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Identification and Quantification of Major Insect Pests of Rice and Their Natural Enemies

Shriti Moses[1*], Deepak Ranjan Kishor[1], A. K. Misra[1] and Md. Abbas Ahmad[1]

[1]Department of Entomology, RPCAU, PUSA, Samastipur (Bihar), PIN-848125, India.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

This survey was conducted in rice field during *kharif* season of year 2017 at Pusa farm of Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar. The rice stem borer, leaf folder and plant hopper are the major insect pest of rice in Pusa region. Rice ecosystem favorable for proliferation of insect-pests is equally congenial for multiplication of the natural enemies of these pests. The month of August and September is identified as the peak activity period for most of the insect pests in sweeping net and hand picking method. Yellow stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*) and brown plant hopper (*Nilaparvata lugens*) were found as the dominant species at Pusa. In species composition study, *Scirpophaga incertulas* (YSB) is the dominant species of rice stem borer, *Cnaphalocrocis medinalis* was the dominant species of leaf folder and *Nilaparvata lugens* is the dominant species of plant hopper. The important predators observed in the rice ecosystem of Pusa are spider, lady bird beetle, staphylinid beetle, green mirid bug, dragonfly and damselfly. Predatory spider, dragonfly and damselfly were found most active during the month of July while lady bird beetle, staphylinid beetle and green mirid bug were found most active in the month of August and September in sweeping net sampling and handpicking method.

**Corresponding author: E-mail: shritimoses361@gmail.com;*
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Keywords: Stem borer; leaf folder; plant hopper; natural enemies.

1. INTRODUCTION

Rice is the most important source of the food energy for more than half of the global human population. About 90 per cent of rice grown in the world is produced and consumed in Asian region. Globally in 2015-16 rice production was 710.64 million tonnes under an area of 158.8 million hectare, China ranking first followed by India with 104.4 million tonnes under 44.1 million hectare. Rice continues to hold the key to sustain food sufficiency in the country. The burgeoning population of India will demand 260 to 264 million tonnes of foodgrains by 2030 which have to be produced under shrinking natural resources [1].

Rice crop is attacked by large number of insect pests of which stem borers, leaf folders, plant hoppers are major. A number of natural enemies such as parasites and predators are also found in the rice fields which help in managing the population of these insect pests. Rice ecosystem is very rich in predatory fauna which plays an important role in regulating the insect pests of rice. Among these, predatory spider fauna are of great importance. Amongst the insect pests, the rice yellow stem borer, *Scirpophaga incertulas* Walker (Lepidoptera: Pyralidae) is reported to be the key pests of lowland rice in Bangladesh, Thailand, India and probably in other countries of Asia also [2]. This pests is the key pest of rice in Bihar [3]. Yellow stem borer infects rice plant right from seedling to maturity stage. It is one of the monophagous species with exclusive host specificity and stage of infestation [4]. Yellow stem borer infects the crop during its vegetative and heading stages resulting in formation of deadhearts and white earhead, respectively which results in substantial yield reduction.

Rice leaf folder, *Cnaphalocrocis medinalis* Guenee (Lepidoptera: Pyralidae) which was considered as a minor pest, now became a serious pest of rice crop in recent years in almosts all rice growing tracts of India. The larva of rice leaf folder folds the leaves and scraps the green tissues of the leaf and resulting in reduction of the photosynthesis ability of the plant and turn down the yield. Outbreaks and serious infestations of rice leaf folder have been reported in many Asian countries including China, India, Japan, Korea, Malaysia, Sri Lanka and Vietnam [5] and [6]. Bautista et al. [7] have clearly shown that loss in yield, due to the rice leaf folder is positively related to the percentage of damaged leaves. In their studies, 17.5 per cent yield occurred with 26.6 per cent damaged leaves. Changes in the physical environments, cultural practices, multiple cropping patterns, reduced genetic variability of high yielding rice varieties, application of high levels of nitrogenous fertilizer and a prophylactic use of pesticides are the major reason of the insect problem [8,9] and [10]. Management of leaf folder by using synthetic chemicals has failed because of not only the pest resistance against them but also due to resulting environmental pollution as well as pest resurgence [11]. During the leaf folder epidemic in Haryana rice crop suffered with 30-80 per cent yield loss [12].

