“RELATIVE ABUNDANCE OF MAJOR INSECT PESTS AND THEIR NATURAL ENEMIES IN DIFFERENT RICE ECOSYSTEM DURING *KHARIF* SEASON”

M. Sc. (Ag.) THESIS

By

YASPAL SINGH NIRALA

DEPATMENT OF ENTOMOLOGY

COLLEGE OF AGRICULTURE

INDIRA GANDHI KRISHI VISWAVIDYALAYA

RAIPUR (C.G.)

2014

“RELATIVE ABUNDANCE OF MAJOR INSECT PESTS AND THEIR NATURAL ENEMIES IN DIFFERENT RICE ECOSYSTEM DURING *KHARIF* SEASON”

THESIS

Submitted to the

Indira Gandhi Krishi Viswavidyalaya,

Raipur

By

YASPAL SINGH NIRALA

IN PARTIAL FULFILMENT OF THE

REQUIRMENTS FOR THE

DEGREE OF

Master of Science

In

Agriculture

(ENTOMOLOGY)

ROLL NO. 15532 **ID NO. 110508051**

JULY, 2014

CERTIFICATE-I

This is to certify that the thesis entitled **"RELATIVE ABUNDANCE OF MAJOR INSECT PESTS AND THEIR NATURAL ENEMIES IN DIFFERENT RICE ECOSYSTEM DURING *KHARIF* SEASON"** submitted in partial fulfilment of the requirements for the degree of **"MASTER OF SCIENCE IN AGRICULTURE"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **YASPAL SINGH NIRALA** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been duly acknowledged by her.

Date: 21/07/2014

Chairman

Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	**(Shri Gajendra Chandrakar)**	
Member	**(Dr. Sanjay Sharma)**	
Member	**(Shri Vikas Singh)**	
Member	**(Dr. Shrikant Chitale)**	
Member	**(Dr. Ravi R. Saxena)**	

CERTIFICATE-II

This is to certify that the thesis entitled **"RELATIVE ABUNDANCE OF MAJOR INSECT PESTS AND THEIR NATURAL ENEMIES IN DIFFERENT RICE ECOSYSTEM DURING *KHARIF* SEASON"** submitted by **YASPAL SINGH NIRALA** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilment of the requirements for the degree of "**M.Sc. (Ag.)**" in the **Department of Entomology** has been approved by the External Examiner and Student's Advisory Committee after oral examination.

Date: 21-8-14

Signature of the External Examiner

(Name Dr. S.A. Dixit)

Major Advisor ____________

Head of the Department ____________

Dean ____________

Director of Instructions ____________

ACKNOWLEDGEMENT

First of all I would like to thank and praise Almighty "God" the most beneficent and merciful, for all his love and blessing conferred upon mankind.

I take this golden opportunity to express my deepest sense of gratitude to the Chairman of my Advisory Committee ***Shri Gagendra Chandrakar****, Assistant Professor, Department of Entomology, for his research insight, valuable guidance, constant encouragement, unique supervision and kind sympathetic attitude, despite his heaviest schedule of work, his helpful, patience, creative guidance has given touch of excellence to this manuscript.*

With extreme pleasure, I extent my heartiest thanks to the members of my Advisory Committee Dr. Sanjay Sharma, Professor, Department of Entomology, Shri Vikas Singh Scientist, Department of Entomology, Dr. Shrikant Chitale, Scientist, Department of Agronomy and R.R. Saxena, Professor Department of Agril. Statistics and Social Science (L) for their excellent guidance, suggestions and regular encouragement during the course of investigation.

I express my sincere and profound gratitude to Dr. V.K. Kosta, Prof. and Head, Department of Entomology for his inspiring suggestions and providing me all the necessary facilities, during my study.

I wish to record my sincere thanks to Dr. S. K. Patil, Hon'ble Vice Chancellor, Dr. J.S. Urkurkar, Director Research Services and Dr. S.S. Shaw, Director of Instructions, Dr.M.P. Thakur, Director Extention Services, Dr.V.K. Kosta,Dean Student Welfare, IGKV, Raipur, Dr.S.R.Patel, Dean, College of Agriculture, Raipur, for their administrative and technical help which facilitated my research work.

I am highly indebted to the teachers of my Department Dr. A.K. Dubey, Dr. V.K. Dubey Dr.Rajiv Gupta, Dr. H.K. Chandrakar, Dr. Shiv.K.Srivastava, Dr. S.K.Srivastava, Dr.Y.K.Yadu, Dr. R.N. Ganguli, Dr. D.K. Rana, Dr. (Smt.) Jaya Laxmi Ganguli, Dr. B.P. Katalam, Shri Navneet Rana, Shri Vikas Singh, Shri P.K. Netam for their constant co-operative suggestion, encouragement and help during my investigation.

I do express my heartiest thanks to Shri R.S. Yadav, Shri D.N. Chandrakar, Shri Kunjulal Sahu, Shri Sankirtan, Shri Babulal, Shri Ghanshyam, Shri Manoj Patel, Shri

Mahadev. Shri Dinesh Sahu, non teaching staff of our department who were always ready to help me during the period of study.

I will be failing in my duties if I don't convey my sincere thanks to my seniors Mangesh sir, Serven sir, Rahul sir, Randeep Kushvaha sir, Harsh sir, Rambihari sir, Tarun sir, Payal mam, Namrata mam, Prashant sir, Ashish Sir, Abhishek sir, P.L. Ahirwar sir, Ghormare Sir, and my batchmates, Sanjay Kumar ghritlahre, Vishvdev, Wadde, Leeladhar, Chandan Gupta, Sevan Das, Jahhar Singh Dahariya, Sonilal, Upendra, Pankaj Nag, Deepika, Surbhi, Alpana, Rakesh mandal, Kishor, Pawn, Nanak, Chandramani, Bhupesh, Yuvraj, Nithish, Satyaprakash, Rakesh, Pritansha, Latesh and Preeti and my juniors, Ghyani, Teju, Bhimeshvari sahu, Sulekha, Monika, Manisha Bhaskar, Manju, Rajesh Patel, Ravindra Patre, Laxmi Kant, Manmohan, Hemkant, Akash, Dhananjay, Yogesh, Birendra, Pankaj, Rupesh, Yeetesh, Nandu, Shimla, Archana, Pooja, Roshni.

I am deeply privileged to express heartfelt thanks to my best friends Sajay Kumar Ghritlahre, Devesh, Devnarayan and Komal Purena who provided me an inner strength and guided me during my entire academic career as to steer up my ambition in a proper way.

For the most important personalities of my life, there aren't enough words to express my gratitude to my parents Mr. Ghanshyam Nirala and Smt. Pushpa Singh Nirala, My Grand father Mr. Prahlad Nirala, My big father Late Mr.Ganpat Nirala, My sister Jyoti, Nilu, Manisha, Vandana and my brother Gautam nirala for their constant encouragement, sincere prayers, expectations and blessings which have always been the most vital source of inspiration and motivation in my life.

I would like to convey my cordial thanks to all those unmentioned persons who helped me directly and indirectly to fulfill my dream come true.

21-7-14

(Yaspal Singh Nirala)

Department of Entomology,
College of Agriculture,
IGKV, Raipur (C.G.)
Date: 21-07-14

CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
%	Per cent
BPH	Brown plant hopper
CW	Case worm
DH	Dead heart
et al.	And other
GB	Gundhi bug
GLH	Green leaf hopper
GT	Grand total
Hrs	Hours
i.e.	That is
IPM	Integrated pest management
LD	Leaf damaged
LF	Leaf folder
LLC	Lowland conventional rice ecosystem
LLO	Lowland organice rice ecosystem
LT	Light trap
mm	milimeter
MNT	Midland normal transplanted rice ecosystem
MSR	Midland system of rice intencification rice ecosystem
NPV	Nuclear polyhedrosis virus
^{O}C	Degree Celsius
OM	Overall mean
PSB	Pink stem borer
r	Correlation coefficient
RH	Relative humidity
SMW	Standard meteorological week
sp.	Species
UDS	Upland direct seeded rice ecosystem
UTP	Upland transplanted rice ecosystem
WBPH	White backed pland hopper
ZZH	Zigzagleaf hopper

Introduction

CHAPTER - I

INTRODUCTION

Rice occupies the prominent place in Indian agriculture. It is the most important staple food crop of the developing world of more than 3 billion people. 'Rice is life'! This has become a worldwide mantra since the International Year of Rice in 2004 (Uphoff 2011). About 90 percent of world rice is produced and consumed in Asia (Anonymous, 2004). Over 1400 insect species attack standing crop and stored rice in the world (Grist and Lever, 1969), while Kalode and Pasalu (1986) reported over 100 species of insect pests attack rice crop at various stages of its growth in India.

Naturally occurring biological control agents have a potential role to play in management of rice pests 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). According to Andrewartha (1961), the scientific study of the distribution and abundance of organisms is termed as ecology. Biodiversity is the species richness in an ecosystem, it provide both opportunity and challenges how ecological communities are affected by human activity and environmental perturbations (Ehrlich & Ehrlich, 1981). Rice fields are very important because they are environmental buffers, they are a dynamic ecosystem that helps balance temperature and wind, it provides a moderating effect on the surroundings (Rogel, 2004). A rice field undergoes three major ecological phases; aquatic, semi-aquatic and a terrestrial dry phase, during a single paddy cultivation cycle (Fernanado, 1995).

Globaly rice agro ecosystems is categorised into five major types: (i) Irrigated rice fields (ii) rainfed rice fields (iii) Deep water rice fields, (iv) Upland rice fields, (v) Tidal water rice fields. The rainfed rice area in the country is about 24.4 m ha with low productivity of less than 980 kg/ha, due to uncertainty of water. It is a fragile ecology and divided into sub ecologies *viz.*, rainfed uplands (plane area and high altitude hill rice), deep water, semi deep water and shallow rainfed (drought prone, lowland favourable and submergence prone) and costal saline rice. In Chhattisgarh there are 5 agro-ecosystems in which rice is cultivated with different practices. These ecosystems are classified mainly on the hydrological characteristics. These ecosystems are: Upland ecosystem, 2. Midland ecosystem, 3. Lowland ecosystem: Drought prone and Lowland favourable, 4. Submergence prone and 5. Irrigated ecosystem: Controlled irrigation and Flood irrigated ecosystem (Annonymous, 2009).

Aerobic rice is direct seeded in non-puddled, non-flooded field requires less water and labour than flooded rice established via transplanting thus aerobic rice system can reduce water application relative to conventionally transplanted system. Rainfed rice is grown under both lowland and upland conditions at the mercy of the monsoon rains. Rainfed lowland rice fields are bunded and get flooded and filled with rainwater for some period of the crop growth. Rainfed upland rice is characterized by dryland conditions without irrigation and usually unbunded fields. Erratic rainfall distribution, brief periods of drought, and flash floods is major production constraints. Rough rice productivity is low in view of several biotic and abiotic and social constraints. Irrigated rice fields, being agronomically managed wetland ecosystems with a high degree of environmental heterogeneity operating on a short temporal scale, harbour a rich and varied fauna (Heckman, 1979).

Conventional rice cultivation has often accomplished high yields and stable crop production, but has been heavily dependent on continuous and excessive inputs of chemical pesticides, which lead to pest resistance, resurgence, pesticide residue, ground water contamination, and risks to human health and animal habitats (Nagata, 1982 and Hirai, 1993) but organic cultivation of rice has been regarded as a sustainable system because it avoids the problems such as “3Rs” (resistance, resurgence and residue) (Regannold *et al.,* 1990). Organic farming is a crop production method respecting the rules of the nature, targated to produce nutritive, healthy and pollution free food. Commitment to protect and preserve nature is a pre-requisite for practicing organic farming. In organic farming, the entire ecosystem (*i.e.* plant, animal, soil, water and microorganisms) is to be protected.

Earlier reports indicated that rice plants grown under SRI method are less susceptible to insect pests and diseases due to their healthy growth (Ngo, 2007). Hence, an attempt was made to assess the insect pest incidence in SRI against conventional methods of rice cultivation and also the impact of SRI on arthropod diversity. The incidence of pests and diseases in SRI crop appears to be influenced by the micro-environment created for plants, starting with younger seedlings, more widely spaced, with less water standing in the field, and later on, having profuse vegetative growth and doing inter cultivation at regular intervals. The resulting rice plants themselves appear to be stronger and more resistant to chewing and sucking insects, perhaps because of the roots’ greater silicon uptake under aerobic soil conditions (David *et al.,* 2005). The physiological and morphological characteristics of rice plants raised under SRI management are significantly different in many respects from non-SRI rice plants, as observed by farmers and by researchers (Thakur *et al*., 2010).

The diversity of upland rice environments gives rise to a more heterogeneous insect fauna compared with the more homogeneous lowlands. A wide array of soil-inhabiting pests -ants, termites etc. common in upland rice cannot tolerate flooding. Insect-vectored virus diseases are rare in upland rice. The less stable upland environment more restricted growing season, smaller area planted, greater drought stress-poses greater problems of survival to insects, which have overcome them by polyphagy, greater longevity, off-season dormancy, and/or dispersal. A rich fauna of natural enemies exists, but they face even greater problems of survival than the pests (Litsinger *et al.,* 1987).

Five species of stem borers are distributed throughout India. Among these, YSB is the most widespread, dominant and destructive pests (Katti *et al*., 2007). White backed plant hopper, *Sogatella furcifera* Horvath is one of the most important rice pests (Watanabe, 1992). With the widespread introduction during the green revolution in the sixties and seventies of fertilizers, of improved varieties and of pesticides to rice crops, leaf and plant hoppers became important pests, most notably the brown planthopper, *Nilaparvata lugens* Stal., whitebacked planthopper, *Sogatella furcifera* Horvath and the green leafhopper, *Nephotettix virescens* Distant. Other herbivores in rice that can be insect pests include the rice gall midge, *Orselia oryzae* Wood-Mason, the rice leaffolder complex of which three have attained pest status: *Cnaphalocrocis medinalis* Guenee, *Marasmia patnalis* Bradley and *M. exigua* Butler, rice bugs, in particular the genus

Leptocorisa, rice hispa, *Dicladispa armigera* Oliver, rice caseworm, *Nymphula depunctalis* Guenee and whorl maggot flies, *Hydrellia* spp. (Pathak & Kahn, 1994).

Natural enemies of rice insect pest include a wide range of predators and parasitoids that are important biological agents. Predation is common among insects and some of the most successful cases of biological control have been possible through predators. Predators include a variety of spiders, and insects such as carabid beetles, coccinellid beetles commonly known as lady bird beetles, aquatic and terrestrial predatory bugs and dragon flies (Heinrichh, 1994). Spiders (Arachnida: Araneae) are often the most ubiquitous and diverse insectivores in terrestrial ecosystems, exhibiting a variety of foraging strategies and prey preferences (Young and Edwards, 1990; Nyffeler *et al.*, 1994). Spiders are potential biological control agents in agroecosystems (Riechert and Bishop, 1990). Rice odonates are beneficial predators that can help control insect pests in rice, so playing a valuable role in the rice ecosystem. The population dynamics of aquatic insects in rice fields such as dragonfly larvae are affected by biotic and abiotic factors (Abu, 1994). Light trap is the ideal tool of pest surveillance. Through light trap adult catches of different paddy insect pests indicates that III week of September to III week of October is the period of maximum activity for major insect pests of rice (Shukla *et al*., 2008).

The internal factors of rice field ecosystem are influenced by two external governing factors i.e., knowledge of the climatic regime and agronomic practices. The climatic factors in turn effect the composition of the biota (organism) as well as the growth of rice plant. Agronomic practices serve as the overriding factor that controls the overall ecology and biodiversity of the rice field ecosystem. Agronomic practices change the physical, chemical and biological condition in the rice ecosystem making them less favorable for certain organisms and temporarily more favorable for others (Bambaradeniya, 2000a;. Simpson *et al*.,1993a). An important principle of integrated pest management is to maximize natural control, therefore, the temporal changes in arthropod abundance, diversity, species richness and community structures are important considerations in designing pest management strategies. Rice field communities may vary with the environment, varieties, cropping patterns, and cultivation practices. It often supports high levels of biodiversity, which play an important role in the agricultural productivity of these systems (Cohen *et al*., 1994). In the context of climate change, it is expected that both the crop in terms of phenology and physiology and the pests in their occurrence and abundance likely to change. Therefore, the present study is formulated to observe the relative abundance of major insect pests and their natural enemies in different rice ecosystem during *kharif* season at Raipur with the following objectives:

Objectives:

1. To study the pest succession in different rice ecosystem during *kharif* season.
2. To record the natural enemies of rice insect pests in different ecosystem during *kharif* season.
3. To monitor the rice insect pests and their natural enemies through light trap collection and correlation with weather parameters during *kharif* season.

Review of Literature

CHAPTER-II

REVIEW OF LITERATURE

The literature pertaining to the objectives envisaged in the previous chapter are presented below. However, literature available on major insect pests and their natural enemies in different rice ecosystem is limited and hence closely related literature are reviewed and presented here under. For the sake of convenience and clarity the review of literature related to **"Relative abundance of major insect pests and their natural enemies in different rice ecosystem during *kharif* season"** has been divided into the following sub headings:

2.1 To study the pest succession in different rice ecosystem during *kharif* season.

2.2 To record the natural enemies of rice insect pests in different ecosystem during *kharif* season.

2.3To monitor the rice insect pests and their natural enemies through light trap collection and correlation with weather parameters during *kharif* season.

2.1 To study the pest succession in different rice ecosystem during *kharif* season.

Litsinger, *et al.*, (1987) studied the ecology, importance and control of insect pests of upland rice. The diversity of upland rice environments gives rise to a more heterogeneous insect fauna compared with the more homogeneous lowlands. A wide array of soil-inhabiting pests common in upland rice cannot tolerate flooding. Insect vectors of virus diseases are rare in upland rice. Small upland rice fields cause concentrations of the more vagile seed pests during ripening. There is no one insect that specializes in upland rice, but yield losses to insects are comparable to those of lowland rice.

Hesler *et al*., (1993) observed that the arthropod fauna of conventional and organic rice fields in California. For 7 major pests, there were no significant differences in abundance or in amount of damage between conventional and organic treatments. However, in 2 organic fields, the combination of high level of infestation by immature *Hydrellia griseola*, an ephydrid leafminer, and low stand densities warranted preventive action to avoid economic loss. Collections revealed a high degree of taxonomic similarity between conventional and organic treatments; species richness did not differ significantly between treatments.

Hidaka (1997) studied the community structure and regulatory mechanism of pest populations in rice paddies cultivated under intensive, traditionally organic and lower input organic farming in Japan. In older traditionally organic rice paddy fields, *Nilaparvata lugens* was uncommon and was controlled by the sedentary nematode parasite, *Agamermis unka*. There were no differences between the intensive paddies and younger traditional paddies. In lower-input organic farming systems *Sogatella furcifera* was much less abundant. Densities of *N. lugens* were similar, but *Agamermis unka* was not present in the lower-input organic systems.

Kamala *et al.,* (2002) recorded new leafhoppers associated with rice ecosystems of Andhra Pradesh, India. Seven leafhoppers, *viz., Austroagallia bifurcata, Cofana unimaculata, Deltocephalus* pruthii, *D. subviridis*, *Balclutha rubrostriata, Orosius orientalis* and *Scaphoideus sabourensis* are reported for the first time to be associated with rice ecosystem in Andhra Pradesh.

Zhimomi and Ao (2011) observed the seasonal abundance of major insect pests and their natural enemies at three different altitudes *viz*. lowland, foothill and upland during September 2002-August 2004. A mean total of 2173.7, 1114.1 and 525.7 of major insect pests were recorded respectively from lowland, foothill and upland rice ecosystems. The major seasonal abundance of the major insect pests was most active from the month of May-November while minimum was recorded mostly during January-March in all the three ecosystems.

Lawanprasert *et al*., (2004) conducted a study to know the comparison between conventional and organic paddy fields in irrigated rice ecosystem at Pathumthani Rice Research Center and Ratchaburi Rice Research Center. The results showed that there was a difference in rice yield and arthropod population between conventional and organic paddy fields. The results obtained at Ratchaburi Rice Research Center indicated that the rice variety LPT123 was suited for organic paddy fields in irrigated rice ecosystem. It was found that organic rice production helped improve the quality of the ecosystem in rainfed area.

Bambaradeniya *et al.*, (2004) reported the biodiversity associated with an irrigated rice agro-ecosystem. The total number of biota recorded and identified from the rice field ecosystem during the entire study period consisted of 494 species of invertebrates belonging to 10 phyla and 103 species of vertebrates, while the flora included 89 species of macrophytes, 39 genera of microphytes and 3 species of macro fungi of the total species documented, 15 species of invertebrates and one weed species are new records. Arthropods were the dominant group of invertebrates (405 species), of which 55 species were rice pest insects, and 200 species were natural enemies of pest insects.

Kandibane *et al.,* (2005) observed the arthropod guilds in irrigated rice ecosystem, Madurai, Tamil Nadu. Four rice cultivars, i.e. MDU 5, ADT 36, ADT 39 and ADT 43, were grown in weeded (all weeds removed) and partially weeded plots (10 weeds allowed per m^2). A total of 110 taxa comprising 2625 individuals were recorded. Phytophages accounted for more than 60% of the total arthropods in weeded plots, whereas predators and parasitoids accounted for more than 50% of the total arthropods in partially weeded plots. Among the phytophages, Hemiptera showed greater dominance than Lepidoptera, Diptera, Coleoptera and Orthoptera in both ecosystems.

Painkra (2005) studied that the incidence of gall midge, *Orseolia oryzae* Wood Mason in low land rice ecosystem. A preliminary screening of 18 rice cultivar against the gall midge during *kharif*. Cultivars R-979-67-2-44-1, IET-17920, IET-17920, IET-17943, R-703-1-52-1-1, R-657-219-1-2, R-1070-2585-1-1, R-1130-100-1-88-1, R-979-66-1-41-1, R-1124-69-145-1 and Mahamaya (control) were found resistant and 3 cultivars (IRH-5, R-1213-460-2-331-1 and Bamleshwani) were found moderately resistant. Four cultivars (R-1238-1820-1-1, R-114-555-2-1-1, R-1213-320-2-363-1 and Vijeta) were found susceptible.

Padmavathi *et al.*, (2005) conducted the experiments in dry and wet seasons in 2005 and 2006 at Directorate of Rice Research – Ramachandrapuram farm to assess the insect pest scenario in system of rice intensification (SRI) and conventional methods and also impact of SRI on arthropod diversity. Yellow stem borer damage was high at all stages of crop growth period and its damage (dead hearts) at maximum tillering stage was low in cv.Shanti grown under SRI (7.0%) as compared to conventional method (11.4%). At reproductive stage, the damage (white ear heads) was high in SRI (28.3%) than conventional method (21.2%).

Choudhury *et al.,* (2005) observed the effect of establishment techniques on yield, crop water relationship in rice and wheat. The pest incidence data indicated that yellow stem borer damage was high at all stages of crop growth period and its damage (dead hearts) was low under system of rice intensification (SRI) (7.0%) as compared to normal transplanting (NTP) (11.4%). However, at reproductive stage, the damage (white ear heads) of yellow stem borer was high in SRI (28.3%) than NTP (21.2%).

Khan and Mishra (2006) reported that the abundance of arthropod fauna in rice ecosystem. An intensive survey on the abundance of arthropods was made at fortnightly intervals in 6 rice cultivated districts, i.e. Varanasi, Chandauli, Deoria, Basti, Sant Kabirnagar and Siddarthnagar, in Uttar Pradesh, India. A total of 226 arthropod species were recorded. Out of these, 128 species are prey and 98 species are predators.

Kumar *et al*., (2006) observed the influence of organic nutrient sources on insect pests and economics of rice production in India at Directorate of Rice Research, Ramachandrapuram farm with three methods of crop husbandry (SRI, Eco-SRI and Conventional). Five insect pest *viz.*, whorl maggot, hispa, yellow stem borer, leaf folder and green leaf hoppers were observed at different stages of crop growth period. Maximum per cent white ear heads were observed in SRI (12.5%) followed by conventional (8.9%) and ECOSRI (6.2%).

Reddy *et al.*, (2007) observed that the incidence of insect pests and natural enemies as influenced by organic treatments in rice ecosystem at Acharya N.G. Ranga Agricultural University, Warangal, Andhra Pradesh for four years during *kharif*. With regards to insect pests, the lowest percent dead hearts, silver shoots and hoppers were recorded in 100% organic manures+need based plant protection, while highest pest incidence was recorded in 100% recommended doses of fertilisers+no plant protection.

Rajendra (2009) conducted an experiment to know the status of paddy insect pests and their natural enemies in rainfed ecosystem of Uttara Kannada district and management of rice leaf folder. Survey indicates, the paddy gall midge was highest in coastal rice ecosystem, whereas, in upghat drill sown rice ecosystem, (Mundgod) paddy gall midge incidence was zero. The highest leaf folder population was found in upghat transplanted paddy and it was least in coastal rice ecosystem. The per cent dead hearts and per cent white ears due to yellow stem borer was more in upghat drill sown rice and lowest in coastal. Among the sucking insects, the Brown plant hopper was observed from October till harvest of the crop. The highest brown plant hopper population was recorded in drill sown area. However, the populations was zero in coastal throughout the cropping period. The incidence of white backed plant hopper was seen from September till harvest of the crop. The maximum population was recorded during first fortnight of November in Mundgod and zero population in Honnavar. The incidence of ear head bug was 3.87 nymphs and adults per hill in coastal Kumta, being highest and the lowest of 0.75 nymphs and adults per hill in upghat transplanted paddy was recorded during reproductive stage.

Girish (2010) studied on insect pests and their predators in upland rice ecosystem. The blue beetle, leafhopper and horned caterpillar appeared in the vegetative phase of the crop growth and peaked at 60 and 75 days after sowing. Their population was significantly high in drill sown rice, followed by transplanted and least in aerobic method. Leaf folder incidence was low and almost static during vegetative phase and higher incidence and its peak activity was noticed during reproductive phase of the crop. Drill sown crop supported significantly higher population compared to aerobic rice. A meager population of grasshopper was found from 60 days onwards until harvest, without any bearing on the economics of the crop. Similarly the population of yellow stem borer crossed ETL only in aerobic method during reproductive phase of the crop. The earhead bug appeared in mild form without influencing much on yield.

Pathak, *et al.*, (2012) observed that the prevalence of insect pests, natural enemies and diseases in system of rice intensification (SRI) and traditional system of cultivation in North East Region. The pooled results of two cropping seasons revealed prevalence of stem borer was significantly lower in SRI system. The prevalence of blue beetle, case worm, leaf folder and gundhi bug/m^2 were lower in SRI as compared to traditional system.

Zhang, *et al.* (2013) studied that the arthropod biodiversity and community structures of organic rice ecosystems. They collected 114 species of arthropods, which consisted of including 58 species of spiders, 16 species of predatory insects, 25 species of phytophagous insects, 15 species of neutral/other insects, in early season crop. Subsequently they collected 109 species of arthropods, which consisted of 50 species of spiders, 19 species of predatory insects, 24 species of phytophagous insects, and 16 species of neutral/other insects, in the late season crop. There were no significant differences ($P<0.05$) between the arthropod communities of the early and late season rice crops.

2.2 To record the natural enemies of rice insect pests in different ecosystem during *kharif* season.

Rawat and Diwakar (1982) observed that the parasites and predators of insect pests of rice on the *kharif* crop from 1975 to 1980 in the Chhattisgarh region of Madhya Pradesh, India, to assist in the planning of integrated control measures. The natural enemies collected are listed, together with their host or prey species (where known), an indication of their abundance and the years in which they were collected.

Shankar and Baskaran (1986) reported that the relative abundance of three species of egg parasitoids, mymarid *Anagrus optabilis*, the trichogrammatid *Oligosita naias* and the eulophid *Tetrastichus sp.* (egg parasites of the rice pest *Nilaparvata lugens* in Tamil Nadu, overall parasitism averaged 42 per cent.

Watanabe *et al*., (1992) studied the parasitic activities of egg parasitoids on the rice planthoppers, *Nilaparvata lugens* Stal. and *Sogatella furcifera* Horváth (Homoptera: Delphacidae), in the Muda Area of Pennisular Malaysia. Who reported that the *Oligosita* spp. parasitized eggs turn dark yellow and chorion is dark grey and so parasitoids cannot be seen and 5% to 68% parasitism rate and *Anagrus* spp. turns host eggs orange or yellow orange and parasitoids can be seen through the transparent chorion and parasitism rate 20 to 47 per cent in Malaysia.

Salmah *et al.,* (1993) observed the influence of physical and chemical factors on the larval abundance of *Neurothemis tullia* Drury (Odonata:Libellulidae) in a rainfed rice field by collecting larvae and water samples weekly over two seasons of rice planting. The larvae were most abundant during extended periods of continuously plentiful water supply except during flooding. Rapid larval population build-ups were observed soon after chemical applications or spells of dry periods reflecting continual oviposition and hatching of eggs.

Afun *et al.,* (1994) observed that the weeds and natural enemy regulation of insect pests in upland rice; a case study from West Africa in Cote d'Ivoire over two years (1994-95). Ants were the most abundant predators in the rice canopy and were most abundant in unweeded treatments. Abundance of both ants and spiders was significantly positively correlated with weed biomass across treatments. Abundance of reduviid bugs was positively correlated with weed biomass only in 1995.

Debjani and Raghuraman (1998) conducted an experiment to monitor biodiversity of hymenopterous parasitoids in rice agroecosystem in New Delhi, India during the *kharif* season of 1998. A total of 645 hymenopterous parasitoids, belonging to 19 families and 5 superfamilies were recorded. The abundance of the parasitoids in the paddy field was highest in August-October.

Sebastian *et al.,* (2002) studied that the spider fauna of the irrigated rice ecosystem in Central Kerala, India across different elevational ranges high ranges, midland and low land areas in two cropping seasons *viz.,* June-September 2002 and October 2002-February. A total of 1130 individuals belonging to 92 species, 47 genera and 16 families were recorded during the study period. The results showed that species richness and diversity were the highest in Parakkadavu, which is a lowland area. Orb weavers were dominant at all study sites.

Madhukar (2005) conducted an experiment to know the predatory natural enemy complex of rice ecosystem in Vidarbha region of Maharashtra, India in both *kharif* and *rabi* seasons. A predatory natural enemy complex of 23 insects including spiders predating on various stages of insect pests belonging to 7 orders and 18 families was prominently recorded and identified. Out of the 4 species of spiders recorded as non-insect predators, *Lycosa pseudoannulata* was found to be predominant species predating on all types of pests. The abundance of dragonflies, *M. discolor* and *P. fuscipes* was more in rabi than in *kharif* season whereas spiders and ground beetle, *O. indica* were dominant during *kharif* season.

Jayakumar and Sankari (2005) observed that the spider population and their predatory efficiency in different rice establishment techniques (namely Transplantation (T1), System of Rice Intensification (T2), Integrated Crop Management (T3), Drum Sowing (T4), Random Planting (T5) and Seedling Throwing (T6)) in Aduthurai, Tamil Nadu between December 2005 and March 2006. A total of five spiders, namely *Lycosa pseudoannulata, Callitrichia formosana, Tetragnatha javanas, Argiope catenulata* and unidentified *Plexippus species* were identified from all the six different technique plots. Among them, Integrated Crop Management, showed the maximum percentage (20.93%) of spiders, whereas the minimum was observed in Seedling Throwing (8.58%). The population of spiders fluctuated during different days after transplantation (DAT). *Lycosa pseudoannulata* and *Callitrichia formosana* were the maximum during 42 DAT to 53 DAT, while *Argiope catenulata* was predominant from 88 DAT to 113 DAT.

Ameilia *et al.*, (2008) conducted a study to know the abundance and diversity of odonata in Upland Rice Field at Manik Rambung, North of Sumatera. Out of 617 individuals from sub-order Zygopteran and 575 individuals from sub order Anisoperan, then three families and 19 species of adults odonata were identified in upland rice field.

Family Coenagrionidae (Zygoptera) were dominant by *Agriocnemis femina, A. pygmaea*, and *Ischnura senegalensis.* Only *Ictinogomphus acutus* recorded from Gomphidae.

Kumar *et al*., (2008) studied the biodiversity of natural enemies in paddy ecosystem and their seasonal abundance. They reported *Telenomus* sp. parasitizing up to 78.4 on October, while the lowest egg parasitization was found in the 1st fort night of August (6.4%).

Zhong *et al.,* (2010) observed the dynamics of major natural enemies in organic rice fields. The results showed that tetragnathids, theridiidae, *Paederus fuscipes* Curtis, *Apanteles ruficrus* were the dominant species. These major enemies immigrated early into organic rice fields, and the amount was higher than that in conventional farming rice fields.

Kasyanov (2010) conducted an experiment to determine the coccinellid species composition in a rice ecosystem at Krasnodar Krai. A total of 13 coccinellid species were identified and their importance in decreasing the number of wheat aphids was indicated.

Claver and Jaiswal (2012) studied the distribution and abundance of two predatory stink bugs (Pentatomidae: Hemiptera) associated with rice field during August to November 2012 at three locations. The population densities of both the PSB were not uniforms in the rice field, the stink bug *E. furcellata* (15.03%) was found less than *A. spinidens* (84.69%).

2.3 To monitor the rice insect pests and their natural enemies through light trap collection and correlation with weather parameters during *kharif* season.

Isahaque and Rahman (1983) studied on the seasonal abundance of *Scirpophaga incertulas* Walk. at Titabar in Assam, India, by means of light-trap catches. The adult activity occurred throughout the year, with one peak in April and a smaller one in August. Although a high positive correlation was found between moth abundance and temperature, rainfall and relative humidity, hours of sunshine appeared to have no significant effect on *Scirpophaga* populations.

Roy *et al*., (1985) operated three light traps in a rice field to monitor populations of *Tryporyza incertulas* (*Scirpophaga incertulas*). Maximum and minimum temperatures and relative humidity were important factors influencing catches. Activity peaks occurred in late October and, to a lesser extent, in late April.

Rai *et al*., (2002) studied on 26 years light trap catch of green leaf hopper, *Nephotettix virescens* and revealed that there was one peak catches during first fortnight of August in the *kharif* (main) season. The fortnightly mean morning relatively humidity for 15 days (nymphet period) prior to light trap catch has positive effect. The other factors like sunshine hours and rainfall had positive influence respectively on the population catches.

Padhi and Saha (2004) investigated the effect of weather parameters on the population build up of YSB and its fluctuation, monitored daily using a LT. The daily data of weather parameters were collected from 1973-2002. The population builds up of YSB moth in the LT catches showed three major peaks during standard meteorological weeks (SMW) 7, 13 and 19 in the dry season and only one peak during SMW 44 in the wet season.

Krishnaiah *et al*., (2006) revealed that during *kharif* BPH nymphs constituted more than 80% of the field population, which could be predicted from light trap catches. The correlation coefficients between BPH nymphs and BPH brachypterous females' present in the field one or two weeks earlier were high (0.9505 to 0.9709) and significant. Among the weather parameters, minimum temperature and sunshine hours were positively correlated with BPH field population during *rabi*.

Varma *et al*., (2008) showed that among the weather parameters, rainfall of preceding month had shown significant positive influence on BPH light trap population *viz.* rainfall of August vs. BPH of September, rainfall of September vs. BPH of October, rainfall of October vs. BPH of November .Maximum temperature of June had significant negative correlation with BPH of August and Maximum temperature of May had significant positive correlation with BPH of September. Morning relative humidity (RH I) of June had significant negative correlation with BPH of October and November. Since first peak of BPH in *kharif* is noticed during September.

Shamim *et al*., (2009) studied the correlation between WBPH peak population and bright sunshine hours also showed positive significant correlation (r = 0.269), while maximum temperature, minimum temperature, rainfall and relative humidity showed non-significant effect on population build up of both GLH and WBPH. Green leaf hopper attained peak population during 43rd standard meteorological week; whereas white backed plant hopper reached peak population during 39th standard meteorological week and decreased considerably thereafter.

Ahmad *et al.*, (2010) reported that the adults of leaf folder trapped 5 adults/trap during 26th SMW and reached its maximum (45 adults) in 33rd SMW. Correlation coefficient between weather parameters and light trap catches revealed that only mean R.H (r =0.793) and minimum temperature (r =0.513) had a significant positive effect on light trap catch of leaf folder adults.

Sharma *et al.,* (2002) conducted a field experiment at research farm during *Kharif* 2002 and 2003 at Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur to know the seasonal activity of *Sogatella furcifera* H., C*naphalocrocis medinalis* Gen and *Mythimna separata* W. Seasonal activity indicated that major activity period of *Sogatella furcifera* H., C*naphalocrocis medinalis* Gen and *Mythimna separata* W. was confined between August-December. Three to four peaks were observed in case of *S. furcifera, C. medinalis* which indicates completion of 3 generations during main cropping season while highest weekly peaks were observed during third week of September and November in case of *Mythimna separata* .Consistently very high collection of these species in trap catches associated with their higher infestation in field during 2003 compared to 2002. This indicated that higher rainfall, lower mean maximum temperature and higher relative humidity were very favorable weather factors for development of these pest species in the year 2003.

Materials and Methods

CHAPTER-III

MATERIAL AND METHODS

This chapter deals with the concise description of soil, weather conditions, materials used and techniques adopted during the course of investigation. The present study entitled "Relative abundance of major insect pests and their natural enemies in different rice ecosystem during *kharif* season " at the research farm of IGKV, College Of Agriculture Raipur, (C.G.). The experiment was conducted during 2013-14 with the following technical program of the present investigation. The **pest succession** and **record the natural enemies of rice insect pests** was undertaken in different rice ecosystem, *viz.*, upland transplanted rice ecosystem, upland direct seeded rice ecosystem, midland normal transplanted rice ecosystem, midland SRI rice ecosystem, lowland conventional rice ecosystem and lowland organic rice ecosystem during *kharif* season.

Geography:-

Raipur is situated in central-eastern part of Chhattisgarh and lies between 21^{o} 6' North latitude and 18^{o} 36' East longitude with an altitude of 289.56 meters above from the mean sea level. Chhattisgarh State is known as the rice bowl of India because nearly 74-76 per cent area during rainy season is under rice cultivation. This state has three different agro climatic zones viz. Chhattisgarh plain, Bastar plateau and Northern hill region, where rice is predominantly cultivated. In Chhattisgarh plain, there is a lot of soil variability ranging from lateritic (bhata) to sandy loam (matasi), clay loam (dorsa) and clayey (Kanker) soils.

Climate:-

The climate of C.G. state in general is Sub humid type with an average rainfall of about 1300 mm. The monsoon sets in around 10th June in the Southernmost tip of Bastar district and finally extends over the entire area by 25th June. Rainfall during July and August is high (about 350-400 mm) at all places. It occurs till mid September. The maximum temperature reaches at its peak in the month of May (about 42 to 47 ^{o}C). During this period of year, plains area suffer from extreme heating and hot winds, while the mean minimum temperature is in the month of December and January. The variation of temperature ranges from 19.8^{o} C in January to 34.7 ^{o}C in the month of May. Raipur comes under dry moist sub humid regions. It has a seasonal average rainfall of 1325 mm (based on 80 years mean). Nearly 85 per cent of the annual rainfall is received from third week of June to mid of September. The maximum and minimum temperature goes to 46 ^{o}C and 6 ^{o}C, respectively in the months of May and December or January. The present study was carried out with the following main objectives:-

3.1 To study the pest succession in different rice ecosystem during *kharif* season.

3.2 To record the natural enemies of rice insect pests in different ecosystem during *kharif* season.

3.3 To monitor the rice insect pests and their natural enemies through light trap collection and correlation with weather parameters during *kharif* season.

3.1 To study the pest succession in different rice ecosystem during *kharif* season.

The pest succession in different rice ecosystem during *kharif* season was recorded through sweeping net for lepidopterous, hemipterous, coleopterous and dipterous insect pests. A specification of sweep net is 30 cm diameter and 65cm depth. The sampling will be done in morning or late afternoon at the periodic interval. Observations were recorded for insect pests damage symptoms on random plants for internal feeders, foliage feeders and sap suckers. Two sampling methods were adopted at the periodical intervals throughout the crop season:

3.1.1 Sweeping net sampling

3.1 2 Hill based sampling

3.1.1 Sweeping net sampling:

This sampling device is use full for catching immature and adult stages of insect pest present in the different rice ecosystem. The observations on occurrence of major insect pests were recorded by taking total 4 samples from 4 locations in each ecosystem. One sample consisting a 25 sweeps at weekly interval. The insect collected while sampling were shorted, counted and collected, and then transferred to transparent polythin bag which were returned to the laboratory for identification. All samples were collected near the center of the ecosystem, at least 5 m from the edge in order to reduce edge effects.

Experimental details:

- Specification of sweep net - 30 cm diameter and 65 cm depth of net.
- No. of sweep in each sampling – 25 sweeps
- Time of sampling - Morning or late afternoon
- Frequency of observations - weekly interval

3.1. 2 Hill based sampling:

The observations on insect pests occurrence/incidance was recorded on 10 randomly selected hills at four spots (m^2) in each ecosystem (upland direct seeded rice ecosystem, upland transplanted rice ecosystem, midland normal transplanted rice ecosystem, midland SRI rice ecosystem, lowland conventional rice ecosystem and lowland organic rice ecosystem) and averaged to per hill basis separately. Standard procedure was followed to record the observations on the incidence of insect pests of rice

3.1.2.1 Leaf folder:

The damaged leaves and total number of leaves from 10 randomly selected hills at four spots were observed in each ecosystem. The percentage of leaf damage was calculated as follows:

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

3.1.2.2 Stem borer:

Counts were taken on number of dead hearts/white ears and total number of tillers/panicles from 10 randomly selected hills at four spots. The per cent incidence (dead heart/ white ears) was calculated as follows.

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

$$\text{White earhead percent} = \frac{\text{Number of white earheads}}{\text{Total number of panicles}} \times 100$$

3.1.2.3 Rice butterfly, rice skipper, case worm, world maggot and hispa:

The damaged leaves and total number of leaves from 10 randomly selected hills at three spots were observed in each ecosystem. The percentage of leaf damage was calculated as follows.

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

Additional work: Stem borer species composition in different rice ecosystem at Raipur during *kharif* season 2013-14.

The observations were recorded in different rice ecosystem. After harvesting of crop rice stable of one meter area were randomly selected and dissected in each ecosystem. Than type of stem borer larva/pupa inside the tiller i.e., pink stem borer, yellow stem borer etc. were identified. The adult catches observed in the light trap collection were also separated on the basis of external characteristics of species for deciding the species composition.

3.2 To record the natural enemies of rice insect pests in different ecosystem during *kharif* season.

The natural enemies of rice insect pests were recorded in different ecosystem during *kharif* through sweeping net for spiders, coleopterous, hemipterous, hymenopterous, dipterous and other natural enemies. The observation of predator/parasite/parasitoids was recorded from different yrice ecosystem by random sampling during *kharif*, 2013-14. Sweeping net sampling method was adopted at the weekly intervals throughout the crop season:–

Sweeping net sampling:

This sampling device is use full in catching of natural enemies present in the rice ecosystem. The observations on occurrence of important predators like staphylinid beetle, spider, mirid bug, lady bird beetle, carabids, damselfly and dragonfly etc. were recorded by taking 4 samples from 4 locations in each ecosystem. One sample consisting a 25 sweeps at four places. All samples were collected near the center of the ecosystem, at least 5 meter from the edge in order to reduce edge effects. All natural enemies inside the enclosure were collected, and then transferred to transparent polythin bag than sample jars containing 70% ethanol, which were returned to the laboratory for identification. Parasitisation were recorded by collecting the host insects and observed for parasite emergence and also per cent parasitisms were calculated.

