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Status of Insect Pests and Natural Enemies in MID Hill Rainfed Rice Agroecosystem

B. Vinothkumar*
Hybrid Rice Evaluation Centre, Tamil Nadu Agricultural University,
Gudalur, The Nilgiris, Tamilnadu.

A study was conducted at Hybrid Rice Evaluation Centre, Tamil Nadu Agricultural University, Gudalur during *Kharif* 2010 - 2012 for documentation of seasonal incidence of pest and natural enemy spectra in the high altitude rice ecosystem. Results revealed that, there were 12 pests belonging to 6 orders and 7 natural enemies belonging to 4 orders. A total of 11 species of spiders from 7 families, 13 species of coccinellids ; one species each of rove beetle and ground beetle were also noticed in the rice fields. A total of 19 species of Odonata belonging to 16 genera representing five families and two suborders were collected from the mid hill high rainfall region of Tamil Nadu. Data on the seasonal incidence revealed that the population of GLH and BPH started from the first fortnight of September, the leaf folder and stem borer damage was observed from the third week of September and continued till harvest. Spiders were observed in the field from September first week till the harvest. Peak population of spiders (4.00 per ten hills) was observed during third week of December. Peak population of coccinellids (2.44 per ten hills) and rove beetles (1.44 per ten hills) were observed during the third week of November and first week of December, respectively. The correlation and multiple regression analysis revealed that, the pest species such as GLH, BPH, leaf folder and yellow stem borer, showed significant positive impact on natural enemy incidence. The results of correlation analysis showed R^2 values of 0.98, 0.95 and 0.93 for spider, coccinellid and rove beetle population with respect to availability of pest species.

Key words: Seasonal incidence, GLH, BPH, Leaf folder, Yellow stem borer, Mid hill rainfed rice

Rice (*Oryza sativa* L.) is the most important and extensively grown food crop in the tropical and subtropical regions of the world. Rice plays a vital role in our national food security and is a means of livelihood for millions of rural households. Rice agro-ecosystems of the world are categorized into five major types: (i) Irrigated rice fields (ii) Rainfed rice fields, (iii) Deep water rice fields, (iv) Upland rice fields and (v) Tidal water rice fields. In India, rice is grown over an area of 43.8 m ha with a production of 96.4 m tonnes. The rainfed rice area is about 24.4 million hectare with productivity of less than 0.98 tonnes/hectare, due to uncertainty of available water. It is a fragile ecology and divided into sub-ecologies *viz.,* rainfed uplands (plain area and high altitude hill rice), deep water, semi-deep water and shallow rainfed (drought prone, lowland and submergence prone) and coastal saline rice. Upland rice is grown in unfavorable rainfed soil and weather conditions. Over 1400 insect species attack standing and stored rice in the world (Grist and Lever, 1969), while Kalode and Pasalu (1986) reported over 100 species of insect pests attacking rice crop at various stages of its growth. Naturally occurring biological control agents have a potential role to play in management of rice fields of tropical south and South East Asia and there is a need to emphasize the impact of indigenous natural enemies as an essential part of IPM programmes (Way and Heong, 1994; Ooi and Shephard, 1994). In India, there is sufficient evidence to justify the vital role of natural enemies in suppressing the pest populations in rice (Rao *et al,*1983; Chelliah *et al.,*1989). Conservation of the natural enemy fauna *in situ* for suppressing the pest population seems to be a very good alternative. Farmers continue to resort to insecticidal use for checking pest incidence in their fields without being aware of either the role played by natural biocontrol agents or the impact of the insecticides on the natural biocontrol agents.

The species composition of rice pest and natural enemies throughout the world is relatively well documented, but only a few studies have examined the overall insect biodiversity associated with the rice crop. A comprehensive work on the insect diversity of this unique man made ecosystem is still scanty, scattered and in an unsatisfactory condition. Due to these reasons, substantial data on different aspects of biodiversity and ecosystems necessary for quantitative analysis is currently not available. This dilemma along with accelerated species and ecosystems extinction has raised the need for diversity studies and its documentation.

*Corresponding author email :drbvinothkumar@gmail.com

Therefore, documentation of insect diversity is necessary and primary requisite for its conservation (Ehrlich and Wilson, 1991). This study represents for the first time a most comprehensive insects' faunal inventory and analysis related to high altitude rainfed rice crop in Gudalur, The Nilgiris, Tamil Nadu. The present study was taken up with the objective of documentation of insect pests, seasonal incidence of major pests and natural enemies, and to assess the relationship between the major pest and natural enemy incidence in the high altitude rainfed rice ecosystem.