Plant hoppers of rice comprise brown planthopper, *Nilaparvata lugens* Stat. (Hemiptera: Delphacidae) and white backed plant hopper, *Sogatella furcifera* Horvath (Hemiptera: Delphacidae). In India, it has become very serious on high yielding varieties of paddy in many states including Punjab, Uttar Pradesh, Madhya Pradesh, West Bengal, Andhra Pradesh and Tamil Nadu. White backed plant hopper occur all over the country but in southern states where paddy crop is available throughout the year, it breed continually. WBPH is widely distributed in rice growing regions of south, south east and east, Asia, some pacific Islands of northern part of Australia. It has become a serious threat to rice growing cultivation in most of the growing countries including India, causing 10-100 per cent yield loss [13]. Under favourable conditions, the hoppers produces several generations and cause damage or hopper burn in the rice crop. Severely attacked seedling do not grow, show stunting and wilting and eventually die. Feeding punctures and wound produced by egg laying, predispose rice plants to bacterial infection and fungal infection. Generally BPH maintains a numerical superiority over WBPH, but on BPH resistant varieties the WBPH tend to multiply faster.

2. MATERIALS AND METHODS

To estimate the population fluctuation of major insect pests and natural enemies such as spiders, coccinellids and other important predators in the experimental plots were counted. The collected insect pests and natural enemies were brought to the laboratory and identification were done with the help of key published by IRRI, Philippines, Manila. The

relation to abiotic factors with parasites and predators were studied and its impact on pest population were estimated.

2.1 Determination of Major Insect Pest of Rice

The immature stages of insect pest are mostly harmful to rice plant and they may be observed through direct sampling in the field. The observations of insect pest were recorded in the unsprayed experimental plots by random sampling during *kharif* 2017. A number of sampling techniques have been devised for determination of insect pest population in rice field such as sweeping net technique, hand picking and counting, fixed plant sampling technique, visual counting per unit area, light trapping etc.

Here, sweeping net sampling and hand picking techniques were adopted at weekly intervals throughout the crop season for estimation of insect pests population in rice field.

2.2 Sweeping Net Sampling

The sampling technique is useful for catching immature and adult stages of insect pest present in the paddy fields. A total of 25 samples were taken to observe the occurrence of major insect pests like stem borer, leaf folder and plant hopper from the paddy fields. Insects were collected by making ten successive double stroke sweep on randomly selected site using sweeping net of 30 cm diameter with handle 75 cm long. One sample consists of ten sweeps at one place at weekly intervals. The samples were brought to laboratory for further identification and estimation.

2.3 Experimental Details

Specification of sweep net - 30 cm diameter with handle 75 cm long.

Time of sampling - Morning.

Frequency of observations - Weekly.

No. of samples - Twenty five.

No. of sweep in each sampling - Ten.

2.4 Handpicking Method

Insect pests present on the leaf sheath, leaf blades were directly collected into glass tubes of 2.5 X 10 cm and tapping with cotton lid. Small insects were collected with the help of brush. Collected specimen were brought to laboratory for further identification and estimation. The unidentified insect species were placed in the petri dish and examined under a binocular microscope for identification of species.

2.5 Quantification of Major Insect Pest of Rice and Their Natural Enemies

The hundred hills were marked with bamboo pegs each for stem borer, leaf folder and plant hopper at the onset of pest. These selected plants were observed throughout the season for intensity of pest on the basis of their respective damage symptoms. Quantification was done by counting the insect pests population.