The insects got identified from Dr. Ankita Gupta National Bureau of Agriculturally Important Insects (formerly PDBC), Bangalore and pathogens were got identified from Dr. Sanjay Sharma, Professor of Entomology, IGKV, Raipur. The insects and spiders collected from the rice fields were identified and classified into the smallest possible taxa using available keys and guides for the different taxa. Tikader (1987) and Barrion and Litsinger (1994) study was used as a reference for rice pests, their predators and parasitoids. The adult spiders were identified on species level and others on genus or family level using available literature (Tikader, 1987 and Barrion &Litsinger, 1995).

Experimental details: A specification of sweep net is 30 cm diameter and 65cm depth. Number of sweep: 25 weep in each sampling during morning or late ofternoon at weekly interval

Stem borer egg mass parasitisation:

The observations were recorded in the Research farm of IGKV, Raipur Chhattisgarh during *kharif,* 2013-14. For the estimation of parasitism of yellow stem borer, 10 egg masses were randomly collected from the unsprayed field at weekly interval and brought to the laboratory for the emergence of larvae and parasitoids. Each of the egg mass was kept separately in glass vials, which was provided with sufficient moisture to prevent desiccation of larvae and leaf pieces. The vials were covered with cotton and numbered with date. Egg masses were observed every day and were recorded on number of larvae hatched. Based on the no. of emerged larvae and parasitoids the percent egg parasitisms were calculated.

$$\text{Per cent parasitization (egg)} = \frac{\text{Number of parasitoids emerged}}{\text{No of parasitoids emerged + No of larvae hatched}} \times 100$$

Stem borer larval parasitisation:

The observation of larval parasitization were recorded in the experimental field of IGKV, Raipur during *kharif*, 2013-14 by taking different ecosystem of rice *viz*. upland transplanted, midland system of rice intensification (SRI) and lowland conventional rice ecosystem. For stem borer larval parasitization observations the panicles bearing white ears were removed from plant and dissected to see the larvae/pupae present inside. Total 10 plants from each ecosystem were examined for the presence of parasitized or unparasitized larvae at the weekly intervals. The larval parasitization was calculated by the following formulas:

$$\text{Percent parasitization (larvae)} = \frac{\text{Number of parasitized larvae}}{\text{Total number of larvae}} \times 100$$

Brown plant hopper egg mass parasitisation:

The observations on BPH egg parasitization were recorded in the glass/green house of Entomology where mass culturing is continued since last twenty years. The observations were taken from 30 selected eggs batch/group from stem (Variety: TN1) were dissected at weekly interval. Parasitism was determined by eggs colours and confirmed subsequently by identification of emerging adult parasitoids. Other couse of mortality were scored and identified as for as possible (Fowler *et al.,* 1986). The egg mass which was creamy white/white colour are considered as unparasitized eggs and which are yellow orange to orange red (*Anagrus* spp.), lemon yellow and chorion is dark grey to greenish (*Oligosita* spp.) and bright orange to golden colour (*Gonetocerus* spp.) are considered as parasitized eggs. The observations were carried out by counting the total number of egg in egg masses and those having colored egg mass i.e. parasitized eggs. Parasitized eggs were calculated by the number of emerged wasps plus dead larvae and pupae of the parasitoids, and the host eggs were calculated by the number of parasitized eggs plus hatched nymphs and dead eggs. Percentage of parasitism was calculated by the formula:

$$\text{Per cent parasitization of egg mass} = \frac{A + B \times 100}{A+B+C+D}$$

Where A= number of emerged wasps, B = number of dead larvae and pupae, C = number of hatched nymphs and D = number of dead eggs (Sahad, 1982a.)

3.3 To monitor the rice insect pests and their natural enemies through light trap catches and correlation with weather parameters during *kharif* season.

Light trap is a device effective for monitoring and mass trapping of various insects. It works on the principal of phototrophic behaviour of insects. A SM-84 model light trap was stationed permanently at the Research farm of IGKV with a 200 watt ordinary (candy) bulb. It was operated for 12 hours from 6 p.m. to 6 a.m. daily during the crop season to observe the appearance and disappearance of rice insect-pest. The SM-84 light trap is a mechanical device, made up of 24 gauge G.I. sheet consisting a funnel with 50 cm top diameter, four baffle plates made of G.I. sheet measuring 28×12 cm in size were mounted vertically on rim of the funnel, placed in equidistant and projecting towards the centre of the funnel and a rain shade is fitted over the baffle plates. The insect collecting box is made from three trays of G.I. sheet with different three sized mesh (sieve) for separating insects. Insects were attracted towards the artificial light and they attack the bulb as well as baffle plates and drop down in the collection box through the funnel and died due to presence of fumigating effect of Dichlorovos insecticide. These trapped insects were collected and sorted out in laboratory every day in the morning. The collection was kept in a galvanized tray measuring 30×45 cm and sorted by brush, needles and lens. In case of large collection, insects were counted by sampling of one eight of total collection. Weekly total of daily collection were calculated for determining the seasonal activity of each insect according to standard meteorological weeks prescribed by the Agro-meteorological Department, Raipur IGKV (C.G.) were used. The meteorological data on maximum and minimum temperature (^{o}C), morning (maximum) and evening (minimum) relative humidities (%), sunshine hours and rainfall (mm) of each day were obtained from the meteorological observatory of the institute. Correlation analysis was carried out between weather parameters and light trap collection populations during *kharif* season 2013-14 and regression analysis was worked out as per method given by Gomez and Gomez (1985).

Experimental Details:-

- Light trap Model:-SM 84.
- Type of light source: - Candy bulb of 200 watt.
- Name of insect to be observed:-Major insect-pest of rice.
- Frequency of observation: - Daily.

Results and Discussion

CHAPTER-IV

RESULTS AND DISCUSSION

This chapter deals with the brief description of results obtained under different objectives of the experiment entitled, **“**Relative abundance of major insect pests and their natural enemies in different rice ecosystem during *kharif* season**”**. The findings of the present study are compared with the previous findings of the relevant aspects in justified manner to draw a concrete conclusion. The results and discussion are presented here with the following sub headings:-

4.1 To study the pest succession in different rice ecosystem during *kharif* season.

4.2 To record the natural enemies of rice insect pests in different ecosystem during *kharif* season.

4.3 To monitor the rice insect pests and their natural enemies through light trap collection and correlation with weather parameters during *kharif* season.

4.1 To study the pest succession in different rice ecosystem during *kharif* season.

4.1.1 Sweeping net Sampling:

The observations were recorded at 7 days interval right from 20 days after transplanting (30 day after sowing in direct seeded rice) up to crop maturity stage. Studies on pest succession as it was evident by the field occurrence revealed that about several species of rice insect pests were observed to be associated with various stages of the crop in different rice ecosystem at Raipur, Chhattisgarh in Central India during 2013-14. The major group of insects wich attack in both the vegetative stage/ reproductive stage were - stem borer, *Sciropophaga incertulas* Walk., leaf folder, *Cnapholocris medinalis* Guen., caseworm, *Nymphula depunctalis* Guen., horned caterpillar, *Melantis* *leda isemene* Cram., rice skipper, *Pelopidas(Parnara) mathias* Fb., rice sting bug, *Oebalus* spp., ear head bug/gundhi bug, *Leptocorisa acuta* Thunb., hispa, *Dicladispa armigera* Oliv., whorl maggot, *Hydrellia* spp., grass hopper, *Hieroglyphus banian*, white leaf hopper, *Cofana* spp., blue beetle, *Lyphgma pygmoea* Baly, green leaf hopper, *Nephotettix* spp., whitebacked plant hopper, *Sogatella furcifera* Horv., brown plant hopper, *Nilaparvata lugens* Stal. and zigzag leaf hopper, *Recilia dorsalis* Motsch.. Along with this pink stem borer, *Sesamia inference* Walker, cutworm, *Spodoptera mauritiana*, yellow hairy caterpillar, *Psalis pennatula*, termite, *Microtermus* spp. rats and crabs/canker observed as minor or negligible pests.

4.1.1.1 Pest succession of yellow stem borer, *Sciropophaga incertulas* Walker in different rice ecosystem (through sweep net sampling)

First appearance of the stem borer adult was observed from 32 SMW in month of August with 0.25 adult/25 sweeps and disappears after 38 SMW in month of September in upland direct seeded rice ecosystem (UDS). The stem borer adult population was highest in 1st week (36 SMW) of September with a population of 1.00 adult/25 sweeps. The average population varied from 0.00 to 1.00 adult/25 sweeps during rice cropping season (Table 4.1.1.1).

From the data presented in (Table 4.1.1.1) on the population of stem borer adult initiated in the upland transplanted rice ecosystem (UTP) during 1st week (32 SMW) of August with 0.25 adult/25 sweeps and disappears after 39 SMW in month of September. There was an increase in population in subsequent weeks and the highest stem borer (SB) population was recorded in 2nd week (37 SMW) of September with a population of 1.20

adult/25 sweeps. The average population varied from 0.00 to 1.20 adult/25 sweeps during the rice cropping season.

Perusal of data presented (Table 4.1.1.1) on the population of the stem borer adult was observed 33 SMW in month of August with 0.25 adult/25 sweeps and disappears after 40 SMW in month of October in midland normal transplanted rice ecosystem (MNT). The population of stem borer peak in 36 SMW in month of September with a population of 4.25 adult/25 sweeps. The average population varied from 0.00 to 4.25 adult/25 sweeps during the rice cropping season.

The pest stem borer adult started appearing during 32 SMW in month of August with 0.25 adult/25 sweeps and disappears after 41 SMW in month of October in midland SRI rice ecosystem (MSR).The population of stem borer, peak in 38 SMW in month of September with a population of 2.25 adult/25 sweeps. The average population varied from 0.00 to 2.25 adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

Periodical observations of stem borer on rice crop revealed that the adult population initiated in the lowland conventional rice ecosystem (LLC) during 1st week (32 SMW) of August with 0.25 adult/25 sweep and disappears after 42 SMW in month of October. There was an increase in population in subsequent weeks and the peak stem borer population was recorded in 2nd week (37 SMW) of September with a population of 2.00 adult/25 sweeps. The average population varied from 0.00 to 2.00 adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

In the present piece of investigation stem borer adult population noticed in the lowland organic rice ecosystem (LLO) during 2nd week (33 SMW) of August with 0.25 adult/25 sweeps and disappears after 41 SMW in month of October. There was an increase in population in subsequent weeks and the peak stem borer population was observed in 2nd week (37 SMW) of Septeber with a population of 1.75 adult/25 sweeps. The average population varied from 0.00 to 1.75 adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

The status of stem borer population in different rice ecosystems of Raipur during 2013-14 revealed that the maximum population was found from September. Among the ecosystem highest stem borer adult population was recorded in MNT (0.80 adults/25 sweeps) followed by MSR (0.53 adults/25 sweeps), LLC (0.45adults/25 sweeps), LLO (0.33 adults/ 25 sweeps), UDS (0.27 adults/25 sweeps) and UTP (0.23 adults/25 sweeps) (Table 4.1.1.2).

The present findings on the activity of stem borer are in agreement with the observation made by Lawanprasert, *et al.*, (2004) reported that the incidence of stem borer loweest in organic than conventionl cultivation in irrigated rice ecosystem. Adiroubane and Raja (2005) reported that the incidence of stem borer highest in month of August- September. Ngo (2007) and Karthikeyan *et al.*, (2010) also reported that the lower incidence of stem borer in system of rice intensification (SRI) as compare to normal system of cultivation. Garg (2012) observed that the peak activity for most of the rice insect pests during the 2nd fort night of September to 2nd fort night of October in rice ecosystem at Raipur during *kharif* season. On the contary Rajendra (2009) reported that the minimum population of stem borer in upghat drill sown paddy ecosystem as compare to upghat transplanted paddy ecosystem.

4.1.1.2 Pest succession of leaf folder, *Cnapholocris medinalis* Guen. in different rice ecosystem (through sweep net sampling)

Perusal of data presented (Table 4.1.1.1) on the population of the leaf folder, *Cnapholocris medinalis* larvae/adult was noticed during 32 SMW in month of August with 0.75 larvae/adult/25 sweeps and disappears after 39 SMW in month of September in upland direct seeded rice ecosystem (UDS). The leaf folder larvae/adult population was highest in 37 SMW in month of September with a population of 1.00 larvae/adult/25sweeps. The average population varied from 0.00 to 1.00 larvae/adult/25 sweeps during the rice cropping season.

Leaf folder larvae/adult population initiated in the upland transplanted rice ecosystem (UTP) during last week (31 SMW) of July with 0.50 larvae/adult/25 sweeps and disappears after 39 SMW in month of September. There was an increase in population in subsequent weeks and the highest leaf folder population was recorded in 1st week (36 SMW) of September with a population of 3.00 larvae/adult/25 sweeps. The average population varied from 0.00 to 3.00 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

First appearance of the leaf folder larvae/adult was observed 32 SMW in month of August with 0.25 larvae/adult/25 sweeps and disappears after 40 SMW in month of October in midland normal transplanted rice ecosystem (MNT).The larvae/adult population of leaf folder peak in 38 SMW in month of September with a population of 6.00 larvae/adult/25 sweeps. The average population varied from 0.00 to 6.00 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

From the data presented in (Table 4.1.1.1) on the population of leaf folder larvae/adult was recorded during 34 SMW in month of August with 0.50 larvae/adult/25 sweeps and disappears after 41 SMW in month of October in midland SRI rice ecosystem (MSR).The population of leaf folder, peak in 39 SMW in month of September with a population of 8.25 larvae/adult/25 sweeps. The average population varied from 0.00 to 8.25 larvae/adult/25 sweeps during the rice cropping season.

Periodical observations of leaf folder revealed that the larvae/adult population initiated in the lowland conventional rice ecosystem (LLC) during 1^{st} week (36 SMW) of September with 1.00 larvae/adult/25 sweep and disappears after 42 SMW in month of October. There was an increase in population in subsequent weeks and the peak leaf folder population was recorded in last week (39 SMW) of September with a population of 4.00 larvae/adult/25 sweeps. The average population varied from 0.00 to 4.00 adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

In present piece of investigation leaf folder larvae/adult population initiated in the lowland organic rice ecosystem (LLO) during 1^{st} week (32 SMW) of August with 0.50 larvae/adult/25 sweep and disappears after 42 SMW in month of October. There was an increase in population in subsequent weeks and the peak leaf folder population was observed in last week (39 SMW) of September with a population of 3.00 adult/25 sweeps. The average population varied from 0.00 to 3.00 adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

It is concluded that on the basis of seasonal/overall mean the status of leaf folder population in different rice ecosystems of Raipur during 2013-14 revealed that the maximum population was found in September month. Among the ecosystem highest leaf folder larvae/adult population was recorded in MSR (1.17 larvae/adult/25 sweeps) followed by MNT (0.82 larvae/adult/25 sweeps), LLO (0.70 larvae/adult/ 25 sweeps), LLO (0.67 larvae/adult/25 sweeps), UTP (0.54 larvae/adult/25 sweeps) and UDS (0.29 larvae/adult/25 sweeps) (Table 4.1.1.2).

The present findings on the population of leaf folder are in agreement with the observation made by Kraker *et al.*, (1999) who reported that the leaf folder reached at the peak during tillering and booting stage of crop. Lawanprasert, *et al.*, (2004) reported that leaf folder incidence low in organic than the conventional paddy fields in irrigated rice ecosystem at Nakorn Nayok Province in Ratchaburi Rice Research Center. Dogra and Choudhary (2005) reported leaf folder, *Cnaphalocrocis medinalis* reached at the peak during August- September which coincided with the vegetative stage of the plant. Padmavathi *et al.*, (2005) and Rajendra (2009) reported that the leaf folder highest in SRI method as compare to conventional method of rice cultivation and Upghat transplanted as compare to Upghat drill paddy ecosystem, respectivly. On the opposed Girish (2010) reported that the leaf folder appeared 45 days old rice crop (August) and reached its peak at 105 days old rice crop in October month and highest in drill sown as compaired to transplanted method of cultivation.

4.1.1.3 Pest succession of caseworm, *Nymphula depunctalis* Guen. in different rice ecosystem (through sweep net sampling)

First appearance of caseworm, *Nymphula depunctalis* larvae/adult was observed from 32 SMW in month of August with 0.25 larvae/adult/25 sweeps and disappears after 37 SMW in month of September in upland transplanted rice ecosystem (UTP).The larvae/adult population of *N. depunctalis* was highest in 35 SMW of August with 0.50 larvae/adult/25 sweeps. The average population varied from 0.00 to 0.50 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

During course of study the caseworm, *Nymphula depunctalis* larvae/adult was noticed during 31 SMW of July with 0.25 larvae/adult/25 sweeps and disappears after 37 SMW in month of September in midland normal transplanted rice ecosystem (MNT).The adult population of *N. depunctalis*, peak in 35 SMW of August with a population of 1.25 larvae/adult/25 sweeps. The average population varied from 0.00 to 1.25 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

From the data presented in (Table 4.1.1.1) on the succession of caceworm revealed that the larvae/adult population was initiated from 32 SMW in month of August with 0.50 larvae/adult/25 sweeps and disappear after 38 SMW in month of September in midland SRI rice ecosystem (MSR). The maximum population of caseworm found in 35 SMW of August with 1.00 larvae/adult/25 sweeps. The average population varied from 0.00 to 1.00 larvae/adult/25 sweeps during the rice *kharif* season 2013-14.

Periodical observations of caseworm revealed that the larvae/adult population was initiated in the lowland conventional rice ecosystem (LLC) during last week (31 SMW) of July with 0.50 larvae/adult/25 sweep and disappear after 39 SMW in month of October. The peak population of caseworm was recorded in 1st week (36 SMW) of September with 2.00 larvae/adult/25 sweeps. The average population varied from 0.00 to 2.00 adult/25 sweeps during the rice *kharif* season (Table 4.1.1.1).

In present piece of investigation caseworm larvae/adult population was observed in the lowland organic rice ecosystem (LLO) during last week (31 SMW) of July with 0.75 larvae/adult/25 sweeps and disappear after 37 SMW in month of September. There was an increase in population in subsequent weeks and the peak caseworm population was observed in last week (35 SMW) of August with a population of 3.00 adult/25 sweeps. The average population varied from 0.00 to 1.25 adult/25 sweeps during the rice cropping season. Caseworm, *Nymphula depunctalis* adult population was zero in the upland direct seeded rice ecosystem (UDS) during the rice cropping season (Table 4.1.1.1).

It may be stated that on the basis of seasonal mean the status of caseworm, *Nymphula depunctalis* in different rice ecosystems of Raipur during 2013-14 revealed that the maximum population was found in August-September month. Among the ecosystem highest caseworm, *N. depunctalis* adult population was recorded in LLC (0.44 adults/25 sweeps), followed by LLO (0.31 adults/25 sweeps), MNT (0.25 adults/25 sweeps), MSR (0.15 adults/25 sweeps) and UTP (0.11 adults/25 sweeps) (Table 4.1.1.2).

These finding are in conformity with Wahed (1959) reported the incidence of insect in the rice field from July to September. Pulin and Khound (1998) reported that the caseworm incidence was greatest during the vegetative stage of the crop, infestation started two weeks after transplanting and peak infestations in terms of cut leaves and larvae were recorded 4-5 weeks after transplanting. Devid *at al*., (2005) and Ngo (2007) reported that the caseworm SRI had low pest incidence than normal transplanting (NTP). Karthikeyan *et al*., (2010) reported that the caseworm lower in SRI method than standard system of cultivation in rice ecosystem. Zhimomi and Ao (2011) reported that the major insect pests of rice highest in lowland as compared to upland paddy ecosystem.

4.1.1.4 Pest succession of horned caterpillar, *Melantis leda isemene* Cram. in different rice ecosystem (through sweep net sampling)

From the data presented in (Table 4.1.1.1) on the population of horned caterpillar, *Melantis leda isemene* larvae/adult was started during 32 SMW in month of August with

0.50 larvae/adult/25 sweeps and disappears after 40 SMW in month of October in upland direct seeded rice ecosystem (UDS).The horned caterpillar, larvae/adult population highest in 37 SMW in month of September with a population of 3.75 larvae/adult/25 sweeps. The average population varied from 0.00 to 3.75 larvae/adult/25 sweeps during the rice cropping season.

In present piece of investigation caseworm larvae/adult population horned caterpillar, *Melantis leda isemene* larvae/adult population initiated in the upland transplanted rice ecosystem (UTP) during 2nd week (33 SMW) of August with 0.25 larvae/adult/25 sweeps and disappears after 40 SMW in month of October. There was an increase in population in subsequent weeks and the highest *Melantis leda isemene* population was recorded in last week (35 SMW) of August with a population of 2.25 larvae/adult/25 sweeps. The average population varied from 0.00 to 2.25 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

First appearance of the horned caterpillar, *Melantis leda isemene* larvae/adult was observed on 32 SMW in month of August with 1.25 larvae/adult/25 sweeps and disappears after 39 SMW in month of September in midland normal transplanted rice ecosystem (MNT). The larvae/adult population of *Melantis leda isemene*, peak in 39 SMW in month of September with a population of 3.25 larvae/adult/25 sweeps. The average population varied from 0.00 to 3.25 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

Weekly observations of the horned caterpillar, *Melantis leda isemene* revealed that the larvae/adult was initiated during 32 SMW in month of August with 1.00 larvae/adult/25 sweeps and disappears after 40 SMW in month of October in midland

SRI rice ecosystem (MSR). The population of horned caterpillar, *Melantis leda isemene* peak in 38 SMW in month of September with a population of 2.00 larvae/adult/25 sweeps. The average population varied from 0.00 to 2.00 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

Horned caterpillar, *Melantis leda isemene* larvae/adult population initiated in the lowland conventional rice ecosystem (LLC) during 3rd week (34 SMW) of August with 1.00 larvae/adult/25 sweep and disappears after 44 SMW in month of October. There was an increase in population in subsequent weeks and the peak horned caterpillar, *Melantis leda isemene* population was recorded in 2nd week (37 SMW) of September with a population of 4.50 larvae/adult/25 sweeps. The average population varied from 0.00 to 4.50 larvae/adult/25 sweeps during *kharif* season (Table 4.1.1.1).

Perusal of data presented (Table 4.1.1.1) on the succession of horned caterpillar, *Melantis leda isemene* larvae/adult initiated in the lowland organic rice ecosystem (LLO) during last week (31 SMW) of July with 0.25 larvae/adult/25 sweep and disappears after 41 SMW in month of October. There was an increase in population in subsequent weeks and the peak horned caterpillar, *Melantis leda isemene* population was observed in last week (39 SMW) of September with a population of 7.00 larvae/adult/25 sweeps. The average population varied from 0.00 to 7.00 larvae/adult/25 sweeps during the rice cropping season.

It is relatively clear, that the status of horned caterpillar, *Melantis leda isemene* on the basis of overall mean in different rice ecosystems of Raipur revealed that the maximum population was found in August-September month. Among the ecosystem highest horned caterpillar, *M. leda isemene* larvae/adult population was recorded in LLO

(1.86 larvae/adult/25 sweeps), followed by LLO (1.44 larvae/adult/25 sweeps), UDS (0.98 larvae/adult/25 sweeps), UTP (0.70 larvae/adult/25 sweeps), MNT (0.64 larvae/adult/25 sweeps) and MSR (0.53 larvae/adult/25 sweeps) (Table 4.1.1.2).

Similar finding were reported by Chander, (1998) the damage caused by *M. leda ismene* was greatest during vegetative stage of the crop. Zhimomi and Ao, (2011) reported that the seasonal abundance of major insect pests was high in lowland followed by foothill and upland. Kumar and Patil (2004) reported horned caterpillar as minor pests and active at the tillering stage of the crop. Lawanprasert, *et al.*, (2004) reported that the pests found in the organic paddy fields were higher than the conventional paddy fields in Pathumthani Rice Research Center. Mahender *et al*., (2005) reported that the incidence of pests low in SRI as compared to the normal transplanting (NTP). Girish (2010) reported that the horned caterpillar appeared August (vegetative phase), reached its peak at Agust to September and highest population was recorded in drill sown rice, followed by transplanted and aerobic method in upland rice ecosystem. On contrary Rajendra (2009) reported that the incidence of *M. leda isemene* high in upghat transplanted as compared to upghat drill sown rainfed paddy ecosystem.

4.1.1.5 Pest succession of rice skipper, *Pelopidas (Parnara) mathias* Fb. in different rice ecosystem (through sweep net sampling)

First appearance of the rice skipper, *P.mathias* larvae/adult was observed on 34 SMW of August with 0.50 larvae/adult/25 sweeps and disappears after 38 SMW of September in upland direct seeded rice ecosystem (UDS). The larvae/adult population of rice skipper, *P.mathias* highest in 37 SMW of September with a population of 2.25

larvae/adult/25 sweeps. The average population varied from 0.00 to 2.25 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

Pelopidas (Parnara) mathias larvae/adult population initiated in the upland transplanted rice ecosystem (UTP) during 3rd week (34 SMW) of August with 0.25 larvae/adult/25 sweeps and disappears after 40 SMW of October. There was an increase in population in subsequent weeks and the highest rice skipper population was recorded in 1st week (36 SMW) of September with a population of 1.75 larvae/adult/25 sweeps. The average population varied from 0.00 to 1.75 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

It is evident from the data (Table 4.1.1.1) the rice skipper *P. mathias* larvae/adult was started on 32 SMW of August with 0.25 larvae/adult/25 sweeps and disappears after 39 SMW of September in midland normal transplanted rice ecosystem (MNT).The larvae/adult population of rice skipper peak in 35 SMW of August with a population of 2.50 larvae/adult/25 sweeps. The average population varied from 0.00 to 2.50 larvae/adult/25 sweeps during the rice cropping season.

Results revealed that, the rice skipper *Pelopidas (Parnara) mathias* larvae/adult was started during 34 SMW of August 0.25 larvae/adult/25 sweeps and disappears after 39 SMW of September in midland SRI rice ecosystem (MSR).The population skipper reached peak at 39 SMW of September with a population of 2.00 larvae/adult/25 sweeps. The average population varied from 0.00 to 2.00 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

Initial population of rice skipper, *P. mathias* was very low started appearing in the lowland conventional rice ecosystem (LLC) during 3rd week (34 SMW) of August with

0.75 larvae/adult/25 sweep and disappears after 45 SMW in month of October. The peak rice kipper population was recorded in last week (39 SMW) of September with a population of 3.00 larvae/adult/25 sweeps. The average population varied from 0.00 to 3.00 larvae/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

The pest was noticed during last week (31 SMW) of July with 0.50 larvae/adult/25 sweep and disappears after 42 SMW in month of October in the lowland organic rice ecosystem (LLO). There was an increase in population of *Pelopidas (Parnara) mathias* in subsequent weeks and reached peak at 3rd week (34 SMW) of August with a population of 2.50 larvae/adult/25 sweeps. The average population varied from 0.00 to 2.50 larvae/adult/25 sweeps during the rice cropping season(Table 4.1.1.1).

It is quite clear, that the adundance of rice skipper, *P. mathias* population in different rice ecosystems of Raipur revealed that, maximum population was found in August-September month. Among the ecosystem based on overall mean highest rice skipper larvae/adult population was recorded LLO (1.11 larvae/adult/25 sweeps), followed by LLO (0.84 larvae/adult/25 sweeps), UTP (0.50 larvae/adult/25 sweeps), MNT (0.48 larvae/adult/25 sweeps), UDS (0.36 larvae/adult/25 sweeps) and midland MSR (0.30 larvae/adult/25 sweeps) (Table 4.1.1.2).

These findings on the relative population of skipper are in agreement with the reports of Zhimomi and Ao (2011) reported that seasonal abundance of major insect pests was high in lowland followed by foothill and upland. Lawanprasert, *et al.,* (2004) reported that the number of insect pests found in the organic paddy fields was higher than the conventional paddy fields in Pathumthani Rice Research Center. Kumar and Patil (2004) reported skipper, (*Parnara guttatus*) as minor pests active at the tillering stage in paddy ecosystem. Mahender *et al*., (2005) recorded that the incidence of pests was low in SRI as compared to the normal transplanting (NTP). Rajendra (2009) also reported that the paddy skipper appeared a month after transplanting (second fortnight of September) till first fortnight of November and highest in upghat transplanted than in drill sown rainfed paddy ecosystem.

4.1.1.6 Pest succession of rice gundhi bug *Leptocorisa acuta* Thunb. in different rice ecosystem (through sweep net sampling)

First appearance of the rice gundhi bug, *Leptocorisa acuta* nymph/adult was observed from 35 SMW in month of August with 0.25 nymph/adult/25 sweeps and remains up to crop harvesting in upland direct seeded rice ecosystem (UDS). The *Leptocorisa acuta* nymph/adult population was highest in 42 SMW of October with a population of 50.00 nymph/adult/25 sweeps. The average population varied from 0.00 to 50.00 nymph/adult/25 sweeps during *kharif* season (Table 4.1.1.1).

Rice gundhi bug, *L. acuta* nymph/adult population initiated in the upland transplanted rice ecosystem (UTP) during 1st week (36 SMW) of September with 0.75 nymph/adult/25 sweeps and remains up to crop harvesting. The highest population of gundhi bug was recorded in 3rd week (42 SMW) of October with a population of 83.75 nymph/adult/25 sweeps. The average population varied from 0.00 to 83.75 nymph/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

Periodical observations, of rice gundhi bug revealed that the nymph/adult was initiated during 36 SMW in month of September with 0.50 nymph/adult/25 sweeps and remain up to crop harvesting in midland normal transplanted rice ecosystem (MNT).The nymph/adult population of *L. acuta*, peak during 40 SMW of October with a population of 20.00 nymph/adult/25 sweeps. The average population varied from 0.00 to 20.00 nymph/adult/25 sweeps (Table 4.1.1.1).

Perusal of data presented (Table 4.1.1.1) on the succession of rice gundhi bug, *L. acuta* revealed that the nymph/adult was started during 36 SMW of September with 0.75 nymph/adult/25 sweeps and remain up to crop harvesting in midland SRI rice ecosystem (MSR). The population of gundhi bug was maximumm in 42 SMW of October with a population of 171.25 nymph/adult/25 sweeps. The average population varied from 0.00 to 171.25 nymph/adult/25 sweeps.

From the data presented (Table 4.1.1.1) on the succession of gundhi bug, *L. acuta*, it was evident that the nymph/adult population initiated in the lowland conventional rice ecosystem (LLC) during 3rd week (38 SMW) of September with 1.00 nymph/adult/25 sweeps and remain up to crop harvesting. The peak gundhi bug, *L. acuta* population was recorded in 3rd week (43 SMW) of October with a population of 121.25 nymph/adult/25 sweeps. The average population varied from 0.00 to 121.25 nymph/adult/25 sweeps during the rice cropping season.

The data presented on the succession of rice gundhi bug *L. acuta* (Table 4.1.1.1) revealed that the nymph/adult population was initiated from 2nd week (37 SMW) of September with 1.50 nymph/adult/25 double sweep and remain up to crop harvesting in the lowland organic rice ecosystem (LLO). There was an increase in population in subsequent weeks and the peak rice gundhi bug population was observed in 1st week (45 SMW) of November with a population of 160.56 nymph/adult/25 sweeps. The average population varied from 0.00 to 160.56 nymph/adult/25 sweeps during the rice cropping season.

Table: 4.1.1.1 Succession of rice insect pests in different rice ecosystem through sweeping net sampling at Raipur during *kharif* season 2013-14

Insect pests	1. Mean population of stem borer at weakly interval																							
Month	July		August					September					October						November					
SMW	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.25	0.25	0.50	0.75	1.75	1.00	0.75	0.25	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	3.75	0.27
UTP	0.00	0.00	0.25	0.00	0.25	0.50	1.00	0.75	1.20	0.00	0.25	2.20	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	3.20	0.23
MNT	0.00	0.00	0.00	0.25	0.75	2.25	3.25	4.25	2.00	1.50	0.75	8.50	0.25	0.00	0.00	0.00	0.00	0.25	0.00	-	0.00	12.00	0.80
MSR	0.00	0.00	0.25	0.00	0.25	0.50	1.00	1.00	1.75	2.25	1.00	6.00	0.75	0.25	0.00	0.00	0.00	1.00	0.00	-	0.00	8.00	0.53
LLC	0.00	0.00	0.25	0.50	1.00	1.00	2.75	1.25	2.00	1.00	0.00	4.25	0.00	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.00	7.25	0.45
LLO	0.00	0.00	0.00	0.25	0.25	0.75	1.25	1.00	1.75	1.00	0.00	3.75	0.00	0.25	0.00	0.00	0.00	0.25	0.00	0.00	0.00	5.25	0.33
	2. Mean population of leaf folder at weakly interval																						
UDS	0.00	0.00	0.75	0.25	0.50	0.00	1.50	0.25	1.00	0.75	0.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	4.00	0.29
UTP	0.50	0.50	0.00	0.25	0.00	1.00	1.25	3.00	1.75	0.75	0.25	5.75	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	7.50	0.54
MNT	0.00	0.00	0.25	0.00	0.25	0.00	0.50	0.25	0.25	6.00	4.25	10.75	1.00	0.00	0.00	0.00	0.00	1.00	0.00	-	0.00	12.25	0.82
MSR	0.00	0.00	0.00	0.00	0.50	0.25	0.75	0.75	2.00	3.00	8.25	14.00	2.50	0.25	0.00	0.00	0.00	2.75	0.00	-	0.00	17.50	1.17
LLC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	2.00	4.00	8.00	1.50	0.50	1.25	0.00	0.00	3.25	0.00	0.00	0.00	11.25	0.70
LLO	0.00	0.00	0.50	1.25	1.00	1.25	4.00	0.00	0.75	1.75	3.00	5.50	1.00	0.00	0.25	0.00	0.00	1.25	0.00	0.00	0.00	10.75	0.67
	3. Mean population of caseworm at weakly interval																						
UDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00
UTP	0.00	0.00	0.25	0.00	0.25	0.50	1.00	0.25	0.25	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	1.50	0.11
MNT	0.25	0.25	0.00	0.50	0.75	1.25	2.50	0.75	0.25	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	3.75	0.25
MSR	0.00	0.00	0.25	0.25	0.25	1.00	1.75	0.25	0.00	0.25	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	2.25	0.15
LLC	0.50	0.50	0.50	0.75	1.00	1.25	3.50	2.00	0.50	0.25	0.25	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.44
LLO	0.75	0.75	0.25	0.75	1.00	1.25	3.25	0.75	0.25	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.31

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, SMW=Standard meteorological week, - = Crop harvested.

Continue…

Table: 4.1.1.1 Succession of rice insect pests in different rice ecosystem through sweeping net sampling at Raipur during *kharif* season 2013-14

Insect pests	4. Mean population of rice horned caterpillar at weakly interval																							
Month	July		August					September					October						November					
SMW	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.50	0.00	1.00	0.25	1.75	3.25	3.75	2.50	2.25	11.75	0.25	0.00	0.00	0.00	0.00	0.25	-	-	0.00	13.75	0.98
UTP	0.00	0.00	0.00	0.25	0.75	2.25	3.25	1.75	1.00	2.00	1.25	6.00	0.50	0.00	0.00	0.00	0.00	0.50	-	-	0.00	9.75	0.70
MNT	0.00	0.00	1.25	0.00	0.00	1.00	2.25	0.75	1.00	2.25	3.25	7.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	9.50	0.63
MSR	0.00	0.00	1.00	0.25	0.50	0.75	2.50	1.25	1.00	2.00	1.00	5.25	0.25	0.00	0.00	0.00	0.00	0.25	0.00	-	0.00	8.00	0.53
LLC	0.00	0.00	0.00	0.00	1.00	2.00	3.00	3.25	4.50	1.75	1.00	10.50	0.50	1.00	1.25	3.75	3.00	9.50	0.00	0.00	0.00	23.00	1.44
LLO	0.25	0.25	0.75	1.75	1.25	5.00	8.75	2.00	3.50	1.50	7.00	14.00	6.50	0.25	0.00	0.00	0.00	6.75	0.00	0.00	0.00	29.75	1.86
	5. Mean population of rice skipper at weakly interval																							
UDS	0.00	0.00	0.00	0.00	0.50	1.25	1.75	0.25	2.25	0.75	0.00	3.25	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	5.00	0.36
UTP	0.00	0.00	0.00	0.00	0.25	1.50	1.75	1.75	0.75	1.50	1.00	5.00	0.25	0.00	0.00	0.00	0.00	0.25	-	-	0.00	7.00	0.50
MNT	0.00	0.00	0.25	0.00	0.50	2.50	3.25	0.25	1.00	1.00	1.75	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	7.25	0.48
MSR	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.25	0.75	1.25	2.00	4.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	4.50	0.30
LLC	0.00	0.00	0.00	0.00	0.75	0.00	0.75	1.25	1.50	2.00	3.00	7.75	1.00	0.25	0.75	0.50	1.75	4.25	0.75	0.00	0.75	13.50	0.84
LLO	0.50	0.50	1.50	2.00	2.50	2.25	8.25	1.00	1.25	2.25	1.75	6.25	0.75	0.75	1.25	0.00	0.00	2.75	0.00	0.00	0.00	17.75	1.11
	6. Mean population of rice stink bug (rice stink bug and dusky stink bug) at weakly interval																							
UDS	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.50	1.50	2.00	1.75	5.75	1.50	1.00	3.75	2.50	1.25	10.00	-	-	0.00	16.00	1.14
UTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.75	1.00	1.25	3.50	2.50	2.25	18.75	12.50	3.75	39.75	-	-	0.00	43.25	3.09
MNT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.50	1.75	7.50	11.25	4.50	3.75	23.75	26.25	10.00	68.25	12.50	-	12.50	92.00	6.13
MSR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.75	3.75	2.75	1.50	17.50	28.75	15.00	65.50	20.00	-	20.00	89.25	5.95
LLC	0.00	0.00	0.00	0.00	1.00	2.00	3.00	3.25	3.50	1.75	2.25	10.75	0.50	1.00	1.25	3.75	6.25	12.75	0.00	0.00	0.00	26.50	1.66
LLO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.50	2.25	3.00	1.33	0.50	2.00	2.60	3.00	9.43	7.50	20.00	27.50	39.93	2.50

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, SMW=Standard meteorological week, - = Crop harvested

Continue…

Table: 4.1.1.1 Succession of rice insect pests in different rice ecosystem through sweeping net sampling at Raipur during *kharif* season 2013-14

Insect pests	**7. Mean population of rice gundhi bug/ear head bug at weakly interval**																							
Month	July		August					September					October						November					
SMW	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.00	0.00	0.00	0.25	0.25	1.25	1.50	3.75	2.25	8.75	5.00	8.50	50.00	22.50	8.75	94.75	-	-	0.00	103.75	7.41
UTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.50	4.50	4.75	10.50	6.25	8.25	83.75	25.00	0.50	123.75	-	-	0.00	134.25	9.59
MNT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	2.75	10.00	17.50	30.75	20.00	11.75	16.25	5.00	6.25	59.25	8.00	-	8.00	98.00	6.53
MSR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	2.00	6.00	7.75	16.50	9.25	13.75	171.25	64.25	15.00	273.50	11.25	-	11.25	301.25	20.08
LLC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.25	2.25	0.25	4.00	37.50	121.25	76.25	239.25	23.75	21.25	45.00	286.50	17.91
LLO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	3.75	2.25	7.50	4.00	5.50	42.50	87.00	150.0	289.00	160.56	91.25	251.81	548.31	34.27
	8. Mean population of hispa at weakly interval																							
UDS	0.00	0.00	0.00	0.25	0.50	1.00	1.75	0.25	0.25	0.25	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	2.50	0.18
UTP	0.25	0.25	0.25	0.50	1.25	0.75	2.75	0.25	0.00	0.25	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	3.50	0.25
MNT	0.25	0.25	2.00	2.50	1.25	1.00	6.75	0.25	0.50	1.25	0.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	9.50	0.63
MSR	0.00	0.00	0.25	0.25	1.50	1.00	3.00	0.50	0.25	0.25	0.75	1.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	4.75	0.32
LLC	0.00	0.00	0.00	0.25	0.75	1.00	2.00	1.50	1.00	0.50	1.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.38
LLO	0.25	0.25	0.50	0.75	1.75	2.75	5.75	1.25	0.25	0.50	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	0.50
	9. Mean population of whorl maggot at weakly interval																							
UDS	0.00	0.00	0.25	0.00	0.75	1.25	2.25	3.75	2.50	1.00	0.50	7.75	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	10.00	0.71
UTP	0.00	0.00	0.00	0.25	1.50	1.75	3.50	5.00	4.00	1.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	13.50	0.96
MNT	1.50	1.50	1.00	0.00	0.75	1.25	3.00	1.75	6.00	2.75	1.75	12.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	16.75	1.12
MSR	1.00	1.00	0.25	0.50	1.25	1.00	3.00	2.25	1.00	1.75	0.25	5.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	9.25	0.62
LLC	0.50	0.50	4.50	1.75	1.00	5.25	12.50	5.00	10.0	1.50	2.25	18.75	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	32.75	2.05
LLO	0.00	0.00	0.75	1.50	1.25	3.25	6.75	4.75	3.75	2.00	1.50	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.75	1.17

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, SMW=Standard meteorological week, - = Crop harvested

Continue…

Table: 4.1.1.1 Succession of rice insect pests in different rice ecosystem through sweeping net sampling at Raipur during *kharif* season 2013-14

Insect pests	10. Mean population of grass hopper at weakly interval																						
Month	July		August					September					October						November				
SMW	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.25	1.00	1.75	2.25	5.25	4.00	4.25	3.00	1.00	12.25	0.25	0.50	2.00	1.25	0.50	4.50	-	-	0.00	22.00	1.57
UTP	0.00	0.00	0.00	0.25	0.75	0.25	1.25	2.00	2.75	1.50	0.25	6.50	0.50	0.25	0.00	0.00	0.00	0.75	-	-	0.00	8.50	0.61
MNT	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.75	2.00	2.50	0.50	5.75	1.00	0.50	0.00	0.00	0.00	1.50	0.00	-	0.00	7.50	0.50
MSR	0.00	0.00	0.00	0.00	0.25	1.00	1.25	3.00	1.50	0.25	0.00	4.75	0.00	0.00	0.25	0.00	0.00	0.25	0.00	-	0.00	6.25	0.42
LLC	0.50	0.50	0.00	1.50	7.75	1.00	10.25	1.75	4.25	2.25	1.75	10.00	1.50	0.50	3.00	4.00	1.25	10.25	0.00	0.00	0.00	31.00	1.94
LLO	0.00	0.00	0.50	0.75	0.75	1.50	3.50	1.00	3.00	0.50	1.25	5.75	1.25	0.75	0.00	0.00	0.00	2.00	0.00	0.00	0.00	11.25	0.70
	11. Mean population of white hopper at weakly interval																						
UDS	0.00	0.00	0.00	0.00	0.25	0.50	0.75	0.75	0.25	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	1.75	0.13
UTP	0.00	0.00	0.00	0.25	0.25	0.00	0.50	0.50	0.25	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	1.25	0.09
MNT	0.25	0.25	0.00	0.00	0.25	0.00	0.25	0.25	0.50	0.25	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	1.50	0.10
MSR	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.50	0.25	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	1.00	0.07
LLC	0.50	0.50	0.00	0.25	0.00	0.75	1.00	0.25	1.75	0.50	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.25
LLO	0.00	0.00	0.00	0.25	0.25	0.00	0.50	0.50	1.00	0.25	0.00	1.75	0.25	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	2.50	0.16
	12. Mean population of blue beetle at weakly interval																						
UDS	0.25	0.25	0.75	1.00	0.25	0.00	2.00	0.00	0.00	0.25	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	2.50	0.18
UTP	0.25	0.25	0.50	0.00	0.25	0.00	0.75	0.25	0.25	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	1.50	0.11
MNT	0.00	0.00	0.75	0.25	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	1.00	0.07
MSR	0.25	0.25	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.75	0.05
LLC	0.00	0.00	0.25	0.75	0.00	1.00	2.00	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.14
LLO	0.25	0.25	0.00	0.25	0.75	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.08

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, SMW=Standard meteorological week, - = Crop harvested

Continue…

Table: 4.1.1.1 Succession of rice insect pests in different rice ecosystem through sweeping net sampling at Raipur during *kharif* season 2013-14

Insect pests	13. Mean population of green leaf hopper at weakly interval																						
Month	July		August					September					October						November				
SMW	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.25	0.25	0.25	1.00	3.00	3.50	7.75	2.50	2.50	13.00	35.00	53.00	21.25	14.75	10.25	4.00	0.00	50.25	-	-	0.00	111.25	7.95
UTP	0.75	0.75	0.00	2.25	0.00	1.00	3.25	3.50	6.00	9.75	16.00	35.25	53.25	45.00	22.25	13.00	9.00	142.50	-	-	0.00	181.75	12.98
MNT	1.75	1.75	5.50	5.00	2.25	2.50	15.25	3.50	5.75	8.75	19.50	37.50	55.75	76.25	48.00	37.25	22.25	239.50	14.75	-	14.75	308.75	20.58
MSR	0.00	0.00	1.00	0.75	1.50	1.75	5.00	1.00	9.00	25.00	35.00	70.00	45.00	80.25	143.00	24.00	17.25	309.50	19.75	-	19.75	404.25	26.95
LLC	0.00	0.00	1.25	0.75	0.00	0.00	2.00	1.00	4.50	9.75	25.00	40.25	56.75	64.00	131.25	45.00	32.50	329.50	18.25	0.00	18.25	390.00	24.38
LLO	0.50	0.50	3.00	1.75	2.00	4.25	11.00	1.50	4.25	5.00	9.50	20.25	17.75	28.25	63.75	35.00	13.25	158.00	16.25	10.75	27.00	216.75	13.55
	14. Mean population of white backed plant hopper at weakly interval																						
UDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.25	1.25	0.00	0.25	1.25	0.00	0.00	1.50	-	-	0.00	2.75	0.20
UTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	1.00	1.50	1.75	1.00	5.00	8.75	1.25	17.75	-	-	0.00	19.25	1.38
MNT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.00	0.00	1.25	1.00	1.50	4.00	12.00	7.00	25.50	0.00	-	0.00	26.75	1.78
MSR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.50	1.00	4.75	11.25	24.75	42.25	0.00	-	0.00	42.50	2.83
LLC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.00	0.75	7.25	11.75	8.75	28.50	2.50	0.00	2.50	31.25	1.95
LLO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.75	0.00	1.00	1.75	1.25	6.25	2.50	1.25	13.00	0.00	1.00	1.00	15.00	0.94
	15. Mean population of brown plant hopper at weakly interval																						
UDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	1.25	1.50	4.00	1.00	0.25	2.50	3.75	0.00	7.50	-	-	0.00	11.50	0.82
UTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	3.00	5.00	3.50	1.75	1.25	5.00	5.25	16.75	-	-	0.00	21.75	1.55
MNT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	1.00	2.25	4.00	4.75	2.75	8.50	9.25	42.00	67.25	38.25	-	38.25	109.50	7.30
MSR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.75	1.00	2.25	2.00	1.25	0.00	8.75	25.00	37.00	28.00	-	28.00	67.25	4.48
LLC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.00	2.25	5.00	7.25	8.75	23.25	26.25	8.25	34.50	58.00	3.63
LLO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	1.50	2.25	0.25	1.25	10.00	0.25	7.25	19.00	13.25	10.00	23.25	44.50	2.78

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, SMW=Standard meteorological week, - = Crop harvested

Continue…

Table: 4.1.1.1 Succession of rice insect pests in different rice ecosystem through sweeping net sampling at Raipur during *kharif* season 2013-14

Insect pests	**16. Mean population of zigzag leaf hopper at weakly interval**																						
Month	July		August					September					October						November				
SMW	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.50	0.75	0.25	1.00	0.25	2.25	0.00	3.75	-	-	0.00	4.50	0.32
UTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.50	1.00	1.75	0.75	1.25	1.50	2.50	12.75	18.75		-	0.00	20.50	1.46
MNT	0.00	0.00	0.75	0.00	0.00	0.00	0.75	0.50	0.00	0.00	0.00	0.50	3.00	1.50	2.75	0.75	1.25	9.25	8.00	-	8.00	18.50	1.23
MSR	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.50	0.25	0.75	1.00	2.50	1.75	1.25	3.75	1.50	6.25	14.50	19.50	-	19.50	36.75	2.45
LLC	0.00	0.00	0.25	0.00	0.00	0.25	0.50	0.00	0.75	1.00	0.25	2.00	1.25	0.75	2.75	2.00	3.75	10.50	8.25	5.25	13.50	26.50	1.66
LLO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.50	0.25	1.00	0.25	1.00	0.75	1.00	2.75	5.75	0.50	0.00	0.50	7.25	0.45

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, SMW=Standard meteorological week, - = Crop harvested

Table: 4.1.1.2 Overall status of rice insect pests in different rice ecosystem at Raipur during *kharif* season 2013-14

Insect pests	Stem borer	Leaf folder	Case worm	Rice Horned caterpillar	Rice Skipper	Rice stink bug	Whorl Maggot	Hispa	Gundhi bug	Grass hopper	White hopper	Blue beetle	Green leaf hopper	White backed plant hopper	Brown plant hopper	Zigzag leaf hopper
UDS	0.27	0.29	0.00	0.98	0.36	1.14	0.71	0.18	7.41	1.57	0.13	0.18	7.95	0.20	0.82	0.32
UTP	0.23	0.54	0.11	0.70	0.50	3.09	0.96	0.25	9.59	0.61	0.09	0.11	12.98	1.38	1.55	1.46
MNT	0.80	0.82	0.25	0.63	0.48	6.13	1.12	0.63	6.53	0.50	0.10	0.07	20.58	1.78	7.30	1.23
MSR	0.53	1.17	0.15	0.53	0.30	5.95	0.62	0.32	20.08	0.42	0.07	0.05	26.95	2.83	4.48	2.45
LLC	0.45	0.70	0.44	1.44	0.84	1.66	2.05	0.38	17.91	1.94	0.25	0.14	24.38	1.95	3.63	1.66
LLO	0.33	0.67	0.31	1.86	1.11	2.50	1.17	0.50	34.27	0.70	0.16	0.08	13.55	0.94	2.78	0.45

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem.