Materials and Methods

Study area

Gudalur is in the mid hill high rainfall region in the Nilgiri district of Tamil Nadu and it is a valley in the Western Ghats located between Doddabetta peak and Mudumalai Wildlife Sanctuary at 11.50°N latitude and 76.50°E longitude at an altitude of 1350 m above MSL. It has typical sub tropical climate and temperature ranges from a minimum of 4-18°C to a maximum 20-32°C with a relative humidity of 35 - 65% to 70-100 %. Annual precipitation is 2200-2500 mm. Ninety per cent of the precipitation takes place within four months, from June to September, July and August being the rainiest months. Rice is one of the major crops cultivated in this area during Kharif season (June to December).

Documentation and seasonal incidence

The study was conducted in rice variety Bharathy at Puliyambarai farm at Hybrid Rice Evaluation Centre, Gudalur during *Kharif* 2010 and 2012 for documentation of seasonal incidence of pest and natural enemy spectra in the high altitude rice ecosystem. Transplanting was done during 34 to 35thstandard week (August second fortnight). The number of natural enemies and pests found in the field was recorded through net sweeping and visual observations. Management practices such as fertilizer application and weed management were followed as per the crop production guide (2005) and no plant protection measures were taken up. Observations were made from transplanting and continued till harvest. The incidence of major pests (*viz.,* green leaf hopper (GLH), brown plant hopper (BPH), leaf folder, stem borer and ear head bug) and natural enemies (*viz.,* spiders, coccinellids and rove beetles) was recorded on the ten hills at random in three locations within the plot which served as replications. The insect species, larval population and per cent damage were recorded at weekly interval till harvest.

Survey on the incidence of rice pests and natural enemies

A roving survey was conducted during the Kharif 2010 to Kharif 2012 in ten villages around Gudalur (growing rainfed rice) namely, Puliyamparai, Padanthorai, Cherumulli, Thottamula, Putturvayal, Manvayal, Srimadurai, Nugalpula, Pulpalli and Ambalavayal. The survey was conducted six times in a season during both the vegetative (three times) and reproductive phases (three times) of the crop . The observations were recorded in three fields at each location on the incidence of yellow stem borer, leaf folder, GLH, BPH, ear head bug, grasshopper and natural enemies by following standard procedures. The insect pests and natural enemies were identified based on standard reference materials.

Observation and analysis

The observation on insect pests and natural enemy occurrence was recorded on 10 hills in each field randomly in three replications and averaged to per hill basis for expression. Standard procedure was followed to record the observations on the incidence of insect pests of paddy. Counts were taken on number of dead hearts / white ears caused by yellow stem borer and total number of tillers/ panicle from 10 randomly selected hills. The per cent incidence (dead heart/ white ears) was calculated as follows:

$$\text{Per cent incidence} = \frac{\text{Number of dead heart / white ears}}{\text{Total number of tillers / panicles}} \times 100$$

The damaged leaves by leaf folder and total leaves from 10 randomly selected hills were observed in each plot. The percentage of leaf damage was calculated as follows:

$$\text{Per cent incidence} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

Observations on leaf hopper (GLH), plant hopper (BPH and WBPH) and ear head bugs were recorded as number of motile stages (adult and nymphs) on 10 hills by tapping and counting. The number of spiders, rove beetles and coccinellids were recorded on ten randomly selected hills and expressed in number per ten hills. Three years data on pests and natural enemies in the seasonal incidence study were pooled for statistical analysis. The population of GLH, BPH, ear head bug and per cent damage of leaf folder and yellow stem borer recorded were correlated with the population of spiders, coccinellids and rove beetle using the population of different insect species as dependent variable (Y) and each of the natural enemy as independent variable (X). Based on step down regression analysis (Using SPSS software), pest species were shortlisted and significant pest species alone were selected for multiple regression analysis to know the interaction between pests and natural enemies.