2.6 Stem Borer

The observations were recorded from tillering stage of rice plant and 25 affected tillers (dead heart/white ear) were brought to the laboratory and dissected. Then, the type of stem borer larva/pupa inside the tiller i.e., yellow stem borer, pink stem borer etc. were identified. The adult catches observed in the sweep net collection were also separated on the basis of external characteristics of species for deciding the species composition. Similarly, natural enemies of rice stem borer were also identified and counted.

The infestation of yellow stem borer *Scirpophaga incertulas* (Walker) was recorded on 25 randomly selected hills in the plot by counting total number of tillers and damaged tillers as “Dead hearts” on each hill and then the per cent damage was calculated by using following formula:

Dead heart (%) = [Damaged tillers / Total tillers (Healthy+Damage)] x 100

White ear head (%) = [Damaged panicles / Total panicles (Healthy+Damage)] x 100

2.7 Leaf Folder

The adults of leaf folders were collected by sweeping net and then the adults were separated into species and the number recorded as percentage of total moths observed. Twenty five larvae of leaf folder were collected from leaf folder damaged/folded leaves and observations were taken to identify the leaf folder larvae on the

basis of symptom described for respective species. Similarly, natural enemies of rice leaf folder were also identified and counted.

The incidence of leaf folder *Cnaphalocrocis medinalis* (Guenee) was recorded on the basis of damaged leaves on 25 randomly selected hills from each plot. The data on "damaged leaves" were computed by using following formula:

Damaged leaves (%) = [Damaged leaves / Total leaves (Healthy+Damage)] x 100

2.8 Plant Hopper

BPH and WBPH samples were collected from 25 marked hills at weekly intervals and then identified their species composition from the samples. Similarly, natural enemies of plant hoppers were also identified and counted.

Relative abundance of insect pests and natural enemies was calculated by using the given formula:

Relative abundance (%) = [Total number of individuals of each species / Total number of individuals of all species] X 100

3. RESULTS AND DISCUSSION

3.1 Sweeping Net Sampling and Hand Picking Method

Rice stem borer, leaf folder and plant hoppers were observed through sweeping net sampling and hand picking method. A total of 25 samples were taken from the unsprayed field to observe the occurrence of major insect pests of rice. Each sample consisted of ten double stroke sweeps from randomly selected plot in the paddy field at weekly interval. The appearance of adults of stem borer, leaf folder and plant hoppers were observed in sweep net collection and hand picking from the month of July to October. The stem borer was not observed initially and afterwards it remain continue throughout the crop season. The highest population of stem borer was observed in the 37th standard week of September. The second peak population of stem borer were observed during 38th standard week of September. The leaf folder were observed from 30th standard week of July. The highest population of leaf folder were observed in the 34th standard week of August and second peak population of leaf folder was observed in the 33rd standard week of August. Plant hopper (BPH+WBPH) was not observed in the month of July. It was observed from the 31st standard week of August and remained up to 42nd standard week of October. The highest population of plant hopper (BPH+WBPH) were observed during the 40th standard week of October and second peak population was observed during the 39th standard week of September. Overall the relative abundance of stem borer was found maximum in the field with 55.14% followed by leaf folder with 24.93% and then of plant hoppers with 19.91% (Table 4). Hence we can say that stem borer is major insect pest infesting the rice crop. Dogra and Choudhary [14] reported peak activity period for major insect pest of rice for Kangra Valley (Himachal). The main insects included the stem borer (*Scirpophaga innotata*), leaf folder (*Cnaphalocrocis medinalis*) and rice hispa (*Dicladispa armigera*) appeared from the first week of July and reached at the peak during August- September which coincided with the vegetative stage of the plant. Sachan et al. [15] conducted a survey in Tarai region of Uttar Pradesh to understand the insect fauna and their peak activity period. A total of 28 insect species were recorded as pest and predator/parasites of rice ecosystem. The yellow stem borer, *Scirpophaga incertulas* (July-October), leaf-folder, *Cnaphalocrocis medinalis* (August-September) and brown plant hopper, *Nilaparvata lugens* (August-September) were found as major pests. The striped stalk borer, *Chilo suppressalis* (July-October), gundhi bug, *Leptocorisa acuta* (September-October), white-backed plant hopper, *Sogatella furcifera* (August-September), green leafhopper, *Nephotettix virescens* (August-September), grasshoppers, *Hieroglyphus banian* and *Atractomorpha crenulata* (August-October) and root weevil, *Echinocnemus oryzae* (July-September) were found moderately damaging the crop. The variation in peak activity period of Bihar, Uttar Pradesh and Himachal Pradesh may be due to the variation in agro ecological situation.