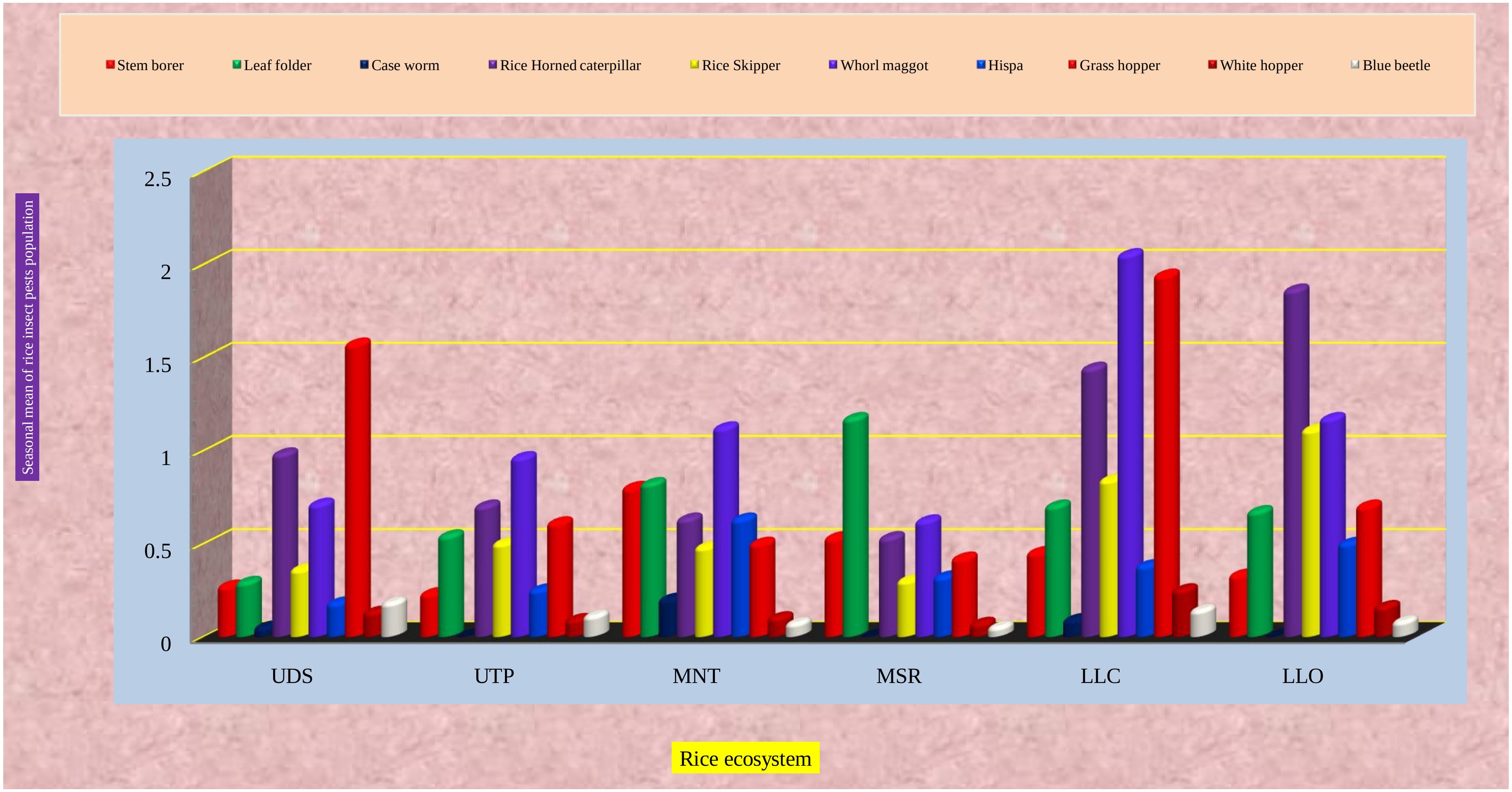

Figure: 4.1.1.2a Overall status of rice insect pests in different rice ecosystem at Raipur during *kharif* season 2013-14

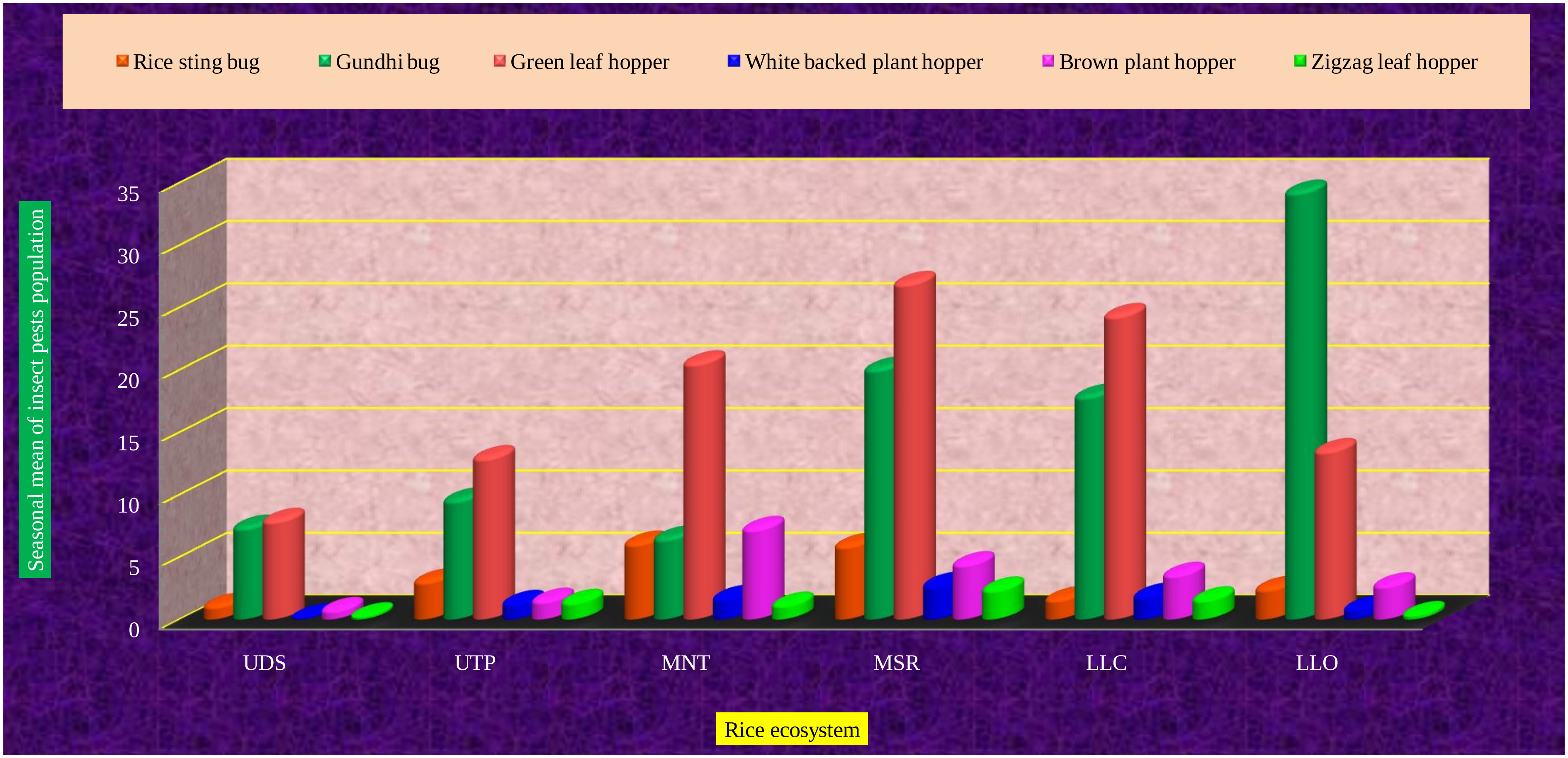

Figure: 4.1.1.2b Overall status of rice insect pests in different rice ecosystem at Raipur during *kharif* season 2013-14

It is concluded that on the basis of week and overall mean the rice gundhi bug, *L.acuta* population in different rice ecosystems of Raipur during 2013-14 revealed that the maximum population was found in October-November month and among the ecosystem highest rice gundhi bug, nymph/adult was recorded in LLO (34.28 nymph/adult/25 sweeps), followed by MSR (20.08 nymph/adult/25 sweeps), LLO (17.91 nymph/adult/ 25 sweeps), UTP (9.59 nymph/adult/25 sweeps), UDS (7.41 nymph/adult/25 sweeps) and MNT (6.53 nymph/adult/25 sweeps) (Table 4.1.1.2).

These finding are in conformity with Banerjee (1961) who reported the maximum activity of paddy ear head bug during August to November and October to mid November, respectivly. Zhimomi and Ao (2011) reported that the seasonal abundance of major insect pests was high in lowland followed by foothill and upland. Lawanprasert *et al.*, (2004) reported that the number of insect pests were highest in the organic paddy fields than the conventional paddy fields in Pathumthani Rice Research Center. David *et al*., (2005) reported that the abundance rice gundhi bug, was equal in both SRI cultivation and conventional cultivation of rice crop. Rajendra (2009) reported that gundhi bug appeared at the reproductive stage of crop and highest population found in upghat transplanted than in drill sown rainfed paddy ecosystem. Girish (2010) reported that gundhi bug population was highest in transplanted method as compared to aerobic rice in upland rice ecosystem in Mugad, Karnataka.

4.1.1.7 Pest succession of rice bug (dusky stink bug, *Euschistus tristigmus* and rice stink bug *Oebalus* spp.) in different rice ecosystem (through sweep net sampling)

Perusal of data presented (Table 4.1.1.1) on the succession of rice bug revealed that the nymph/adult was noticed during 35 SMW of August with 0.25 nymph/adult/25 sweeps and remain up to crop harvesting in upland direct seeded rice ecosystem (UDS). The rice bug nymph/adult population highest on 42 SMW in month of October with a population of 3.75 nymph/adult/25 sweeps. The average population varied from 0.00 to 3.75 nymph/adult/25 sweeps during the rice cropping season.

The data presented on the succession of rice bug revealed that the nymph/adult population initiated in the upland transplanted rice ecosystem (UTP) during 1st week (36 SMW) of September with 0.25 nymph/adult/25 sweeps and remain up to crop harvesting. There was an increase in population in subsequent weeks and the highest rice bug population was recorded in 3rd week (42 SMW) of October with a population of 18.75 nymph/adult/25 sweeps. The average population varied from 0.00 to 18.75 nymph/adult/25 sweeps during the rice cropping season.

From the data presented (Table 4.1.1.1) on succession of rice bug revealed that nymph/adult was started from 36 SMW of September with 0.50 nymph/adult/25 sweeps and remain up to crop harvesting in midland normal transplanted rice ecosystem (MNT). The nymph/adult population of rice bug, was highest during 43 SMW of October with a population of 26.25 nymph/adult/25 sweeps. The average population varied from 0.00 to 26.25 nymph/adult/25 sweeps during the rice cropping season.

First appearance of the rice bug nymph/adult was observed on 37 SMW of September with 1.00 nymph/adult/25 sweeps and remains up to crop harvesting in midland SRI rice ecosystem (MSR).The population of rice bug peak in 43 SMW of October with a population of 28.75 nymph/adult/25 sweeps. The average population varied from 0.00 to 28.75 nymph/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

Rice bug nymph/adult populations initiated in the lowland conventional rice ecosystem (LLC) during 3rd week (34 SMW) of August with 1.00 nymph/adult/25 sweeps and remain up to crop harvesting. There was an increase in population in subsequent weeks and reached peak in 4th week (44 SMW) of October with a population of 6.25 nymph/adult/25 sweeps. The average population varied from 0.00 to 6.25 nymph/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

It is evident from the data (Table 4.1.1.1) the populations of rice bug nymph/adult initiated in the lowland organic rice ecosystem (LLO) during 2nd week (37 SMW) of September with 0.25 nymph/adult/25 sweeps and remain up to crop harvesting. There was an increase in population in subsequent weeks and reached peak during 2nd week (46 SMW) of November with a population of 20.00 nymph/adult/25 sweeps. The average population varied from 0.00 to 20.00 nymph/adult/25 sweeps during the rice cropping season.

It is quite clear, that the status of rice bug population in different rice ecosystems of Raipur during 2013-14 revealed that the maximum nymph/adult population was found in October-November month. Among the ecosystem based overall mean the highest rice bug nymph/adult population was recorded in MNT (6.13 nymph/adult/25 sweeps) followed by MSR (5.91 nymph/adult/25 sweeps), UTP (3.09 nymph/adult/25 sweeps), LLO (2.50 nymph/adult/25 sweeps), LLO (1.66 nymph/adult/ 25 sweeps) and UDS (1.14 nymph/adult/25 sweeps) (Table 4.1.1.2).

These findings on the succession of rice bug are in agreement with Zhimomi and Ao (2002) who reported that the seasonal abundance of major insect pests was high in lowland followed by foothill and upland. Lawanprasert *et al.,* (2004) reported that the incidence of insect pests in the organic paddy fields was higher than the conventional paddy fields in Pathumthani Rice Research Center. Zahirul *et al.*, (2012) reported that the aerobic rice system, invertebrate diversity will probably be lower as compared to irrigated rice.

4.1.1.8 Pest succession of rice hispa, *Dicladispa armigera* Oliv. in different rice ecosystem (through sweep net sampling)

The adult population of rice hispa, *Dicladispa armigera* was initiated in the vegetative stage during 33 SMW of August with 0.25 adult/25 sweeps and disappears after 38 SMW of September in upland direct seeded rice ecosystem (UDS).The highest population of hispa, *D. armigera* adult observed during 35 SMW of August with a population of 1.00 adult/25 sweeps. The average populations varied from 0.00 to 1.00 and overall mean population 0.18 adult/25 sweeps during *kharif* season (Table 4.1.1.1).

The data presented on the succession of rice hispa (Table 4.1.1.1) revealed that the adult population appeared in the upland transplanted rice ecosystem (UTP) from last week (31 SMW) of July with 0.25 adult/25 sweeps and disappears after 38 SMW of September. There was an increase in population in subsequent weeks and the highest hispa population was recorded in 3rd week (34 SMW) of August with a population of 1.25 adult/25 sweeps. The average population ranged from 0.00 to 1.25 adult/25 sweeps during the rice cropping season 2013-14.

The hispa, *Dicladispa armigera* adult started appearing in 31 SMW of July with 0.25 adult/25 sweeps and disappears after 39 SMW of September. The adult population of rice hispa peak in 33 SMW of August with a population of 2.50 adult/25 sweeps. The mean population varied from 0.00 to 2.50 adult/25 sweeps during the rice cropping season in midland normal transplanted rice ecosystem (MNT) (Table 4.1.1.1).

Perusal of data presented (Table 4.1.1.1) on the succession of rice hispa revealed that the adult population was noticed during 32 SMW of August with 0.25 adult/25 sweeps and disappears after 39 SMW of September in midland SRI rice ecosystem (MSR). The pest increased steadily reaching a peak population in 34 SMW of August with 1.50 adult/25 sweeps. The average population varied from 0.00 to1.50 adult/25 sweeps during the rice cropping season.

From the data presented (Table 4.1.1.1) on the succession of hispa, it was evident that the pest was initiated during 33 SMW of August with 0.25 adult/25 sweep and disappears after 39 SMW in month of September in the lowland conventional rice ecosystem (LLC). There was an increase in population in subsequent weeks and the peak rice hispa, *Dicladispa armigera* population was recorded in 1st week (36 SMW) of September with a population of 1.50 adult/25 sweeps. The average population varied from 0.00 to 1.50 adult/25 sweeps during the rice cropping season.

The population of hispa, *Dicladispa armigera* adult was noticed in the lowland organic rice ecosystem (LLO) during 1st week (31 SMW) of July with 0.25 adult/25 sweeps and disappears after 38 SMW in month of September. There was an increase in population in subsequent weeks and the highest hispa, *D.armigera* population was found in 4th week (35 SMW) of August with a population of 2.75 adult/25 sweeps. The mean populations ranged from 0.00 to 2.75 and overall mean population adult/25 sweeps during the *kharif* season 2013-14 (Table 4.1.1.1).

The overall situation of rice hispa, *Dicladispa armigera* adult population in different rice ecosystems of Raipur during 2013-14 revealed that the maximum population was found in August-September month. Among the ecosystem highest hispa, *Dicladispa armigera* adult population (overall mean) was observed in MNT (0.63 adult/25 sweeps) followed by LLO (0.50 adult/25 sweeps), LLC (0.38 adult/ 25 sweeps), MSR (0.32 adult/25 sweeps), UTP (0.25 adult/25 sweeps) and UDS (0.18/ adult/25 sweeps) (Table 4.1.1.2).

These findings are in conformity with Zhimomi and Ao (2011) reported that the seasonal abundance of major insect pests was high in lowland followed by foothill and upland. Lawanprasert *et al.,* (2004) reported that the population of insect pests high in organic field as compared to conventional paddy fields in irrigated rice ecosystem at Nakorn Nayok Province in Pathumthani Rice Research Center. Dogra and Choudhary (2005) reported that hispa, *Dicladispa armigera*, appeared in July and reached at the peak during August- September. Mahender *et al.,* (2005) reported that the incidence of pests low in SRI as compared to the normal transplanting (NTP). Rajendra (2009) reported that the rice hispa appeared in vegetative stage of crop and the highest incidence was observed in upghat transplanted than in drill sown rainfed paddy ecosystem in Uttara Kannada distict (A.P.). Zahirul *et al*., (2012) reported that the invertebrate diversity lower in aerobic rice system as compared to irrigated rice.

4.1.1.9 Pest succession of whorl maggot, *Hydrellia* spp. in different rice ecosystem (through sweep net sampling)

The adult population of whorl maggot, *Hydrellia* spp. was appeared in the vegetative stage during 32 SMW in month of August with 0.25 adult/25 sweeps and disappears after 39 SMW in month of September in upland direct seeded rice ecosystem (UDS).The highest adult population found in August (36 SMW) with 3.75 adult/25 sweeps. The mean population varied from 0.00 to 3.75 adult/25 sweeps during *kharif* season Table 4.1.1.1).

From the data presented (Table 4.1.1.1) on the succession of whorl maggot, *Hydrellia* spp. revealed that the adult population initiated from 1st week (32 SMW) of August with 0.25 adult/25 sweeps and it was not found after 38 SMW in month of September in the upland transplanted rice ecosystem (UTP). The highest population of whorl maggot, *Hydrellia* spp. found in 1st week (36 SMW) of September with 5.00 adult/25 sweeps. The average population varied from 0.00 to 5.00 adult/25 sweeps during the rice cropping season 2013-14.

The data presented on the succession of whorl maggot, *Hydrellia* spp. (Table 4.1.1.1) revealed that the adult population appeared during 31 SMW of July with 1.50 adult/25 sweeps and disappears after 39 SMW in month of September during vegetative stage. The adult population of rice hispa peak in 37 SMW of September with a population of 6.00 adult/25 sweeps. The mean population varied from 0.00 to 6.00 adult/25 sweeps during *kharif* season in midland normal transplanted rice ecosystem (MNT) (Table 4.1.1.1).

The pest whorl maggot adult population was noticed during 31 SMW in month of July with 1.00 adult/25 sweeps and disappears after 39 SMW of September in midland SRI rice ecosystem (MSR). The pest increased steadily reaching a peak with 2.25 adult/25 sweeps in 36 SMW of September. The average population varied from 0.00 to 2.25 adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

Perusal of data presented (Table 4.1.1.1) on the succession of whorl maggot, *Hydrellia* spp. revealed that the adult population initiated during 31 SMW of July with 0.50 adult/25 sweep and disappears after 40 SMW in month of October in the lowland conventional rice ecosystem(LLC). There was an increase in population in subsequent weeks and the peak population of rice whorl maggot was recorded in 2nd week (37 SMW) of September with a population of 10.00 adult/25 sweeps. The average population varied from 0.00 to 10.00 adult/25 sweeps during the rice cropping season.

It is evident from the data (Table 4.1.1.1) that the population of whorl maggot adult was noticed from 1st week (32 SMW) of August with a population 0.75 adult/25 sweeps and disappears after 39 SMW of September in the lowland organic rice ecosystem (LLO). There was an increase in population in subsequent weeks and the highest population was found in 1st week (36 SMW) of September with 4.75 adult/25 sweeps. The mean populations ranged from 0.00 to 4.75 and overall mean population 1.17 adult/25 sweeps during the *kharif* season 2013-14.

The overall status of whorl maggot, *Hydrellia* spp. population in different rice ecosystems of Raipur revealed that the maximum population was found in August-September month. Among the ecosystem highest whorl maggot adult population (overall/seasonal mean) was observed in LLC (2.05 adult/ 25 sweeps), followed by LLO (1.17 adult/25 sweeps), MNT (1.12 adult/25 sweeps), UTP (0.96 adult/25 sweeps), UDS (0.71 adult/25 sweeps) and MSR (0.62 adult/25 sweeps) (Table 4.1.1.2).

The present findings are corroborates with Zhimomi and Ao (2011) who reported the seasonal abundance of major rice insect pests was high in lowland followed by foothill and upland. Lawanprasert *et al.,* (2004) reported that the number of insect pests found in the organic paddy fields was lower than the conventional paddy fields in irrigated rice ecosystem. Prasad and Prasad (2006) reported that the whorl maggot had major economic significance in paddy ecosystem. David *et al*., (2005) reported that the incidence of whorl maggot lower in system of rice intensification (SRI) as compared to normal system of cultivation (NSC). Ravi *et al.*, (2007) and Karthikeyan *et al.*, (2010), Pathak et al., (2012) reported that the incidence of whorl maggot lower in system of rice intensification (SRI) as compared to normal system of cultivation (NSC). On the contrary, Padmavathi *et al*., (2007) reported the SRI plant had more leaves damaged by whorl maggot as compared to conventional cultivation method.

4.1.1.10 Pest succession of rice grass hopper different species in different rice ecosystem (through sweep net sampling)

From the data presented (Table 4.1.1.1) on the succession of grass hopper revealed that the nymph/adult population appeared at vegetative stage during 32 SMW in month of August with 0.25 nymph/adult/25 sweeps and remained up to maturity in upland direct seeded rice ecosystem. The highest population found in 37

SMW of September with 4.25 nymph/adult/25 sweeps. The mean population varied from 0.00 to 4.25 nymph/adult/25 sweeps during *kharif* season.

First appearance of the grass hoppers nymph/adult population was found from 2nd week (33 SMW) of August with 0.25 nymph/adult/25 sweeps and it was not found after 41 SMW in month of October in the upland transplanted rice ecosystem (UTP). The peak population of grass hoppers reached at 2nd week (37 SMW) of September with 2.75 adult/25 sweeps. The average population varied from 0.00 to 2.75 nymph/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

The data presented on the succession of rice of grass hopper (Table 4.1.1.1) revealed that the nymph/adult population was initiated during 35 SMW of August with 0.25 nymph/adult/25 sweeps and disappears after 41 SMW in month of October during vegetative stage. The population of rice grass hopper peak in 38 SMW of September with 2.50 nymph/adult/25 sweeps. The mean population varied from 0.00 to 2.50 nymph/adult/25 sweeps during *kharif* season in midland normal transplanted rice ecosystem (MNT).

Periodical observations, of rice grass hopper revealed that the nymph/adult was noticed during 34 SMW in month of August with 1.00 nymph/adult/25 sweeps and disappears after 42 SMW of October in midland SRI rice ecosystem (MSR). The pest increased steadily reaching a peak 3.00 nymph/adult/25 sweeps in 36 SMW of September. The average population varied from 0.00 to 3.00 nymph/adult/25 sweeps during the rice cropping season Table 4.1.1.1).

Perusal of data presented (Table 4.1.1.1) on the population of grass hopper revealed that the nymph/adult population initiated in the lowland conventional rice ecosystem during 31 SMW of July with 0.50 nymph/adult/25 sweep and disappears after 44 SMW in month of October. The peak population of rice grass hopper was recorded in 3rd week (37 SMW) of August with a population of 7.75 nymph/adult/25 sweeps. The average population varied from 0.00 to 7.75 nymph/adult/25 sweeps during the rice cropping season.

The data presented (Table 4.1.1.1) on the population of grass hopper revealed that the nymph/adult was noticed in the lowland organic rice ecosystem (LLO) during 1st week (32 SMW) of August with a population 0.50 nymph/adult/25 +sweeps and disappears after 41 SMW of October. The highest population was observed in 2nd week (37 SMW) of September with 3.00 nymph/adult/25 sweeps. The mean populations ranged from 0.00 to 3.00 nymph/adult/25 sweeps during the *kharif* season 2013-14.

It is relatively clear, that the grass hopper population in different rice ecosystems of Raipur during 2013-14 revealed that the maximum population was found in August-September month. Among the ecosystem maximum population (overall mean) of grass hopper nymph/adult was observed in LLC (1.94 nymph/adult/25 sweeps), followed by UDS (1.57 nymph/adult/25 sweeps), LLO (0.70 nymph/adult/25 sweeps), UTP (0.61 nymph/adult/25 sweeps), MNT (0.50 nymph/adult/25 sweeps), and MSR (0.42 nymph/adult/25 sweeps) (Table 4.1.1.2).

These finding are in conformity with Zhimomi and Ao (2011) reported that the seasonal abundance of major rice insect pests was high in lowland followed by foothill and upland. Lawanprasert *et al.,* (2004) reported that the population of grass hopper lowest in organic than conventional paddy fields in Ratchaburi Rice Research Center. Mahender *et al*., (2005) reported that the incidence of pests low in SRI as compared to the normal transplanting (NTP). Girish 2010 reported that the grasshopper population starts appearing at late vegetative phase of the crop, attained their peak at September and highest in drill sown than transplanted method in upland rice ecosystem. On the contrary, Padmavathi *et al*., (2007) reported the SRI plant had more leaves damaged by whorl maggot as compared to conventional cultivation method.

4.1.1.11 Pest succession of white leaf hopper, *Cofana* spp. in different rice ecosystem (through sweep net sampling)

It is evident from the data (Table 4.1.1.1) the population of white leaf hopper, *Cofana* spp. adult initiated during 34 SMW in month of August with 0.25 adult/25 sweeps and disappears after 37 SMW in month of September in upland direct seeded rice ecosystem (UDS). The highest population of white leaf hopper, *Cofana* spp. was observed in September (36 SMW) with a population of 0.75 adult/25 sweeps. The average populations varied from 0.00 to 0.75 and overall mean population 0.13 adult/25 sweeps during *kharif* season 2013-14.

Data revealed that the adult population of white leaf hopper, *Cofana* spp. appeared in the upland transplanted rice ecosystem (UTP) from 2nd week (33 SMW) of August with 0.25 adult/25 sweeps and disappears after 37 SMW in month of September. The highest white hopper population was recorded in 1st week (36 SMW) of September with a population of 0.50 adult/25 sweeps. The average population ranged from 0.00 to 0.50 adult/25 sweeps during *kharif* season (Table 4.1.1.1).

Initial population of white leaf hopper, *Cofana* spp. was very low started appearing from 31 SMW of July with 0.25 adult/25 sweeps than it increase and reached peak in 37 SMW of September with a population of 0.50 adult/25 sweeps. The adult population of white leaf hopper disappears after 38 SMW of September with 0.25 adult/25 sweeps. The mean population varied from 0.00 to 0.50 adult/25 sweeps during the rice cropping season in midland normal transplanted rice ecosystem (MNT) (Table 4.1.1.1).

The pest was noticed during 34 SMW in month of August with 0.25 adult/25 sweeps and disappears after 37 SMW of September in midland SRI rice ecosystem (MSR). The pest white leaf hopper, *Cofana* spp. increased steadily reaching a peak population of 0.50 adult/25 sweeps in 34 SMW of September. The average population varied from 0.00 to 0.50 adult/25 sweeps during the *kharif* season (Table 4.1.1.1).

From the data presented (Table 4.1.1.1) on the succession of white leaf hopper, *Cofana* spp. adult initiated in the lowland conventional rice ecosystem (LLC) during 31 SMW of July with 0.50 adult/25 sweep and disappears after 38 SMW in month of September. There was an increase in population in subsequent weeks and the peak white leaf hopper population was observed in 2nd week (37 SMW) of September with a population 1.75 adult/25 sweeps. The average population varied from 0.00 to 1.75 adult/25 sweeps during the rice cropping season.

White leaf hopper *Cofana* spp. adult was noticed on 2nd week (33 SMW) of August with 0.25 adult/25 sweeps and disappears after 40 SMW in month of October. There was an increase in population in subsequent weeks and the highest white hopper *Cofana spp.* population was found in 2nd week (37 SMW) of September with a population of 1.00 adult/25 sweeps. The mean populations ranged from 0.00 to 1.00 and overall mean population 0.15 /25 sweeps during the *kharif* season in the lowland organic rice ecosystem (LLO) (Table 4.1.1.1).

It may be stated that on the basis of seasonal mean, the overall situation of white hopper, *Cofana* spp. population in different rice ecosystems of Raipur revealed that the maximum population was found in September month. Among the ecosystem highest adult population (overall mean) was observed in LLC (0.25 adult/ 25 sweeps) followed by LLO (0.16 adult/25 sweeps), UTP (0.13 adult/25 sweeps), MNT (0.10 adult/25 sweeps), UDS (0.09 adult/25 sweeps) and MSR (0.07 adult/25 sweeps) (Table 4.1.1.2).

These findings are in agreement with Oyediran and Heinrichs (1999) reported that the peak populations occur at 6 WAT (late tillering phase of crop growth) and the populations of *Cofana* species were higher in lowland than in upland fields. Lawanprasert *et al.,* (2004) reported that the lowest persts population in organic fields than conventional paddy fields in Ratchaburi Rice Research Center. Mahender *et al*., (2005) reported that the incidence of pests low in SRI as compared to the normal transplanting. Gangurde (2004) reported that the higher *Cofona spectra* (Cicadellidae) was recorded during the tillering stage and milk stage of the crop in both insecticides treated and untreated irrigated rice production systems of the Philippines in a single season.On the contrary, Sabir *et al*., (2006) reported that the maximum population of white leaf hopper, *Cofana* spp. found in October. Singh and Singh (2010) reported that the white rice leafhopper, *C. spectra* occurs in all rice fields but is most common in rainfed rice and it is minor pest.

4.1.1.12 Pest succession of blue beetle, *Lyphgma pygmoea* Baly in different rice ecosystem (through sweep net sampling)

The blue beetle population (0.25 adult/25 sweeps) first observed on the rice crop during 1st week of July. In subsequent observations, there was gradual increase and reached to the highest blue beetle population (1.00 adult/25 sweeps) during 2nd week of August and gradually declined (0.25 adult/25 sweeps) after 38 SMW at harvest. The blue beetle population ranged from 0.25 to 1.00 adul/25 sweeps was during July to September months in upland direct seeded rice ecosystem (UDS). The overall mean population 0.18 adult/25 sweeps during *kharif* season (Table 4.1.1.1).

Results revealed that the blue beetle, *Lyphgma pygmoea* (0.25 adult/25 sweeps) first noticed on rice crop during last week of July and in subsequent observations, there was an increase in its population. The highest blue beetle population (0.50 adult/25 sweeps) was noticed during 1st week of August, there was gradually declined (0.25 adult/25 sweeps) after 37 SMW at harvest. The population ranged from (0.25 to 0.50 adult/25 sweeps) was noticed during July to September months in the upland transplanted rice ecosystem (UTP) (Table 4.1.1.1).

It is evident from the data (Table 4.1.1.1) the pest started appearing in 32 SMW of August with 0.75 adult/25 sweeps and disappears after 33SMW in month of August during vegetative stage. The blue beetle, *Lyphgma pygmoea* adult populations peak during 32 SMW of August with 0.75 adult/25 sweeps. The mean population varied from 0.00 to 0.75 adult/25 sweeps during the rice cropping season in midland normal transplanted rice ecosystem (MNT) (Table 4.1.1.1).

Perusal of data presented (Table 4.1.1.1) on the succession of blue beetle, *Lyphgma pygmoea* reveled that the adult population was noticed during 31 SMW in month of July with 0.25 adult/25 sweeps and disappears after 33 SMW of September in midland SRI rice ecosystem (MSR). The pest increased steadily reaching a peak population of 0.50 adult/25 sweeps in 33 SMW of August. The average population varied from 0.00 to 0.50 adult/25 sweeps during the rice cropping season.

From the data presented (Table 4.1.1.1) on the succession of blue beetle, *Lyphgma pygmoea* revealed that the adult population initiated in the lowland conventional rice ecosystem (LLC) during 32 SMW of August with 0.25 adult/25 sweep and disappears after 37 SMW in month of September. The peak blue beetle population was recorded in last week (35 SMW) of September with a population of 1.00 adult/25 sweeps. The average population varied from 0.00 to 1.00 adult/25 sweeps during August to September in *kharif* season 2013-14.

Periodical observations of blue beetle, *Lyphgma pygmoea* on rice crop revealed that the adult beetle first appeared with 0.25 adult/25 sweeps during last week of July and reached to its peak population with 0.75 adult/25 sweeps during 3rd week of August in the lowland organic rice ecosystem (LLO). The mean populations ranged from 0.00 to 0.75 and overall mean population 0.08 adult/25 sweeps during the *kharif* season 2013-14 (Table 4.1.1.1).

It is concluded that the blue beetle, *Lyphgma pygmoea* population in different rice ecosystems of Raipur revealed that the maximum population was found in July to August month. Among the ecosystem highest blue beetle, *Lyphgma pygmoea* adult population (overall mean) was observed in UDS (0.18 adult/25 sweeps) followed by LLC (0.14 adult/25 sweeps), UTP (0.11 adult/25 sweeps), LLO (0.08 adult/25 sweeps) MMT (0.07 adult/25 sweeps) and MSR (0.05 adult/25 sweeps) during kharif season (Table 4.1.1.2).

These finding are in conformity with Karticayen *et al.,* (2010) who reported non significant difference between SRI and normal transplanting (NTP) for blue beetle population. Rajendra (2009) reported that the blue beetle *Lyphgma pygmoea* appeared in vegetative stage of crop and the highest incidence was observed in drill sown than in upghat transplanted rainfed paddy ecosystem in Uttara Kannada distict (A.P.). Girish (2010) reported that the blue beetle *Lyphgma pygmoea* appeared 30 day after sowing in month of July, reached peak at 60 DAS in August and highest in drill sown followed by transplanting and aerobic method in upland rice ecosystem in Mugad (A.P.). Pathak *et al.,* (2012) reported that the prevalence of blue beetle lower in SRI as compared to traditional system of cultivation. On the contrary, Karthikeyen *et al.,* (2010) reported that blue beetle population high in SRI as compared to normal transplanting (NTP) in hybrid variety of rice.

4.1.1.13 Pest succession of green leaf hopper, *Nephotettix virescens, N. Nigropictus* Dist in different rice ecosystem (through sweep net sampling)

First appearance of the green leaf hopper, *Nephotettix* spp. nymph/adult was observed 31 SMW in month of July with 0.25 nymph/adult/25 sweeps and despaired after 43 SMW in upland direct seeded rice ecosystem (UDS).The highest nymph/adult population observed during 39 SMW of September with a population of 35.00 nymph/adult/25 sweeps. The average population varied from 0.00 to 35.00 nymph/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

Green leaf hopper, *Nephotettix* spp. nymph/adult population initiated in the upland transplanted rice ecosystem (UTP) during 1st week (36 SMW) of August with 0.75 nymph/adult/25 sweeps and remain up to crop harvesting. The highest rice green leaf hopper population was recorded in 1st week (40SMW) of October with a population of 53.25 nymph/adult/25 sweeps. The average population varied from 0.00 to 53.25 nymph/adult/25 sweeps during *kharif* season (Table 4.1.1.1).

Initial population of green leaf hopper, *Nephotettix* spp. nymph/adult was very low started appearing during 31 SMW of July with 1.75 nymph/adult/25 sweeps than it increase and reached peak in 41 SMW of October with a population 76.25 nymph/adult/25 sweeps. The mean population varied from 0.00 to 76.25 nymph/adult/25 sweeps during the rice cropping season in midland normal transplanted rice ecosystem (MNT) (Table 4.1.1.1).

The pests were noticed from 32 SMW in month of August with 1.00 nymph/adult/25 sweeps and remain up to harvesting in midland SRI rice ecosystem (MSR). Green leaf hopper, *Nephotettix* spp. increased peak with 143.00 nymph/adult/25 sweeps during 42 SMW of October month. The average population varied from 0.00 to 143.00 nymph/adult/25 sweeps (Table 4.1.1.1).

Perusal of data presented (Table 4.1.1.1) on the succession of green leaf hopper, *Nephotettix* spp. revealed that the nymph/adult initiated in the lowland conventional rice ecosystem during 32 SMW of August with 1.25 adult/25 sweep and disappears after 45 SMW in month of November. There was an increase in population in subsequent weeks and the peak population of green leaf hopper, *Nephotettix* spp. was found in 3rd week (42 SMW) of October with 131.25 adult/25 sweeps. The average population varied from 0.00 to 131.25 adult/25 sweeps during the rice cropping season.

Periodical observations of green leaf hopper, *Nephotettix* spp. on rice crop, revealed that the nymph/adult first appeared with 0.50 nymph/adult/25 sweeps during last week of July and reached to its peak population with 63.76 nymph/adult/25 sweeps during 3rd week of October in the lowland organic rice ecosystem (LLO). The mean populations ranged from 0.00 to 63.75 and overall mean population 13.55 nymph/adult/25 sweeps during the *kharif* season 2013-14 (Table 4.1.1.1).