Results and Discussion

The results indicated that, there were 12 pests that belong to 6 orders (Table 1), and 7 natural

Table 1. Insect pest spectra in the high altitude rice ecosystem in Tamil Nadu

Insect	Scientific name	Family	Order
Thrips	*Stenchaetothrips biformis* Bag.	Thripidae	Thysanoptera
Whorl maggot	*Hydrellia sasakii* Yua.& Isi.	Ephydridae	Diptera
Grass hopper	*Oxya nitidula* Walker	Acrididae	Orthptera
	Hieroglyphus banian Fabricius	Acrididae	Orthptera
Leaf folder	*Cnaphalocrocis medinalis* Gue.	Pyralidae	Lepidoptera
	Marasmia patnalis Bradley	Pyralidae	Lepidoptera
Stem borer	*Scirpophaga incertulas* Walker	Pyraustidae	Lepidoptera
Ear head bug	*Leptocorisa acuta* Thunberg	Alydidae	Hemiptera
Green leaf hopper	*Nephotettix virescens* Distant	Cicadellidae	Hemiptera
	Nephotettix nigropictus Stal	Cicadellidae	Hemiptera
Brown plant hopper	*Nilaparvata lugens* Stal	Delphacidae	Hemiptera
White backed plant hopper	*Sogatella furcifera* Hovarth	Delphacidae	Hemiptera
Blue beetle	*Leptispa pygmaea* Baly	Chrysomelidae	Coleoptera
Hispa	*Dicladispa armigera* Olivier	Chrysomelidae	Coleoptera
Army worm	*Spodoptera mauritia* Boi.	Noctuidae	Lepidoptera

enemies belonging to 4 orders (Table 2) at Puliyanbarai farm, Hybrid Rice Evaluation Centre, Gudalur during Kharif 2010-Kharif 2012. Incidence of thrips (*Stenchaeto thrips biformis*) was observed only in the nursery. After transplanting in the main field, infestation of leaf folder (*Cnaphalocrocis*

Table 2. Natural enemy spectra in the high altitude rice ecosystem in Tamil Nadu

Natural enemy	Scientific name	Family	Order
Spider	Lycosa pseudoannulata *Boes & Stand*	*Lycosidae*	*Araneae*
	Tetragnatha javana *Thorell*	*Tetragnathidae*	*Araneae*
	Argiope *species*	*Araneidae*	*Araneae*
	Plexippus *species*	*Salticidae*	*Araneae*
	Oxyopes javanus *Thorell*	*Oxyopidae*	*Araneae*
	Oxyopes rufisternum *Thorell*	*Oxyopidae*	*Araneae*
	Thomisus *species*	*Thomisidae*	*Araneae*
	Clubiona *species*	*Clubionidae*	*Araneae*
	Neoscona rumfi *Thorell*	*Araneidae*	*Araneae*
	Pardosa birmanica *Simon*	*Lycosidae*	*Araneae*
	Leucauge decorata *Blackwell*	*Tetragnathidae*	*Araneae*
Coccinellids	Chilomenes sexmaculatus *Fab*.	*Coccinellidae*	*Coleoptera*
	Coccinella transversalis *Fab*.	*Coccinellidae*	*Coleoptera*
	Brumoides suturalis *Fab*.	*Coccinellidae*	*Coleoptera*
	Hormonia octomaculata *Fab*.	*Coccinellidae*	*Coleoptera*
	Chilocorus nigritus *Fab*.	*Coccinellidae*	*Coleoptera*
	Micraspis discolor *Fab*.	*Coccinellidae*	*Coleoptera*
	Micraspis spp.,	*Coccinellidae*	*Coleoptera*
	Illeis indica *Timberlake*	*Coccinellidae*	*Coleoptera*
	Scymnus nubilus *Mulsant*	*Coccinellidae*	*Coleoptera*
	Propylea dissecta *Mulsant*	*Coccinellidae*	*Coleoptera*
	Rodolia breviuscula *Weise*	*Coccinellidae*	*Coleoptera*
	Rodolia concdor *Lewis*	*Coccinellidae*	*Coleoptera*
	Scymnus coniferarum *Crotch*	*Coccinellidae*	*Coleoptera*
Rove beetle	Paederus fuscipes *Curtis*	*Staphylinidae*	*Coleoptera*
Ground beetle	-	*Carabidae*	*Coleoptera*
Mirid bug	*Cyrtorhinus lividipennis Reuter*	*Miridae*	*Hemiptera*
Dragon fly	Anax ephippiger *Burmeister*	*Aeshnidae*	*Odonata*
	Anax immaculifrons *Rambur*	*Aeshnidae*	*Odonata*
	Onychogomphus nilgiriensis *Fraser*	*Gomphidae*	*Odonata*
	Brachythemis contaminata *Fabricius*	*Libellulidae*	*Odonata*
	Crocothemis servilia *Drury*	*Libellulidae*	*Odonata*
	Diplacodes trivialis *Rambur*	*Libellulidae*	*Odonata*
	Neurothemis tullia *Drury*	*Libellulidae*	*Odonata*
	Orthetrum sabina *Drury*	*Libellulidae*	*Odonata*
	Orthetrum triangulare *Drury*	*Libellulidae*	*Odonata*
	Pantala flavescens *Fabricius*	*Libellulidae*	*Odonata*
	Potamarcha congener *Rambur*	*Libellulidae*	*Odonata*
	Tramea limbata *Desjardins*	*Libellulidae*	*Odonata*
	Urothemis signata signata *Rambur*	*Libellulidae*	*Odonata*
Damsel fly	Agriocnemis pygmaea *Rambur*	*Coenagrionidae*	*Odonata*
	Ceriagrion coromandelianum *Fab.*	*Coenagrionidae*	*Odonata*
	Ischnura senegalensis *Rambur*	*Coenagrionidae*	*Odonata*
	Pseudagrion malabaricum *Fraser*	*Coenagrionidae*	*Odonata*
	Lestes elatus *Hagen in Selys*	*Lestidae*	*Odonata*
	Lestes viridulus *Rambur*	*Lestidae*	*Odonata*