It may be stated that most of the insect pest population were observed during the month of August and September in weekly sampling of sweep net collection and hand picking method.

3.2 Quantification of Major Insect Pests of Rice and Their Natural Enemies

The quantification for the population of stem borer, leaf folder and plant hoppers were recorded on the selected plant by counting the insect pests population at periodic interval. Analyzed data revealed that the infestation of stem borer started from 29th standard week of July then it gradually increased and reached at the highest level of infestation in the 37th standard week of September and the second highest infestation was observed in the 38th standard week of September. The maximum infestation of leaf folder damaged leaves was observed in the 34th standard week of August and after wards it declined. The infestation of plant hopper started from 31st standard week of August and maximum infestation was observed in the 40th standard week of October (Table 1). Shukla et al. [16] reported on the basis of fifteen years trend of rice insect pest at Raipur, that maximum stem borer infest the crop at tillering and panicle stage particularly in the month of September. Peak activity of leaf folder infestation was observed during the month of September and October respectively. Peak population of BPH and WBPH were observed during August-September, September-October and October-November respectively. Kalita et al. [17] concluded that maximum damaged to rice crop occurred in the second forthnight of July with maximum per cent leaf damage of (22.25-24.25). Stem borer infestation was found maximum in the last week of August (6.82-7.62%). The leaf folder population was found maximum in the last week of August and first week of September (14.50-16.75 damaged leaves/hills) and gundhi bug was found maximum when the crop attained milky stage in the first forthnight of October (14.80-16.40 gundhibug/10 hills). The present findings are in the agreement with the previous finding and showing almost similar trend except for leaf folder which may be due to the change in rainfall pattern of Bihar.

It may be stated that the highest infestation of stem borer were observed in the 37th standard week of September when prevailing weather conditions for following parameters were recorded as follows - maximum temperature (34.0°C), minimum temperature (27.0°C), RH morning (91%) , RH evening (71%) and rainfall (2.6 mm) which are favourable for the development of stem borer. The infestation of leaf folder damaged leaves were observed highest in the 34th standard week of August when prevailing weather conditions for following parameters were recorded as follows - maximum temperature (33.2°C), minimum temperature (26.8°C), RH morning (87%), RH evening (71%) and rainfall (41.8 mm) which are favourable for development of these insect. The infestation of plant hopper were observed highest in the 40th standard week of October when the prevailing weather condition for following parameters were recorded as follows- maximum temperature (33.2°C), minimum temperature (25.0°C), RH morning (87%), RH evening (70%) and rainfall (0.0 mm).

3.3 Stem Borer

The stem borer infested tillers and panicles were dissected to remove the larvae/ pupae present inside the stem and then they were sorted on the basis of specific characteristics. A total 25 larvae were collected and identified on the basis of symptoms described for different species. Similarly, the adult population were collected through sweeping net and sorted on the basis of specific symptom of respective species. Then the species composition for Pusa population was worked out. 100% yellow stem borer species was observed throughout the crop season and the population of pink stem borer species was not observed (Table 3). Data revealed that relative abundance of stem borer adult collected through sweeping net was 55.14% in the field (Table 2). Similar findings were reported by Hendarsih and Usyati [18] that the yellow stem borer (*Scirpophaga incertulas*) was the dominant species of stem borers in rice. It may be stated that yellow stem borer is the dominant species of rice stem borer at Pusa found active throughout the season and pink stem borer was not found.