It is crystal clear that the green leaf hopper, *Nephotettix* spp. population was found maximum in September-October months. Among the ecosystem highest population (overall mean) of green leaf hopper, *Nephotettix* spp. nymph/adult was observed in MSR (26.95 nymph/adult/25 sweeps), followed by LLC (24.38 nymph/adult/25 weeps), MNT (20.58 nymph/adult/25 sweeps), LLO (13.55 nymph/adult/25 sweeps), UTP (12.98 nymph/adult/25 sweeps) and UDS (7.95 nymph/adult/25 sweeps) (Table 4.1.1.2).

The present findings corroborates with Lawanprasert *et al.,* (2004) reported that the number of insect pests lower in the organic field than that recorded in the conventional paddy fields in Ratchaburi Rice Research Center. Ravi *et al.,* (2006-08) and Karthikeyan *et al.,* (2010) reported that the green leaf hopper, *Nephotettix* spp. population high in system of rice intensification (SRI) as compared to conventional method of cultivation. Anonymous (2009) reported that the green leaf hopper *Nephotettix* spp. population low in organic rice as compared to inorganic rice fields. Girish (2010) reported that the green leaf hopper population highest in drill sown followed transplanted method and aerobic rice in upland rice ecosystem at Mugad, Karnataka. Shukla *et al.,* (2008), Dogra and Chaudhary (2005), Shamim *et al.,* (2009) and Garg (2012) reported that the peak population of green leaf hopper during October- November, August- September, October (43 SMW) and 2nd fort night of October respectively.

On the contrary, David *et al.,* (2005) and Mahender *et al.,* (2005) reported that the incidence of pests low in SRI as compared to the normal transplanting (NTP).

4.1.1.14 Pest succession of white backed plant hopper, *Sogatella furcifera* Horvath in different rice ecosystem (through sweep net sampling)

The white backed plant hopper, *Sogatella furcifera* (1.00 adult/25 sweeps) first recorded on the rice crop during 2nd week of September. In subsequent observations, there was gradual increase and reached to the highest white backed plant hopper (WBPH) (1.25 adult/25 sweeps) during 3rd week of October and declined at harvest. The *S. furcifera* population ranged from 0.00 to 1.25 adult/25 sweeps was during September to October months in upland direct seeded rice ecosystem (UDS). The overall mean population 0.20 adult/25 sweeps during *kharif* season (Table 4.1.1.1).

The white backed plant hopper, *Sogatella furcifera* (0.50 adult/25 sweeps) first noticed on rice crop during 2nd week of September and in subsequent observations, there was an increase in its population. The highest WBPH, *S. furcifera* population (8.75 adult/25 sweeps) was noticed during 4th week of October, there was gradually declined (1.25 adult/25 sweeps) after 44 SMW at harvest. The population ranged from (0.00 to 8.75 adult/25 sweeps) was noticed during September to October months in the upland transplanted rice ecosystem (UTP) (Table 4.1.1.1).

The pest *S. furcifera* adult started appearing in 36 SMW of September with 1.25 adult/25 sweeps and disappears after 44 SMW in month of October during vegetative stage. The white backed plant hopper, *S. furcifera* adult population peak in 43 SMW of October with a population of 12.00 adult/25 sweeps. The mean population varied from 0.00 to 12.00 adult/25 sweeps during the rice cropping season in midland normal transplanted rice ecosystem (MNT) (Table 4.1.1.1).

Perusal of data presented (Table) on the succession of white backed plant hopper, *Sogatella furcifera* reveled that the adult population was noticed during 38 SMW in month of September with 0.25 adult/25 sweeps and disappears after 44 SMW of October in midland SRI rice ecosystem (MSR). The pest increased steadily reaching a peak population of 24.75 adult/25 sweeps in 44 SMW of October. The average population ranged from 0.00 to 24.75 adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

From the data presented (Table 4.1.1.1) on the succession of white backed plant hopper, *Sogatella furcifera* revealed that the adult population initiated was in the lowland conventional rice ecosystem (LLC) during 38 SMW of September with 0.25 adult/25 sweep and disappears after 45 SMW in month of November. The peak white backed plant hopper, *S. furcifera* population was recorded in 4th week (43 SMW) of October with a population of 11.75 adult/25 sweeps. The average population varied from 0.00 to 11.75 adult/25 sweeps during September to November.

Periodical observations, of white backed plant hopper, *Sogatella furcifera* on rice crop, revealed that the adult WBPH first appeared with 0.25 adult/25 sweeps during 2nd week 37 SMW of September and reached to its peak population with 6.25 adult/25 sweeps during 3rd week 42 SMW of October in the lowland organic rice ecosystem (LLO). The mean populations ranged from 0.25 to 6.25 and overall mean population 0.94 adult/25 sweeps during the *kharif* season (Table 4.1.1.1).

It can be stated that on the basis of seasonal/overall mean the white backed plant hopper, *Sogatella furcifera* population in different rice ecosystems of Raipur revealed that the maximum population was observed in October month. Among the ecosystem highest overall mean of WBPH, *S. furcifera* was observed in MSR (2.83 adult/25 sweeps) followed by LLC (1.95 adult/25 sweeps), MNT (1.78 adult/25 sweeps), UTP (1.38 adult/25 sweeps), LLO (0.94 adult/25 sweeps) and UDS (0.20adult/25 sweeps) (Table 4.1.1.2).

These finding are in conformity with Kajimura *et al.,* (1993) who reported that the population densities of white-backed planthopper, *Sogatella furcifera* Horvath were much lower in an organically farmed than in chemically fertilized rice fields. Zhimomi and Ao (2011) reported that the seasonal abundance of major insect pests was high in lowland followed by foothill and upland. Ravi *et al.,* (2007) and Karthikeyan *et al.*, (2010) reported that the population of WBPH, *S. furcifera* higher in system of rice intensification (SRI) as compared to standard method of cultivation in Pattambi, Kerla. Reddy *et al.,* (1983), Rajendra (2009) and Garg (2012) reported that the *S. furcifera* appeared 2nd fortnight of September and the highest population was observed during October to November. Ngoan (1972) reported that the sudden decline of WBPH at the later part of the growth stage may be attributed to the loss of succulence in the plant as crop moved towards senescence. On the contrary, Rajendra (2009) reported that the *S. furcifera* incidence highest in drill sown as compared to upghat transplanted rainfed paddy ecosystem. Reddy *et al.,* (2007), reported that the population of hoppers highest in 100 per cent organic manure + no protection as compared to 100 per cent organic manure + need based protection.

4.1.1.15 Pest succession of brown plant hopper, *Nilaparvata lugens* Stal in different rice ecosystem (through sweep net sampling)

The brown plant hopper, *Nilaparvata lugens* (1.25 adult/25 sweeps) first recorded on the rice crop during 2nd week (37 SMW) of September. In subsequent observations, there was gradual increase and reached to the highest (3.75 adult/25 sweeps) during 4th week (43 SMW) of October and declined at harvest. The brown plant hopper, *N. lugens* population ranged from 0.00 to 3.75 adult/25 sweeps was during September to October months in upland direct seeded rice ecosystem (UDS). The overall mean population 0.82 adult/25 sweeps during *kharif* season (Table 4.1.1.1).

The first appearance of brown plant hopper, *Nilaparvata lugens* (2.00 adult/25 sweeps) noticed on rice crop during 3rd week of September and in subsequent observations, there was an increase in its population. The highest BPH, *N. lugens* population (5.25 adult/25 sweeps) was observed during last week (44 SMW) in month of October. The population ranged from (0.00 to 5.25 adult/25 sweeps) was noticed during September to October months in the upland transplanted rice ecosystem (UTP) (Table 4.1.1.1).

The pest brown plant hopper, *N. lugens* adult started appearing in 37 SMW of September with 0.75 adult/25 sweeps and remains up to harvest. The brown plant hopper, *Nilaparvata lugens* adult populations peak in 44 SMW of October with 42.00 adult/25 sweeps. The mean population varied from 0.00 to 42.00 adult/25 sweeps during the rice cropping season in midland normal transplanted rice ecosystem (MNT) (Table 4.1.1.1).

Perusal of data presented (Table) on on the succession of brown plant hopper revealed that the adult population was noticed during 37 SMW in month of September with 0.50 adult/25 sweeps and remain up to harvest in midland SRI rice ecosystem (MSR). The pest increased steadily reaching a peak population of 28.00 adult/25 sweeps in 45 SMW of November. The average population ranged from 0.00 to 28.00 adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

From the data presented (Table4.1.1) on the succession of brown plant hopper revealed that the adult initiated in the lowland conventional rice ecosystem (LLC) during 39 SMW of September with 0.25 adult/25 sweep and remain up to harvest. The peak brown plant hopper population was recorded in 1st week (45 SMW) of November with a population of 26.25 adult/25 sweeps. The average population varied from 0.00 to 26.25 adult/25 sweeps during September to November in *kharif* season2013-14 (Table 4.1.1.1).

Periodical observations, of brown plant hopper, *N. lugens* on rice crop, revealed that the adult BPH first appeared with 0.75 adult/25 sweeps during 3rd week 38 SMW of September and reached to its peak population with 13.75 adult/25 sweeps during 1st week 45 SMW of October in the lowland organic rice ecosystem (LLO). The mean populations ranged from 0.00 to 13.75 and overall mean population 2.81 adult/25 sweeps during the *kharif* season (Table 4.1.1.1).

It is concluded that on the population of brown plant hopper, *N. lugens* in different rice ecosystems of Raipur during 2013-14 revealed that the maximum population was observed in October-November month. Among the ecosystem highest brown plant hopper, *N. lugens* adult population (overall mean) was observed in MNT (7.30 adult/25 sweeps) followed by MSR (4.48 adult/25 sweeps), LLC (3.66 adult/25 sweeps), LLO (2.81 adult/25 sweeps), UTP (1.55 adult/25 sweeps) and UDS (0.82 adult/25 sweeps) (Table 4.1.1.2).

These finding are in conformity with David *et al.*, (2005), Mahender *et al.,* (2005), Ravi *et al.*, (2007), Ngo (2007) and Karthikeyan *et al.*, (2010) who reported that the BPH low in Sri as compared to conventional. Kajimura *et al.,* (1993) that the brown plant hopper was lowest in organically formed than chemically fertilized rice field. The peak incidence of brown plant hopper are in agreement with the reports of Prabhuswamy (1972), Khaire and Dumbere (1984) and Kittur *et al.*, (1985), Rajendra (2009) and Garg (2012) who reported that the highest population *S. furcifera* found during October to November. Ngoan (1972), reported the sudden decline of BPH at the later part of the growth stage may be attributed to the loss of succulence in the plant as crop moved towards senescence.

On the contrary, Rajendra (2009) reported that the brown plant hopper, *N. lugens* incidence highest in drill sown as compared to upghat transplanted rainfed paddy ecosystem in Uttara Kannada district (A.P.). Reddy *et al.*, (2007), reported that the hoppers highest in 100 per cent organic manure + no protection as compared to 100 per cent organic manure plus need based protection.

4.1.1.16 Pest succession of zigzag leaf hopper, *Recilia dorsalis* Motsch Dist in different rice ecosystem (through sweep net sampling)

First appearance of the zigzag leaf hopper, *Recilia dorsalis* nymph/adult was observed 37 SMW in month of September with 0.25 nymph/adult/25 sweeps and despaired after 43 SMW of October in upland direct seeded rice ecosystem (UDS).The zigzag leaf hopper, *R. dorsalis* nymph/adult population highest in 43 SMW in month of October with a population of 2.25 nymph/adult/25 sweeps. The average population varied from 0.00 to 2.25 nymph/adult/25 sweeps during the rice cropping season (Table 4.1.1.1).

From the data presented (Table 4.1.1.1) on the succession of zigzag leaf hopper, *Recilia dorsalis* revealed that nymph/adult population initiated in the upland transplanted rice ecosystem (UTP) during 1st week (36 SMW) of September with 0.25 nymph/adult/25 sweeps and remain up to crop harvesting. There was an increase in population in subsequent weeks and the highest zigzag leaf hopper, *R. dorsalis* population was recorded in last week (44 SMW) of October with a population of 12.75 nymph/adult/25 sweeps. The average population varied from 0.00 to 12.75 nymph/adult/25 sweeps during *kharif* season.

Results revealed that the zigzag leaf hopper, *Recilia dorsalis* nymph/adult population noticed during 32 SMW of August with 0.75 nymph/adult/25 sweeps than it increase and reached peak in 45 SMW of November with a population 8.00 nymph/adult/25 sweeps. The mean population varied from 0.00 to 8.00 nymph/adult/25 sweeps during the rice cropping season in midland normal transplanted rice ecosystem (MNT) (Table 4.1.1.1).

The data presented on the succession of zigzag leaf hopper, *Recilia dorsalis* (Table 4.1.1.1) revealed that the nymph/adult was appeared during 35 SMW of August with 0.25 nymph/adult/25 sweeps and remain up to harvesting in midland SRI rice ecosystem (MSR). Zigzag leaf hopper, *Recilia dorsalis* increased steadily reaching a peak population of 19.50 nymph/adult/25 sweeps in 45 SMW of November. The average population varied from 0.00 to 19.50 nymph/adult/25 sweeps during the *kharif* season 2013-14.

Perusal of data presented (Table 4.1.1.1) on the succession of zigzag leaf hopper, *Recilia dorsalis* revealed that the nymph/adult initiated in the lowland conventional rice ecosystem during 32 SMW of August with 0.25 adult/25 sweep and remain up to. There was an increase in population in subsequent weeks and the peak population of zigzag leaf hopper, *R. dorsalis* was found in 2nd week (45 SMW) of November with a population of 8.25 adult/25 sweeps. The average population varied from 0.00 to 8.25 adult/25 sweeps during the rice cropping season.

Periodical observations, of zigzag leaf hopper, *Recilia dorsalis* on rice crop, revealed that the zigzag leaf hopper first appeared with 0.25 nymph/adult/25 sweeps during 1st week of September and reached to its peak population with 2.75 nymph/adult/25 sweeps during last week 44 SMW of October in the lowland organic rice ecosystem (LLO). The mean populations ranged from 0.00 to 3.75 nymph/adult/25 sweeps during the *kharif* season 2013-14 (Table 4.1.1.1).

It is quite clear, that the zigzag leaf hopper, *Recilia dorsalis* population in different rice ecosystems of Raipur during 2013-14 revealed that the maximum population was found in October-November months. Among the ecosystem highest overall mean population of zigzag leaf hopper, *R. dorsalis* nymph/adult was observed in MSR (2.45 nymph/adult/25 sweeps), followed by LLC (1.66 nymph/adult/25 weeps), UTP (1.46 nymph/adult/25 sweeps), MNT (1.23 nymph/adult/25 sweeps), LLO (0.45 nymph/adult/25 sweeps), and UDS (0.32 nymph/adult/25 sweeps). The peak population during October-November in the rice field is probably due to the standing crop in the field which attracted the zigzag hopper for food, shelter and sex.

The present finding corroborates with Pathak and Khan (1994) who reported the seasonal occurrence varies distinctly between areas where the insects undergo dormancy and diapause on the one hand, and where they remain active year-round on the other. The females of *Recilia dorsalis* occur in four generations lay 100-200 eggs and hibernate as eggs. Green leaf hopper, *Nephotettix* spp. and whitebacked plant hopper, *Sogatella furcifera* are usually more common during early crop stages but *Nilaparvata lugens* and *Recilia dorsalis* become more prevalent during later stages. On the contrary, Nath and Bhagabati (1998) reported that the first appearance of zigzag leafhopper, *R. dorsalis* was slightly delayed and was recorded on 29th July during 1998 and 1st July during 1999. The maximum numbers were recorded on 9th September during 1998 and 12th August during 1999 in Jorhat (India). The early disappearance of the zigzag leafhopper population might be due to maturity of the rice plant during October -November and the population might migrate to some other

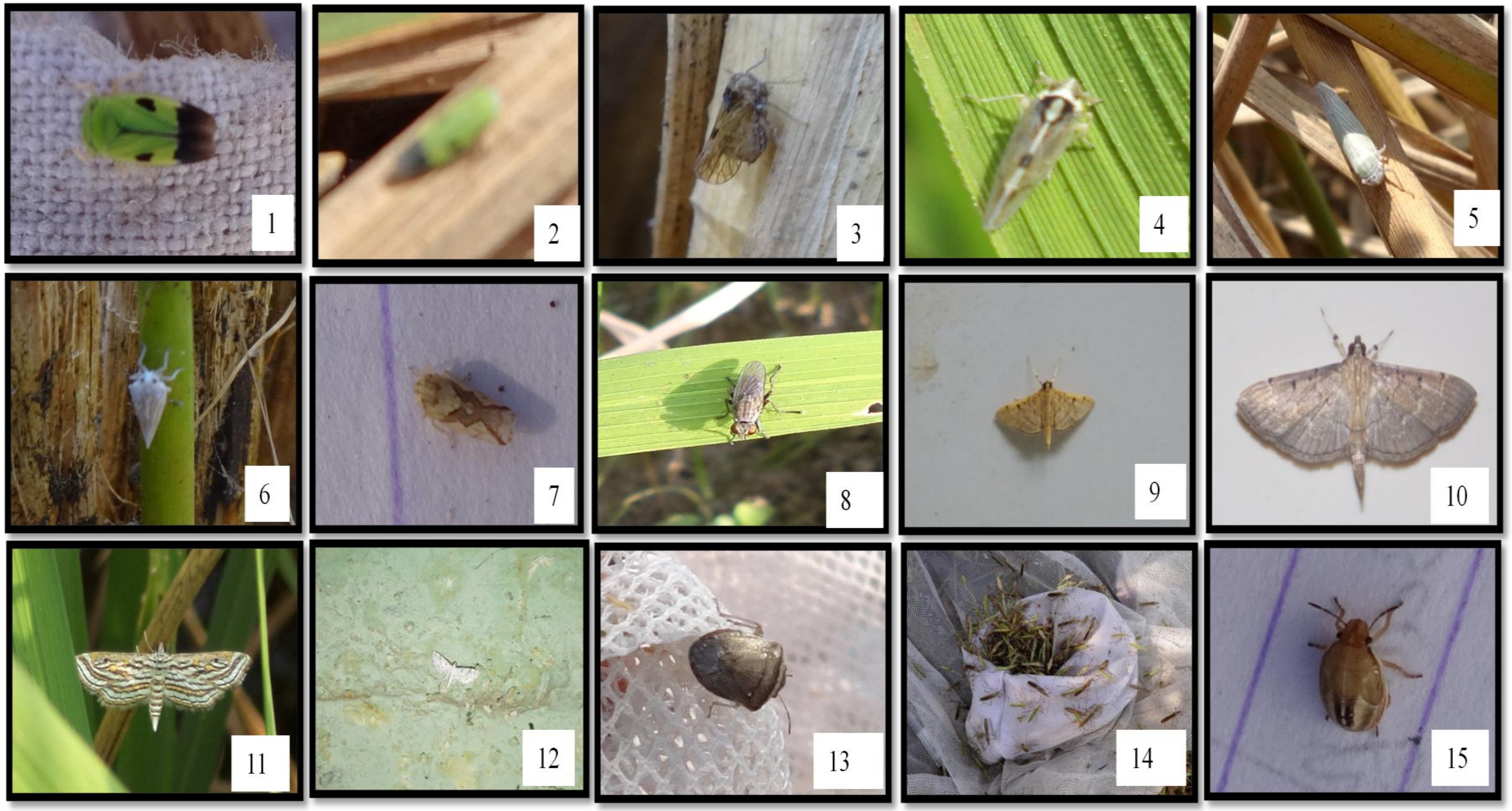

Plate No. 1 a: Rice insect pests found in different rice ecosystem: (1) *Nephotettix. nigropictus*, 2. *N.virescens*, 3. *Nilaparvata lugens*, 4. *Sogatella furcifera* 5. *Cofana* spp., 6. white jassid, *Nisia nervosa* 7. *Recilia dorsalis,* 8. *Hydrellia* spp., 9. *Cnapholocris* sp., 10.*Cnapholocris medinalis*,11. *Parapoynx fluctuosalis Zeller* 12.*Nymphula depunctalis,* 13. *Euschistus tristigmus,* 14. *Leptocorisa acuta*, 15.*Oebalus* spp.

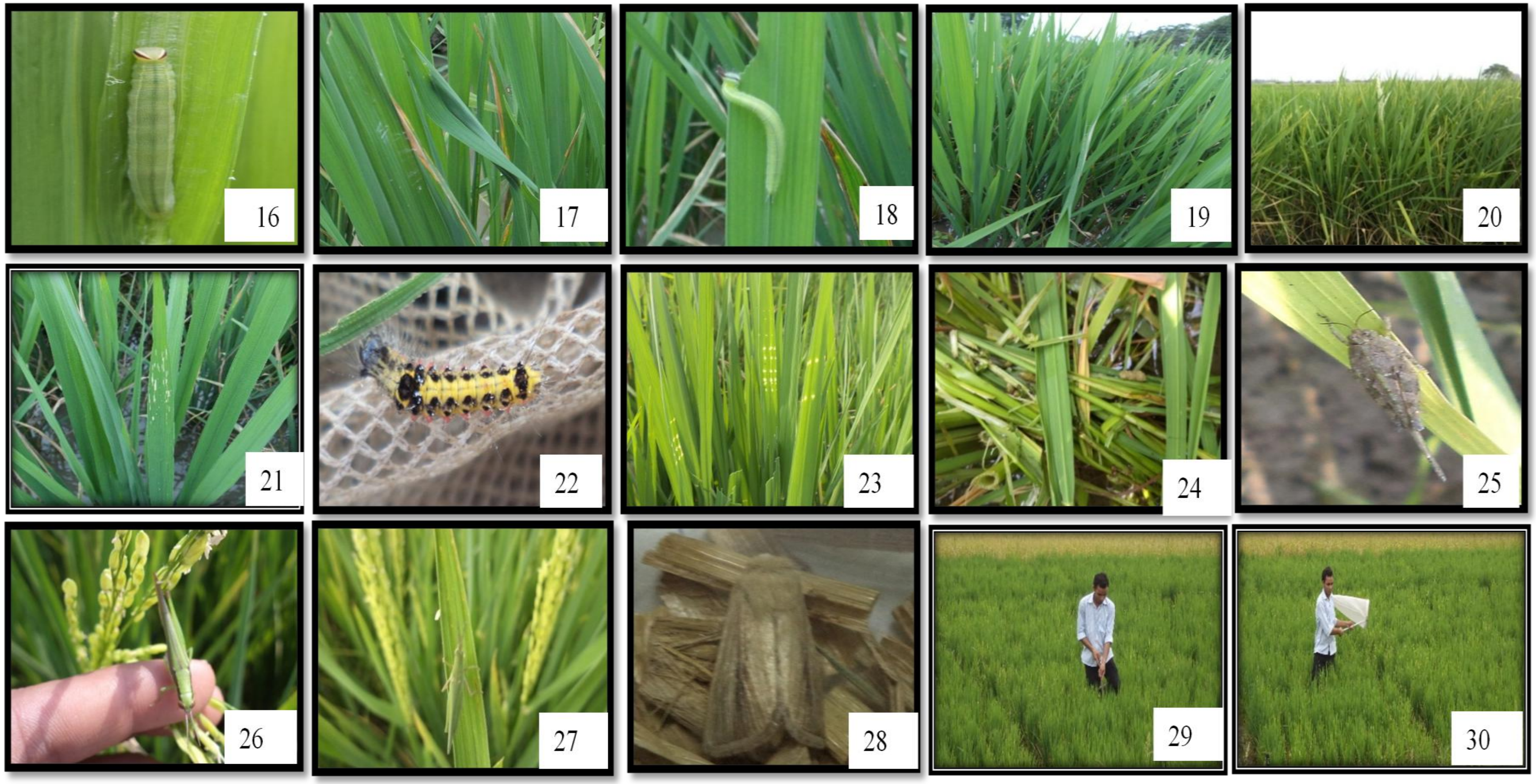

Plate No.1 b. Rice insect pests found in different rice ecosystem : 16. & 17. *Pelopidas(Parnara) mathias* larvae, and damage. 18. *Melantis leda isemene* damage, 19. *Cnapholocris medinalis* damage, 20. *Sciropophaga incertulas* damage, 21. *Dicladispa armigera* damage, 22. *Psalis pennatula*, 23.*Hydrellia* spp. damage, 24.Rate damage, 25. *Attarctom orpha crenulata* 26. *Oxya nitidula*, 27.*Atractomorpha similis,28. Sesamia inference* 29. Draging of sweep for aquatic insect, 30. Sweeping on field preferred hosts other than rice. The population of *R. dorsalis* appeared late and disappeared early compared to the GLH population.

4.1.1.17 Others:

Pink stem borer, *Sesamia inference* Walker, *Cletus punctiger,* Riptortus *linearis linearis,* Green stink bug, *Sitotroga cerealella,* Blister beetle, plum moth, RHC, BHC, Grain moth, cricket, *Epilachna* sp. rice water weevil and Aphid population also observed during *kharif* season but population, very negligible. Similarly termite, field rats and crabs populations/infestation were recordd in upland rice ecosystem but population very low.

4.1.2 Hill based sampling method:

Among the observed different type of insect which attacks the crop majority of the rice insect pests were left out and only seven insect pests: horned caterpillar, *Melantis leda isemene* Cram., rice skipper, *Pelopidas(Parnara) mathias* Fb., Hispa, *Dicladispa armigera* Oliv., caseworm, *Nymphula depunctalis* Guen., whorl maggot, *Hydrellia* spp. leaf folder, *Cnapholocris medinalis* Guen. and stem borer, *Sciropophaga incertulas* Walker selected and their per cent infestation/damage were recorded during the study period. The per cent infestations were presented in the Table No 4.1.2.1 and 4.1.2.2.

4.1.2.1 Per cent leaf damage/infestation of horned caterpillar, *Melantis leda isemene* Cram. in different rice ecosystem

First appearance of horned caterpillar, *Melantis leda isemene* was observed from 31 to 33 SMW (standard meteorological week) *i.e.* vegetative stage of crop with 1.70, 1.25, 2.74, 0.44, 1.95 and 0.18 per cent leaf infestation/hill and peak with 3.44, 2.17, 3.50, 3.00, 5.20 and 9.81 per cent leaf infestation/hill in upland direct seeded rice ecosystem (UDS), upland transplanted rice ecosystem (UTP), midland normal transplanted rice ecosystem, midland SRI rice ecosystem (MSR), lowland organic rice ecosystem (LLO), lowland conventional rice ecosystem (LLO), respectively. The peak per cent infestation was recorded during 33 SMW to 37 SMW in month of August to September and declined after 38 SMW to 42 SMW in month of September to October in among the ecosystem. The status of horned caterpillar, *Melantis leda isemene* in different rice ecosystems of Raipur during *kharif* in all locations (Table) revealed that the maximum per cent of leaf infestation was found in LLO with 1.86 2.28 per cent leaf damage/hill followed by LLC with 1.52 per cent leaf damage/hill, UDS with 1.52 per cent leaf damage/hill, UTP with 1.52 per cent leaf damage/hill, MNT with 1.52 per cent leaf damage/hill and MSR with 1.52 per cent leaf damage /hill (Table 4.1.2.1and 4.1.2.2).

Present findings corroborates with the Chander (1998) who reported that damage caused by horned caterpillar, *Melantis leda isemene* was maximum during vegetative stage of the crop. Kumar and Patil (2004) also reported that the *Melantis leda isemene* as minor pest active at the tillering stage in paddy ecosystem. Lawanprasert *et al.*, (2004) reported that the number of insect pests found in the organic paddy field was higher than conventional paddy field in Pathumthani rice research center. Mahender *et al.*, (2005) reported that the incidence of pests low in SRI as compared to the normal transplanting. Girish (2011) reported that the horned caterpillar, *Melantis leda isemene* appeared 45 days old rice crop (vegetative phase), reached its peak at 60-75 days old rice crop and their population was high in drill sown rice, followed by transplanted and least in aerobic method in upland rice ecosystem .

On contrary, Lawanprasert *et al.*, (2004) reported that the number of insect pests found in the organic paddy field was lower than those conventional paddy fields in Ratchaburi Rice Research Center. Rajendra (2009) reported that the incidence of *M. leda isemene* high in upghat transplanted as compared to upghat drill sown rainfed paddy ecosystem.

4.1.2.2 Percent leaf damage of rice skipper, *Pelopidas (Parnara) mathias* Fb. in different rice ecosystem

Rice skipper, *Pelopidas (Parnara) mathias* Fb. per cent leaf infestation/hill initiated from 32 to 35 SMW (standard meteorological week) *i.e.* vegetative stage of crop and disappeared after 40 to 42 SMW in month of August and October, respectively in among the ecosystem. Rice skipper maximum per cent leaf damage/hill observed during September with 1.15, 0.52, 0.27, 0.07, 0.69 and 2.29 per cent leaf infestation/hill in upland direct seeded rice ecosystem (UDS), upland transplanted rice ecosystem (UTP), midland normal transplanted rice ecosystem, midland SRI rice ecosystem (MSR), lowland organic rice ecosystem (LLO), lowland conventional rice ecosystem (LLO), respectively. It can be stated that on the basis of seasonal/overall mean the maximum percent of leaf damage/hill was recorded in LLO with (0.55 % leaf damage/hill) followed by LLC (0.19% leaf damage/hill), UDS (14% leaf damage/hill), UPT (0.10% leaf damage/hill), MNT (0.05 % leaf damage/hill) and MSR (0.02 % leaf damage /hill) (Table 4.1.2.1and 4.1.2.2).

The present investigations on the per cent leaf damage of rice skipper, *Pelopidas (Parnara) mathias* are in close agreement with Zhimomi and Ao (2011) who reported that seasonal incidance of major insect pests was high in lowland followed by foothill and upland. Lawanprasert *et al.*, (2004) reported that the number of insect pests found in the organic paddy fields was higher than the conventional paddy fields in Pathumthani Rice Research Center. Kumar and Patil (2004) reported skipper, (*Parnara guttatus*) as minor pests active at the tillering stage in paddy ecosystem. Mahender *et al*., (2005) recorded that the incidence of pests low in SRI as compared to the normal transplanting (NTP) whereas, it differed from Rajendra (2009) reported that the paddy skipper appeared a month after transplanting (second fortnight of September) till first fortnight of November and highest in upghat transplanted than in drill sown rainfed paddy ecosystem.

4.1.2.3 Per cent leaf damage of rice hispa, *Dicladispa armigera* Oliv. in different rice ecosystem

From the data presented (Table 4.1.2.1and 4.1.2.2) on the incidence of hispa, *Dicladispa armigera* revealed that the percent leaf damage initiated during 31 to 32 SMW of July to August with 0.47 to 5.59 and disappears after 37 to 39 SMW of September in among the rice ecosystem. There was an increase in population in subsequent weeks and the peak percent leaf infestation was recorded during 33 to 35 SMW of August with (1.16%), (2.65%), (7.82%), (3.29%), (3.14%) and (5.60%) leaf infestation/hill in upland direct seeded rice ecosystem (UDS), upland transplanted rice ecosystem (UTP), midland normal transplanted rice ecosystem, midland SRI rice ecosystem (MSR), lowland organic rice ecosystem (LLO), lowland conventional rice ecosystem (LLO), respectively. It is quite clear, that the maximum percent of leaf damage/hill was recorded in MNT (1.36 % leaf damage/hill) followed by LLO with (0.96 % leaf damage/hill), LLC (0.73 % leaf damage/hill), MSR (0.66 % leaf damage /hill), UPT (0.44 % leaf damage/hill) and UDS (0.34% leaf damage/hill).

These findings are in conformity with Zhimomi and Ao (2011) who reported that the seasonal incidence of major insect pests was high in lowland followed by foothill and upland. Lawanprasert *et al.,* (2004) reported that the incidance of insect pests high in organic field as compared to conventional paddy fields in Pathumthani Rice Research Center. Dogra and Choudhary (2005) reported that hispa, *Dicladispa* *armigera*, appeared in July and reached at the peak during August- September. Mahender *et al.*, (2005) reported that the incidence of pests low in SRI as compared to the normal transplanting. Rajendra (2009) reported that the rice hispa appeared in vegetative stage of crop and the highest incidence was observed in upghat transplanted than in drill sown rainfed paddy ecosystem in Uttara Kannada distict (A.P.).

4.1.2.4 Per cent leaf damage of caseworm, *Nymphula depunctalis* Guen. in different rice ecosystem

Perusal of data presented (Table 4.1.2.1) on the incidence of caseworm, *N. depunctalis* revealed that the per cent leaf infestation was noticed from 31 to 32 SMW of July to August with 0.08 to 0.20 and disappears after 37 to 38 SMW of September in among the rice ecosystem . There was an increase in population in subsequent weeks and the maximum percent of leaf infestation was recorded during 34 to 37 SMW of August-September with (0.00%), (0.19%), (0.46%), (0.31%), (0.69%), and (0.46%) leaf infestation/hill in upland direct seeded rice ecosystem (UDS), upland transplanted rice ecosystem (UTP), midland normal transplanted rice ecosystem, midland SRI rice ecosystem (MSR), lowland organic rice ecosystem (LLO), lowland conventional rice ecosystem (LLO), respectively. It is crystal clear from the (Table 4.1.1.2) that the maximum percent of leaf damage/hill was recorded in LLC (0.20 % leaf damage/hill), followed by LLO with (0.13 % leaf damage/hill), MNT (0.10 % leaf damage/hill), MSR (0.0.07 % leaf damage /hill), UPT (0.0.05 % leaf damage/hill) and UDS (0.00% leaf damage/hill).

These finding are in conformity with Hazarika, (1952) and Janjua (1957) who reported that the rice caseworm normally occur during September to October in Bangladesh. Wahed (1959) reported the incidence of insect in the rice field from July

Table: 4.1.2.1 Percent damage of rice insect pests in different rice ecosystem at Raipur during *kharif* season 2013-14.

Insect pests	**1. Horned caterpillar/rice butterfly (per cent leaf damage /hill)**																						
Month	July		August					September					October						November				
SMW	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.00	1.70	2.25	1.89	5.84	3.44	1.68	2.69	1.36	9.16	0.30	0.00	0.00	0.00	0.00	0.30	-	-	0.00	15.29	1.09
UTP	0.00	0.00	1.25	1.21	1.58	0.21	4.25	2.17	1.08	0.88	0.78	4.92	0.40	0.31	0.34	0.00	0.00	1.05	-	-	0.00	10.22	0.73
MNT	0.00	0.00	2.74	3.50	0.56	2.02	8.82	0.82	0.46	0.19	0.00	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	10.30	0.69
MSR	0.00	0.00	0.44	0.31	3.00	0.70	4.45	0.36	0.15	1.35	0.50	2.35	0.54	0.31	0.18	0.00	0.00	1.03	0.00	-	0.00	7.83	0.52
LLC	1.95	1.95	1.54	5.20	4.60	1.15	12.49	2.77	3.06	1.74	0.57	8.14	0.81	0.62	0.34	0.00	0.00	1.77	0.00	0.00	0.00	24.35	1.52
LLO	0.18	0.18	0.13	0.36	1.88	1.16	3.54	5.78	9.81	8.76	7.81	32.16	5.00	3.00	1.36	0.00	0.86	10.22	0.00	0.00	0.00	46.09	2.88
	2. Rice skipper (per cent leaf damage /hill)																						
UDS	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.20	0.43	1.15	0.08	1.86	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	2.00	0.14
UTP	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.30	0.52	0.24	0.06	1.12	0.08	0.13	0.00	0.00	0.00	0.21	-	-	0.00	1.34	0.10
MNT	0.00	0.00	0.00	0.00	0.18	0.24	0.42	0.27	0.04	0.03	0.00	0.34	0.01	0.00	0.00	0.00	0.00	0.01	0.00	-	0.00	0.78	0.05
MSR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.11	0.09	0.04	0.00	0.00	0.00	0.13	0.00	-	0.00	0.24	0.02
LLC	0.00	0.00	0.00	0.00	0.24	0.42	0.66	0.06	0.45	0.69	0.51	1.72	0.56	0.08	0.00	0.00	0.00	0.64	0.00	0.00	0.00	3.01	0.19
LLO	0.00	0.00	0.19	0.30	0.83	1.48	2.80	2.29	1.52	0.96	0.21	4.97	0.14	0.30	0.52	0.00	0.00	0.96	0.00	0.00	0.00	8.73	0.55
	3. Hispa/spiny beetle (per cent leaf damage /hill)																						
UDS	0.00	0.00	0.47	0.84	0.82	1.14	3.26	0.85	0.39	0.32	0.02	1.58	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	4.84	0.35
UTP	0.47	0.47	1.00	2.65	1.56	0.09	5.30	0.15	0.18	0.04	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	6.13	0.44
MNT	1.52	1.52	5.59	7.82	3.03	0.94	17.39	0.48	0.81	0.00	0.18	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	20.38	1.36
MSR	0.00	0.00	1.25	3.29	2.65	1.99	9.18	0.25	0.15	0.31	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	9.89	0.66
LLC	0.00	0.00	1.14	1.59	1.91	3.14	7.78	1.52	1.00	0.99	0.11	3.62	0.20	0.10	0.00	0.00	0.00	0.30	0.00	0.00	0.00	11.70	0.73
LLO	0.81	0.81	1.56	2.47	5.60	2.65	12.28	0.69	0.93	0.57	0.00	2.20	0.00	0.05	0.01	0.00	0.00	0.06	0.00	0.00	0.00	15.35	0.96

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, SMW = standard meteorological week and - = Crop harvested.

Continue…

Table: 4.1.2.1 Percent damage of rice insect pests in different rice ecosystem at Raipur during *kharif* season 2013-14.

Insect pests	4. Caseworm (per cent leaf damage /hill)																						
Month	July		August					September					October						November				
SWM	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00
UTP	0.00	0.00	0.08	0.09	0.18	0.19	0.54	0.14	0.04	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.72	0.05
MNT	0.11	0.11	0.14	0.16	0.24	0.46	1.00	0.26	0.13	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	1.50	0.10
MSR	0.00	0.00	0.09	0.12	0.14	0.26	0.61	0.31	0.06	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.98	0.07
LLC	0.20	0.20	0.35	0.38	0.47	0.41	1.61	0.48	0.69	0.17	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.15	0.20
LLO	0.17	0.17	0.21	0.27	0.39	0.45	1.32	0.46	0.12	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.07	0.13
	5. Whorl maggot (per cent leaf damage /hill)																						
UDS	0.00	0.00	0.00	0.00	0.09	0.26	0.35	0.76	0.23	0.10	0.00	1.09	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	1.44	0.10
UTP	0.00	0.00	0.00	0.07	0.92	0.31	1.30	0.25	0.11	0.18	0.20	0.75	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	2.05	0.15
MNT	0.00	0.00	0.02	0.31	0.40	0.65	1.38	1.02	0.78	0.50	0.02	2.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	3.70	0.25
MSR	0.00	0.00	0.00	0.09	0.13	0.48	0.70	0.17	0.00	0.05	0.07	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.98	0.07
LLC	0.00	0.00	0.24	0.85	0.98	1.07	3.14	1.65	0.76	0.59	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.14	0.38
LLO	0.00	0.00	0.31	0.74	1.32	1.01	3.38	0.46	0.33	0.53	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.71	0.29
	6. Leaf folder (per cent leaf damage /hill)																						
UDS	0.00	0.00	0.00	0.23	0.76	1.88	2.87	2.34	1.44	1.94	0.25	5.97	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	8.84	0.63
UTP	1.85	1.85	0.82	0.65	1.34	1.41	4.22	2.45	3.21	0.23	0.11	6.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	12.07	0.86
MNT	1.98	1.98	2.12	1.01	1.68	3.00	7.81	3.45	4.35	3.00	0.61	11.41	0.03	0.00	0.00	0.00	0.00	0.03	0.00	-	0.00	21.23	1.42
MSR	0.00	0.00	0.63	1.00	2.00	2.94	6.57	4.00	4.95	5.58	3.56	18.09	1.00	0.56	0.00	0.00	0.00	1.56	0.00	-	0.00	26.22	1.75
LLC	2.02	2.02	2.06	0.94	1.00	1.52	5.52	1.98	3.12	3.25	2.25	10.60	0.45	0.25	0.00	0.00	0.00	0.70	0.00	0.00	0.00	18.83	1.18
LLO	0.04	0.04	0.48	2.19	3.12	2.68	8.47	2.13	1.86	1.68	1.00	6.67	0.87	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	16.05	1.00

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, SMW = standard meteorological week and - = Crop harvested.

Continue…

Table: 4.1.2.1 Percent damage of rice insect pests in different rice ecosystem at Raipur during *kharif* 2013-14.

Insect pests	**7.1 Stem borer (per cent dead hearts /hill)**																					
Month	July		August					September					October						November			
SWM	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.00	0.28	1.68	4.36	6.32	5.25	0.31	0.01	0.00	5.57	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	11.89	0.85
UTP	0.00	0.00	0.00	1.00	1.09	1.26	3.35	3.08	0.56	0.00	0.00	3.64	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	6.99	0.50
MNT	0.00	0.00	0.00	0.00	4.03	13.77	17.80	18.48	6.80	0.00	0.00	25.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	43.08	2.87
MSR	0.00	0.00	0.25	1.25	3.56	7.08	12.14	8.56	10.25	0.00	0.00	18.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	30.95	2.06
LLC	0.00	0.00	0.00	0.59	2.78	4.61	7.98	5.81	6.96	3.12	0.00	15.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.87	1.49
LLO	0.00	0.00	0.00	0.00	2.56	5.49	8.05	6.78	3.04	0.00	0.00	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.87	1.12
	7.2 Stem borer (per cent white ears/hill)																					
UDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.41	3.41	6.24	8.12	15.84	13.27	12.00	55.47	-	-	0.00	58.88	4.21
UTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.65	9.01	15.56	8.45	38.67	-	-	0.00	38.67	2.76
MNT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.48	9.58	15.06	17.56	18.32	24.21	19.89	12.35	92.33	9.02	-	9.02	116.41	7.76
MSR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.45	9.28	10.73	12.37	19.04	21.62	23.15	19.46	95.64	14.78	-	14.78	121.15	8.08
LLC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.02	10.02	12.32	14.25	17.49	21.38	12.02	77.46	9.00	8.91	17.91	105.39	6.59
LLO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.78	9.25	16.03	10.00	12.13	14.08	16.65	10.98	63.84	7.78	6.20	13.98	93.85	5.87

Table: 4.1.2.2 Overall status of per cent damage of rice insect pests in different rice ecosystem at Raipur during *kharif season*, 2013-14.

Insect pests / Ecosystem	Rice horned caterpillar	Rice skipper/hill	Hispa/hill	Caseworm/hill	Whorl Maggot/hill	Leaf folder/hill	Stem borer (Dead heart)/hill	Stem borer (White ears)/hill
UDS	1.09	0.14	0.35	0.00	0.10	0.63	0.85	4.21
UTP	0.73	0.10	0.44	0.05	0.15	0.86	0.50	2.76
MNT	0.69	0.05	1.36	0.10	0.25	1.42	2.87	7.76
MSR	0.52	0.02	0.66	0.07	0.07	1.75	2.06	8.08
LLC	1.52	0.19	0.73	0.20	0.38	1.18	1.49	6.59
LLO	2.88	0.55	0.96	0.13	0.29	1.00	1.12	5.87

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) rice ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, SMW = standard meteorological week and - = Crop harvested.