medinalis and *Marasmia patnalis*) was more than other pests like yellow stem borer (*Scirpophaga incertulas*), green leaf hopper (*Nephotettix virescens* and *Nephotettix nigropictus*), brown plant hoppers (*Nilaparvata lugens*), whorl maggot (*Hydrellia sasakii*), grass hoppers (*Oxya nitidula* and *Hieroglyphus banian*) and ear head bug (*Leptocorisa acuta*). A total of 11 species of spiders from 7 different families *viz*., *Lycosa pseudoannulata* Boes & Stand (Lycosidae), *Tetragnatha javana* Thorell (Tetragnathidae), *Argiope* species (Araneidae), *Plexippus* species (Salticidae), *Oxyopes javanus* Thorell, *Oxyopes rufisternum* Thorell (Oxyopidae), *Thomisus* species (Thomisidae), *Clubiona* species (Clubionidae), *Neoscona rumfi* Thorell (Araneidae), *Pardosa birmanica* Simon (Lycosidae) and *Leucauge decorata* Blackwell (Tetragnathidae) were observed from upland rice crop at different days after transplantations. A total of 13 species of coccinellids *viz*., *Chilomenes sexmaculatus* Fab., *Coccinella transversalis* Fab., *Brumoides suturalis* Fab., *Hormonia octomaculata* Fab., *Chilocorus nigritus* Fab., *Micraspis discolor* Fab., *Micraspis* spp.,, *Illeis indica* Timberlake, *Scymnus nubilus* Mulsant, *Propylea dissecta* Mulsant, *Rodolia breviuscula* Weise, *Rodolia concolor* Lewis, and *Scymnus coniferarum* Crotch were observed from upland rice crop at different days after transplantations. Ground dwelling insects like rove beetle *Paederus fuscipes* Curtis (Staphylinidae) and ground beetle (Carabidae) were also noticed in the rice fields. A total of 19 species of Odonata belonging to 16 genera, five families and two suborders were also collected from the ecosystem during the survey periods. Among the 19 species collected, 13 species belong to three families *viz*., Aeshnidae, Gomphidae and Libellulidae of sub order Anisoptera and 6 species belong to two families *viz*., Coenagrionidae and Lestidae of sub order Zygoptera (Table 2).