3.4 Natural Enemies of Rice Yellow Stem Borer

i. Spiders

Two species of spider were found dominant during the crop growing season. Wolf spider, *Lycosa pseudoannulata* was found in more abundant number. The highest number was observed in tillering stage of the crop. Lynx spider population showed no significant difference in different growth stages of rice. The highest number was observed in heading stage

which was similar to the number recorded in tillering stage. The relative abundance of spiders in the rice field was 18.64% (Table 4).

ii. Lady bird beetle

Ladybird beetle, *Micraspis discolor* were found dominant in rice growing season. Ladybird beetle differed significantly among different stages with 31.69% relative abundance (Table 4). The highest number was found at the flowering stage of rice. Rahman et al. [19] reported that ladybird beetle, *Micraspis discolor* were found dominant in rice growing season. This species was taken into consideration in this experiment. Ladybird beetle differed significantly among different stages with 49.95% relative abundance. The highest number was found in tillering stage (130.70) and lowest number was found in seedling stage (13.67).

iii. Green mirid bug

The relative abundance of green mirid bug, *Cyrtorhinus lividipennis* observed was 9.90% (Table 4). The highest number of green mirid bug was recorded in heading stage.

iv. Damselfly

The population of damselfly showed significant differences in various growth stages with the relative abundance of 12.94% (Table 4). The highest number was observed in tillering stage of the crop.

v. Dragonfly

The population of dragonfly showed no significant differences with the population of damselfly in different growth stages of rice showing relative abundance of 13.04% (Table 4). The highest number was found in the tillering stage of the crop.

3.5 Leaf Folder

A total 25 larvae were collected from leaf folder damaged leaves and identified on the basis of symptom described for different species, similarly the adult population were collected through sweeping net and sorted on the basis of specific symptoms of respective species. Then the species composition for Pusa population was worked out. On the basis of sample size of respective leaf folder species at larval and adult stage observation *Cnaphalocrocis medinalis* was observed as the dominant species on both stages of leaf folder species. Based on larval characteristics, *Cnaphalocrocis medinalis* accounted for 84 per cent and *Marasmia* sp. was 16%. Based on adult observation through sweep net *Cnaphalocrocis medinalis* accounted for 88% of population while *Marasmia* sp. was 12% of the total population (Table 3). Data revealed that the relative abundance of leaf folder collected through sweeping net was 24.93% in the field (Table 3). As per the DRR report [20] *Cnaphalocrocis medinalis* is reported as the dominant species of leaf folder at Nawagam, Malan, Ludhiana and Raipur. The present findings are almost similar to the previous finding, *Marasmia patnalis* was observed in very low number at Pusa during *kharif* 2017. It may be stated that the *Cnaphalocrocis medinalis* was observed as the dominant species and the *Marasmia patnalis* was observed as the second species during *kharif* 2017 at Pusa.

3.6 Natural Enemies of Rice Leaf Folder

i. Spiders

Species of spider, Lynx sp. was recorded as major predator of leaf folder. They made their first appearance on the crop in the 29th standard week of July. They were observed feeding on the larval and adult stages of leaf folder. Their activity continued till 42nd standard week of October. Peak activity of spider was observed during 29th standard week of July. A spider *Lycosa sp*. also predated upon larvae of pest but in the present studies spider, *Lynx sp.* was recorded as major predator against the pest.

ii. Greenmirid bug

Besides the spider, mirid bug, *Cyrtorhinus lividipennis* was observed feeding on every larval stage of leaf folder. Bug was active from 29th standard week of July to 42nd standard week of October. Peak activity of mirid bug was recorded during 36th standard week of September.

iii. Damselfly

Besides the above predators damselfly, *Enallagma cyathigerum* was also observed from 29th standard week of July with peak population recorded during 30th standard week of July.