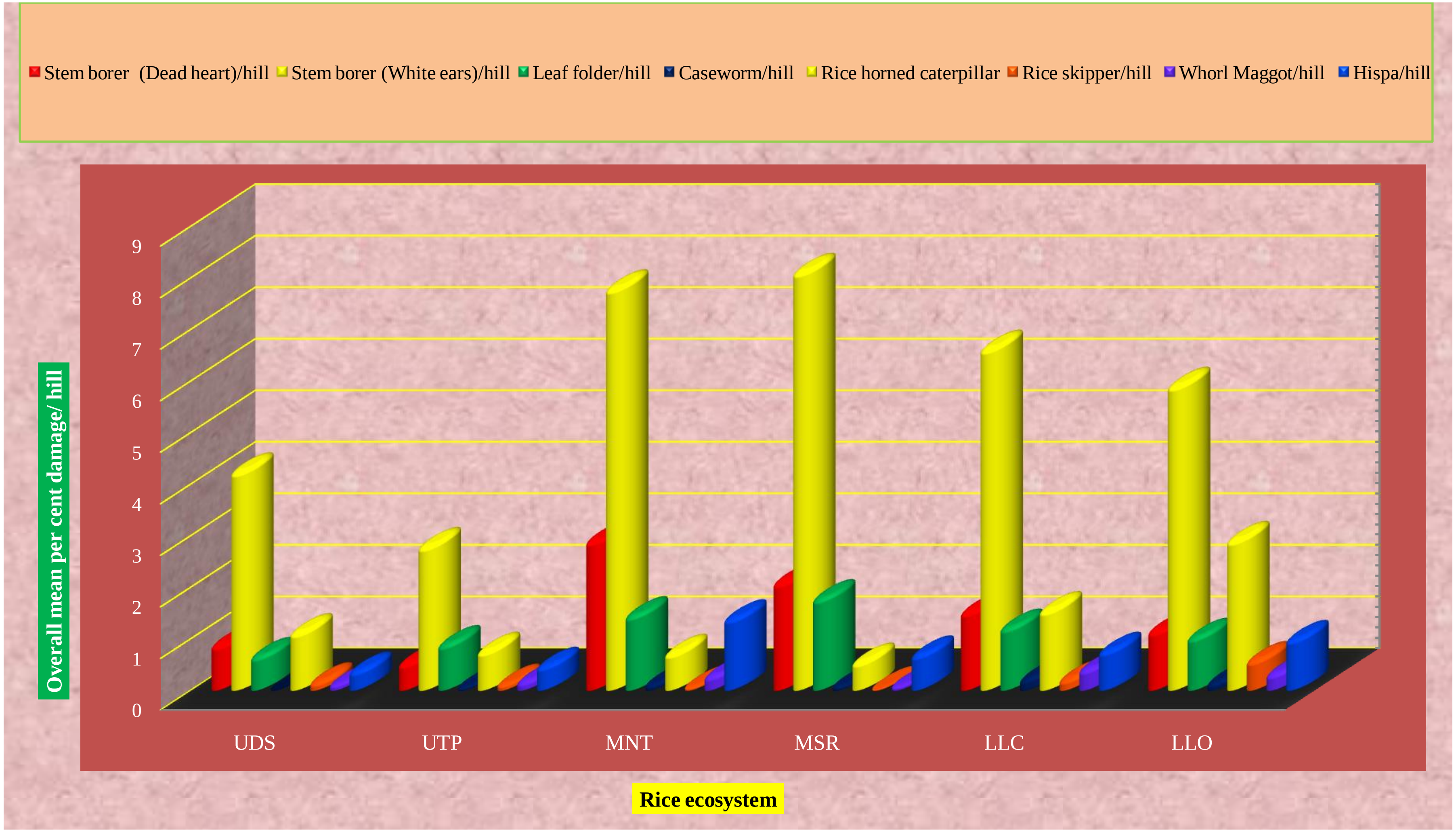

Fig: 4.1.2.2 Overall status of per cent damage of rice insect pests in different rice ecosystem at Raipur during *kharif* season 2013-14

to September. Pulin and Khound (1998) reported that the caseworm incidence was much more during the vegetative stage of the crop and peak infestations in terms of cut leaves and larvae were recorded 4-5 weeks after transplanting. Kumar and Patil (2004) reported that the caseworm as minor pests. Devid *at al.*, (2005), Ngo (2007) and Karthikeyan *et al*., (2010) reported that the caseworm lower in SRI than normal transplanting method of cultivation. Zhimomi and Ao (2011) reported that the major insect pests of rice highest in lowland as compared to upland paddy ecosystem.

4.1.2.5 Per cent leaf damage of whorl maggot, *Hydrellia* spp. in different rice ecosystem

It is evident from the data (Table 4.1.2.1) the per cent leaf infestation of whorl maggot, *Hydrellia spp.* initiated during 31 to 33 SMW of July-August and disappears after 38 to 39 SMW of September in all ecosystem. The peak per cent leaf infestations of whorl maggot, *Hydrellia spp.* observed during 34-36 SMW in month August-September with (0.76%), (0.88%), (1.02%), (0.48%), (1.65%) and (1.32%) leaf infestation/hill in upland direct seeded rice ecosystem (UDS), upland transplanted rice ecosystem (UTP), midland normal transplanted rice ecosystem, midland SRI rice ecosystem (MSR), lowland organic rice ecosystem (LLO), lowland conventional rice ecosystem (LLO), respectively. It is crystal clear from the data (Table 4.1.2.2) the highest and lowest per cent leaf infestation was recorded in LLC with (0.38 % leaf infestation/hill) and UDS (0.10% leaf infestation/hill) respectively.

The present findings corroborates with the reports of Zhimomi and Ao (2011) who reported that the seasonal abundance of major rice insect pests was high in lowland followed by foothill and upland. Lawanprasert *et al.,* (2004) reported that the number of insect pests found in the organic paddy fields was lower than the conventional paddy fields in irrigated rice ecosystem. Prasad and Prasad (2006) reported that the whorl maggot had major economic significance in paddy ecosystem.

David *et al*., (2005), Ravi *et al.*, (2007) and Karthikeyan *et al.*, (2010), Pathak, *et al.*, (2012) reported that the incidence of whorl maggot lower in system of rice intensification (SRI) as compared to normal system of cultivation. On the contrary, Padmavathi *et al*., (2007) reported the SRI plant had more leaves damaged by whorl maggot as compared to conventional cultivation method.

4.1.2.6 Per cent dead hearts and white ears of yellow stem borer, *Sciropophaga incertulas* Walker in different rice ecosystem

The data presented on the incidence of yellow stem borer, *Sciropophaga incertulas* Walk. (Table 4.1.2.1) revealed that the per cent dead hearts and white earhead were appeared from 32 to 34 SMW of August and 38 to 41 SMW of October in among the ecosystem respectivly. The maximum per cent dead hearts observed during 36 SMW to 37 SMWof September and per cent white earhead observed during 42 SMW to 43 SMW in among the ecosystem. It is quit clear from data table 4.1.2.2 the maximum per cent of dead hearts/hill was recorded in midland normal transplanted rice ecosystem (MNT) with 2.87 per cent followed by midland SRI rice ecosystem (MSR) with 2.06 per cent, lowland conventional rice ecosystem (LLC) with 1.49 per cent, lowland organic rice ecosystem (LLO) with 1.12 per cent, upland direct seeded rice ecosystem (UDS) with 0.85 per cent and upland transplanted rice ecosystem (UTP) 0.50 per cent and the maximum percent of white ear head/hill was recorded in MSR (8.08%) followed by MNT (7.76%), LLC (6.50%), LLO (5.87%), UDS (4.21%) and UTP (2.76%) in Raipur during *kharif* season 2013-14.

The present findings are in conformity with the Lawanprasert *et al.*, (2004) reported the incidence of stem borer lowest in organic than conventionl cultivation. Padmavathi *et al.*, (2005) also reported the dead heart (DH) lowest in system of rice intensification (SRI) as compaired to conventional method of cultivation but white earhead (WEH) highest in SRI as compaired to conventional method of cultivation.

David *et al.*, (2005) reported that the DH and WE much more in SRI than conventional method while Ravi *et al.,* (2007) and Karthikeyan *et al*., (2009) reported that the DH and WEH lowest in SRI as compare to normal system of cultivation. Rajendra (2009) reported that the percent DH and WEH minimum in upghat drill sown paddy ecosystem as compare to upghat transplanted paddy ecosystem.

4.1.3 Stem borer species composition in different rice ecosystem at Raipur during *kharif* season 2013-14

From the data presented table 4.1.3 on the species composition of stem borer in rice ecosystem revealed that the 100 per cent of yellow stem borer species present in upland direct seeded, upland transplanted and midland normal transplanted rice ecosystem and lowland conventional rice ecosystem. In lowland organic rice ecosystem and mid land SRI rice ecosystem 92.59 per cent, 63.15 per cent of yellow stem borer and 7.40 per cent, 36.84 per cent of pink stem borer were present respectively. On the basis of light trap observation 88.07 per cent of yellow stem borer and 11.92 per cent pink stem borer were observed in rice ecosystem at Raipur during *kharif* season (Table 4.3.1.1).

Table 4.1.3 Observation of stem borer species composition in different rice ecosystem at Raipur during *kharif* season 2013-14

Ecosystem	Larvae of yellow stem borer/m^2	Larvae of pink stem borer/m^2	Total larvae/m^2	Per cent population of YSB larvae	Per cent population of PSB larvae
UDS	4	0	4	100	0
UTP	13	0	13	100	0
MNT	18	0	18	100	0
MSR	12	7	19	63.15	36.84
LLC	16	0	16	100	0
LLO	25	2	27	93.15	7.40

UDS = Upland Direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem

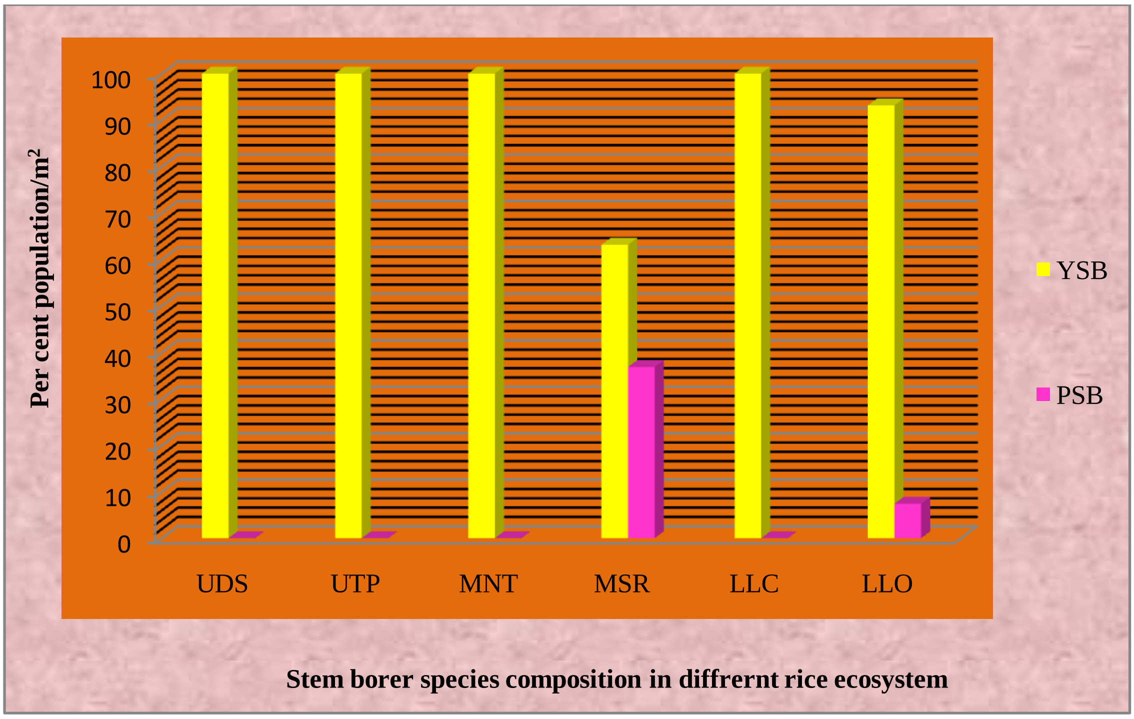

Figure: 4.1.3 Observation of stem borer species composition in different rice ecosystem at Raipur during *kharif* season 2013-14

4.2 To record the natural enemies of rice insect pests in different ecosystem during *kharif* season.

4.2.1 Record of spiders in different rice ecosystem (through sweeping net sampling)

The spider populations were recorded from 30 days old crop up to maturity with varied population level in different rice ecosystem. Spiders were recorded in different rice ecosystem belonging to 17 families and 44 species include *Pardosa pseudoannulata*, *Tetragnatha* spp. and *Tibellus* sp., *Leucauge* sp., *Agelena* sp., *Oxyopes* spp., *Thomisus* sp., *Araneus* spp., *Atypena* sp. *etc.* (Table 4.2.3). The highest population of spider was recorded on 42 SMW with (15.00/25 sweeps), 43 SMW with (11.00/25 sweeps), 45 SMW with (17.00/25 sweeps), 45 SMW with (28.75/25 sweeps), 46 SMW with (20.00/25 sweeps) and 46 SMW with (25.25/25 sweeps) of October-November in upland direct seeded rice ecosystem (UDS), upland transplanted rice ecosystem (UTP), midland normal transplanted rice ecosystem (MNT), midland system of rice intensification rice ecosystem (MSR), lowland

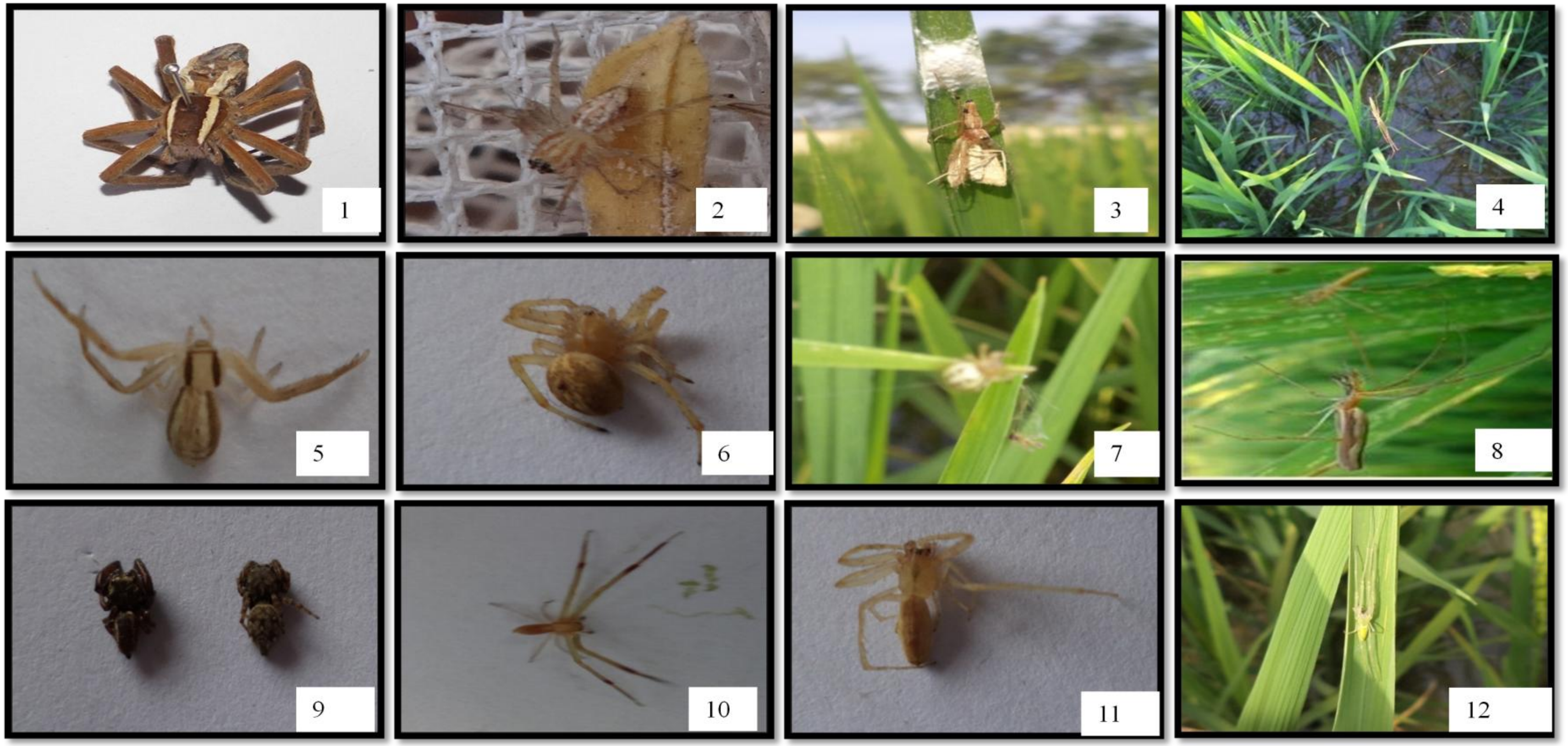

Plate No: 3a: Different species of spiders found in rice ecosystem: 1. *Agelena* sp. 2. *Pardosa* sp. 3. *Oxypopes* sp. 4.*Tetragnatha* sp. 5. *Thomisus* sp. 6. *Araneus* sp. 7. *Atypena* sp. 8. *Leucauge* sp. 9. *Phidippus* sp. 10. Unidentified spider 11. Unidentified spider 12. Unidentified spider

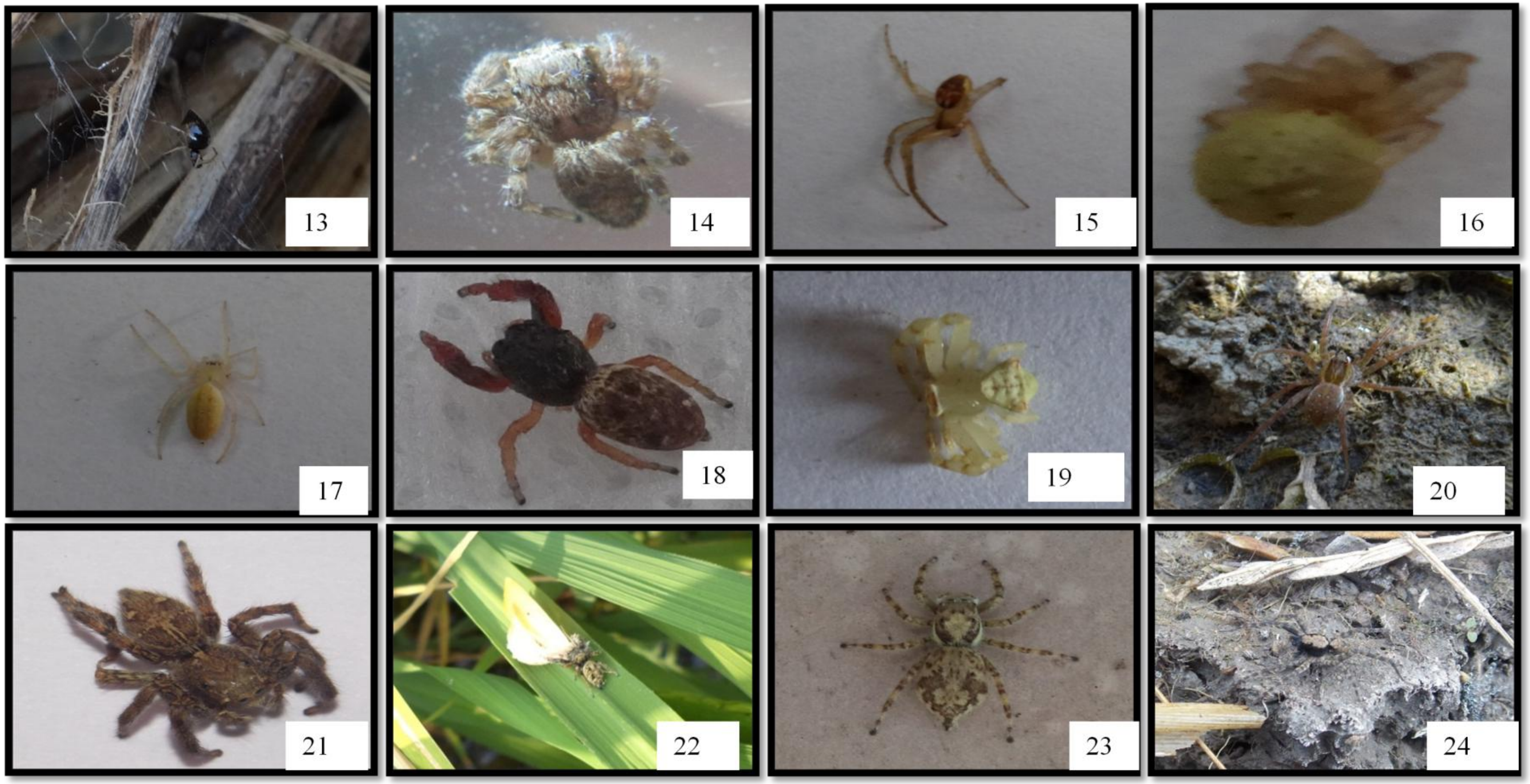

Plate No. 3b. : Different species of spiders found in different rice ecosystem: : 13. Unidentified spider, 14. Unidentified spider, 15. Unidentified spider, 16. Unidentified spider, 17. Unidentified spider, 18. Unidentified spider, 19. Unidentified spider, 20. Unidentified spider, 21. Unidentified spider, 22. Unidentified spider, 23. Unidentified spider, 24. Unidentified spider, 25.Unidentified spider, conventional rice ecosystem (LLC) and lowland organic rice ecosystem rice ecosystem (LLO) respectively (Table 4.2.1).

The status of spider population in different rice ecosystems of Raipur during 2013-14 revealed that the maximum population was found in October-November month. Among the ecosystem highest overall mean population of spider was recorded in LLO (7.48/25 sweeps), followed by LLC (6.19/ 25 sweeps), MSR (6.17/25 sweeps), MNT (5.97/25 sweeps), UTP (5.29/25 sweeps) and UDS (3.80/25 sweeps) (Table 4.2.2).

The present findings on the activity of spiders are in agreement with Okuma *et al.*, (1978) who also reported that the spiders fauna as relatively poor in the early period of crop growth (July) and from August onwards, spider fauna became rich. At International Rice Research institute, Philippines peak spider populations were observed during mid-late October (Anonymous, 1985). Shivamurthappa (1993) recorded a maximum of 8.1 spiders per hill during first fortnight of November. Venkateshalu (1996) reported that the most of the dominant species of spiders throughout the crop growth period. Sahu *et. al*., (1996) observed that the spider population highest in IPM rice field followed by SRI and transplantation. Sebastian et *al.*, (2002) reported that the total 1130 individuals belonging to 92 species, 47 genera and 16 families were recorded during the study period and results showed that species richness and diversity were the highest in lowland rice ecosystem in Central Kerala, India across different elevation ranges (rice fields of high ranges, midland and low land areas). Zhimomi and Ao (2011) reported that the natural enemies highest in lowland than foothill and upland Nagaland in India.

Reddy *et al.*, (2007) reported that the population of spiders highest in 100 per cent organic manures + no plant protection and lowest in 100 per cent organic manures + need based plant protection. Padmavathi *et al.*, (2007) reported that the beneficial arthropods diversity (total abundance) and species richness higher in SRI than that conventional method of cultivation. Rajendra (2009) reported the maximum populations of spiders were cbserved during November in rainfed upland paddy ecosystem. Karthikeyan *et al.*, (2010) and Zhong *et al.*, (2010) reported that the spiders were higher in organic rice fields than conventional rice fields. Girish (2010) reported that the population of spider highest in transplanted followed by drill and aerobic method in upland rice ecosystem. On the contrary, Rajendra (2009) reported that the predators were highest in upghat transplanted than upghat drill shown upland rainfed paddy ecosystem. Garg (2012) reported the spider was most active during September.

4.2.2 Record of wasps in different rice ecosystem (through sweeping net sampling)

During the study period 42 species of hymenopterous parasitoids belongs to 14 families were recorded (Table 4.2.3). Parasitoids from the family Ichneumonidae and Braconidae were the most dominant. The braconids collected included *Dolicchogenidia* sp., *Sternobracon nicerillei* Bingham, *Rogas* sp., *Cotesia* sp., and *Macrocentrus* sp. and the predominant Ichneumonids included *Xanthopimpla* spp., *Isothima javensis*, *Ischnojoppa luteator*, *Temelucha* sp., *Charops bicolor* Szepligeti, *Echthromorpha agrestoria notalatoria* Fabr. and *Amauromorpha* spp. It is crystal clear on the basis of overall/seasonal mean population of wasps in different rice ecosystems of Raipur revealed that, the maximum populations were recorded in September-November month (Table 4.2.1). Among the ecosystem highest overall mean populations of wasps were recorded in lowland organic rice ecosystem (4.08 adult/25 sweeps), followed by midland SRI rice ecosystem (3.23 adult/25 sweeps), lowland conventional rice ecosystem (3.09 adult/25 sweeps), midland normal

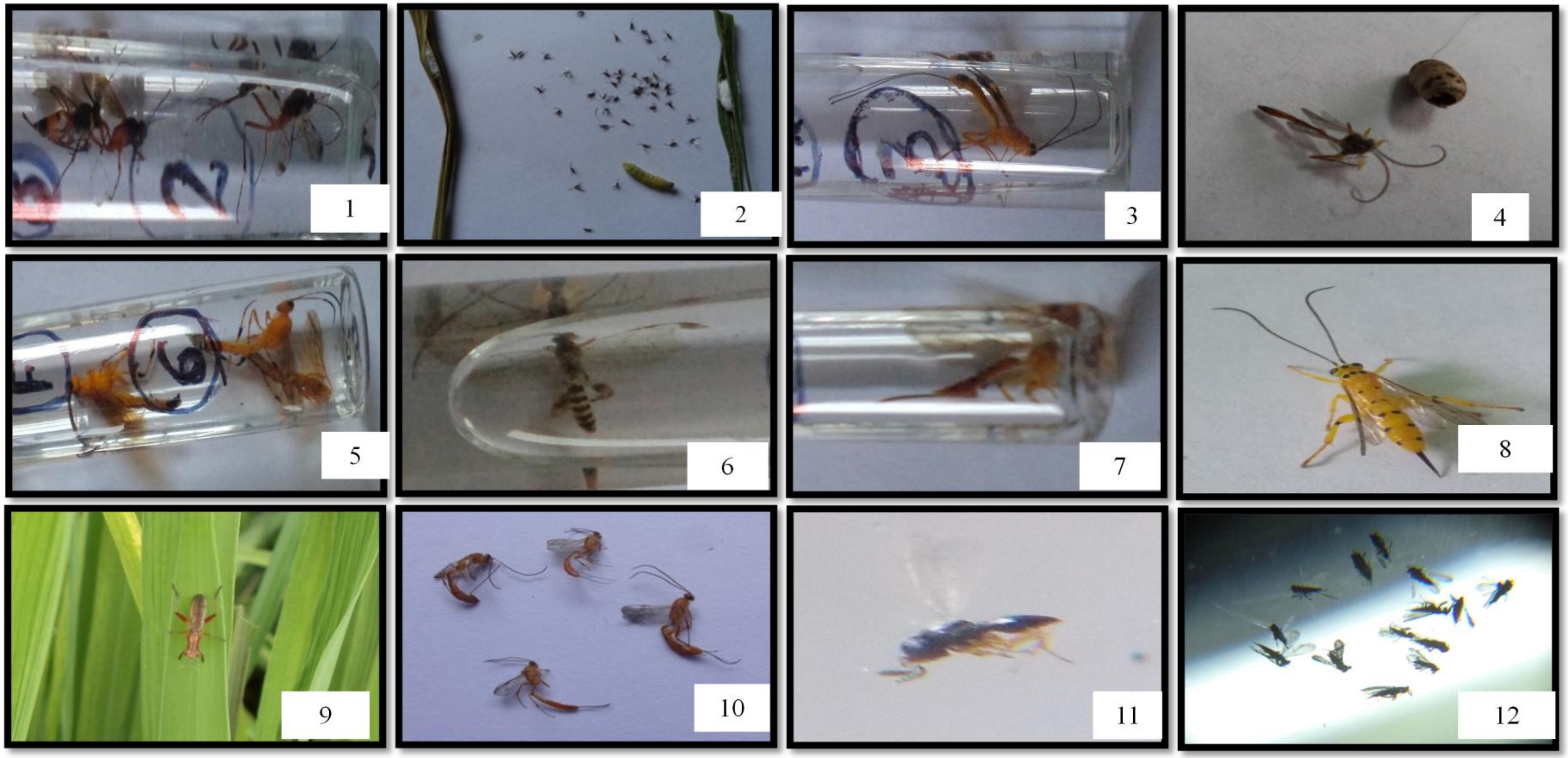

Plate No. 4 a. Different species of wasps found in rice ecosystem: : 1. *Isothima javensis*, 2. *Dolicchogenidia sp.3. Sternobracon nicerillei* Bingham 4. *Charops bicolor* Szepligeti, 5. *Ischnojoppa luteator* Fabr., 6. *Echthromorpha agrestoria notalatoria* Fabr. 7. *Xanthopimpla flavolineata,* 8. *Xanthopimpla stemmator* 9. *Rogus* sp. 10. *Temelucha* sp.11. *Telonomus* sp. 12. *Tetrasticus* sp.

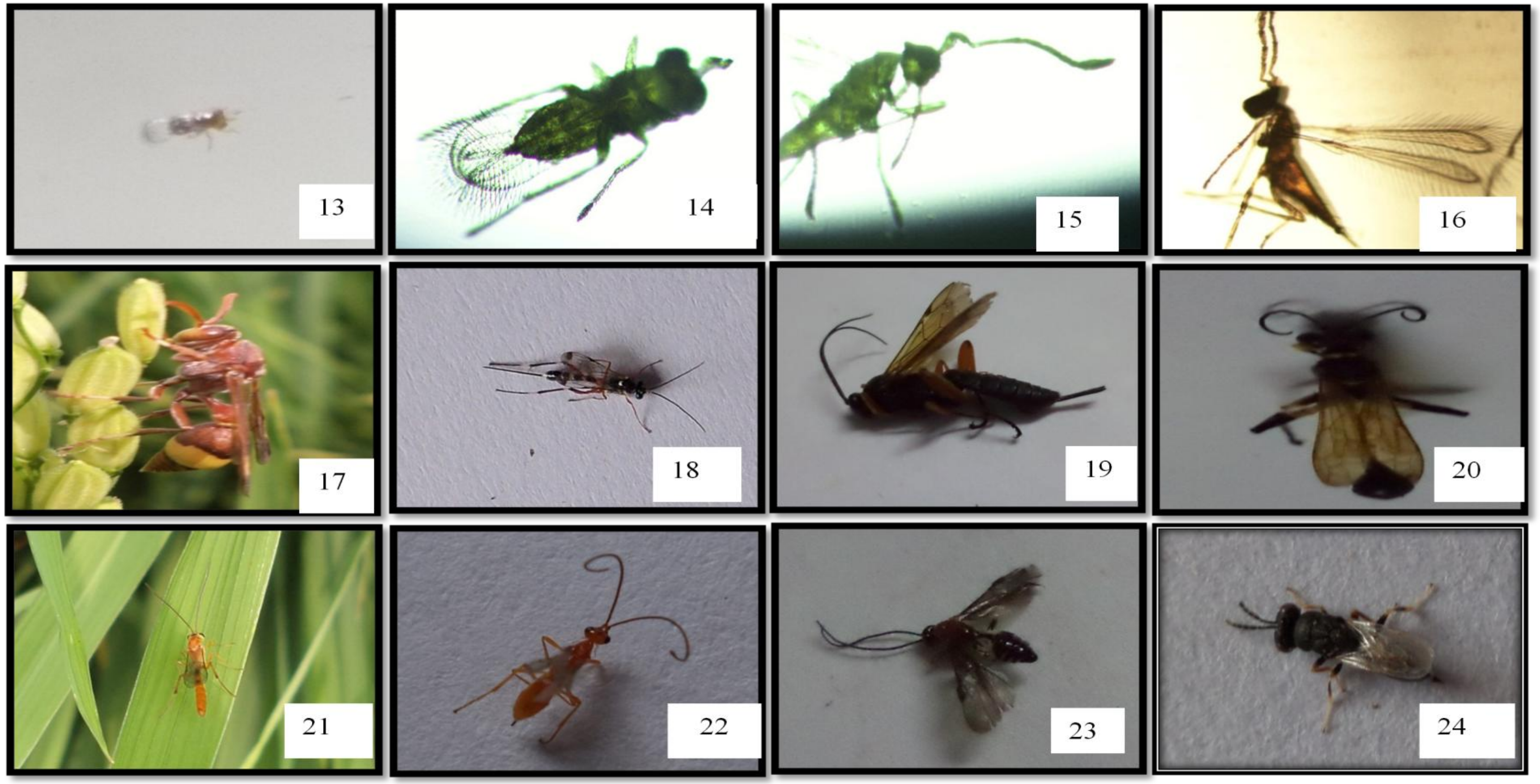

Plate No. 4 b: Different species of wasps found in different rice ecosystem: 13. *Trichogramma* sp.14. *Oligosita* sp.15. *Anagrus* sp. 16. *Gonetoserus* sp. 17. *Vespa cincta* and 17 to 24 unidentified species of wasps.

transplanted rice ecosystem (2.78 adult/25 sweeps), upland transplanted rice ecosystem (1.39 adult/25 sweeps) and upland direct seeded rice ecosystem (1.14 adult/25 sweeps) during *kharif* 2013-14 (Table 4.2.2).

These findings on the peak population of wasps are in agreement with the reports of Debjani and Raghuraman (1998) who reported total 645 hymenopterans parasitoids, belonging to 19 families and 5 super families and abundance of the parasitoids were highest in August-October in New Delhi, India. Khan and Alam (2007) also reported that the predators and parasitoid highest during mid tillering to reproductive stages respectively. Rajendra (2009) reported that the hymenopterans predators and parasitoids highest in upghat transplanted than upghat drill shown paddy ecosystem. Padmavathi *et al.*, (2007) and Karthikeyan *et al.*, (2010) reported that the larval parasitoids higher in SRI than that conventional method of cultivation. Zhong *et al.*, (2010) reported that the amount of major natural enemies were highest in organic as compaired to conventional farming.

4.2.3 Record of damselflies in different rice ecosystem (through sweeping net sampling)

In different rice ecosystem of Raipur damsel flies, *Ischnura aurora* Brauer, *Ceriagrion coromandelianum* Fabricius *Agriocnemis* sp., *A. axilis, Telebesis* sp. that belongs to family Coengrionidae were recorded (Table 4.2.3). Among the predators, damsel flies found as general predators. Perusal of data presented (Table 4.2.1 and 4.2.2) on the basis of week mean and seasonal mean concluded that the maximum populations of damselflies were recorded during last week of August to October month in different rice ecosystems. The population of damselflies were maximum in lowland organic rice ecosystem (3.97 adult/25 sweeps) followed by lowland conventional rice ecosystem (3.86 adult/25 sweeps), midland SRI rice ecosystem (3.57 adult/25 sweeps), upland transplanted rice ecosystem (3.05 adult/25 sweeps),

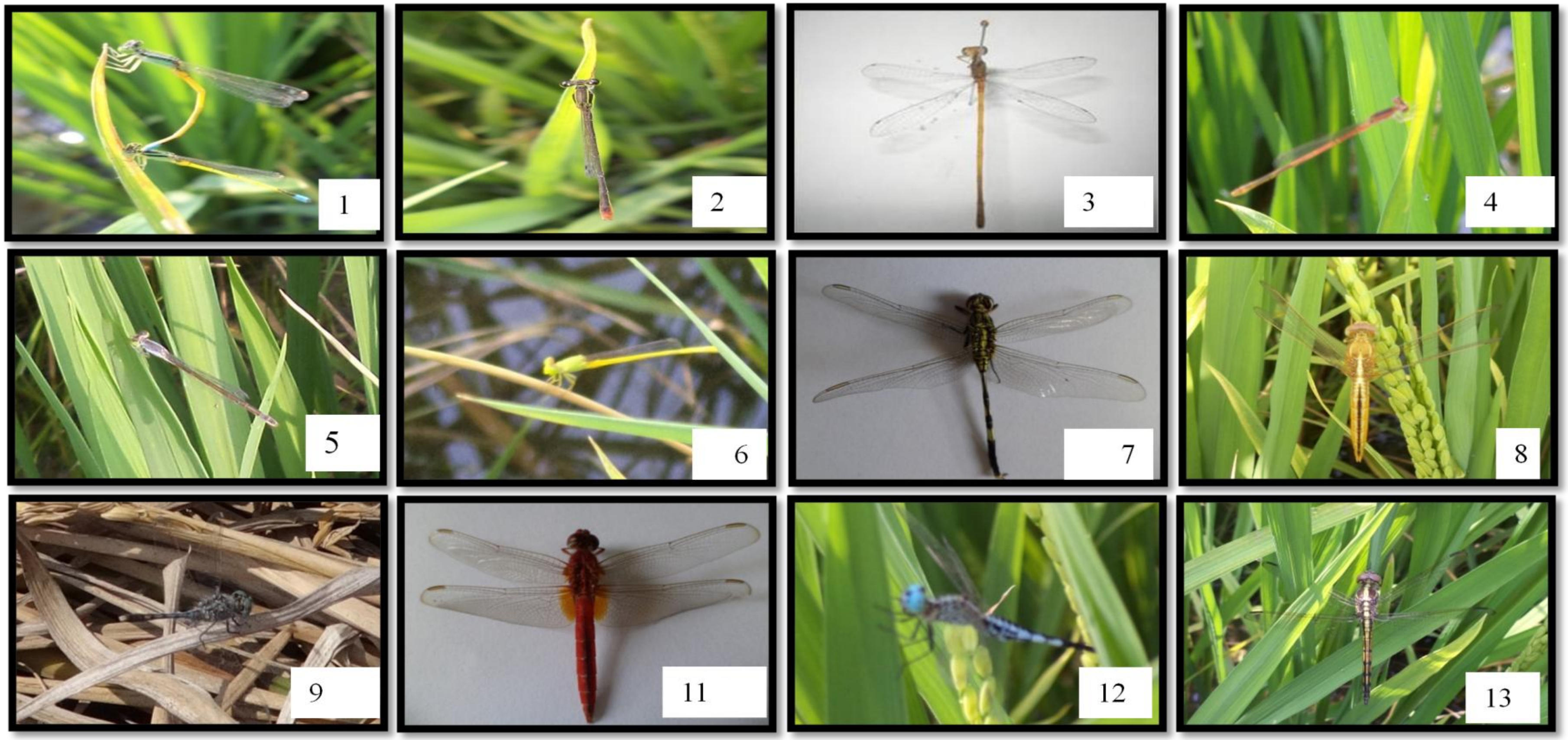

Plate No 2. Different species of damsel and dragon flies found in different rice ecosystem: 1. *Ischnura aurora* (Brauer), 2. *Ischnura Heterosticta* (Brauer) 3. *Ceriagrion coromandelianum*, 4. *Telebesis* sp. *Agriocnemis* sp. 5. Unidentified species. 6. Unidentified species, 7. *Orthetrium Sabina,* 8. *Pantala flavescens,* 9. *Diplacodes trivialis,* 10. *Crocothemis servilia,* 11.Unidentified species, 12. Unidentified species.

midland normal transplanted rice ecosystem (3.57 adult/25 sweeps) and upland direct seeded rice ecosystem (1.96 adult/25 sweeps).

The present findings on the records of damsel flies populations are in agreement with Lawanprasert *et al.,* (2004) who reported that the population of odonata/predators higher in organic than conventional rice fields. Rajendra (2009) also reported that the population of damsel flies peak during vegetative phase of crop. Zhong *et al.,* (2010) observed that the odonata/predators higher in organic than conventional rice fields. Girish (2010) reported that the population of damsel flies highest in transplanted than aerobic rice field and peak in September (drill sown) followed October (transplanted) and September (aerobic rice fields) month. Garg (2012) who reported the population of damsel flies were peak during September. On the opposing Rajendra (2009) and Karthikeyan *et al.,* (2010) reported that the population of damsel flies highest in upghat drill shown than upghat transplanted paddy ecosystem and conventional method than system of rice intensification (SRI), respectively.

4.2.4 Record of dragon flies in different rice ecosystem (through sweeping net sampling)

Dragon flies species recorded in different rice ecosystems that belonging to order odonata and family libelluidae include *Pantala flavescens* Fabricius, *Crocothemis servilia* Drury, *Orthetrium sabina* Drury, and *Diplacodes trivialis* Rambur (Table 4.2.3), were found predating many insect as a general predators. From the data presented (Table4.2.1 and 4.2.2) on the basis of week mean and seasonal/overall mean concluded that the peak populations of dragonflies were recorded during 1st week of September to October month and among the ecosystem dragon flies populations were maximum in lowland organic rice ecosystem (1.14

adult/25 sweeps) followed by lowland conventional rice ecosystem (1.00 adult/25 sweeps), midland normal transplanted rice ecosystem (0.92 adult/25 sweeps), midland SRI rice ecosystem (0.87 adult/25 sweeps) upland direct seeded rice ecosystem (0.57 adult/25 sweeps) and upland transplanted rice ecosystem (0.48 adult/25 sweeps).

Similar finding were also reported by Lawanprasert *et al.,* (2004) the odonata/predators higher in organic than conventional rice fields. Rajendra (2009) also reported the population of dragon flies peak during vegetative phase and highest in upghat drill shown than upghat transplanted paddy ecosystem. Karthikeyan *et al.,* (2010) reported that the damsel flies (odonata) highest in conventional method than system of rice intensification (SRI). Zhong *et al.,* (2010) recorded that the population of odonata/predators higher in organic than conventional rice fields. Girish (2010) reported that the population of odonata maximum in drill sown followed by transplanted and aerobic rice field and peak during September, October and September month respectivly. Garg (2012) also reported the population of predators and damsel fliespeak during September month.

On the contrary, Salokhe *et al.,* (2007) and Padmavathi *et. al.,* (2007) reported that the natural enemies higher in system of rice intensification (SRI) than conventional rice fields.

4.2.5 Record of carabids in different rice ecosystem (through sweeping net sampling)

Observations of the carabids in different rice ecosystem at Raipur during *kharif* season revealed that the presence of carabids *Ophionea nigrofasciata* Thunberg, *Ophionea indica* Thunberg belonging to family carabidae order coleoptera (Table 4.2.3). It is evident from the data (Table 4.2.1) the population of *Ophionea* spp. 1st peak in September and 2nd peak during October month. Among the ecosystem maximum overall mean populations of carabids were recorded in lowland conventional rice ecosystem (1.83 adult/25 sweeps) followed by midland SRI rice ecosystem (1.55 adult/25 sweeps), midland normal transplanted rice ecosystem (1.12 adult/25 sweeps), lowland organic rice ecosystem (0.69 adult/25 sweeps), upland transplanted rice ecosystem (0.59 adult/25 sweeps) and upland direct seeded rice ecosystem (0.48 adult/25 sweeps) (Table 4.2.2).

Similar finding were also reported by Salokhe *et al.,* (2007) and Padmavathi *et. al.,* (2007) the natural enemies of rice insect pest higher in system of rice intensification (SRI) than conventional rice fields. Elanchezhyan (2007) reported the *Ophionea* sp. predators on BPH and rice folder highest during vegetative than reproductive stage of crops. Khan and Alam (2007) reported that the carabids were peak during mid tillering to reproductive stage and highest in insecticide free plot as compared to insecticide treated plot. Rajendra (2009) also observed that the highest population of carabids recorded during vegetative phase and reproductive phase in upghat drill sown paddy ecosystem at Banvasi and Mundgod respectively and maximum in upghat drill sown paddy ecosystem than upghat transplanted paddy ecosystem in Uttara Kannada district of (A.P.). Girish (2010) reported that the peak population of carabids recorded during 75-90 DAS in month of September and maximum in transplanting method than drill and aerobic method in upland rice ecosystem. Garg (2012) reported that the 1st and 2nd peak activity of carabids were observed during 1st fort night of October and 2nd fort night of November in rice ecosystem at Raipur.