Table 3. Seasonal incidence of insect pests and natural enemies of high altitude rice in Tamil Nadu

		Insect pests					Rove beetle (No/Plant)		
Std Week	Time of observation	GLH (No./Plant)	BPH (No./Plant)	LF damage (%)	YSB damage (%)	EHB (No./ Plant)	Spider (No./Plant)	Coccinellid (No./Plant)	Natural enemy
36	August 4thweek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	September 1stweek	0.27	0.00	0.00	0.00	0.00	0.22	0.00	0.00
38	September 2ndweek	1.73	1.97	0.21	0.00	0.00	0.56	0.00	0.00
39	September 3rdweek	2.85	3.77	2.42	0.15	0.00	1.22	0.33	0.22
40	September 4thweek	3.90	5.63	4.47	1.47	0.00	2.00	0.33	0.67
41	October 1stweek	5.57	6.78	7.53	3.68	0.00	2.33	1.56	0.89
42	October 2ndweek	4.46	8.05	8.04	4.27	0.09	2.67	1.67	1.00
43	October 3rdweek	4.92	8.77	9.83	4.76	0.40	3.22	1.56	1.33
44	October 4thweek	5.20	8.24	10.25	5.31	0.43	3.33	1.22	0.89
45	November 1stweek	4.80	10.23	10.75	4.22	0.95	3.00	2.22	1.33
46	November 2ndweek	5.87	9.96	12.89	5.66	1.88	3.22	2.00	1.00
47	November 3rdweek	5.87	10.41	14.07	5.86	2.07	3.55	2.22	1.22
48	November 4thweek	5.72	10.26	16.68	5.72	1.99	3.56	2.44	1.00
49	December 1stweek	5.01	8.94	17.40	4.91	2.47	3.67	1.89	1.44
50	December 2ndweek	3.92	8.13	18.27	3.66	2.14	3.34	1.33	0.89
51	December 3rdweek	2.99	7.29	19.64	3.30	1.66	4.00	1.33	0.67
52	December 4thweek	2.71	7.37	21.08	2.40	1.22	3.78	1.00	0.56

T max – Maximum temperature, T min – Minimum temperature, RH (M) – Relative humidity (Morning), RH(E) – Relative humidity (Evening), RF – Rainfall, LF - Leaf folder, YSB – Yellow stem borer, EHB – Ear head bug

Data on the seasonal incidence of major pests (*viz.,* GLH, BPH, leaf folder, stem borer and ear head bug) and natural enemies (*viz.,* spiders, coccinellids and rove beetles) of high altitude rice revealed that the population of GLH started from the first week of September *i.e* 15 days after transplanting (DAT) and continued till harvest (December) of the crop (Table 3). The peak population was observed during second and third week of November (5.87 GLH per hill). Incidence of BPH started from second week of September with a peak during third week of November (10.41 BPH per hill) the leaf folder damage started from third week of September and continued till harvest (December) of the crop (Table 3). The mean leaf folder damage ranged from 0.21 to 21.08 per cent on second week of September and last week of December, respectively (Fig 1). Yellow stem borer damage was increasing from September third week (39 thstandard week) (0.15 %), and attained the peak during third week of November (47thstandard week) (5.86 %), and then decreased gradually registering 2.40 per cent damage at the time of harvest. Ear head bug population was noticed during second week of October (42ndstandard week), which coincided with the flowering of the crop, with a peak during December first week (49 thstandard week) (2.47 bugs per hill) and persisted up to harvest (Table 3). Spiders were observed in the field from September first week till the harvest of the crop. Peak population of spiders (4.00 per ten hills) was observed during third week of December. Coccinellid and rove beetles

were observed from third week of September till harvest. Peak population of coccinellids (2.44 per ten hills) and rove beetle (1.44 per ten hills) were observed during third week of November and first week of December, respectively (Table 3).

The correlation and multiple regression analysis revealed that, the pest species such as GLH, BPH, leaf folder and yellow stem borer had showed significant positive correlation with spider incidence with a correlation coefficient (r) of 0.76, 0.92, 0.93 and 0.85 respectively (Table 4). Incidence of coccinellid indicated positive correlation with GLH (r = 0.87), BPH (r = 0.94), leaf folder (r = 0.78) and stem borer (r = 0.94). Rove beetle population showed significant positive correlation with GLH (r = 0.88), BPH (r = 0.92) and stem borer (r = 0.90), but the influence of leaf folder was not significant. Impact of ear head bug population on the incidence of natural enemy was not significant. The results of multiple regression analysis showed R^2values of 0.98, 0.95 and 0.93 indicating that 98, 95 and 93 per cent influence on spider, coccinellid and rove beetle population by availability of pest species (Table 4). The multiple regression equation fitted with pest species to predict the natural enemy population in the field is

$$Y_1 = 0.22 + 0.08\ X_1 + 0.13\ X_2 + 0.10\ X_3 + 0.01\ X_4$$

$$Y_2 = -0.10 - 0.09\ X_1 + 0.16\ X_2 - 0.01\ X_3 + 0.21\ X_4$$

$$Y_3 = -0.07 + 0.03\ X_1 + 0.07\ X_2 + 0.06\ X_4$$

Where, Y_1– population of spider, Y_2– population of coccinellid, Y_3– population of rove beetle, X_1– population of GLH, X_2– population of BPH, X_3– population of leaf folder and X_4– population of yellow stem borer.

