ns}
Total development period	45.72	±13.44	49.36	±13.98	0.1559^{ns}

* = significant different, ns = not significantly different.

Comparison between RGB in Rice and String beans: In order to understand the effect of host plants (rice and string beans) to the development of RGB, the mean duration of the different stages of the insect reared in two hosts were compared using two independent samples t-test analysis (Table 6). It was found that the difference in egg incubation of RGB in two hosts was not significant as well as the duration of nymphs on 2^{nd}, 5^{th} and 6^{th} instars. The nymphs on 1^{st}, 3^{rd} and 4^{th} instar were significantly different, however, the 1^{st} instar nymph of RGB in rice (5.71±1.28) molted faster than on string beans (7.7±1.31). The same was observed in 3^{rd} instar nypmhs with a mean duration of 4.52±0.96 in rice and 5.04±1.69 in string beans, and in 4^{th} instar nymphs with a mean duration of 3.8±1.71 in rice and 4.46±1.33 in string beans. Regardless of the difference in the duration of nymphal instars, the total developmental period of RGB on rice and string beans are not significant. Adult longevity in two hosts was also not significant. In the screenhouse, the total developmental period of RGB on rice and string beans when compared was significantly different (Table 7). Egg incubation in the two hosts were not significant as well as the duration of nymphs in 2nd and 4th instars. Similar trend was observed in screen house. The insects molted faster when fed on rice than on string beans in the 1st, 3rd 5th and 6thnymphal instar. However, the adult longevity of RGB in rice and string beans were not significant. From the initial population of 60 RGB reared on rice and string beans in the laboratory, 23.33% mortality rate was recorded in two hosts (Table 8). Compared in screen house, mortality rate was higher at 76.66% in rice and 55% in string beans.

Table 7. Two independent sample t-test analysis between the duration (in days) of the different stages of RGB, *Paraeucosmetus pallicornison* rice and string beans under screenhouse condition.

Stages	Rice		String beans		P value
	Mean	Std. Dev.	Mean	Std. Dev.	
Eggs	8.49	± 0.50	8.45	± 0.50	0.6480ns
1st instar	5.49	± 1.56	7.51	± 1.42	0.0000*
2nd instar	6.28	± 0.85	6.44	± 1.51	0.5354 ns
3rd instar	3.74	± 1.31	5.67	± 1.72	0.0000*
4th instar	3.25	± 1.37	4.67	± 1.37	0.8704ns
5th instar	5.43	± 1.75	5.37	± 1.07	0.0041*
6th instar	7.21	± 0.89	8.37	± 1.04	0.0011*
Adult longevity	12.86	± 1.29	13.50	± 1.70	0.2165ns
Total development period	30.75	± 15.94	43.59	± 19.19	0.0003*

* = significant different, ns = not significantly different.

Table 8. Percent mortality of *Paraeucosmetus pallicornis*on rice and string beans under laboratory and screenhouse conditions.

Rice		String beans	
Laboratory	Screenhouse	Laboratory	String beans
23.33	76.66	23.33	55

Discussion

Rice grain bugs can complete their development on either host although data suggest that development of the insect was more successful on rice than on string beans. The fact that string beans was the original host and rice was supposedly an alternate, this implies a great threat to both crops. Planting string beans along with the rice plant in the bunds of the rice field would encourage the build-up of the insect population. Thus, in an area wherein RGB is found to be dwelling on string beans or on rice, planting string beans as intercrop is unwise. Nymphs of Rice grain bug was observed to molt faster when reared in rice plant but has a shorter life span compared to the RGB on string beans. This implies that rice as food host provided sufficient nutritional requirements that enable the nymphs to develop faster compared to string beans.

According to Anderwartha and Birch (1984), food resources contribute the chemicals from which the body is built. It provides energy. The abundance of food and other resources such as water and oxygen served as signal to the insect that it is time to prepare for the next stage in the life cycle. The result suggests that there could be a possibility of second generation in one cropping season of rice plant. In a general rice growth stage, the reproductive to ripening phase is about 65 days. Since RGB could attain complete development in 30.75 days, adults of this generation can produce eggs which will feed on the same rice plant. This attribute seemed to be the reason of its capacity to cause damage as much as 80% yield reduction as recorded in Ragay, Camarines Sur. The mortality rate in the screen house was attributed to high temperature and the disturbances brought by the daily observations which required regular opening of the cages. The process seemed to expose the RGB to stress which led to higher mortality rate. Whereas in the laboratory, the insects were placed in plastic cups although regular checking was done but the observation was conducted by opening the plastic covering without further disturbing the food host. With the findings, it is recommended to explore further on the aspect of host-insect relationship such as an experiment on host preference between rice and string beans; and possible management scheme such as proper timing of planting string beans that would benefit the farmers and the rice plant. With the impending problem RGB pose to rice production, it is also recommended to explore available biological control agents in the field.

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