4.2.6 Record of rove beetle/staphylinids in different rice ecosystem (through sweeping net sampling)

Staphylinids species were recorded as *Paederus fuscipes* Curtis (Table 4.2.3) in different rice ecosystem. From the data presented in Table 4.2.1 on the observation of natural enemies revealed that, the staphylinids first appeared in the month of July and attain peak during 38 SMW to 42 SMW of September to October in among the ecosystem. The maximum overall mean populations of rove beetle, *Paederus fuscipes* Curtis were recorded in lowland organic rice ecosystem (0.55/25 sweeps) followed by midland SRI rice ecosystem (0.52/25 sweeps), upland transplanted rice ecosystem (0.73/25 sweeps), midland normal transplanted rice ecosystem (0.37/25 sweeps), lowland conventional rice ecosystem (0.39/25 sweeps) and upland direct seeded rice ecosystem (UDS) (0.36/25 sweeps) (Table 4.2.2).

These finding are in conformity with David *et al*., (2005) who reported the populations of rove beetles maximum in SRI as compared to conventional rice field. Rajendra (2009) also reported that the population of rove beetles highest in upghat transplanted paddy ecosystem than upghat drill sown paddy ecosystem at Sirsi and Banvsi in Uttara Kannada district of (A.P.). Madhukar (2005) also reported that the population of rove beetle, *Paederus fuscipes* Curtis was more in *rabi* than in *kharif* season. Zhong *et al.*, (2010) observed that the population of *Paederus fuscipes* Curtis higher in organic than that in conventional farming. Garg (2012) also reported that the peak activity of rove beetle was found during 2nd fort night of October in rice ecosystem at Raipur. On the opposing, Rajendra (2009) also reported that the populations of rove beetles peak during vegetative than reproductive phase of crops and highest in upghat drill sown than upghat transplanted paddy ecosystem at Siddapura and Banvsi in Uttara Kannada district of (A.P.).

4.2.7 Record of lady bird beetle/coccinellids in different rice ecosystem (through sweeping net sampling)

In present piece of investigation on the record of coccinellids as predators included *Harmonia octomaculata* Fabricius, *Coccinella transversalis* Fabricius, *Micraspis discolor*, *Micraspis* sp., *Verania* sp., *Monochilus sexmaculata* and *Adalia*

Table: 4.2.1 Observations of natural enemies found in different rice ecosystem at Raipur during *kharif* season 2013-14

Natural enemies	1. Mean population of spiders at weakly interval																						
Month	July		August					September					October						November				
SMW	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	1.00	1.00	2.25	2.50	3.25	2.00	10.00	3.50	3.75	2.75	1.25	11.25	2.25	6.00	15.00	7.75	0.00	31.00	-	-	0.00	53.25	3.80
UTP	0.00	1.25	2.00	3.50	3.00	6.00	14.50	4.25	7.25	6.50	5.00	23.00	3.00	8.50	6.00	11.00	8.00	36.50	-	-	0.00	74.00	5.29
MTN	4.25	4.25	4.50	2.00	3.00	2.00	11.50	0.75	4.00	1.50	2.25	8.50	4.25	4.75	13.00	12.25	14.00	48.25	17.00	-	17.00	89.50	5.97
MSR	0.50	1.75	1.00	2.75	4.75	2.25	10.75	1.00	3.00	2.50	2.00	8.50	6.00	7.25	8.75	10.25	11.75	44.00	28.75	-	28.75	92.50	6.17
LLC	1.00	1.75	3.75	3.50	7.50	3.50	18.25	5.25	7.00	3.50	2.00	17.75	1.25	2.50	3.00	7.75	12.50	27.00	15.00	20.00	35.00	99.00	6.19
LLO	1.25	1.25	4.00	7.00	9.00	8.00	28.00	4.00	6.00	2.25	1.50	13.75	3.00	1.75	4.00	10.75	15.00	34.50	17.00	25.25	42.25	119.75	7.48
	2. Mean population of wasps at weakly interval																						
UDS	0.00	0.00	0.25	1.75	0.75	1.25	4.00	2.25	1.75	1.25	2.25	7.50	3.50	1.00	0.00	0.00	0.00	4.50	-	-	0.00	16.00	1.14
UTP	0.00	0.00	1.50	1.25	0.25	1.00	4.00	3.50	2.50	3.25	2.75	12.00	1.50	0.75	0.00	0.00	1.25	3.50	-	-	0.00	19.50	1.39
MTN	1.00	1.00	0.75	1.25	0.00	1.00	3.00	0.25	1.00	3.75	3.00	8.00	3.50	2.75	4.00	6.25	8.25	24.75	5.00	-	5.00	41.75	2.78
MSR	0.25	0.25	1.00	1.75	0.50	0.75	4.00	0.75	2.75	2.00	1.75	7.25	2.50	3.00	0.00	11.25	13.25	30.00	7.00	-	7.00	48.50	3.23
LLC	2.00	2.00	3.50	2.00	0.75	1.00	7.25	0.00	2.00	1.00	1.25	4.25	1.50	4.00	5.00	3.00	16.25	29.75	2.50	3.75	6.25	49.50	3.09
LLO	0.25	0.25	0.50	1.00	1.75	2.00	5.25	1.25	3.00	3.50	7.25	15.00	5.25	2.25	6.00	4.00	8.50	26.00	12.50	6.25	18.75	65.25	4.08
	3. Mean population of damsel flies at weakly interval																						
UDS	0.25	0.25	1.00	3.25	3.75	4.25	12.25	8.25	3.50	2.00	0.75	14.50	0.50	0.00	0.00	0.00	0.00	0.50	-	-	0.00	27.50	1.96
UTP	0.25	0.25	2.75	6.00	4.00	3.25	16.00	6.50	9.00	3.00	2.25	20.75	1.50	1.75	2.50	0.00	0.00	5.75	-	-	0.00	42.75	3.05
MTN	4.00	4.00	3.00	0.00	2.00	4.00	9.00	2.75	3.75	2.75	5.00	14.25	2.00	3.00	4.25	4.00	3.00	16.25	0.00	-	0.00	44.50	2.97
MSR	2.25	2.25	1.75	1.25	3.00	2.25	8.25	2.25	2.75	3.00	3.75	11.75	6.25	8.75	7.00	2.25	5.00	29.25	0.00	-	0.00	53.50	3.57
LLC	1.25	1.25	3.50	11.00	4.00	9.25	27.75	2.00	5.75	3.50	2.25	13.50	3.00	4.00	4.50	6.75	0.75	19.00	0.00	0.00	0.00	61.75	3.86
LLO	1.75	1.75	2.25	3.00	4.25	3.75	13.25	4.25	4.00	1.75	3.50	13.50	5.50	7.75	8.25	5.00	4.75	31.25	0.50	0.00	0.50	63.50	3.97

SMW= Standard meteorological week, UDS = Upland direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, - = Crop harvested.

Continue…

Table: 4.2.1Observations of natural enemies found in different rice ecosystem at Raipur during *kharif* season 2013-14

Natural enemies	**4. Mean population of dragon flies at weakly interval**																						
Month	July		August					September					October						November				
SMW	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.25	0.75	1.25	1.75	4.00	2.00	0.25	0.75	0.25	3.25	0.50	0.00	0.25	0.00	0.00	0.75	-	-	0.00	8.00	0.57
UTP	0.00	0.00	0.25	0.25	0.00	0.50	1.00	1.75	0.50	0.75	0.25	3.25	0.50	0.50	1.25	0.25	0.00	2.50	-	-	0.00	6.75	0.48
MTN	0.00	0.00	0.25	0.25	1.25	1.50	3.25	0.75	0.75	1.00	1.75	4.25	1.00	1.25	2.75	1.00	0.25	6.25	0.00	-	0.00	13.75	0.92
MSR	0.00	0.00	0.25	0.50	0.25	1.00	2.00	0.25	0.50	0.75	2.50	4.00	1.00	0.50	0.75	1.50	2.00	5.75	0.00	-	0.00	11.75	0.78
LLC	0.50	0.50	0.25	0.25	0.25	0.50	1.25	0.75	1.75	4.00	2.75	9.25	1.75	1.00	1.75	0.25	0.00	4.75	0.25	0.00	0.25	16.00	1.00
LLO	0.75	0.75	0.50	1.25	2.25	0.75	4.75	1.75	3.75	2.50	2.00	10.00	1.00	0.75	0.50	0.25	0.00	2.50	0.00	0.25	0.25	18.25	1.14
	5. Mean population of carabids beetles at weakly interval																						
UDS	0.00	0.00	0.00	0.00	0.25	0.75	1.00	1.00	2.50	1.25	0.75	5.50	0.25	0.00	0.00	0.00	0.00	0.25	-	-	0.00	6.75	0.48
UTP	0.00	0.00	1.25	0.25	0.25	0.75	2.50	1.00	1.25	2.00	0.75	5.00	0.50	0.25	0.00	0.00	0.00	0.75	-	-	0.00	8.25	0.59
MTN	1.00	1.00	0.75	0.25	0.25	0.50	1.75	1.00	1.00	1.25	1.75	5.00	0.75	0.25	1.00	3.00	4.00	9.00	0.00	-	0.00	16.75	1.12
MSR	0.75	0.75	0.25	0.25	0.50	1.00	2.00	1.25	1.50	2.75	0.25	5.75	0.50	1.75	2.25	3.75	5.75	14.00	0.75	-	0.75	23.25	1.55
LLC	0.25	0.25	1.00	0.25	0.50	1.25	3.00	0.25	0.75	1.00	2.75	4.75	0.50	1.75	3.00	6.00	6.25	17.50	3.75	0.00	3.75	29.25	1.83
LLO	0.00	0.00	0.25	0.25	0.50	1.00	2.00	0.25	0.25	0.75	1.00	2.25	1.00	3.00	2.00	0.75	0.00	6.75	0.00	0.00	0.00	11.00	0.69
	6. Mean population of rove beetles (staphylinids) at weakly interval																						
UDS	0.00	0.00	0.00	0.00	0.25	0.25	0.50	0.50	0.75	1.00	1.25	3.50	0.50	0.25	0.00	0.25	0.00	1.00	-	-	0.00	5.00	0.36
UTP	0.00	0.00	0.00	0.00	0.25	0.50	0.75	0.75	1.75	1.00	0.50	4.00	0.75	1.25	3.00	0.25	0.25	5.50	-	-	0.00	10.25	0.73
MTN	0.25	0.25	0.00	0.00	0.25	0.00	0.25	0.25	0.50	1.75	1.00	3.50	0.75	0.25	0.25	0.00	0.00	1.25	0.25	-	0.25	5.50	0.37
MSR	0.00	0.00	0.25	0.50	0.25	0.00	1.00	0.25	0.25	2.00	1.50	4.00	1.00	0.75	0.25	0.50	0.00	2.50	0.25	-	0.25	7.75	0.52
LLC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.50	1.00	2.00	2.25	1.00	0.50	0.25	0.00	4.00	0.00	0.25	0.25	6.25	0.39
LLO	0.00	0.00	0.50	1.00	0.00	0.25	1.75	0.25	0.25	1.00	1.25	2.75	2.00	1.00	0.75	0.25	0.00	4.00	0.25	0.00	0.25	8.75	0.55

SMW= Standard meteorological week, UDS = Upland direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, - = Crop harvested.

Continue…

Table: 4.2.1 Observations of natural enemies found in different rice ecosystem at Raipur during *kharif* season 2013-14

Natural enemies	**7. Mean population of coccinellids at weakly interval**																						
Month/ SMW	July		August					September					October						November				
Ecosystem	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.25	0.00	0.25	0.00	0.50	0.00	0.25	2.25	0.75	3.25	1.00	1.50	3.75	1.75	0.00	8.00	-	-	0.00	11.75	0.84
UTP	0.75	0.75	1.00	1.25	0.00	0.00	2.25	0.00	0.25	2.00	1.00	3.25	1.75	0.00	0.00	0.00	1.25	3.00	-	-	0.00	9.25	0.66
MTN	0.00	0.00	0.25	0.00	0.00	0.75	1.00	0.00	0.25	0.00	0.50	0.75	0.25	0.00	1.75	2.00	4.75	8.75	7.00	-	7.00	17.50	1.17
MSR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.50	0.00	0.75	0.00	0.00	0.00	3.75	8.75	12.50	12.50	-	12.50	25.75	1.72
LLC	0.00	0.00	0.25	0.25	0.00	0.00	0.50	0.00	0.25	0.25	0.50	1.00	0.00	0.50	0.75	1.25	1.75	4.25	5.00	3.50	8.50	14.25	0.89
LLO	0.00	0.00	0.00	0.25	0.00	0.25	0.50	0.50	1.00	0.25	0.00	1.75	0.50	0.25	18.75	0.00	2.50	22.00	6.25	8.75	15.00	39.25	2.45
	8. Mean population of mirids at weakly interval																						
UDS	0.25	0.25	0.00	0.50	0.75	2.00	3.25	1.25	2.25	2.50	0.00	6.00	0.25	0.75	4.25	0.75	0.00	6.00	-	-	0.00	15.50	1.11
UTP	0.25	0.25	1.00	0.25	0.00	0.25	1.50	0.50	0.00	0.25	0.50	1.25	0.50	1.00	2.75	1.25	0.00	5.50	-	-	0.00	8.50	0.61
MTN	0.00	0.00	0.00	0.25	0.00	0.00	0.25	0.25	0.50	1.00	0.50	2.25	0.25	0.75	1.25	2.50	1.25	6.00	1.00	-	1.00	9.50	0.63
MSR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.50	0.25	1.25	0.25	0.25	2.25	2.75	3.25	8.75	7.50	-	7.50	17.50	1.17
LLC	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	1.25	1.75	2.25	5.50	3.00	3.75	6.75	13.25	0.83
LLO	0.00	0.00	0.50	0.00	0.25	0.50	1.25	1.00	1.75	2.25	3.00	8.00	0.75	0.50	0.50	0.75	1.00	3.50	1.75	4.50	6.25	19.00	1.19
	9. Mean population of assassian bugs at weakly interval																						
UDS	0.00	0.00	0.00	0.00	0.25	0.25	0.50	0.25	0.50	0.25	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	1.50	0.11
UTP	0.00	0.00	0.00	0.25	0.25	0.75	1.25	1.00	1.25	0.25	0.50	3.00	0.25	0.00	0.00	0.00	0.00	0.25	-	-	0.00	4.50	0.32
MTN	0.00	0.00	0.00	0.00	0.25	0.25	0.50	0.00	0.25	0.75	1.25	2.25	0.50	0.25	0.00	0.00	0.00	0.75	0.00	-	0.00	3.50	0.23
MSR	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.50	1.00	0.75	2.50	0.00	0.25	0.25	1.00	0.00	1.50	0.00	-	0.00	4.25	0.28
LLC	0.00	0.00	0.00	0.00	0.00	0.25	0.25	1.00	1.25	1.50	0.75	4.50	0.25	0.25	0.75	0.00	0.00	1.25	0.00	0.00	0.00	6.00	0.38
LLO	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.25	0.25	1.00	2.75	4.25	0.75	0.25	0.00	0.00	0.00	1.00	1.00	2.25	3.25	8.75	0.55

SMW= Standard meteorological week, UDS = Upland direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT=Grand total of month, OM=Overall mean, - = Crop harvested.

Continue…

Table: 4.2.1 Observation of natural enemies found in different rice ecosystem at Raipur during *kharif* season 2013-14

Natural enemies	**10. Mean population of technid flies at weakly interval**																						
Month/ SMW	July		August					September					October						November				
Ecosystem	31	T	32	33	34	35	T	36	37	38	39	T	40	41	42	43	44	T	45	46	T	GT	OM
UDS	0.00	0.00	0.00	0.25	0.25	0.50	1.00	0.75	0.25	0.25	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	-	--	0.00	2.25	0.16
UTP	0.00	0.00	0.25	0.25	0.00	0.50	1.00	1.00	1.50	1.25	0.25	4.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	5.00	0.36
MTN	0.25	0.25	0.25	0.00	0.50	1.00	1.75	0.75	0.75	0.00	0.50	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	4.00	0.27
MSR	0.25	0.25	0.50	0.25	0.75	0.25	1.75	0.25	0.25	0.50	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	3.00	0.20
LLC	0.00	0.00	0.00	0.25	0.00	0.25	0.50	0.25	0.75	0.25	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.11
LLO	0.25	0.25	0.50	0.75	1.00	1.75	4.00	0.50	0.50	0.00	0.00	1.00	0.00	0.25	1.25	0.00	0.00	1.50	0.00	0.00	0.00	6.75	0.42
	11. Mean population of NPV infected larvae (leaf folder, rice skipper and horned caterpillar)																						
UDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00
UTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00
MTN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00
MSR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.25	0.02
LLC	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.00	0.50	0.00	0.25	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.06
LLO	0.00	0.00	0.00	0.00	0.25	0.25	0.50	0.25	0.25	0.00	0.50	1.00	0.25	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	1.75	0.11

SMW= Standard meteorological week, UDS = Upland direct seeded (Aerobic) rice ecosystem, UTP = Upland transplanted rice ecosystem, MNT = Midland normal transplanted rice ecosystem, MSR = Midland SRI (System of rice intensification) ecosystem, LLC = Lowland conventional rice ecosystem, LLO = Lowland organic rice ecosystem, T= Month total, GT= Grand total of month, OM= Overall mean, - = Crop harvested.

Table: 4.2.2 Overall situations of natural enemies (seasonal mean) of rice insect pestsfound in different rice ecosystem at Raipur during *kharif* season 2013-14

Natural enemies	Spiders	Wasps	Damsal flies	Dragon flies	Carabids	Rove beetle	Coccinellids	Mirids	Assassian bugs	Technid flies	NPV infected larvae
UDS	3.8	1.14	1.96	0.57	0.48	0.36	0.84	1.11	0.11	0.39	0.00
UTP	5.29	1.39	3.05	0.48	0.59	0.73	0.66	0.61	0.32	0.16	0.00
MTN	5.97	2.78	2.97	0.92	1.12	0.37	1.17	0.63	0.23	0.27	0.00
MSR	6.17	3.23	3.57	0.78	1.55	0.52	1.72	1.17	0.28	0.20	0.02
LLC	6.19	3.09	3.86	1.00	1.83	0.39	0.89	0.83	0.38	0.08	0.06
LLO	7.48	4.08	3.97	1.14	0.69	0.55	2.45	1.19	0.55	0.42	0.11

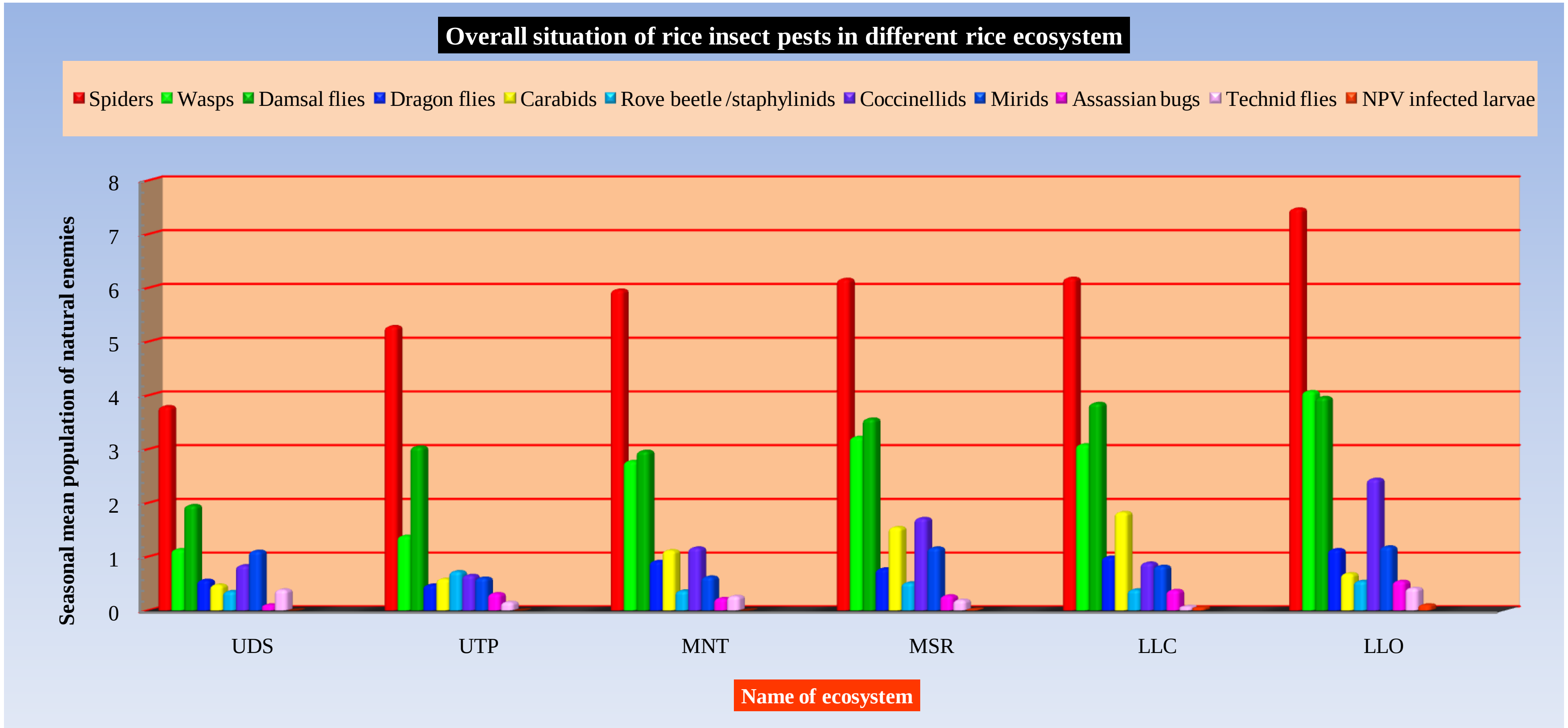

Figure: 4.2.2 **Overall situations of natural enemies of rice insect pests found in different rice ecosystem at Raipur during *kharif* 2013-14**

bipunctata (Table 4.2.3) in different rice ecosystem at Raipur. From the data presented in Table 4.2.1 revealed that the peak populations of coccinellids were observed from 38 SMW to 46 SMW of September-November in across the rice ecosystem. The maximum overall mean population of coccinellids grubs/adult were recorded in lowland organic rice ecosystem (2.45/25 sweeps), followed by midland SRI rice ecosystem (1.72/25 sweeps), midland normal transplanted rice ecosystem (1.17/25 sweeps), lowland conventional rice ecosystem (0.89/25 sweeps), upland direct seeded rice ecosystem (0.84/25 sweeps) and upland transplanted rice ecosystem (0.66/25 sweeps).

The present findings are corroborates with reports of Lawanprasert *et al.,* (2004), the highest population of coccinellids observed in organic method as compaired to conventional method of cultivation. Madhukar (2005) also reported that the population of lady bird beetles, *Micraspis* (=*Verania*) *discolor* and *Hormonia octamaculata,* was more in *rabi* than *kharif* season. Salokhe *et al.,* (2007), Padmavathi *et al.,* (2007) reported that the natural enemies of rice insect pest higher in system of rice intensification (SRI) than conventional rice fields from Thailand and India. Reddy *et al.,* (2007) and Rajendra (2009) reported that the coccinella higher in 100 per cent organic manure plus no plant protection than 100 per cent organic manure plus need based plant protection and upghat drill shown than upghat transplanting paddy ecosystem respectively. Kasyanov (2010) reported 13 coccinellid species in rice ecosystems of Krasnodar, Russia. Girish (2010) reported that the coccinella higher in drill than aerobic and transplanting method in upland rice ecosystem, respectively.

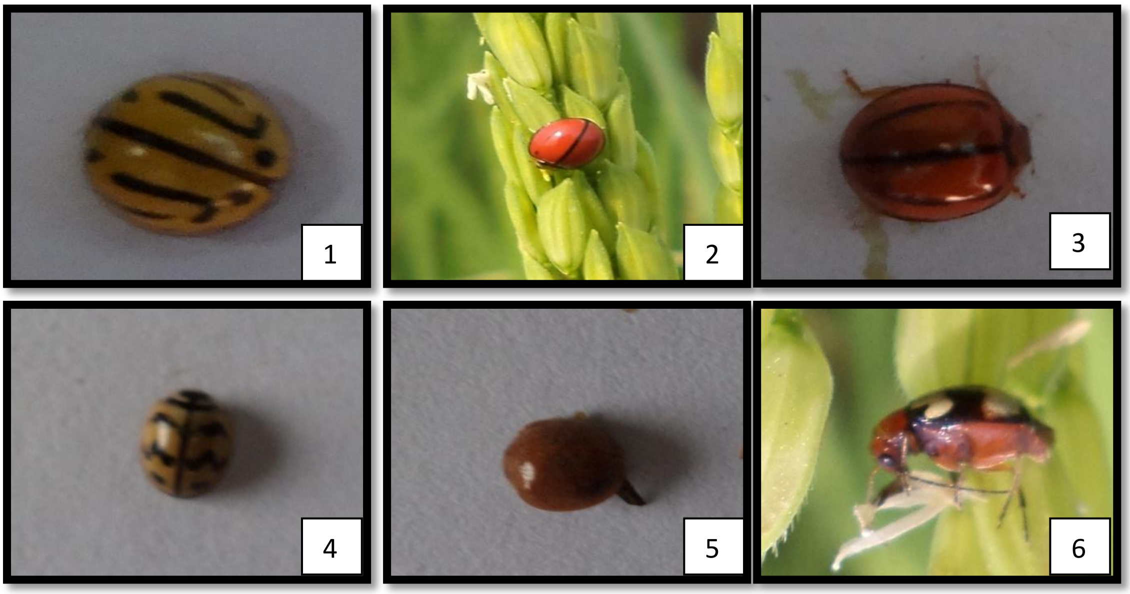

Plate No 5.Diffrent species of lady bird beetle found in different rice ecosystem: 1. *Verania* sp. 2. *Micraspis* discolor, 3 *Micraspis* sp., 4.*Monochilus sexmaculata* 5. Unidentified species, 6. Unidentified species

Plate No 6. Mirid bugs adult and nymph found in different rice ecosystem: 1. *Thythus* sp. 2. *Cyrtorhinus lividipennis* 3. Nymph of *Thytus* sp.

Plate No7 Ground beetle, *Ophionea nigrofasciata*, Plate No 8. Rove beetle, *Paederus fuscipes*, Plate No 9. Ear wigs, *Doru aculeatum* (Scudder)

4.2.8 Record of mirids in different rice ecosystem (through sweeping net sampling)

In present piece of investigation, mirids were recorded as *Cyrtorhinus lividipennis* Reuter and *Tythus* sp. in different rice ecosystem (Table 4.2.3). The peak population of mirids observed from 42 SMW to 46 SMW of October-November in veried population level in among the ecosystem (Table 4.2.1). The maximum population (overall mean) of mirids nymph/aduld were recorded in lowland organic rice ecosystem (1.19/25 sweeps), followed by midland SRI rice ecosystem (1.17/25 sweeps), upland direct seeded rice ecosystem (1.11/25 sweeps), lowland conventional rice ecosystem (0.83/25 sweeps), midland normal transplanted rice ecosystem (0.63/25 sweeps), and upland transplanted rice ecosystem (0.61/25 sweeps) (Table 4.2.2).

The present findings are in agreement with the report of Das and Thomas (1977), Chiu (1979), Kajjinura (1993,1995), Gururaj *et al.,* (1996), David *et al.,* (2005) but disagree with the report of Mohan and Janarthanan (1985) who reported uniform distribution of *C. lividipennis* during the rice crop season. Xian *et al.,* (2006) also reported that the Nitrogen fertilizer substantially reduced the predatory behaviour of mirid bug, *Cyrtorhinus lividipennis,* and its predation capacities both on eggs and young nymphs of brown planthoppers, *Nilaparvata lugens,* on rice crop. Rajendra (2009) reported that the population of *Cyrtorhinus lividipennis* and *Tythus* sp. was highest during November month and the maximum populations were recorded in upghat drill shown than upghat transplanting paddy ecosystem.

4.2.9 Record of assassian bug in different rice ecosystem (through sweeping net sampling)

Assassian bug were common predators of larvae of moth and butterfly recorded in different rice ecosystem *Polytoxus fuscovittatus* Stal belonging to family reduvidae, order hemiptera (Table 4.2.3). Weekly observations in rice ecosystem revealed that (Table 4.2.1) the peak populations of assassian bug were recorded during 37 SMW to 39 SMW in month of September with veried population level. Among the ecosystem the maximum overall mean population of assassian bug nymph/adult was recorded in lowland organic rice ecosystem (0.55 adult/25 sweeps), followed by lowland conventional rice ecosystem (0.38 adult/25 sweeps), upland transplanted rice ecosystem (0.32 adult/25 sweeps), midland SRI rice ecosystem (0.28 adult/25 sweeps), MNT (0.23 adult/25 sweeps) and upland direct seeded rice ecosystem (0.11 adult/25 sweeps).

These finding are in conformity with Rajendra (2009)) who reported the reduviid species identified were *Ectrychotes crudelis* and *Acanthaspis* sp. found predating on rice insect pests maximum in upghat transplanted paddy ecosystem than upghat drill sown paddy ecosystem. Afun *et al.* (1994-95) reported the abundance of reduviid bugs was positively correlated with weed biomass only in 1995 in upland rice in Cote d'Ivoire over two years.

4.2.10 Record of technid flies in different rice ecosystem (through sweeping net sampling)

In present piece of investigation, technid fly *Chaetomylobia javana* Brauer belonging to family tachinidae and order diptera recorded in different rice ecosystem (Table 4.2.3). Weekly observation, on rice ecosystem (Table 4.2.1) revealed that, the peak population of technid flies obsrved during 34 SMW to 37 SMW of August-September in the all ecosystem. Among the ecosystem maximum population (overall mean) of technid fly *C. javana* was recorded in lowland organic rice ecosystem (0.42 adult/25 sweeps), followed by upland transplanted rice ecosystem (0.36 adult/25 sweeps), midland normal transplanted rice ecosystem (0.27 adult/25 sweeps), midland

Plate No 10. Syrphid fly adult, Plate No 11. Techanid fly pupa, Plate No 12. Assassin bug, adult

Plate No. 13. Dragon and damselfly naiad, Plate No. 14 Water strider, Plate No 15 Water beetle

Plate No. 16. Virus infected rice skipper larvae, Plate No. 17 Virus infected horn caterpillar larvae

Plate No 18 Pathogenic fungus infected rice skipper larvae

SRI rice ecosystem (0.20 adult/25 sweeps), upland direct seeded rice ecosystem (0.16 adult/25 sweeps) and lowland conventional rice ecosystem (0.11 adult/25 sweeps).

These are in conformity with Rajendra (2009) who reported that the tachnid parasitoid, *Chaetomylobia javana* was active during vegetative phase of rice crops and absolutely zero per cent parasitism in upghat drill sown ecosystem than upghat transplanted upland rainfed paddy ecosystem in Uttara Kannada (A.P.).

4.2.11 Record of virus infected larvae in different rice ecosystem (through sweeping net sampling)

From the data presented in Table 4.2.1 and 4.2.2 the NPV infected larvae were recorded in midland SRI rice ecosystem, lowland conventional rice ecosystem (LLC) and lowland organic rice ecosystem (LLO) and it was found attacking on rice leaf folder, horned caterpillar and rice skiper larvae. The NPV infected larvae was zero in upland direct seeded rice ecosystem (UDS), upland transplanted rice ecosystem (UTP) and midland normal transplanted rice ecosystem (MNT) during study periods. The maximum population of virus infected larvae were observed in LLO with 0.11/25 sweeps followed LLC with 0.06/25 sweeps and MSR with 0.02/25 sweeps) in rice ecosystem and peak during vegetative stage of crops in month of September.

4.2.12 Others

The aquatic natural enemies water treader, *Mesovelia vittigera* Horvath, water strider, *Limnogonus* sp., water bug, *Microvelia* sp., hydrophilid beetle, *Dytiscus* sp., back swimmer, *Notonecta* sp., water boatmen, *Arctocoriza sp.*, water measurers, *Hydrometa* sp. damselfly naiad and dragon fly naiad were recorded by visual observation and drag net only in lowland conventional rice ecosystem (LLC) and lowland organic rice ecosystem (LLO). Maximum numbers of these natural enemies were observed in LLO as compared to LLC rice ecosystem. Naiad populations of odonata were maximmum during August to October in rice ecosystem at Raipur.

Table: 4.2.3 List of the natural enemies found in different rice ecosystem at Raipur during *kharif* season 2013-14

Name of natural enemies	Scientific name	Family	Class/Order	Host
	Predators			
Mirid bug	*Cyrtorhinus lividipennis* Reuter	Miridae	Hemiptera	Leafhopper and plant hopper eggs, nymphs and adults of BPH
	Tytthus parviceps, Tytthus chinensis			
Pentatomid bug	*Andrallus spinidens* Fabricius	Pentatomidae		Predaceous on lepidopterous larvae
Reduviid bug	*Ectrychotes crudelis* Fabricius	Reduviidae		Leafhoppers
	Acanthaspis sp.			Leafhoppers
Assassin bug	*Polytoxus fuscovittatus* Stal.			Larvae of moths and butterflies
Water treader	*Mesovelia vittigera* Horvath	Gerridae		Leaf hoppers, plant hoppers, and moths
Water strider	*Limnogonus fossarum* Fabricius			Leafhoppers and plant hoppers
Water bug	*Microvelia* sp.,*Microvelia douglasi atrolineata*	Veliidae		Stem borers, leaf hoppers, and plant hoppers
Big eyed bug	*Geocoris* sp.	Lygaeidae		Small insects and insect eggs.
Hydrophilid beetle	*Dytiscus* sp.	Hydrophilidae		Preys caseworm larva
Damsel bug	*Nabis* sp.	Nabidae		Small insects and insect eggs.
Water measurers	*Hydrometa* sp.	Hydrometidae		Leafhoppers and plant hoppers
Wasp	*Vespa cincta*	Vespidae	Hymenoptera	General predators, caterpillar
Lady bird beetle	*Harmonia octomaculata* Fabricius	Coccinellidae	Coleoptera	General predators
	Coccinella transversalis Fabricius			
	Micraspis discolor, Micraspis sp.			
	Verania sp.			
	Monochilus sexmaculata			
	Adalia bipunctata			
Rove beetle	*Paederus fuscipes* Curtis	Staphylinidae		General predators
Carabid beetle	*Ophionea nigrofasciata* Schmidt-Goebel, *Ophionea indica* Thunberg,	Carabidae		General predators
	Chlaenius msdioguttatus			
	Calosoma maderea			
Tiger beetle	*Cicindela duponti* Dejean	Cicindelidae		Feeds on nymphs of gundhi bug
	Cicindela sexguttata Fabricius			
Earwig	*Doru aculeatum* Scudder, *Euborellia Stali*	Forficulidae	Dermaptera	Leaffolder and stem borer larvae.
Green lace wigs	*Chrysopa sp.*, *Mallada signata*	Chrysopidae	Neuroptera	General predators
Mantid	*Unidentified* sp.	Mentidae	Dictyoptera	General predators
Sword-tailed cricket	*Metioche vittaticollis* Stal	Gryllidae	Orthoptera	Bugs, hoppers, larvae of whorl maggot, leaf folder, stem borers
Meadow Grasshopper	*Conocephalus longipennis* De Haan	Tettigoniidae		Eggs of rice bugs and stem borers & nymphs of leafand plant hoppers

Continuo…

Table: 4.2.3 List of the natural enemies found in different rice ecosystem at Raipur during *kharif* season 2013-14

Name of natural enemies	Scientific name	Family	Class/Order	Host
	Parasitoids			
Wasp	*Isothima javensis*	Ichneumonidae	Hymenoptera	Rice skiper
	Ischnojoppa luteator Fabr.			Rice skiper
	Charops bicolor Szepligeti			parasitoid
	Echthromorpha agrestoria notalatoria Fabr.			Larval parasitoid Larval parasitoid
	Xanthopimpla flavolineata			Papal parasitoid
	Xanthopimpla punctata Fabricius			Papal parasitoid
	Temelucha sp.			Larval parasitoid stem borer
	Amauromorpha accepta,			Larval parasitoid stem borer
	Metathoracica sp.			
	Apanteles(Cotesia) angustibasis, A.boais	Braconidae		Folder larval parasitoid
	Dolicchogenidia sp.			Rice skipper, Rice folder larval parasitoid
	Sternobracon nicerillei Bingham			Larval parasitoid stem borer
	Rogas sp., *Bracon* sp., *Microbracon* sp.			parasitoid
	Macrocentrus sp.			Leaf folder larval parasitoid
	Opius barrioni Fisher			Parasite of whorl maggot
	Phanerotoma sp.			
	Elasmus sp.	*Elasmdae*		parasitoid
	Tetrastichus sp.	Eulophidae		Eggs parasitoid stem borer
	Telenomus sp.	Scelionidae		Eggs parasitoid stem borer
	Goniozus sp., *Goniozus nr. triangulifer* Kieffer	Drynidae		Leaf folder larval parasitoid
	Panstenon nr. Collaris	Pteromalidae		parasitoid
	Aleiodes indiscretus			
	Brachymeria sp.	Chalcididae		Pupal parasitoids of leaf folder
	Trichogramma sp.	Trichogrammatidae		Eggs parasitoids of stem borer and leaf folder
	Oligosita sp.			Eggs parasitoids of BPH
	Anagrus sp.	Mymaridae		Eggs parasitoids of BPH
	Gonatocerus sp.			Eggs parasitoids of BPH
Tachinid fly	*Chaetomylobia javana* Brauer	Tachinidae	Diptera	Leaf folder

Continuo…

Table: 4.2.3 List of the natural enemies in different rice ecosystem record at Raipur during 2013-14

Name of natural enemies	Scientific name	Family	Order	Host
	Predators			
Damselfly	*Ischnura aurora* Brauer *Ischnura heterosticta* Burmeister	Coengrionidae	Odonata	General predators
	Ceriagrion coromandelianum Fabricius			General predators
	Agriocnemis sp., *A. axilis,*			General predators
	Telebesis sp.			General predators
Dragon fly	*Pantala flavescens* Fabricius	Libelluidae		General predators
	Crocothemis servilia Drury			General predators
	Orthetrium sabina Drury			General predators
	Diplacodes trivialis Rambur			General predators
Spiders:-				
Wolf spider	*Pardosa* sp.	Lycosidae	Araneae	Predator on leafhopper, Plant hoppers and leaf eating caterpillars
	Lycosa pseudoannulata,			
	Pirata piraticus,			
	Agelena sp.			
	Tibellus sp.			
Lynx spider	*Oxyopes* sp. *Oxyopes javanus*	Oxyopidae		
Long-jawed Orb Weavers	*Tetragnatha* sp.	Tetragnathidae		
	T.mandibulata, T.javana, Tetragnatha maxillosa			
	Leucauge sp.			
Crab spiders	*Thomisus* sp.	Thomisidae		
Orb Spider	*Argiope* sp.	Araneidae		
	Araneus spp.			
	Cyclosa spp.			
	Araniella spp.			
Jumping spiders	*Phidippus* sp.	Salticidae		
	Heliophanus spp.			
Dwarf spiders	*Atypena formosana* Oi.	Linyphiidae		
Spiders	*Clubiona* sp.	Clubionidae		
Spiders	*Enoplognatha japonica*	Theridiidae		

Earwig, *Doru aculeatum* Scudder, *Euborellia Stali*., pentatomid, *Andrallus spinidens*, reduviids *Ectrychotes crudelis*, sword-tailed cricket, *Metioche vittaticollis and* meadow grasshopper, *Conocephalus longipennis* Haan, mantid, *Mentis* sp., green lace wigs *Chrysopa* sp., *Mallada signata*, tiger beetle, *Cicindela duponti* Dejean, *Cicindela sexguttata* Fabricius, damsel bug, *Nabis sp. Beauveria* sp. N*omuraea* sp.*infected larvae* were recorded among the rice ecosystem but their population was very negligible.

Aditional work: Stem borer egg mass parasitization:

Freshly laid ten egg mass of stem borer were collected from the infested field at weekly interval. This egg mass were brought in the laboratory and kept in glass vials separately along with leaf pieces and vials were covered with cotton and observed everyday for the emergence of larvae and parasites. Based on the number of emerged larvae and parasitoids percent egg mass parasitization was calculated. From the data presented (Table 4.2.4) revealed that the maximum percent of egg parasitization by *Telenomus* sp. was observed in the second week of October (53.95%). The 1st week (40 SMW) of October shows (42.97%) second position in percent egg parasitization. The minimum percent of egg parasitization by *Telenomus* sp. was observed in the 39 SMW of September (13.99%). Parasitization by Trichogramm sp. was maximum with (17.31%) during 39 SMW of September and parasitization by *Tetrastichus* sp. was zero during *kharif* season. The seasonal average of percent egg mass parasitization was 37.99 per cent and ranged from 23.5 to 58.36 per cent.

Similar findings were reported by Kumar *et al*., (2008) who reported that the *Telenomus* sp. parasitizing up to 78.4 per cent on October, while the lowest egg parasitization was found in the 1st fort night of August (6.4%). Chakraborty (2008) also reported that the presence of three parasitoids species in a single egg mass is

Table 4.2.4 Observation of stem borer egg mass parasitization at Raipur during *kharif* season 2013-14

Month	September		October					November	Seasonal Average
SMW	38	39	40	41	42	43	44	45	
No of larvae/10EM	1012.00	889.00	560.00	274.00	367.00	360.00	442.00	309.00	527.88
No of parasitoids /10EM	401.00	405.00	422.00	384.00	258.00	240.00	272.00	95.00	310.13
Expected No of total fertile eggs/10 EM	1413.00	1294.00	982.00	658.00	625.00	600.00	714.00	404.00	838.00
No of fertile eggs/EM	141.30	129.40	98.20	65.80	62.00	60.00	71.40	40.40	83.74
No of parasitoids/EM	40.10	40.50	42.20	38.40	25.80	24.00	27.20	9.50	30.96
Per cent egg mass parasitization by *Telonomus* sp.	18.40	13.99	36.86	53.95	41.28	40.00	38.10	23.51	33.26
Per cent egg mass parasitization by *Trichogramma* sp.	9.98	17.31	6.11	4.41	0.00	0.00	0.00	0.00	4.73
Per cent egg mass parasitization by *Tetrastichus* sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total per cent egg mass parasitization	28.38	31.30	42.97	58.36	41.28	40.00	38.10	23.51	37.99

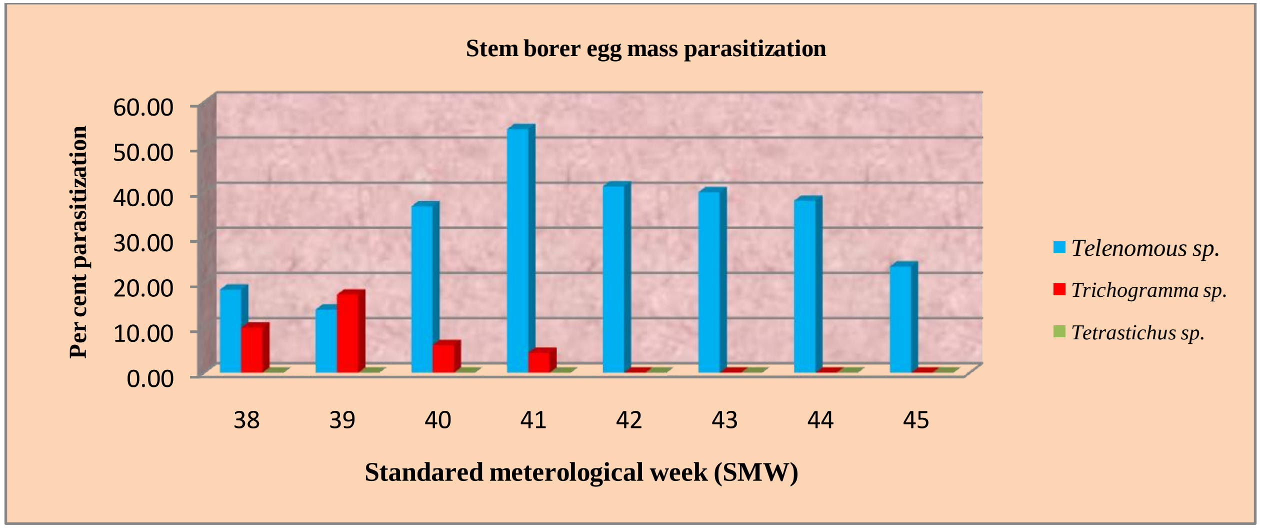

Figure: 4.2.4 Relative composition of egg parasitoids of rice yellow stem borer, *Scirpophaga incertulas* Walker at Raipur during *kharif* season 2013-14

Plate No:19. 1.Eggmass of rice stem borer, 2.Parasitized eggmass, 3.Glass vials with eggmass, 4. Hatched and unhached eggs of YSB, 5.*Tricogramma* sp., 6.*Telonomus* sp.

uncommon. Incidence of parasitization by only *Trichogramma* sp., *Telonomus* sp. and*Tetrastichus* sp. was 6.12 per cent, 9.53 per cent and 48.44 per cent, respectively. Parasitization by *Trichogramma* sp. +*Telonomus* sp., *Telonomus* sp. + *Tetrastichus* sp. and *Trichogramma* sp. + *Tetrastichus* sp. were 3.46 per cent, 21.06 per cent, and 2.35 per cent, respectively. Activity of *Telonomus rowani* was recorded from late August to middle of October. Varma *et al.*, (2009) reported that the *Trichogramma* was the predominant egg parasitoid during September, while *Tetrastichus schoenobii* and *Telenomus dignus* have become dominant during October. Baghel (2011) observed *Telenomus* sp. most active during the fourth week of October and capable in parasitizing 0.00 to 71.02 per cent eggs at Raipur. Egg mass was mostly parasitized either by single or by two parasitoid species.