Table 4. Correlation and multiple regression analysis of the relationship between major pests and natural enemies of high altitude rice

Insect	Spider	Coccinellid	Rove beetles
	Correlation coefficient		
Green leaf hopper	0.76*	0.87*	0.88*
Brown plant hopper	0.92**	0.94**	0.92**
Leaf folder	0.93**	0.78*	0.63^{NS}
Yellow stem borer	0.85*	0.94**	0.90**
Ear head bug	0.73^{NS}	0.68^{NS}	0.57^{NS}
	Multiple regression analysis		
Green leaf hopper$^{@}$	0.08 ± 0.13	-0.09 ± 0.13	0.03 ± 0.07
Brown plant hopper$^{@}$	0.13 ± 0.09	0.16 ± 0.09	0.07 ± 0.05
Leaf folder$^{@}$	0.10 ± 0.02	-0.01 ± 0.02	-
Yellow stem borer$^{@}$	0.01 ± 0.09	0.21 ± 0.09	0.06 ± 0.07
Constant "a"	0.22	-0.10	-0.07
R^2Value	0.98	0.95	0.93

** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level, ^{NS}– Non significant, $^{@}$- Regression coefficient ± Standard error

The results of roving survey in the villages around Gudalur growing rainfed rice revealed that the pest population was low in all the 10 villages. The highest mean GLH population was 2.78 per hill at Ambalavayal village and the lowest population was recorded at Thottamula (0.84 GLH/ hill) (Table 5). The population of BPH was observed in almost all the villages and it varied from 0.49 to 2.58 per hill. Yellow stem borer damage was observed from 0.49 to 1.42 per cent in different villages. However, considerable leaf folder damage of 3.77 to 5.99 per cent was observed in different villages. Spider populations during vegetative phase in the different villages varied from 0.50 to 0.90 per ten hills. Coccinellids, ground beetle and rove beetle population were generally low. Ear head bug was observed in all the villages and the incidence ranged from 0.57 to 1.18 per hill (Table 5).

Table 5. Incidence of rice pests and natural enemies in high altitude rice in Tamil Nadu during *Kharif* 2010 to 2012

Mean of Three replications

Location	GLH (No. / Plant)	BPH (No. / Plant)	LF damage (%)	YSB damage (%)	GH (No. / Plant)	Spider (No. / Plant)	Rove beetle (No. / Plant)	Coccinellid (No. / Plant)	Ground beetle (No./ Plant)	EHB (No. / Plant)
Puliyamparai	2.67	2.58	5.36	0.75	0.17	0.87	0.18	0.35	0.00	1.18
Padanthorai	0.96	0.68	4.92	0.49	0.14	0.78	0.08	0.22	0.01	0.90
Cherumulli	2.34	0.49	4.33	0.94	0.21	0.68	0.16	0.25	0.02	1.50
Thottamula	0.84	1.55	4.99	0.51	0.32	0.87	0.10	0.31	0.15	1.16
putturvayal	0.90	1.40	4.85	0.57	0.14	0.78	0.17	0.23	0.02	0.72
Manvayal	1.76	2.47	3.77	1.42	0.21	0.56	0.03	0.14	0.07	0.86
Srimadurai	1.88	1.61	4.14	0.70	0.24	0.72	0.16	0.23	0.02	1.18
Nugalpula	2.52	2.55	4.23	0.77	0.19	0.57	0.14	0.38	0.01	0.57
Pulpalli	1.45	1.32	5.99	0.80	0.20	0.50	0.15	0.13	0.08	0.90
Ambalavayal	2.78	1.89	5.86	0.46	0.19	0.90	0.09	0.17	0.04	0.86

GLH - Green leaf hopper; BPH - Brown plant hopper; LF - Leaf folder; YSB – Yellow stem borer; GH- Grass hopper; EHB- Ear head bug