Table 1. Major insect pests of rice collected through sweeping net and handpicking at weekly interval during *kharif* 2017

Month	Std. week	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Wind speed (Km/hr)	Stem borer (adults)	Leaf folder (adults)	Plant hopper (mixed population)
		Max.	Min.	Mor.	Even.					
Jul.	29	34.3	27.3	85	68	12.8	6.9	06	00	00
Jul.	30	32.1	26.2	86	75	31.4	8.7	09	03	00
Aug.	31	33.0	26.3	90	77	12.4	3.6	28	11	05
Aug.	32	32.8	26.5	93	79	116.3	5.2	36	17	09
Aug.	33	31.0	25.3	94	79	214.4	4.1	49	38	16
Aug.	34	33.2	26.8	87	71	41.8	4.7	58	41	11
Sept.	35	32.8	26.5	88	76	02.6	5.5	62	24	23
Sept.	36	33.9	26.3	88	65	11.2	3.3	65	22	25
Sept.	37	34.0	27.0	91	71	02.6	3.4	70	26	21
Sept.	38	33.5	26.1	88	70	30.0	6.0	68	24	22
Sept.	39	34.3	25.8	88	62	00.0	3.1	57	21	30
Oct.	40	33.2	25.0	87	70	00.0	3.6	54	20	34
Oct.	41	33.1	25.0	89	69	03.5	4.2	56	29	25
Oct.	42	33.4	22.8	88	63	00.0	3.5	52	27	21

Table 2. Relative abundance of major insect pests of rice (%)

Name of insect	Total (no.)	Relative abundance (%)
Stem borer	670	55.14
Leaf folder	303	24.93
Plant hopper	242	19.91

Table 3. Species composition of stem borer, leaf folder and plant hopper collected through hand picking and sweeping net

1. Stem borer	**Yellow stem borer (YSB)**	**Pink stem borer (PSB)**	**%YSB**	**%PSB**
Larvae	25	0	100	0
Adult	670	0	100	0
2. Leaf folder	***Cnaphalocrocis medinalis* (CM)**	***Marasmis patnalis* (MP)**	**%CM**	**%MP**
Larvae	21	4	84	16
Adult	266	37	88	12
3. Plant hopper	**Brown plant hopper (BPH)**	**White backed plant hopper (WBPH)**	**%BPH**	**%WBPH**
Adult	181	61	75	25

Table 4. Relative abundance of predators of major insect pests of rice (%)

Name of insect	Total (no.)	Relative abundance (%)
Spider	386	18.64
Lady bird beetle	656	31.69
Staphylinid beetle	285	13.76
Green mirid bug	205	09.90
Dragonfly	268	12.94
Damselfly	270	13.04

3.7 Plant Hopper (BPH+WBPH)

Plant hoppers were counted from 25 marked hills at the weekly interval and they were separately counted by identifying their species composition. Data revealed that out of collected population of plant hoppers 75% BPH and 25% WBPH was observed (Table 3). The initiation of the plant hopper population started from the 31st standard week of August and afterward it increased. The highest activity of plant hoppers was observed in the 40th standard week of October (Table 1). Among the two species of plant hoppers the infestation of BPH was observed more than that of WBPH. Data revealed that the relative abundance of plant hoppers collected through sweeping net was 19.91% in the rice field (Table 2). AICRIP centers situated at the different part of country i.e. New Delhi, Maruteru and Khudwani had reported on the status of hoppers in the annual report of DRR [21]. At New Delhi, the brown plant hopper (BPH), white backed plant hopper (WBPH) and green leafhopper (GLH) were observed on 36, 66, 78 and 96 DAT. The mean BPH population per 10 hills increased from 0.0 to 115.37 near the time of harvest whereas the WBPH population was negligible. At Maruteru, the hopper population comprised of only BPH which increased up to 15 per hill during the crop growth period.