On the contrary Garg (2012) reported that the maximum percent of egg parasitization by *Telenomus* sp. was observed in the first fortnight of November (38%). It may be stated that the *Telenomus* sp. is the most important egg parasitoid of rice stem borer egg found most active during second week of October at Raipur.

❖ **Stem borer larval parasitization by NPV:**

The observation of larval parasitization were recorded in the experimental field of IGKV, Raipur during *kharif*, 2013-14 by taking different ecosystem of rice *viz*. upland transplanted (UPT), midland SRI rice ecosystem (MSR) and lowland conventional rice ecosystem (LLC). For stem borer larval parasitization observations the panicles bearing white ears were removed from plant and dissected to see the larvae/pupae present inside. Total 10 plants from each ecosystem were examined for the presence of parasitized or unparasitized larvae at weekly intervals from 41 to 45 SMW of October -November. Periodical observation of stem borer larval parasitization by NPV revealed that, the maximum per cent of NPV parasitized larvae was observed in lowland conventional followed by midland system of rice intensification(SRI) and upland transplanted rice ecosystem (Table: 4.2.5)

Table: 4.2.5 Observation of stem borer larval parasitization in different rice ecosystem at Raipur during *kharif* season 2013-14

Ecosystem	Lowland conventional rice ecosystem			Midland SRI rice ecosystem			Upland transplanted rice ecosystem		
SMW	NPV infected larvae	Total larvae	Per cent NPV parasitization	NPV infected larvar	Total larvae	%NPV parasitization	NPV infected larvae	Total larvae	%NPV parasitization
41	4.00	17.00	23.53	1.00	13.00	7.69	0.00	8.00	0.00
42	5.00	15.00	33.33	0.00	9.00	0.00	2.00	13.00	15.38
43	2.00	15.00	13.33	3.00	14.00	21.43	0.00	11.00	0.00
44	1.00	13.00	7.69	2.00	15.00	13.33	0.00	12.00	0.00
45	2.00	16.00	12.50	2.00	17.00	11.76	0.00	12.00	0.00
Total	14.00	76.00	90.39	8.00	68.00	54.22	2.00	56.00	15.38
Average	2.80	15.20	18.08	1.60	13.60	10.84	0.40	11.20	3.08

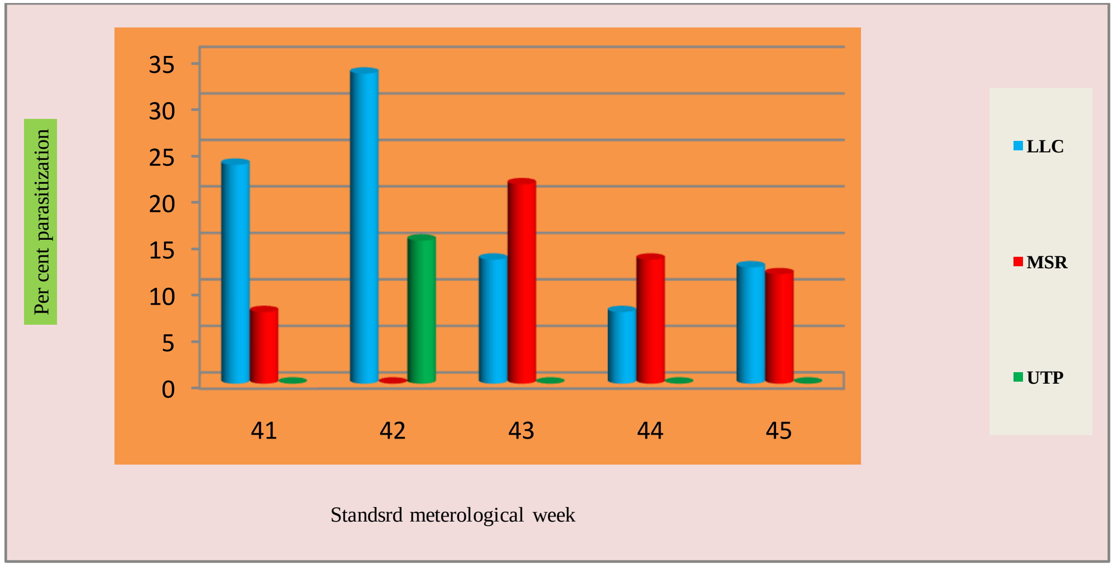

Figure: 4.2.5 Observation of stem borer larval parasitization in different rice ecosystem at Raipur during *kharif* season 2013

- **Stem borer larval-pupal parasitization:**

In the present piece of investigation 200 fresh larvae were collected from YSB damage white ear heads and seperatlly put in contamination free petriplates 20 larvae/plates with rice stem cutting in 10 petri plates.Foods were changed at constant interval. Results showed that the 75 larvae of yellow stem borer reached larvae to adult stage and 25 larvae were infected with fungus pathogen. 100 larvae of yellow stem borer dead due to the natural facters. Petriplate no one (R1) and two (R2) parasitzed by *Dentichasmiasis* sp. *Xanthopimpla* sp. but petriplate no five (R5) parasitized by *Cotesia* sp. and a unidentified small wasp these all wasp are emerge out in place of YSB adult that showed the larval and pupal parasitization. The adult of yellow stem borer categorized in male and female that showed that the 34.67 per cent male and 65.33 per cent female. Six per cent of larvae are dead by fungus and NPV pathogen.

Table: 4.2.6 Stem borer larval-pupal parasitization

Replication	Larvae/plate	Total YSB adult		Pathogen infected	Natural death	Parasitoid emerged
		Male	Female			
R1	20	3	9	0	8	4
R2	20	0	0	2	18	2
R3	20	4	6	3	7	0
R4	20	0	1	1	18	0
R5	20	6	10	1	3	2
R6	20	3	5	2	10	0
R7	20	4	8	1	7	0
R8	20	6	10	2	2	0
R9	20	0	0	0	20	0
R10	20	0	0	0	20	0

❖ **Brown plant hopper egg mass parasitisation:**

The observations on BPH egg parasitization were recorded in the glass/green house of Entomology where mass culturing is continued since last twenty years. The observations were taken from 30 selected eggs batch/group from stem were dissected at weekly interval from 4 SMW of January to 23 SMW of May month during 2013-14 .Parasitism was determined by eggs colours and confirmed subsequently by identification of emerging adult parasitoids. Other causes of mortality were scored and identified as for as possible (Fowler *et al.*, 1986). From the data presented Table 4.2.6 revealed that the maximum per cent of BPH egg mass parasitization by *Anagrus* spp. was observed 26.01 per cent followed by *Oligosita* spp. 15.10 per cent and *Gonatocerus* spp. 2.13 per cent during study periods. The per cent of BPH egg mass parasitization by *Anagrus* spp. was recorded higest during 23 SMW of May but active throughout study period while the maximum per cent of egg mass parasitization by *Oligosita* spp. was observed during 4 SMW to 14 SMW of January-February after that it declined with slight fluctuation.

Present findings corroborates with the Chiu (1979) who reported the parasitism rates of *Anagrus* sp. nr *flaveolus* are greatest in May and June (11.3–29.6%) and September–November (3.3–38.1%) in Japan. The most dominant parasitoid species was shown to be *Anagrus* spp. which constituted 50.78 per cent of the total eggs parasitization, followed by *Oligosita* spp. (39.31%) and *Gonatocerus* spp. represented 8.42% out of total. Chandra (1980) reported that the *Oligosita* spp. hatched larvae are light yellow, becoming brighter when they pupate: 5 days after oviposition the pupae, with pink eyes and body segments, can be observed easily through the chorion and the host egg to become dark grey in colour obscuring the view of the developing parasitoid and the *Anagrus* spp. parasitised egg turns yellowish which can than be seen within the host egg: pupates within 24hrs, pupa:

bright orange-red turning brown, larvae wiggle lots within the egg to break up the host tissue for ingestion - pupation takes 6-7 days, adults emerge from host eggs 11-13 days after oviposition, males emerge first at Philippines.

Gupta and Pawar (1989) reported that the *Oligosita* spp. along with *Anagrus* spp. to be the most common parasitoids of *Nilaparvata lugens* in India. Li & He., (1991) also reported that the *Anagrus* spp. peaking in October and June with parasitism rate of *N. lugens*: 20-60 per cent in Guangdong, China. Watanabe *et al*., (1992) who reported that the *Oligosita* spp. parasitized eggs turn dark yellow and chorion is dark grey and so parasitoids cannot be seen and 5% to 68% parasitism rate and *Anagrus* spp. turns host eggs orange or yellow orange and parasitoids can be seen through the transparent chorion and parasitism rate 20 to 47 per cent in Malaysia. Singh *et al*., (1993) observed that the *Anagrus flaveolus* Waterhouse activity peaked in July and October-November but active throughout year in India. Hachiya, (1995) reported that the *Anagrus* spp. 66%-96% parasitism measured by 'trap method' – late June to early August at Japan. Claridge *et al*., (1999) reported that the parasitism rate of *Anagrus* spp. low to higher in wet season and more uniform higher levels in dry seasons in Indonesia.

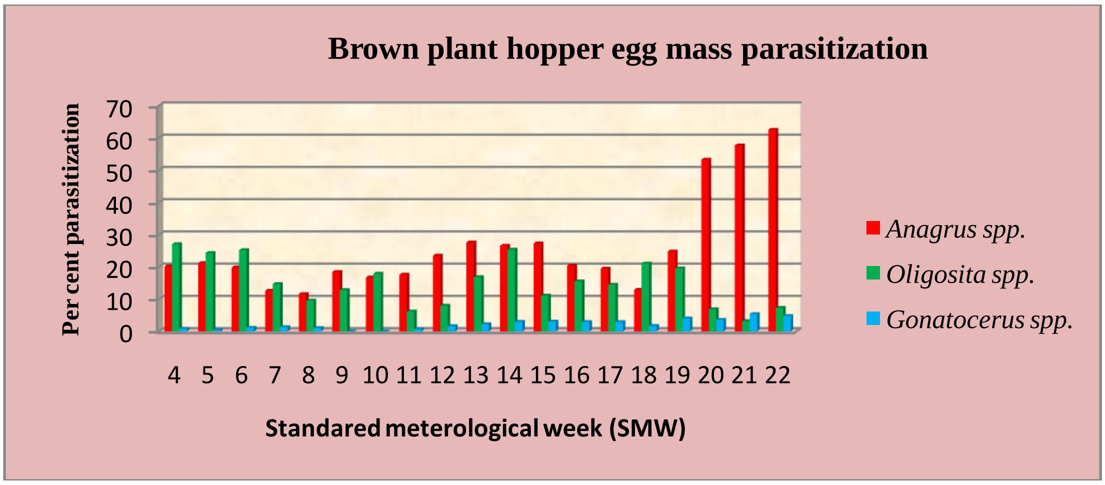

Figure: 4.2.6 Observation of BPH egg mass parasitization at weekly interval in Raipur during *kharif* season 2013-14.

Table 4.2.7 Observation of brown plant hopper egg mass parasitization at weekly interval in Raipur during *kharif* season 2013-14

Month	SMW	Parasitized eggs of BPH (mean/batch/week)			Mean total of BPH eggs / batch/week	Yellow orange to orange-red	Lemmon yellow /dark grey to greenish	Bright orange to golden colour	Total per cent parasitization of BPH eggs/week
		Anagrus spp.	*Oligosita* spp.	*Gonatocerus* spp.		*Anagrus* spp.	*Oligosita* spp.	*Gonatocerus* spp.	
January	4 SMW	2.90	3.17	0.20	15.23	20.19	27.07	0.81	48.07
	5 SMW	2.70	3.40	0.07	14.00	21.17	24.34	0.41	45.92
February	6 SMW	2.63	2.10	0.13	12.23	19.85	25.22	1.13	46.20
	7 SMW	1.90	1.47	0.17	12.80	12.60	14.70	1.32	28.62
	8 SMW	1.70	0.97	0.13	13.67	11.58	9.56	1.06	22.20
	9 SMW	2.13	0.77	0.00	11.67	18.43	12.83	0.00	31.27
March	10 SMW	1.93	1.70	0.00	12.93	16.73	17.87	0.00	34.60
	11 SMW	1.40	0.50	0.10	11.23	17.64	6.15	0.67	24.46
	12 SMW	2.53	0.93	0.30	13.30	23.49	7.95	1.61	33.04
	13 SMW	2.90	1.30	0.20	10.77	27.60	16.84	2.25	46.69
April	14 SMW	3.40	2.20	0.53	12.60	26.53	25.36	2.95	54.84
	15 SMW	3.63	1.17	0.53	14.90	27.28	11.09	3.02	41.39
	16 SMW	1.43	1.17	0.17	9.03	20.40	15.50	2.92	38.82
	17 SMW	2.03	1.53	0.17	11.93	19.47	14.45	2.92	36.84
May	19 SMW	1.40	1.93	0.10	11.17	12.93	21.06	1.74	35.73
	20 SMW	1.63	1.70	0.07	8.73	24.77	19.55	4.00	48.32
	21 SMW	5.00	0.53	0.30	9.33	53.26	6.88	3.61	63.75
	22 SMW	5.93	0.34	0.53	11.20	57.69	3.22	5.38	66.29
	23 SMW	5.83	0.63	0.63	10.43	62.52	7.27	4.74	74.53
Total		53.03	27.51	4.33	227.17	494.14	286.92	40.53	821.59
Average		2.79	1.45	0.23	11.96	26.01	15.10	2.13	43.24

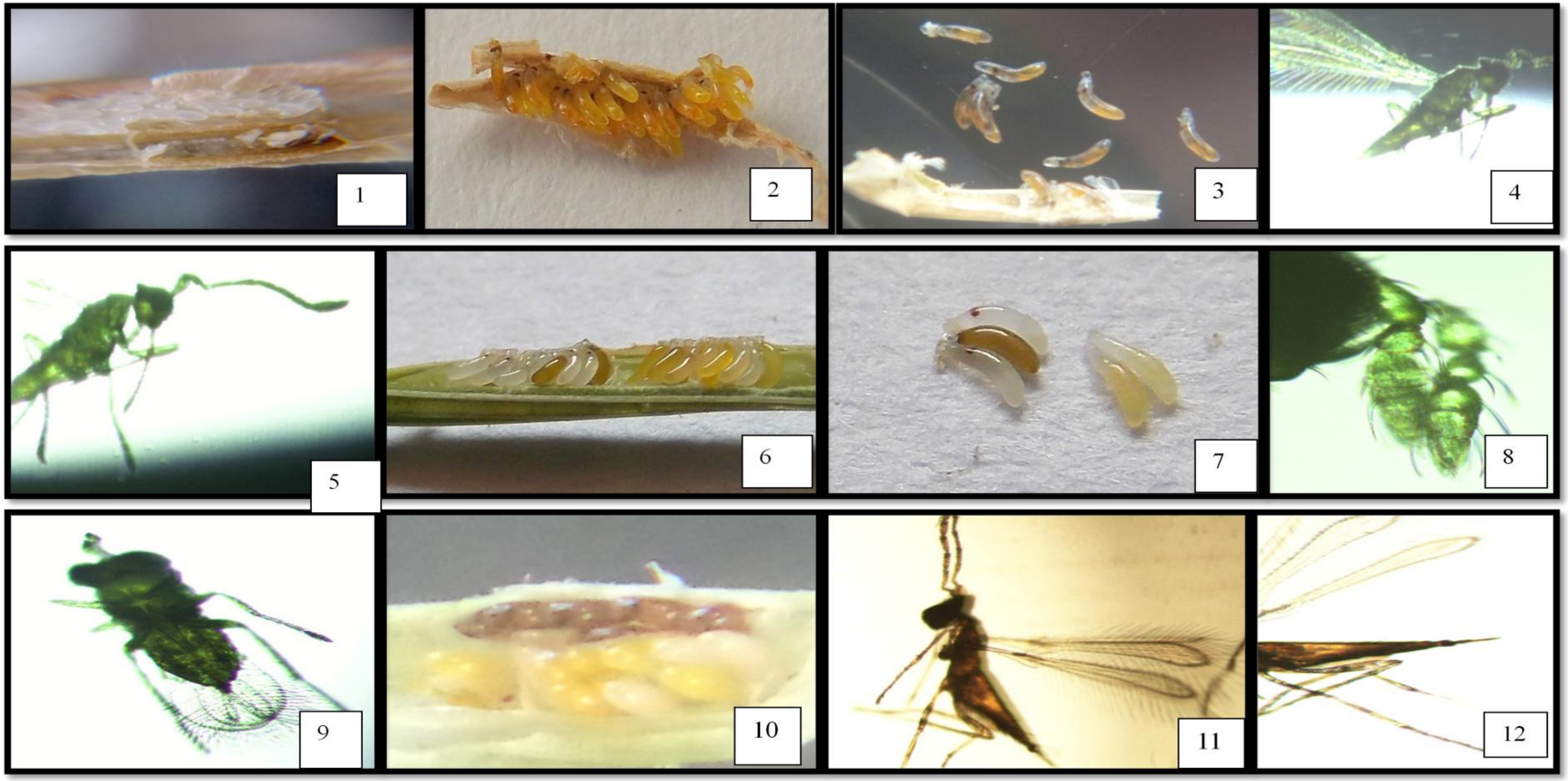

Plate No 20 **:** 1.Unparasitized eggs, 2.Prasitized eggs by *Anagrus* sp., 3. Developing pupa of *Anagrus* sp., 4&5 Adult of *Anagrus* sp., 6.&7 Parasitized eggs by *Oligosita* sp., 8.*Oligosita* sp. antenae, 9. Adult of *Oligosita* sp., 10. Parasitized eggs by *Gonatocerus* sp., 11 Adult of *Gonatocerus* sp., 12.Abdominal portion (Ovipositors) of *Gonatocerus* sp.,

4.3 To monitor the rice insect pests and their natural enemies through light trap collection and correlation with weather parameters during *kharif* season.

Important insect-pest of rice observed through light trap catches during 27th standard meteorological week to 52nd standard meteorological week were correlated with the weather parameters. The weekly total count of rice insect-pest and their natural enemies and weekly average weather parameters are given below table 4.3.1.1 and 4.3.2.1. The correlation between weekly counts of insect-pest and their natural enemies and meteorological parameters were worked out and shown in the table 4.3.1.2 and 4.3.2.2. The significance of correlation was tested at five per cent and one percent probability levels.

4.3.1 Monitor the rice insect pests through light trap collection and correlation with weather parameters during *kharif* season.

4.3.1.1 Yellow stem borer, *Sciropophaga incertulas* Walker

The yellow stem borer (YSB) male and female catches were observed during 27th SMW to 52nd SMW of *kharif* 2013-14 at the IGKV research farm of Raipur. The first and second peak population of male and female was observed during 45th, 44th SMW and 44th, 38th SMW respectively. Similarly first and second peak population of YSB total (male + female) was observed during 44th SMW and 45th SMW (Table 4.3.1.1). There was significant positive correlation between yellow stem borer total (M+F) and male with sun shine hours (r = + 0.506*), (r = + 0.576**) respectively. Whereas, rainfall (r = - 0.440*), and relative humidity evening (r = - 0.498*) showed significant negative correlation with male yellow stem borer. Except above another weather parameters not influence the yellow stem borer population (Table 4.3.1.2).

Ganguli (1996) reported that the peak population of stem borer was observed in month of September in (1997) and October in (1996). Padhi and Saha (2004) and

Chakraborty and Nanda (2011) also reported the sunshine hours were positively correlated to the stem borer moth population recorded in the light trap catches. Garg (2012) reported the highest peak population of YSB during 40th SMW and no statistically significant correlation could be established between YSB population and weather parameters.

4.3.1.2 Pink stem borer, *Sesamia inference* Walker

The pink stem borer (PSB) catches were observed during 27th SMW to 52nd SMW of *kharif* 2013 at the IGKV research farm of Raipur. The first and second peak population of PSB was observed during 45th and 49th SMW respectively (Table 4.3.1.1). There was significant positive correlation between pink stem borer with sun shine hours (r = + 0.539**) at 5 per cent of level of significance. Whereas, maximum temperature (r = - 0.440*), minimum temperature (r = - 0.688**) and relative humidity evening (r = - 0.694**) showed significant negative correlation with pink stem borer. Except above another weather parameters not influence the pink stem borer population (Table 4.3.1.2).

Huang *et al*., (2008) also reported striped rice borer, *Chilo suppressalis* Walker and pink borer, *Sesamia inferens* Walker are the common insect pests of rice in Taiwan and the light trap catches of striped rice borer was higher than the pink borer. Chakraborty and Nanda (2011) reported the sunshine hours were positively correlated to the stem borer moth population recorded in the light trap catches.

4.3.1.3 Leaf folder, *Cnapholocris medinalis* Guen.

Initial population of leaf folder (LF) adult was very low during 31st SMW, then it gradually increases and reached up to 52nd SMW. The maximum adult catches of LF were observed during 45th SMW and then adult population gradually decreased as the crop departing towards maturity stage (Table 4.3.1.1). Data revealed that, their was significant negative correlation between leaf folder population and morning relative humidity and evening relative humidity with r value (r = - 0.619**) and (r = - 0.467*) at 1 per cent and 5 per cent level of significance. There was a non significant negative correlation between LF and maximum temperature (r = - 0.120), minimum temperature (r = - 0.392), rainfall (r = - 0.393). Whereas correlation between LF population with relative humidity-I (r = + 0.376) showed no significant positive correlation at 1 per cent level and at 5 % level of significance (Table 4.3.1.2).

The present findings on the activity of LF are in agreement with the Harinkhere, (1998) and Sharma *et al.*, (2003) who reported that, the peak population was observed during September and October at Balaghat and Tikamgarh (M.P.), respectively. Garg (2012) also reported that, the significant negative correlation between leaf folder population relative humidity-II. The maximum adult catches of LF were observed during 48th SMW.

4.3.1.4 Green leaf hopper, *Nephotettix* spp.

Green leaf hopper (GLH) attained highest peak population during 42nd SMW. Apart from 42nd SMW two more peak population were observed during 41st and 43rd SMW and after that the population decline (Table 4.3.1.1). Data revealed that, there was a non significant positive correlation between GLH and maximum temperature (r = + 0.252), minimum temperature (r = + 0.145), relative humidity-II (r = + 0.013) and bright sunshine hours (r= + 0.187). The correlation between GLH population with rainfall (r = - 0.297), and relative humidity-II (r = - 0.095) showed non significant negative correlation at 1 per cent and at 5 per cent level of significance (Table 4.3.1.2).

Observations made by earlier researchers Sharma *et al.*, (1988) who reported that the green leaf hopper, *Nephotettix virescens* maximum population was found during the third week of October. The direct contribution of maximum temperature and rainfall on population build up of male green leafhopper was negative. Shamim *et al*., (2009) also reported that, the GLH attained maximum population during 43rd standard meteorological week of October. Garg (2012) also reported that the peak population of GLH found during 40th SMW of October and showed significant positive correlation with bright sunshine hours while significant negative correlation with rainfall, minimum temperature and relative humidity-II.

4.3.1.5 Brown plant hopper, *Nilaparvata lugens* Stal.

It was evident from the data (Table 4.3.1.2) that the brown plant hopper, *N. lugens* showed significant negative correlation with morning relative humidity (r = - 0.495*) at 5 per cent level of significance. There was non significant negative correlation with minimum temperature (r = - 0.281), evening relative humidity (r = - 0.406) and average rainfall (r = - 0.339). Similarly, a non significant positive relationship was noticed with maximum temperature (r = + 0.068) and sun shine hours (r= + 0.372). The BPH adult catches in light trap was started from 27th SMW and remained continued up to 52nd SMW. The highest numbers of adult catches were observed during 47th SMW of November afterwards it declined (Table 4.3.1.1).

The present findings corroborates with Garg (2012) who reported that the highest numbers of BPH adult catches were observed during 46th SMW of November and morning relative humidity (RH-I) showed significant negative correlation. Observations made by earlier scientist Kerketta *et al.*, (1990) also reported that the *Sogatella furcifera* and *Nilaparvata lugens* were active from September to December in trap catches in Chattisgarh.

4.3.1.6 White backed plant hopper, *Sogatella furcifera* Horv.

The results of the correlation studies made on white backed plant hopper population showed negative and non significant relationship with minimum temperature (r = - 0.029), rainfall (r = - 0.325) and evening relative humidity (r = - 0.183). Similarly, positive and non significant relationship with maximum temperature (r = + 0.068), morning relative humidity (r = - 0.002) and sun shine hours (r= +0.361) was found at 1per cent and 5 per cent level of significance (Table 4.3.1.2). The highest numbers of adult catches were observed during 42nd SMW of October afterwards it declined (Table 4.3.1.1).

Observations made by earlier scientist Kerketta *et al.*, (1990) who reported that the *Sogatella furcifera* were active from September to December in trap catches in Chattisgarh. Shamim *et al*., (2009) also reported the correlation between WBPH peak population and bright sunshine hours also showed positive significant correlation while maximum temperature, minimum temperature, rainfall and relative humidity showed non-significant effect on population build up of WBPH. Garg (2011) reported the plant hopper (BPH + WBPH) adult catches in light trap was highest during 46th SMW of November afterwards it declined.

4.3.1.7 Zigzag leaf hopper, *Recilia dorsalis* Motsch.

Zigzag leaf hopper (ZZH) attained maximum population during 47th SMW and after that the population decline (Table 4.3.1.1). Data revealed that the correlation between ZZH population with rainfall (r = -0.410*) showed significant negative correlation at 5 per cent level of significance. Similarly non significant negative correlation between ZZH and minimum temperature (r = - 0.199), morning relative humidity (r = - 0.376) and evening relative humidity (r = - 0.339) while non significant positive correlation between ZZH and maximum temperature (r = + 0.099) and sunshine hours (r = + 0.380) (Table 4.3.1.2).

Similar finding also reported by Pathak and Khan (1994) the seasonal occurrence of *Nilaparvata lugens* and *Recilia dorsalis* become more prevalent during later stages.

4.3.1.8 Caseworm, *Nymphula depunctalis* Guen.

` The correlation studies on caseworm (CW) population revealed negative and non significant relationship with rainfall (r = - 0.342), RH-I (r = - 0.136) and RH-II (r = - 0.024) and positive non significant relation with maximum temperature (r = + 0.163), minimum temperature (r = + 0.095) and sun shine hours(r = + 0.108). There was no significant correlation was found between CW and weather parameter (Table 4.3.1.2).The caseworm adult catches in light trap was started from 27th SMW and remained continue up to 52nd SMW. The first and second peak population of CW was observed during 41st SMW and 43rd SMW of October, respectivly (Table 4.3.1.1). The present investigations on the monitor of pests through light trap are in close agreement with Shukla *et al*., (2008) who reported that, the peak activity of caseworm was observed during September and October month

Garg (2012) reported that the maximum temperature, minimum temperature and relative humidity-I did not show any significant effect on the buildup of CW population. The highest peak population of CW was observed during 40th SMW of October and the second peak was observed during 39th SMW of September.

Table 4.3.1.1 Weekly observations of insect pests of rice in the light trap collection data at Raipur during *kharif* season 2013-14.

SMW	Yellow Stem borer			PSB	LF	GLH	BPH	WBPH	ZZH	CW	GB	SPD	GR	Temperature (^{0}C)		Rainfall (mm)	Relative humidity (%)		Sun Shine (hours)
	YSB (M+F)	M	F											Maxi. Temp.	Mini. Temp.		Morn.	Even.	
27	47	47	0	1	0	28	16	36	0	4	0	0	0	31.3	24.5	73.5	90.3	70.4	4.4
28	27	25	2	2	0	29	10	28	0	5	0	0	0	31.2	24.3	144.4	93.0	78.1	3.9
29	16	14	2	4	0	30	8	145	0	10	0	0	0	30.5	25.3	44.6	94.6	74.4	2.3
30	7	7	0	5	0	7	2	25	0	6	0	0	0	28.4	24.7	88.2	92.4	84.9	0.7
31	25	23	2	10	1	43	21	74	0	19	0	0	0	28.3	23.9	255.8	95.1	83.9	1.3
32	18	17	1	1	8	3	0	11	0	5	0	0	0	31.1	24.7	87.4	93.1	76.0	3.3
33	44	39	5	7	2	188	55	39	0	18	0	1	0	31.3	24.4	177.0	94.7	79.6	3.3
34	11	11	0	3	4	178	21	73	0	0	0	2	0	27.8	23.8	60.5	92.0	83.6	1.5
35	27	16	11	8	2	360	170	150	0	74	1	2	2	29.3	24.5	120.8	94.9	78.1	3.1
36	26	26	0	1	5	574	179	312	0	124	2	5	4	31.1	24.8	54.8	92.6	75.7	4.2
37	95	76	19	6	2	1656	568	831	24	89	8	8	7	31.9	25.2	11.6	91.7	73.3	6.2
38	72	51	21	4	2	1901	193	10	152	43	0	6	6	29.9	24.1	92.6	93.4	76.9	2.5
39	109	89	20	0	1	6272	1016	218	688	139	23	1	0	32.0	24.9	28.6	93.0	68.0	6.3
40	52	39	13	1	1	2560	444	0	214	133	35	0	0	30.1	24.2	45.2	95.0	75.3	4.2
41	72	55	17	1	13	8335	4670	460	542	416	21	0	73	30.2	23.3	8.6	83.7	71.1	3.5
42	25	20	5	1	1	16826	11722	4597	2369	270	152	0	0	30.7	21.4	0.0	91.4	56.3	8.6
43	55	43	12	9	0	7140	8880	1948	1880	404	31	0	11	28.8	22.6	32.6	95.9	73.1	2.1
44	176	137	39	12	3	3709	6024	2485	676	304	35	0	0	30.5	17.3	0.0	92.3	38.4	8.9
45	156	138	18	19	17	2938	15142	1900	679	166	14	0	0	30.0	16.7	0.0	90.9	37.3	8.2
46	59	54	5	15	16	126	2769	146	148	78	6	1	0	27.5	13.2	0.0	90.6	36.0	7.6
47	64	61	3	12	10	1138	54528	514	2870	59	7	0	0	30.3	16.7	0.0	87.0	40.3	7.3
48	73	71	2	22	13	469	19758	246	1621	49	5	2	0	30.0	15.5	0.0	83.0	34.9	8.5
49	43	43	0	24	5	93	5982	66	418	38	1	2	0	28.1	11.8	0.0	90.6	31.4	8.5
50	40	40	0	12	2	11	209	18	56	13	1	0	0	27.7	9.8	0.0	90.0	27.3	9.0
51	30	30	0	10	0	13	74	4	110	6	0	0	0	28.2	11.7	0.0	90.1	33.7	8.0
52	57	57	0	3	6	13	60	2	178	7	0	0	0	28.3	12.7	0.0	92.8	40.3	6.5

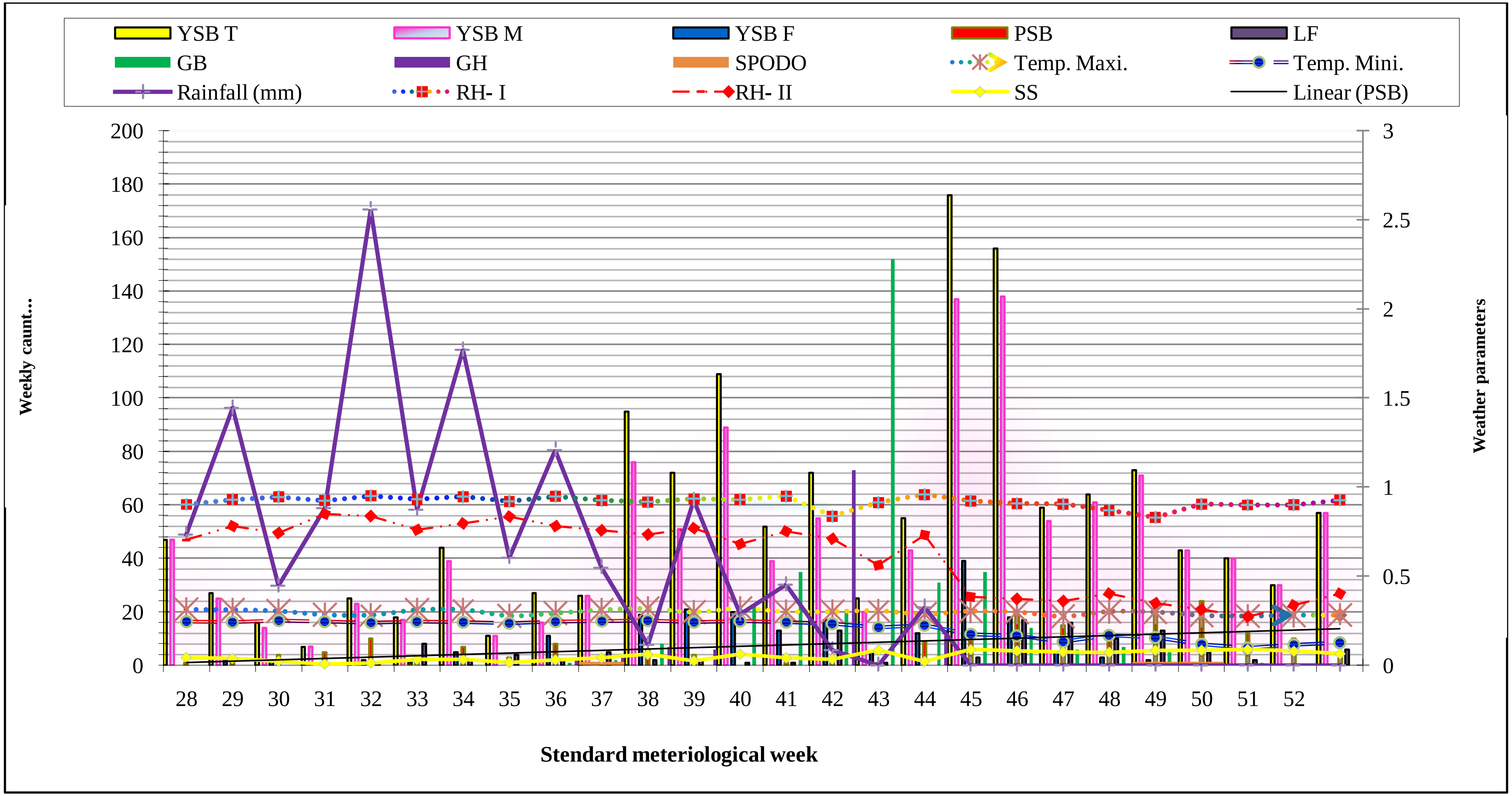

Figure No 4.3.1.1a Weekly observations of insect pests of rice in the light trap collection data at Raipur during *kharif* season 2013-14

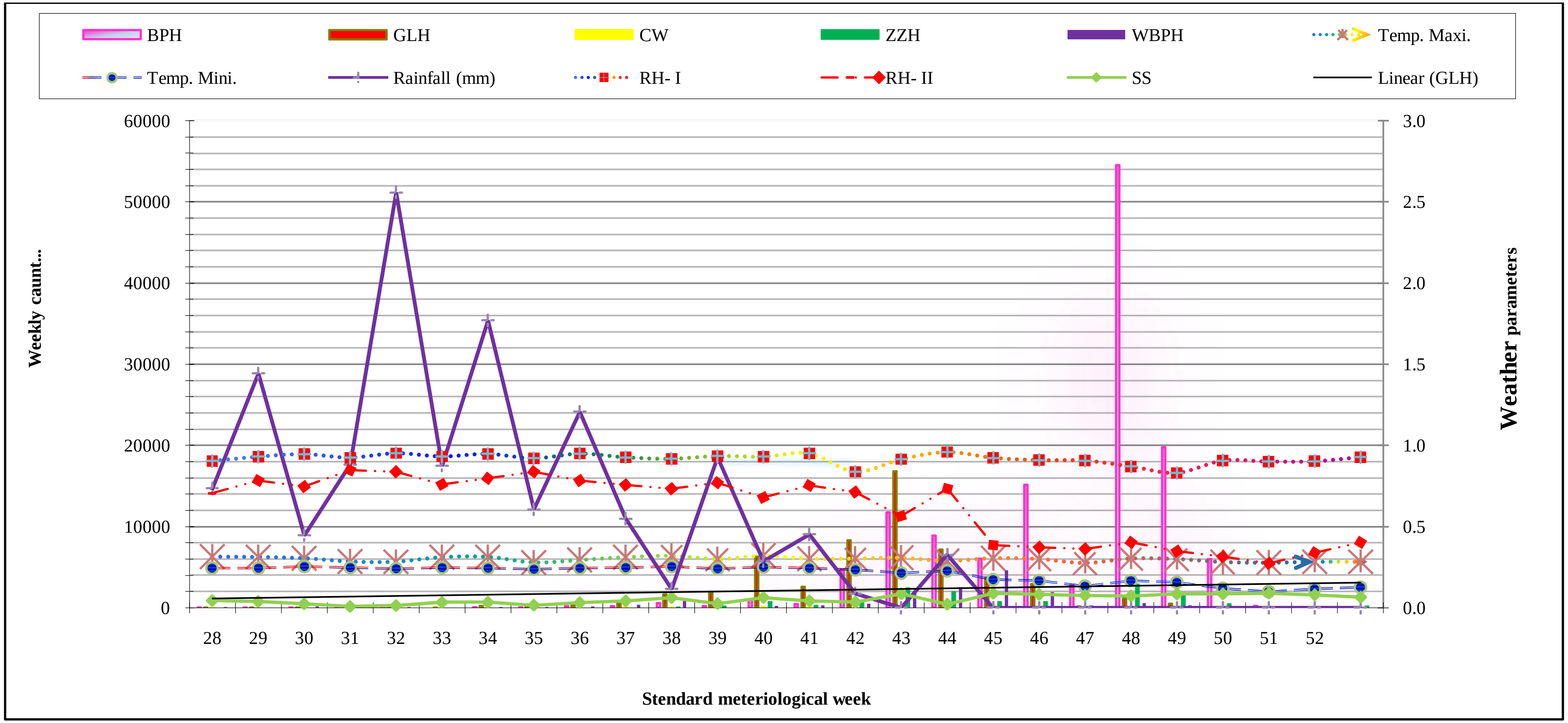

Figure No 4.3.1.1b Weekly observations of insect pests of rice in the light trap collection data at Raipur during *kharif* season 2013-14

Table 4.3.1.2: Correlation coefficient (r) between insect population and weather parameters at Raipur during *kharif* season 2013-14

Insects	Weather parameter					
	Max. Temp.	Min. Temp.	Rainfall (mm)	RH I (%)	RH II (%)	SS (hrs)
YSB(M+F)	0.281	-0.214	-0.403	-0.202	-0.409	0.506*
YSB(M)	0.244	-0.307	-0.440*	-0.269	-0.498*	0.576**
YSB (F)	0.347	0.155	-0.188	0.073	-0.010	0.155
PSB	-0.440*	-0.688**	-0.269	-0.357	-0.694**	0.539*
LF	-0.120	-0.392	-0.393	-0.619**	-0.467*	0.376
GLH	0.252	0.145	-0.297	-0.095	0.013	0.187
BPH	0.068	-0.281	-0.339	-0.495*	-0.406	0.372
WBPH	0.182	-0.029	-0.325	0.002	-0.183	0.361
ZZH	0.099	-0.199	-0.410*	-0.376	-0.339	0.380
CW	0.163	0.095	-0.342	-0.136	-0.024	0.108
GB	0.195	0.054	-0.274	-0.002	-0.071	0.298
SPODO	0.246	0.241	-0.012	0.033	0.210	-0.059
GRASS	0.082	0.159	-0.135	-0.454*	0.152	-0.178

*Significant at 5 per cent level
** Significant at 1 per cent level

4.3.1.9 Gundhi bug, *Leptocorisa acuta* Thunb.

From the data presented in Table 4.3.1.1 showed that the highest peak of Gundhi bug population was observed during 42nd SMW of October. There was non significant negative correlation between gundhi bug and morning relative humidity (r = - 0.002), evening relative humidity (r = - 0.071) and rainfall (r = - 0.274). Similarly, positive non significant relationship with maximum temperature (r = + 0.195) and sun shine hours (r = + 0.298) and minimum temperature (r = + 0.054) (Table 4.3.1.2).