The results are in accordance with the reports of Pangtey and Sachan (1982), who observed rice leaf folder, *Cnaphalocrocis medinalis* causing heavy damage during 1979 wet season (June - November) within early September by recording an incidence level of upto 70 per cent. Leaf folder incidence was more in late transplanted crop than in early transplanted crop as reported by Kushwaha and Sharma (1983). Ayyanna and Hamidali (1970) reported that *S.incertulas* emergence had started from second week of September, with a peak activity during the first week of October when the ambient temperature was between 30.6°C and 21.6°C, respectively along with 82.7 per cent relative humidity

on an average. Saroja (1982) reported stem borer damage below the economic threshold (5%) on crops planted in September and from December to June. In India, the outbreak of BPH was recorded in Tamil Nadu, Kerala, Andhra Pradesh, West Bengal, Himachal Pradesh, Uttara Pradesh, Bihar, Haryana and Punjab (Chelliah and Subramaniyam, 1972; Kalode, 1974). The armyworm *Mythimna separata* (Walker) is a sporadic pest and appears in swarms. It generally appears at the ear head stage in November and December months. Basilio and Mochida (1985) observed the incidence of *M. separat*a on paddy at all the growth stages, but the most damaging during level was heading, when they cut rice panicles. Sarkar and Bhattacharjee (1988) reported serious outbreak of rice hispa during 1985 kharif season in Tripura, India. The area of paddy infested by the hispa was to the extent of about 33 per cent. The rice thrips, *Stenochaetothrips biformis* (Bagnall) is distributed throughout south and south east Asia and is considered as a major pest in Bangladesh, China, India, Indonesia, Japan and Srilanka (Nugaliyadde and Heinrichs, 1984). Chatterjee (1987) reported a severe outbreak of rice thrips from West Bengal in September 1986, wherein an estimated 60,000 ha was affected. Banerjee (1961) reported that the maximum activity of paddy ear head bug during August to November on Aman paddy and recorded losses upto 10-40 per cent. Israel and Rao (1961) observed the ear head bug infestation in severe from October to mid November, when the temperature varied from 27-28°C and the relative humidity 80-82.1 per cent.

Amongst the predators, spiders are the most familiar and ubiquitous obligate carnivores, which feed on different types of prey in different cropping systems. The present findings corroborate with the reports of Shivamurthappa (1993) Venkateshalu (1996) and Schoenly *et al.* (1998) from India, and China. The spider populations were 1.43 and 1.94 per hill during vegetative and reproductive stages, respectively. The population increased due to the increase in WBPH population. In India, 76 spider species have been reported from Orissa, Andhra Pradesh (Ghode *et al*.,1985 and Gupta *et el.,*1986) and among them 21 common species belonged to the genera Tetragnatha, Necoscona, Oxyopes and Pardosa. Lua (1985) reported that the density of spiders (Theridiids, Erigonids and Lycosids) in the field was positively correlated with that of *N. lugens*. *Lycosa pseudoannualata* exhibited positive correlation with the hopper population having the regression equation of $Y = - 4.09 + 42.8 X_1 – 3.42 X_2 + 19.7 X_3$(Kaushik *et al.,*1985). The fluctuation of plant hoppers and leaf hoppers population in the rice fields was closely correlated to that of the spiders (Ye and Wang, 1987; Cheng, 1989). Bambaradenyia and Edirisinghe (2001) reported more than 50 per cent of the terrestrial arthropod species in rice fields have been shown to consist of predators with spiders as the dominant predatory group comprising 60 species. Coccinellid beetles are important members of arthropod communities in paddy fields where, they play a valuable role in the biological control of insect pests of rice. Sasaji (1968) studied the fauna of oriental coccinellids in paddy fields and 33 species were recorded, of which seven were predators of BPH. Yasumatsu *et al.* (1975) reported six species of coccinellids in the rice fields of Thailand. Among them *Micropis discolor* Fabr. and *Micropis* sp. were abundant *M. discolor* was also dominant in Malaysia.*Cyrtorhinus lividipennis* Reuter is widely distributed in southeast asia, Australia and the Pacific islands. It preys on eggs, nymphs and adults of rice leaf hoppers and plant hoppers, and has been considered as an effective predator of BPH and GLH (Manjunath *et al.,*1977; Kamal *et al.,*1987). Samal and Misra (1978) reported that the carabid ground beetle *Casnoidea indica* Thunberg predates on an average six nymphs/adults of *N.lugens* daily, leaving behind legs and wings of prey.

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