From the above observation, it may be stated that BPH was the dominant species. Both the species of hopper i.e. brown plant hopper (BPH), white-backed plant hopper (WBPH) were observed in Pusa.

3.8 Natural Enemies of Plant Hoppers

i. Spiders

Two species of spiders, wolf spider and lynx spider was mainly observed predating on plant hoppers. The relative abundance of spiders in the field was 18.64% (Table 4). The results were similar with the findings reported by Kawahara et al. [22]. They observed that approximately 1-7 spiders were found per hill and each spider preys

upon 2 leaf hopper per day. They also reported that the invasion of spiders into paddy field was prolonged beyond 20 to 60 days after transplanting and most species peaked in immediately before harvest.

ii. Lady bird beetle

Lady bird beetle, *Micraspis discolor* were found in abundant numbers feeding on hoppers egg. The relative abundance of lady bird beetle was 31.69% in the field (Table 4).

iii. Greenmirid bug

Green mirid bug was also observed in the field with sufficient number predating on plant hoppers eggs. The relative abundance of green mirid bug was 9.90% in the field (Table 4).

3.9 Rank Order of Relative Abundance of Natural Enemies of Major Insect Pest of Rice in Field

Lady bird beetle (31.69%) > Spiders (18.64%) > Staphylinid beetle (13.76%) > Damselfly (13.04%) > Dragonfly (12.94%) > Green mirid bug (9.90%) (Table 4).

4. CONCLUSION

Higher intensity of insect pest were observed during first week of August to second week of October. Yellow stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*) and brown plant hopper (*Nilaparvata lugens*) were found as the dominant species at Pusa. The peak activity period for most of the rice insect pest was observed during the 33rd standard week of August to 40th standard week of October. The damage symptom was highest for stem borer infestation which was observed in the 37th standard week of September. The infestation of leaf folder damaged leaves was observed in highest intensity during the 34th standard week of August. The peak activity period for BPH and WBPH was observed during the 40th standard week of October. In species composition study, *Scirpophaga incertulas* (YSB) is the dominant species of rice stem borer, *Cnaphalocrocis medinalis* was the dominant species of leaf folder and *Nilaparvata lugens* is the dominant species of plant hopper.

The important predators observed in the rice ecosystem of Pusa are spider, lady bird beetle, staphylinid beetle, green mirid bug, dragonfly and damselfly. Predatory spider, dragonfly and damselfly were found most active during the month of July while lady bird beetle, staphylinid beetle and green mirid bug were found most active in the month of August and September in sweeping net sampling and handpicking method.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Paroda RS, Woodhead T, Singh RB. Sustainability of rice-wheat production systems in Asia. RAPA Publication 1994/11. FAO Bangkok; 2002.
2. Catling HD, Islam Z, Rahman L. Status of pests and disease in Asian deepwater rice. Proc. Int. Deepwater rice workshop (1987). IRRI, Manila, Philippines. 1998;525-537.
3. Singh BN, Dubey R, Singh SL, A.K. Studies on stem borers in deepwater rice in Bihar, India, Proc. Int. deepwater rice workshop, 1987, IRRI, Manila, Philippines, pp. 559-561. Three planting time. Indonesian Journal of Agricultural Science. 1998;6(2):42.
4. Reddy DB. Pests of food crops, Plant Protection in India. Allied Publ., Calcutta, pp. 133-134. Rice plant hoppers. Plant Hoppers: Their Ecology and Management. 1968;571-5 98.
5. Wada T, Shimazu M. Seasonal population trends of the rice leaf folder, *Cnaphalocrocis medinalis* (G.N.) (Lepidoptera: Pyralidae) in the paddy field at Chicago in 1977. Rev. Appl. Entomol. 1980;68(3):1409.
6. Heong KL. Rice leaf folder: Are they serious pests? In: Hu, G.W., Guo, Y.J., Li, S.W. (Eds.) Research on Rice leaf folder management in China, March 4-6, 1992, Beijing. China Agricultural science and technology Publisher, Beijing, China. 1993; 8-11.
7. Bautista RC, Heinrichs FA, Rejesus RS. Economic injury levels for Rice leaf folder *Cnaphalocrosis medinalis* (Lepidoptera: Pyralidae). Insect Infestation and Artificial leaf removal. Environmental Entomology. 1984;13(2):439-443.
8. Khan ZR, Rueda BP, Caballero P. Behavioural and Physiological responses of rice leaf folder, *Cnaphalocrosis medinalis* to selected wild rices. Entomol. Exp. Appli. 1989;52:7-13.

9. Shepard BM, Khan ZR, Pathak MD, Heinrichs EA. Management of insect pests of rice in Asia. In: D. Pimentel, Editor, Handbook of Pests Management in Agriculture (second ed.) CRC Press. 1991; 225-278.
10. De Kraker, Rabbinge R, Van Huis A, Van Lenteren JC, Hoeng KL. Impact of nitrogenous fertilization on the population dynamics and natural control of rice leaf folder (Lepidoptera: Pyralidae). Intl. Pest Manag. 2000;46:225-235.
11. Dale D. Insect Pests of rice plant, their biology and ecology. In: Heinrichs, E.A.(Ed.) Biology and Management of rice Insects. Wiley Eastern Ltd. New Delhi. 1994;363-485.
12. Kushwaha KS. Insect pests compled of rice in Haryana. Bulletin of Entomology. 1988;25:100-102.
13. Chatterjee SM, Dani RC. Ecological studies on rice pests. Ann. Rep. Cont. Rice Res. Inst., Cuttack. 1976;263-64.
14. Dogra I, Choudhary A. Some insect pests of rice, *Oryza sativa* Linn. In Kangra Valley of Himachal Pradesh. Insect-Environment. 2005;11(1):21-22.
15. Sachan SK, Singh DV, Chaudhary AS. Seasonal abundance of insect pests associated with basmati rice. Annals of Plant Protection Sciences. 2006;14(1): 247-248.
16. Shukla BC, Phoply DJ, Chandrakar HK, Gupta R, Dubey VK, Yadu YK, Rana DK, Sharma S, Rana N, Gupta A. Souvenir of National Conference on Pest Management Strategies for Food Security. IGKV, Raipur. 2008;2-3.
17. Kalita H, Avasthe RK, Ramesh K. Effect of Weather Parameters on Population buildup of different insects pests of rice and their Natural Enemies. Indian Journal of Hill Farming. 2015;28(1):68-72.
18. Hendarsih S, Usyati N. The stem borer infestation on rice cultivars at three planting time. Indonesian Journal of Agricultural Science. 2005;6(2):42.
19. Rahman MM, Islam KS, Jahan M, Mamum MAA. Relative abundance of stem borer species and natural enemies in rice ecosystem at Madhupur, Tangail, Bangladesh. Journal of Bangladesh Agricultural Universities. 2014;12(2):267-272.
20. Anonymous. Monitoring of pest species and their natural enemies. All India Coordinated Rice Improvement Programme. *Annual Progress Report*, Vol. 2 DRR ICAR, Rajendra Nagar, Hyderabad (AP). – Entomology. 2010;60-79.
21. Anonymous. Department of Revenue and Land Record. Government of Chhattisgarh; 2011.
22. Kawahara S, Kritant K, Sasaba T, Naka-Sufig F, Okuma C. Seasonal changes in abundance and the faunal composition of spiders in the paddy fields with special references to their relation, to the seasonal prevalence of the green leafhopper, *Nephotettix cinticeps* Uhler. In Proc. Ass. Pl. Prot. Sikoku. 1968;4:33-44.