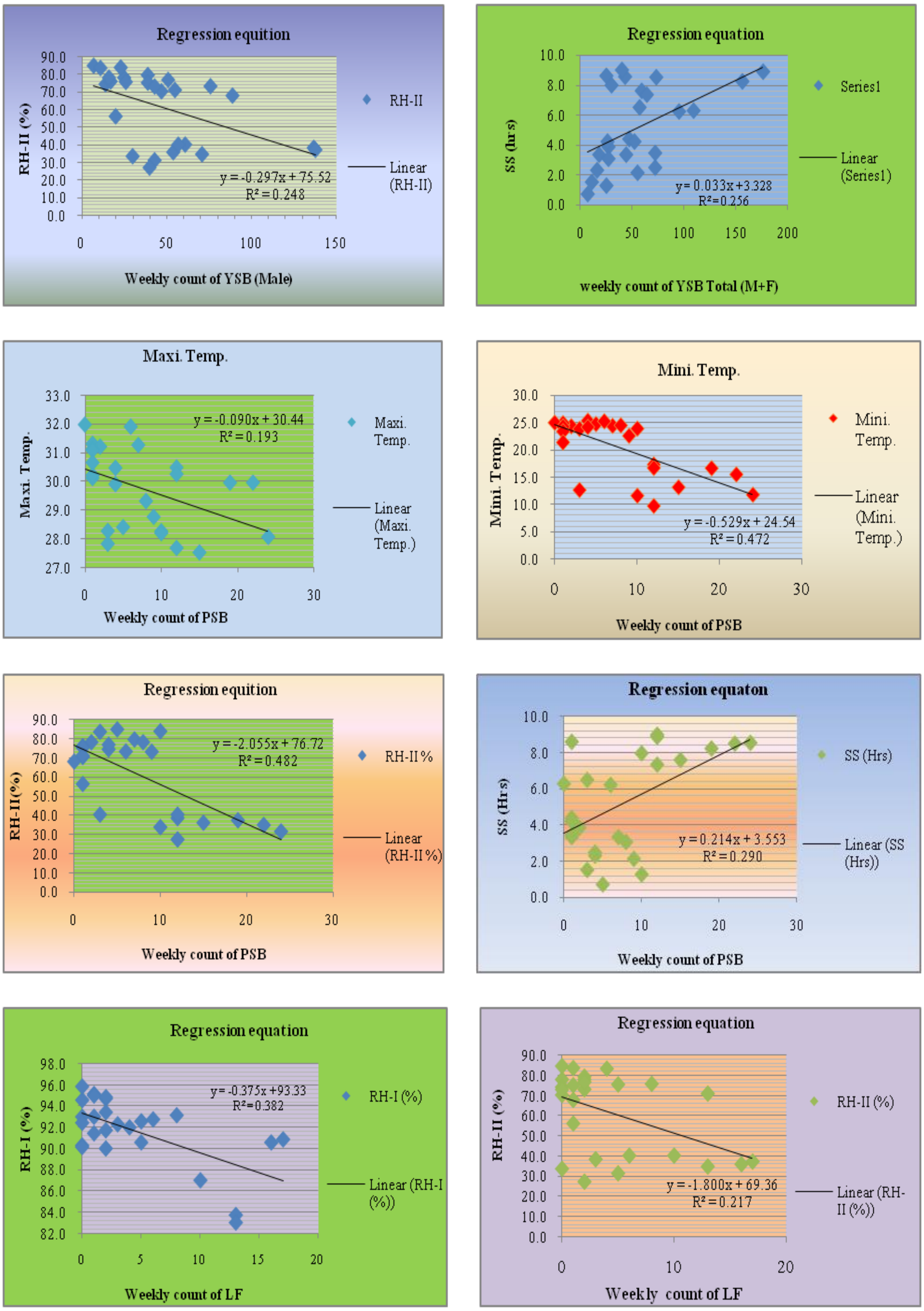

Figure No 4.3.1.2 Regression equation between weather parameter and different rice insect pests

Garg (2012) reported that the peak population of GB was observed during 43rd SMW. Apart from 43rd SMW, two more peaks populations were observed during 40 SMW and 42nd SMW and minimum temperature and relative humidity-I showed non-significant effect on the population buildup of gundhi bug. Similar findings were reported in Anonymous (2010) that the highest activity of gundhi bug was observed during 41st SMW week of October.

4.3.1.10 Grasshopper

From the data presented in Table 4.3.1.1 the maximum population of rass hopper was observed during 41st SMW of October. There was significant negative correlation between grasshopper and morning relative humidity (r = - 0.454*). Other parameters did not showed significant correlation with grasshopper population.

4.3.1.9 Swarming caterpillar, *Spodoptera mauritia*

Perusal of data presented on (Table 4.3.1.1) revealed that the peak population of swarming caterpillar, *Spodoptera mauritia* observed during 37th SMW of September. There was no significant correlation between swarming caterpillar, *S. mauritia* and weather parameters.

During the entire *kharif* season, the maximum adult catches for all the rice insects were observed during the month of October and November. At this time the range of prevailing weather parameters were 30.1 to 30.1^{0}C for maximum temperature and 15.5 to 24.2 ^{0}C for minimum temperature, the rainfall ranging from 0.0 to 45.2 mm, the average RH-I was 83.0 to 95.0 per cent and RH-II was 34.9 to 73.3 per cent and sunshine hours were observed 4.2 to 8.5 hour per day. It may be stated that October month is very crucial for maximum activity of most of the rice insect pest as depicted in the form of maximum collection in the light trap apparatus installed in the field.

4.3.2 Monitor the natural enemies of rice insect pests through light trap collection and correlation with weather parameters during *kharif* season.

4.3.2.1 Carabid/ground beetle, *Ophionea* spp.

It is evident from the data (Table 4.3.2.1) the population of carabid/ground beetle observed peak during 47th standard meteorological week. There was non significant positive correlation with maximum temperature (r = + 0.103) and sun shine hours (r = + 0.092). Similarly, non significant negative relationship with average rainfall (r = - 0.314), minimum temperature (r = - 0.022), morning relative humidity (r = - 0.330) and evening relative humidity (r = - 0.121).

Garg (2012) reported that the *Ophionea* sp. attained 1st and 2nd peak during 43rd standard meteorological week and 42nd standard meteorological week of October (Table 4.3.2.1). *Ophionea* sp. adult population showed significant negative correlation with minimum temperature, rainfall and relative humidity-II and significant positive correlation with sunshine hours.

4.3.2.2 Rove beetle, *Paederus fuscipes* Curtis.

The results of rove beetle revealed that the positive and non significant relationship with maximum temperature (r = + 0.181), minimum temperature (r = + 0.172), morning relative humidity (r = + 0.156) and evening relative humidity (r = + 0.089). Similarly, a non significant negative correlation with average rainfall (r = - 0.017) and sun shine hours (r = - 0.063) (Table 4.3.2.2). The highest population of rove beetle was observed during 43rd standard meteorological week, respectively (Table 4.3.2.1).

Garg (2012) also reported that the 1st peak population of rove beetle was observed during 41st and the second highest population was observed during 43rd standard meteorological week. The correlation studies between sunshine hours and rove beetle population collection on light trap showed significant positive correlation while relative humidity II and rainfall showed significant negative correlation.

Table 4.3.2.1: Weekly observation of natural enemies in the light trap collection data at Raipur during *kharif* season 2013-14

SMW	Carabids beetle	Rove beetle	Coccinella	Ear wig	Temperature (^{0}C)		Rainfall (mm)	Relative humidity (%)		Sun Shine (hours)
					Maxi. Temp.	Mini. Temp.		Morning	Evening	
27	36	155	1	153	31.3	24.5	73.5	90.3	70.4	4.4
28	17	86	0	121	31.2	24.3	144.4	93.0	78.1	3.9
29	20	38	0	74	30.5	25.3	44.6	94.6	74.4	2.3
30	9	32	0	24	28.4	24.7	88.2	92.4	84.9	0.7
31	30	53	1	61	28.3	23.9	255.8	95.1	83.9	1.3
32	6	31	0	12	31.1	24.7	87.4	93.1	76.0	3.3
33	29	60	0	97	31.3	24.4	177.0	94.7	79.6	3.3
34	9	32	0	62	27.8	23.8	60.5	92.0	83.6	1.5
35	16	84	1	119	29.3	24.5	120.8	94.9	78.1	3.1
36	21	54	1	248	31.1	24.8	54.8	92.6	75.7	4.2
37	26	49	5	147	31.9	25.2	11.6	91.7	73.3	6.2
38	22	21	0	14	29.9	24.1	92.6	93.4	76.9	2.5
39	46	36	1	56	32.0	24.9	28.6	93.0	68.0	6.3
40	149	55	4	32	30.1	24.2	45.2	95.0	75.3	4.2
41	281	41	15	109	30.2	23.3	8.6	83.7	71.1	3.5
42	153	114	7	114	30.7	21.4	0.0	91.4	56.3	8.6
43	339	258	32	122	28.8	22.6	32.6	95.9	73.1	2.1
44	102	104	9	69	30.5	17.3	0.0	92.3	38.4	8.9
45	133	92	8	57	30.0	16.7	0.0	90.9	37.3	8.2
46	24	39	0	41	27.5	13.2	0.0	90.6	36.0	7.6
47	402	120	9	84	30.3	16.7	0.0	87.0	40.3	7.3
48	100	47	7	25	30.0	15.5	0.0	83.0	34.9	8.5
49	9	15	1	6	28.1	11.8	0.0	90.6	31.4	8.5
50	5	21	0	0	27.7	9.8	0.0	90.0	27.3	9.0
51	14	26	1	33	28.2	11.7	0.0	90.1	33.7	8.0
52	20	33	3	80	28.3	12.7	0.0	92.8	40.3	6.5

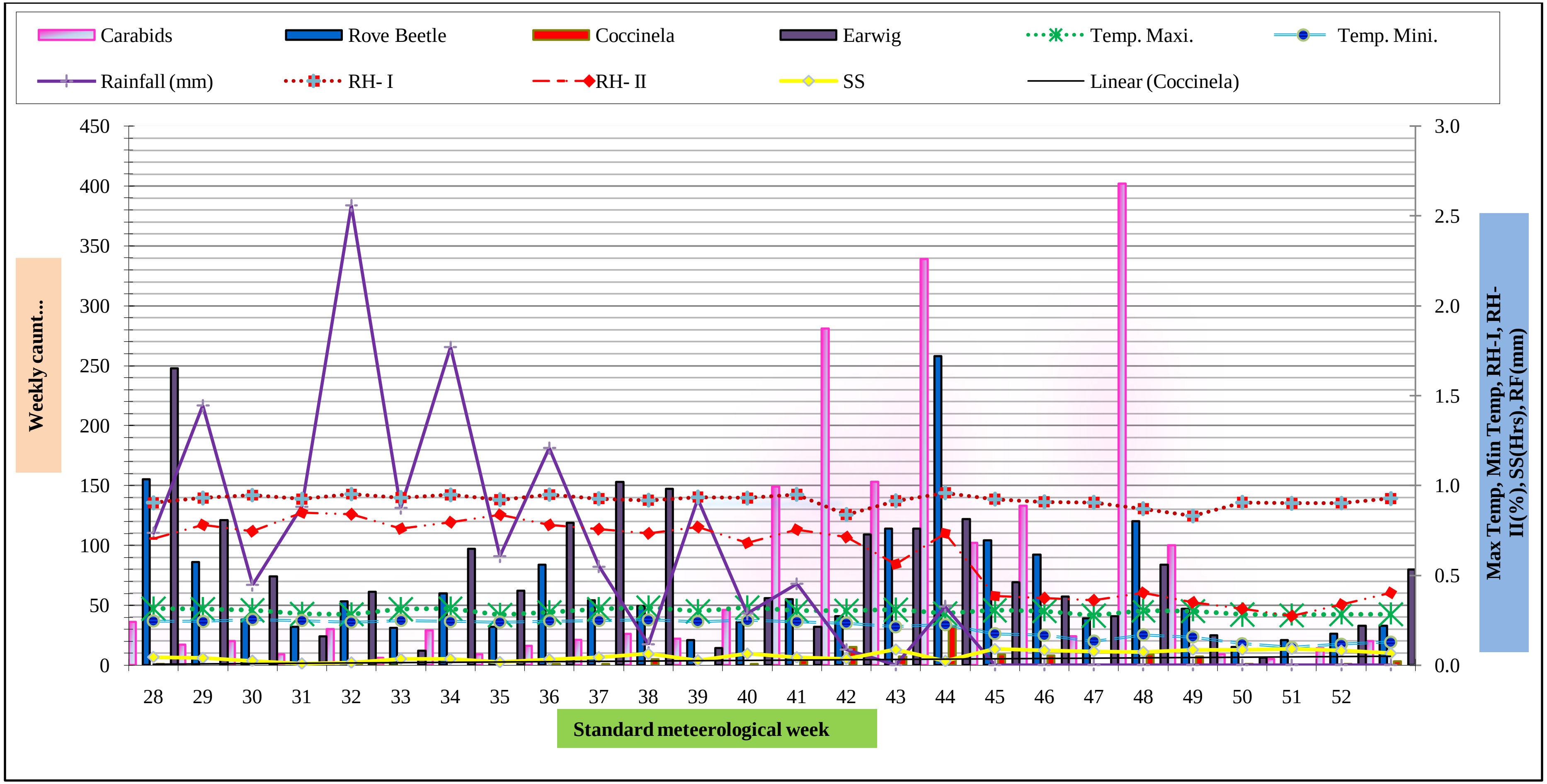

Figure: 4.3.2.1 Weekly observation of natural enemies in the light trap collection data at Raipur during *kharif* season 2013-14

4.3.2.3 Lady bird beetle/coccinellids different species

The peak populations of coccinellids were observed during 43rd standard meteorological week, (Table 4.3.2.1). The results of the correlation studies has been made on cocinellids population revealed that, the non significant negative relationship with minimum temperature (r = - 0.009), rainfall (r = -0.306), morning relative humidity (r = - 0.131) and evening relative humidity (r = -0.067). The positive and non significant relationship was found between maximum temperature (r = + 0.004) and sun shine hours (r= + 0.018) (Table 4.3.2.2).

Table 4.3.2.2: Correlation coefficient between natural enemies population and weather parameters during *kharif* season 2013-14.

Natural Enemies	**Weather parameters**					
	Temperature (^{0}C)		**Rainfall (mm)**	**Relative Humidity (%)**		**Sun shine (hours)**
	Maxi. Temp.	**Mini. Temp.**		**Morning**	**Evening**	
Carabids beetle	0.103	-0.022	-0.314	-0.330	-0.121	0.092
Rove beetle	0.181	0.172	-0.017	0.156	0.089	-0.063
Coccinella	0.004	-0.009	-0.306	-0.131	-0.067	0.018
Ear wig	0.481*	0.446*	0.116	0.108	0.368	-0.186

*Significant at 5 per cent level
**Significant at1 per cent level

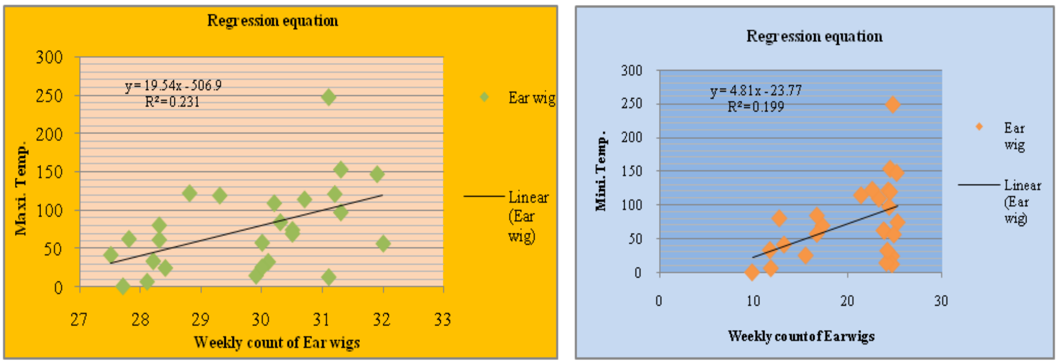

Figure 4.3.2.2 Regression equation between weather parameter and Ear wigs

4.3.2.4 Ear wigs, *Doru aculeatum* Scudder

There was negative non significant correlation between ear wig and sun shine hours (r = - 0.186). Similarly, positive significant correlation with maximum temperature (r = + 0.481*) and minimum temperature (r = + 0.446*) at 5 per cent level of significance. Whereas positive and non significant relationship with morning relative humidity (r = + 0.108) evening relative humidity (r = + 0.368) and average rainfall r = + 0.116) (Table 4.3.2.2). The peak population of ear wig was observed during 36^{th} standard meteorological week, respectively (Table 4.3.2.1).

4.3.2.5 Others

Others natural enemies of rice insect pests viz, mired bug, dragon flies, water beetle, ceccindellids and water strider etc. also attract to light by their own chaarechter or by confused to light and their populations was very low.

During the *kharif* season, the maximum adult catches for all the natural enemies of rice insects were observed during the month of September and November. At this time the range of prevailing weather parameters were 30.0 to 31.1^0C for maximum temperature and 15.6 to 24.8 ^{0}C for minimum temperature, the rainfall ranging from 0.0 to 54.8 mm, the average RH-I was 83.0 to 93.0 % and RH-II was 35.9 to 78.0 % and sunshine hours were observed 4.2 to 8.4 hour per day. It may be stated that September and October month is very crucial for maximum activity of most of the natural Enemies of rice insect pest as depicted in the form of maximum collection in the light trap apparatus installed in the field.

Summary Conclusion and Suggestions for Future Research Work

CHAPTER - V

SUMMARY CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH WORK

Investigation on **"Relative abundance of major insect pests and their natural enemies in different rice ecosystem during *kharif* season''** was undertaken at the at the research farm of Indira Gandhi Krishi Viswavidayalaya, Raipur (C. G.) during *kharif* season, 2013-14 and findings are summarized with the following finding:

4.1 To study the pest succession in different rice ecosystem during *kharif* season.

4.1.1 Sweep net sampling:

The status of stem borer population in different rice ecosystems of Raipur during 2013-14 revealed that, the maximum population was found during September month. Among the ecosystem highest stem borer adult population was observed in midland normal transplanted (MNT) with 0.80 adults/25 sweeps and lowest in upland transplanted rice ecosystem (UTP) with 0.23 adults/25 sweeps.

Similarly leaf folder population in different rice ecosystems of Raipur revealed that, the maximum population was found in September month. Among the ecosystem highest leaf folder larvae/adult population was recorded in midland system of rice intensification (MSR) with 1.17 larvae/adult/25 sweeps and lowest upland direct seeded rice ecosystem (UDS) with 0.29 larvae/adult/25 sweeps.

The maximum population of caseworm, *Nymphula depunctalis* was found during August-September month in different rice ecosystems of Raipur. Among the ecosystem maximum caseworm, *N. depunctalis* adult population was observed in lowland conventional (LLC) with 0.44 adults/25 sweeps and minimum in upland transplanted rice ecosystem UTP with 0.11 adults/25 sweeps.

The period of maximum activity of horned caterpillar, *Melantis leda isemene* was found in August-September month. Among the ecosystem highest horned caterpillar, *M. leda isemene* larvae/adult population was recorded in lowland organic rice ecosystem (LLO) with 1.86 larvae/adult/25 sweeps and lowest in MSR 0.53 larvae/adult/25 sweeps.

Studies on pest succession in different rice ecosystem revealed that, the maximum activity of rice skipper, *P. mathias* was recorded in August-September month. Among the ecosystem highest rice skipper larvae/adult population was recorded in lowland organic rice ecosystem (LLO) with 1.11 larvae/adult/25 sweeps and lowest in midland SRI rice ecosystem (MSR) with 0.30 larvae/adult/25 sweeps during *kharif* season.

The rice gundhi bug, *L.acuta* population in different rice ecosystems of Raipur revealed that, the maximum population was found in October-November month and among the ecosystem maximum population of rice gundhi bug, nymph/adult was recorded in lowland organic (LLO) with 34.28 nymph/adult/25 sweeps and minimum in midland normal transplanted rice ecosystem (MNT) with 6.53 nymph/adult/25 sweeps during the cropping season.

The status of rice sting bug population in different rice ecosystems of Raipur during 2013-14 in all locations, the maximum nymph/adult population was found in October-November month. Among the ecosystem highest rice sting bug nymph/adult population was recorded in midland normal transplanted rice ecosystem (MNT) with 6.13 nymph/adult/25 sweeps and lowest in upland direct seeded rice ecosystem (UDS) with 1.14 nymph/adult/25 sweeps.

The overall situation of rice hispa, *Dicladispa armigera* adult population in different rice ecosystems of Raipur showed that, the maximum population was found in August-September month. Among the ecosystem maximum hispa, *Dicladispa armigera* adult population was observed in midland transplanted (MNT) with 0.63 adult/25 sweeps and lowest in upland direct seeded rice ecosystem (UDS) with 0.18/ adult/25 sweeps during *kharif* season 2013-14.

The overall status of whorl maggot, *Hydrellia* spp. population in different rice ecosystems of Raipur revealed that, the maximum population was found in August-September month. The highest whorl maggot adult population was observed in lowland conventional (LLC) with 2.05 adult/25 sweeps and lowest in midland SRI rice ecosystem (MSR) with 0.62 adult/25 sweeps.

During study period the maximum population of grass hoppers recorded in August- September month. The highest population of grass hopper nymph/adult was found in lowland conventional (LLC) with 1.94 nymph/adult/25 sweeps and lowest in midland SRI (MSR) with 0.42 nymph/adult/25 sweeps.

The maximum population of white leaf hopper, *Cofana* spp. was found in September month in different rice ecosystems of Raipur. Among the ecosystem highest adult population was observed in lowland conventional with LLC 0.25 adult/25 sweeps and lowest in midland SRI rice ecosystem (MSR) with 0.07 adult/25 sweeps during cropping season.

The maximum population of blue beetle, *Lyphgma pygmoea* was recorded in July-August month in different rice ecosystems of Raipur. Among the ecosystem highest blue beetle, *Lyphgma pygmoea* adult population was observed in upland direct seeded (UDS) with 0.18 adult/25 sweeps and lowest in midland SRI (MSR) with 0.05 adult/25 sweeps during *kharif* 2013-14.

The maximum population of green leaf hopper, *Nephotettix* spp. was found in September-October months. The highest population of green leaf hopper nymph/adult was observed in midland SRI (MSR) with 26.95 nymph/adult/25 sweeps and lowest in upland direct seeded (UDS) with 7.95 nymph/adult/25 sweeps.

The highest population white backed plant hopper, *Sogatella furcifera* was observed during October month in different rice ecosystems of Raipur. Among the ecosystem maximum WBPH was observed in Midland SRI (MSR) with 2.83 adult/25 sweeps and minimum in upland direct seeded (UDS) with 0.20adult/25 sweeps during cropping season.

The maximum population of brown plant hopper, *N. lugens* was found in October-November month in different rice ecosystems of Raipur during 2013-14. Among the ecosystem highest brown plant hopper adult was observed in midland normal transplanted with 7.30 adult/25 sweeps and lowest in upland direct seeded with 0.82 adult/25 sweeps.

Studies on pest succession of rice in different rice ecosystems of Raipur during 2013-14 revealed that, the maximum population of zigzag leaf hopper, *Recilia dorsalis* was recorded in October-November month. The highest population of zigzag leaf hopper, *R. dorsalis* nymph/adult was observed in midland SRI (MSR) with 2.45 nymph/adult/25 sweeps and lowest in upland direct seeded rice ecosystem (UDS) with 0.32 nymph/adult/25 sweeps.

4.1.2 Hill based sampling:

The maximum per cent infestation of horned caterpillar, *Melantis leda isemene* was observed from 33 SMW to 37 SMW in month of August to September in among the ecosystem. The status of horned caterpillar in different rice ecosystems of Raipur during *kharif* season revealed that, the maximum per cent of leaf infestation was recorded in lowland organic (LLO) with 1.86 2.28 per cent leaf damage/hill and lowest in midland SRI rice ecosystem (MSR) with 1.52 per cent leaf damage /hill.

Rice skipper, *Pelopidas (Parnara) mathias* Fb. maximum per cent leaf infestation/hill observed during September month. On the basis of seasonal mean the maximum percent of leaf infestation/hill was recorded in lowland organic (LLO) with 0.55 per cent leaf infestation/hill and lowest midland SRI rice ecosystem (MSR) 0.02 per cent leaf infestation /hill.

Results on the incidence of hispa, *Dicladispa armigera* reveled that, the peak percent leaf infestation was recorded during 33 to 35 SMW of August month. Among the ecosystem maximum percent of leaf infestation/hill was recorded in midland normal transplanted (MNT) with 1.36 per cent leaf infestation /hill and lowest in upland direct seeded (UDS) with 0.34 per cent leaf infestation/hill.

The maximum percent leaf infestation of caseworm, *N. depunctalis*. was recorded on 34 to 37 SMW of August-September month and among the rice ecosystem maximum percent of leaf infestation/hill was recorded in lowland conventional (LLC) with 0.20 per cent leaf infestation/hill and lowest in upland direct seeded (UDS) with 0.00 per cent leaf infestation/hill during *kharif* season.

Results on the per cent leaf infestation of whorl maggot, *Hydrellia* spp. showed that, the highest per cent leaf infestations of whorl maggot, observed during 34-36 SMW in month August-September month. The highest and lowest per cent leaf infestation was recorded in lowland conventional (LLC) with 0.38 per cent leaf infestation/hill and upland direct seeded rice ecosystem (UDS) with 0.10 per cent leaf infestation/hill respectively.

The incidence (% dead hearts and white ears) of yellow stem borer, *Sciropophaga incertulas* Walker were appeared from 32 to 34 SMW of August and 38 to 41 SMW of October in among the ecosystem respectively. The maximum per cent dead hearts observed during 36 SMW to 37 SMW of September and maximum per cent white ears observed during 42 SMW to 43 SMW in among the ecosystem. During study period the maximum per cent of dead hearts/hill was recorded in midland normal transplanted rice ecosystem (MNT) with 2.87 per cent and lowest in upland transplanted rice ecosystem (UTP) with 0.50 per cent but the maximum percent of white ears/hill were recorded in midland SRI (MSR) with 8.08 per cent and upland transplanted (UTP) with 2.76 per cent in Raipur during *kharif* season 2013-14.

Stem borer species composition in rice ecosystem at Raipur during *kharif* season 2013-14

The species composition of stem borer in rice ecosystem revealed that the 100 per cent of yellow stem borer species present in upland direct seeded, upland transplanted and midland, normal transplanted rice ecosystem and lowland conventional rice ecosystem. In lowland organic and mid land SRI rice ecosystem 92.59 per cent, 63.15 per cent of yellow stem borer and 7.40 per cent, 36.84 per cent of pink stem borer were present respectively. On the basis of light trap observation 88.07 per cent of yellow stem borer and 11.92 per cent pink stem borer were observed in rice ecosystem at Raipur during *kharif* season 2013-14.

4.2 To record the natural enemies of rice insect pests in different ecosystem during *kharif* season.

The status of spider population in different rice ecosystems of Raipur revealed that, the maximum population was found in October- November month. Among the ecosystem highest population of spider was recorded in lowland organic rice ecosystem with 7.48/25 sweeps and upland direct seeded rice ecosystem with 3.80/25 sweeps during cropping season.

During the study period hymenopterous parasitoids, belonging to 10 families were recorded. The maximum populations of wasps were recorded in September-

November month. Among the ecosystem highest populations of wasps were recorded in lowland organic rice ecosystem with 4.08 adult/25 sweeps and lowest in upland direct seeded rice ecosystem with 1.14 adult/25 sweeps during *kharif* season 2013-14.

Among the predators, damsel flies found as general predators. The maximum populations of damsel flies were recorded during last week of August to October month and highest in lowland organic rice ecosystem with 3.97 adult/25 sweeps and lowest in upland direct seeded rice ecosystem with 1.96 adult/25 sweeps during *kharif* season. Similarly the maximum populations of dragonflies were recorded during 1^{st} week of September to October month and highest in lowland organic rice ecosystem with 1.14 adult/25 sweeps and upland transplanted rice ecosystem with 0.48 adult/25 sweeps.

Observations of the carabids in different rice ecosystem at Raipur during *kharif* season revealed that, the population of *Ophionea* spp. 1^{st} peak in September and 2^{nd} peak during October month. Among the ecosystem maximum populations of carabids were recorded in lowland conventional rice ecosystem with 1.83 adult/25 sweeps and lowest in upland direct seeded rice ecosystem with 0.48 adult/25 sweeps.

The peak population of staphylinids were recorded from 38 SMW to 42 SMW of September to October and among the ecosystem the maximum populations of rove beetle, *Paederus fuscipes* Curtis were recorded in lowland organic rice ecosystem with 0.55/25 sweeps and lowest in upland direct seeded rice ecosystem (UDS) with 0.36/25 sweeps.

The peak populations of coccinellids were observed during 38 SMW to 46 SMW of September-November in across the rice ecosystem and maximum in lowland organic rice ecosystem with 2.45/25 sweeps and upland transplanted rice ecosystem with 0.66/25 sweeps. The peak population of mirids observed during 42 SMW to 46

SMW of October- November in varied population level in among the ecosystem and maximum in lowland organic rice ecosystem with 1.19/25 sweeps and upland transplanted rice ecosystem with 0.61/25 sweeps.

The highest population of assassian bug recorded on 37 SMW to 39 SMW in month of September with varied population level. Among the ecosystem the maximum population of assassian bug nymph/adult was recorded in lowland organic rice ecosystem with 0.55 adult/25 sweeps and upland direct seeded rice ecosystem with 0.11 adult/25 sweeps.

The maximum population of technid flies observed during 34 SMW to 37 SMW of August- September in the entire ecosystem. Among the ecosystem maximum population of technid flies were recorded in lowland organic rice ecosystem with 0.42 adult/25 sweeps and lowland conventional rice ecosystem with 0.11 adult/25 sweeps.

During study period the unidentified entomopathogenic virus infected larvae populations were recorded in midland SRI (MSR), lowland conventional (LLC) and lowland organic (LLO) rice ecosystem. The virus infected larval population were highest in LLO with 0.11/25 sweeps followed LLC with 0.06/25 sweeps and MSR with 0.02/25 sweeps in rice ecosystem and peak during vegetative stage of crops in month of September.

The maximum percent of egg parasitization by *Telenomus* sp. was observed in the second week of October (53.95%). Parasitization by *Trichogramm* sp. was maximum with (17.31%) during 39 SMW of September. Parasitization by *Tetrastichus* sp. was zero during *kharif* season. The seasonal average of percent egg parasitization was 37.99 per cent and ranged from 23.5 to 58.36 per cent. Periodical observation of stem borer larval parasitization by NPV revealed that the maximum per cent of NPV parasitized larvae was observed in lowland conventional followed by midland system of rice intensification(SRI) and upland transplanted rice ecosystem.

During study period the maximum per cent of BPH egg mass parasitized by *Anagrus* spp. was observed 26.01 per cent followed by *Oligosita* spp. 15.10 per cent and *Gonatocerus* spp. 2.13 per cent. The maximum per cent of egg mass parasitized by *Anagrus* spp. was recorded during 23 SMW in month of May, by *Oligosita* spp. was observed during 4 SMW to 14 SMW of January-February and *Gonatocerus* spp. april- May during 2013-14.

4.3.1 Monitor the rice insect pests through light trap collection and correlation with weather parameters during *kharif* season.

The first and second peak population of male and female was observed during 45th, 44th SMW and 44th, 38th SMW respectively. Similarly first and second peak population of YSB total (male + female) was observed during 44th SMW and 45th SMW (Table 4.3.1.1). There was significant positive correlation between yellow stem borer total (M+F) and male with sun shine hours (r = + 0.506*), (r = + 0.576**) respectively. The first and second peak population of PSB was observed during 45th and 49th SMW respectively. There was significant correlation between pink stem borer with sun shine hours (r = + 0.539**), maximum temperature (r = - 0.440*), minimum temperature (r = - 0.688**) and relative humidity evening (r = - 0.694**).

The maximum adult catches of leaf folder (LF) were observed during 45th SMW of November and there was significant negative correlation with morning relative humidity and evening relative humidity with r value (r= - 0.619**) and (r= - 0.467*) at 1 per cent and 5 per cent level of significance. The highest of population of grass hopper was observed during 41st SMW of October and there was significant negative correlation with morning relative humidity (r = - 0.454*).

The brown plant hopper, *N. lugens* showed significant negative correlation with morning relative humidity (r = - 0.495*) at 5 per cent level of significance. The highest numbers of adult catches of BPH were observed during 47th SMW of November. Zigzag hopper (ZZH) attained highest peak population during 47th SMW of November and the correlation between ZZH population with rainfall (r= -0.410*) showed significant negative correlation at 5 per cent level of significance.

The highest population of Green leaf hopper, White backed plant hopper, ear head bug were observed during 42nd SMW of October. The highest population of caseworm was observed during 41st SMW of October. The peak population of swarming caterpillar, *Spodoptera mauritia* observed during 37th SMW of September. There was non significant correlation between above the insects and weather parameters.

The maximum population of carabid/ground beetle, rove beetle and coccinellids were recorded peak during 47th, 43rd and 43rd standard meteorological week, respectively. There was non significant correlation with weather parameter. The peak population of ear wigs was observed during 36th standard meteorological week and there was positive significant correlation with maximum temperature (r = + 0.481*) and minimum temperature (r = + 0.446*) at 5 per cent level of significance.

CONCLUSION

At the end of citations of studies entitled **"Relative abundance of major insect pests and their natural enemies in different rice ecosystem during *kharif* season"**following conclusions were made:

- Stem borer, leaf folder, horned cuterpillar, rice skipper, gundhi bug, caseworm, hispa, green leaf hopper, white- backed plant hopper, brown plant hopper and zigzag leaf hopper were observed as important pest in dfferent rice ecosysetem at Raipur. The populations were captured of all the insect pests higher in lowland rice ecosystem.

- Spiders, wasps, demsal flies, dragon flies, carabids, rove beetles and coccinellids were dominant natural enemies of rice insect pests in different rice ecosystem of Raipur found most active during September to November. The maximum population of natural enemies was found in lowland organic rice ecosystem.
- Yellow stem borer was found as dominant species in different rice ecosystem of Raipur during *kharif* 2013-14. The *Telenomus* sp. was dominant eggs parasitoids of stem borer and most active during 41 SMW of October. *Trichogramm* sp. was dominant during 39 SMW of September. The indigenous species of stem borer larval parasite found in Raipur was the NPV; it is a potential larval parasitoid at the reproductive stage of crop and mostly observed in lowland conventional rice ecosystem.
- The *Anagrus* sp. followed by *Oligosita sp*. and *Gonatocerus sp*. were important egg parasitoids of BPH eggs at Raipur. The maximum percent of BPH egg parasitized by *Anagrus* spp. was recorded during 23 SMW in month of May during 2013-14.
- The month of October and November is identified as the peak activity period for most of the insect pests and natural enemies in light trap collection study.

SUGGESTION FOR FUTURE WORK

1. This study should be repeated for confirmation of observations.
2. Taxonomy and bionomics study of rice insect pests and their natural enemies are required.

3. Host range and feeding efficiency of different predators and parasites should be worked out.
4. Mass multiplication technique for inhabitant races of predators and parasites should be standardized.
5. Abandance, diversity and influence of physical and chemical factors of aquaitic natural enemies in dfferent rice ecosystem should be worked out.
6. Morphological and molecular differentiation of the natural enemis of rice insect pests in rice ecosystem should be worked out.
7. Effects of *Bt* transgenic rice line on rice stem borer and its consequences on egg parasitoid in the laboratory should be worked out.

Abstract

"RELATIVE ABUNDANCE OF MAJOR INSECT PESTS AND THEIR NATURAL ENEMIES IN DIFFERENT RICE ECOSYSTEM DURING *KHARIF* SEASON"

By
Yaspal Singh Nirala

ABSTRACT

Rice ecosystem favorable for proliferation of insect-pests is equally congenial for multiplication of the natural enemies of these pests. In view of the changing cultural practices the pest and natural enemy population dynamics needs closely monitoring for suitable amendments in rice IPM strategies. The present investigation entitled "Relative abundance of major insect pests and their natural enemies in different rice ecosystem during *kharif* season'' at the research farm of IGKV, College of Agriculture Raipur, (C.G.) during 2013-14.

Stem borer, leaf folder, horned cuterpillar, rice skipper, gundhi bug, caseworm, hispa, green leaf hopper, white- backed plant hopper, brown plant hopper and zigzag leaf hopper were observed as important pest in dfferent rice ecosysetem at Raipur during *kharif* season. The month of October and November is identified as the peak activity period for most of the insect pests in light trap collection study. In field sampling study, the higher intensity of major insect pest was observed during last week of August to second week of November. The important predators observed in different rice ecosystem of Raipur are spiders, wasps, carabids, coccinelids, rove beetles and damselflies. Predatory spiders and mirids were found most active during October-November but carabids, coccinellids, dragon flies, demsal flies and rove beetle were found most active in the month of September - October in the field sampling. The highest count of carabids, rove beetles, coccinellids and ear wigs in the light trap catchs observed during 36-47 SMW of September and November.

The important parasitoids in different life stages of important rice insect pest were also observed for stem borer egg mass& larvae, and BPH egg mass. Dominant egg parasitoid actively present throughout the *kharif* season on stem borer eggs was *Telenomus* sp. it was found most active during second week of October and *Trichograma* sp. during September. Stem borer larvae present inside the plant at the maturity stage of crop were found parasitoid by NPV; this larval parasitization was mostly observed in the lowland conventional rice ecosystem. BPH eggs were found parasitized by *Anagrus* spp. was recorded during 23 SMW in month of May, by *Oligosita* spp. was observed during 4 SMW to 14 SMW of January-February and *Gonatocerus* spp. april- May. In this study 206 species of arthropods belonging to 85 families in 11 orders which include 152 species of natural enemies and 54 species of rice insect pests were recorded in defferent rice ecosystem at Raipur. The peak activity period for most of the rice insect pest was observed during the last week of September to first week of November. The highest count for most of the predators and parasitoids were observed in the month of October at Raipur during *kharif* season.

Department of Entomology
College of Agriculture, Raipur
Date: 21-07-14

Shri Gajendra Chandrakar
(Major Advisor)

References

REFERANCES

Adiroubane, D and Raja, K. 2005. Influence of weather parameters on the occurrence of rice yellow stem borer, *Scirpophaga incertulus* Walker. *Journal of Rice Research.* **3** (1): 5-9**.**

Afun, J.V.K., Johnson, D.E. and Smith, A. R. 1994. Weeds and natural enemy regulation of insect pests in upland rice; a case study from West Africa. *Bulletin-of-Entomological-Research.* **89** (5): 391-402.

Ahmad, H., Khan, B. B., Sharma, D., Jamwal, V. V. S. and Gupta, S. 2010. Seasonal incidence, infestation and trap catches of *Cnaphalocrocis medinalis* in rice. *Annal. Plant. Protection*. *Sci.* **18** (2): 380-383.

Andrewartha, H.G.1961. Introduction to the study of animal population. *Methuen and Co. Ltd*. London. pp.11-12.

Anonymous, 1985. *International Rice Research Institute Report*, Manila, Philippines, pp. 160-165.

Anonymous, 2004. Production oriented survey. *Dir. rice res.* Hyderabad. pp. 57-59.

Anonymous, 2009a. *Centre for Monitoring Indian Economy Report*. pp. 54-58.

Anonymous, 2009b. Status paper on rice Chhattisgarh. *Dir. rice res.* Hyderabad. pp. 11-16.

Anonymous, 2010. Monitoring of pest species and their natural enemies. All India Coordinated Rice Improvement Programme. *Annual Progress Report, DRR*, Rajendra Nagar, Hyderabad (AP). pp. 60-79.

Baghel, M. 2011. Studies on some important IPM tools influencive for the intensity of rice stem borer and its parasitoids. *M.Sc(Ag.) thesis*. Department of Entomology, IGKV, Raipur. p.77.

Bambaradeniya, C.N.B. 2000. Ecology and biodiversity in an irrigated rice field ecosystem in Sri Lanka. *Ph.D.thesis* University of Peradeniya, Sri Lanka. p.525.

Bambaradeniya, C.N.B., Edirisinghe, J.P., Silva, D.N., Gunatilleke, C.V.S., Ranawana, K.B. and Wijekoon, S. 2004. Biodiversity associated with an irrigated rice agro-ecosystem in Sri Lanka. *Biodiversity-and-Conservation.* **13** (9): 1715-1753.

Banerjee, S. N. 1961. Incidence of the rice gunghi bug and its control in North Bengal in 1958. *Proc. Rice Res. Work. Conf.,* Cuttack. pp. 295-97.

Barrion, A.T. and Litsinger, J.A. 1994. Taxonomy of rice insect pests and their arthropod parasites and predators, In: E.A. Heinrichs. Biology and management of rice insects. New Delhi, Wiley Eastern. pp.13–362, 779.

Barrion, A.T. and Litsinger, J.A. 1995. Rice land spiders of South and South East Asia. *Philippine Entomol.* **13** (1): 12-15.

Chakraborty, K. 2008. Relative composition of egg parasitoid species of yellow stem borer, *Scirpophaga incertulas* Wlk. in paddy field at Uttar Dinajpur, West Bengal, India. *Current Biotica.* **6** (1): 42-52.

Chakraborty, K. and Nanda, P. S. 2011. Incidence of paddy yellow stem borer, *Scripophaga incertulas* Walker in relation to the agroclimatic region of Hemtabad, Uttar Dinajpur, west Bengal, India.*International Referred Research Journal*. pp. 48-49.

Chander, S. 1998. Distribution and damage of green-horned caterpillar, *Melanitis leda ismene* in paddy. *Ann. Plant Prot. Sci*. **6** (1): 110-112.

Chandra, G. 1980. Taxonomy and bionomics of the insect parasites of rice leafhoppers and planthoppers in the Philippines and their importance in natural biological control, *Philippine Entomologist*. **4** (3): 119-139.

Chiu, S.C. 1979. Biological control of the brown planthopper. In Brown Planthopper: Threat to rice production in Asia, Manila, Philippines: International Rice Research Institute. pp. 335–355.

Choudhury, B.U., Singh, A.K. and Bouman, B. A. M. 2005. Effect of establishment techniques on yield, crop water relationship in rice and wheat. In: T.M. Thiyagarajan, H. Hengsdijk, and P.S. Bindraban (eds). *Transitions in Agriculture for Enhancing Water Productivity: Proceedings of an International Symposium held in Killikulam, Tamil Nadu, India, September 23-25, 2003.* pp. 19 - 38.

Claridge, M.F., Morgan, J.C., Steenkiste, A.E., Iman, M. and Damayanti, D. 1999. Seasonal patterns of egg parasitism and natural biological control of rice brown planthopper in Indonesia, *Agricultural and Forest Entomology*. **1** (4):297-304.

Claver, M. A. and Jaiswal, P. 2012. Distribution and abundance of two predatory stink bugs (Pentatomidae: Hemiptera) associated with rice field. *Academic Journal of Entomology.* **6** (1): 33-36.

Cohen, J. E., Schoenly, K., Heong, K. L., Justo, H., Arida, G., Barrion, A. T. and Litsinger, J. A. 1994. A food web approach to evaluation of the effect of insecticide spraying on insect pest population dynamics in a Philippine irrigated rice ecosystem. *J. Appl. Ecol.* **31**: 747-763.

David, P. M. M., K. Ezhilrani and T. M. Thiyagarajan. 2005. Relative abundance of insects in SRI and conventional rice. Paper presented at the National

Symposium on Biodiversity and Insect Pest Management held on 3-4, February, 2005 at Entomology Research Institute, Chennai.pp.96-99.

Debjani, D. and Raghuraman, M. 2008. Monitoring biodiversity of hymenopterous parasitoids in rice agroecosystem - a preliminary study. *Indian-Journal-of-Entomology*. **66** (3): 268-270.

Dogra, I. and Choudhary, A. 2005. Some insect pests of rice, Oryza sativa Linn. in Kangra Valley of Himachal Pradesh. *Insect-Environment*. **11** (1): 21-22.

Ehrlich, P. R., and A. H. Ehrlich. 1981. Extinction: the causes and consequences of the disappearance of species. Random House, New York.pp.12-25.

Elanchezhyam. K. 2007. Biological control: An eco – friendly pest management strategy. Sustainable pest management by D. Prasad. pp. 69-82.

Fernando, C.H. 1995. Rice fields are aquatic, semi-aquatic, terrestrial and agricultural: a complex and questionable limnology. *Tropical limnology*. **1**: 121-148.

Fowler, S.V., Claridge, M.F., Morgan, J.C., Peries, I.D.R. and Nugaliyadde, L. 1991. Egg mortality of the brown planthopper, *Nilaparvata lugens* (Homoptera: Delphacidae) and green leafhoppers, *Nephotettix* spp. (Homoptera: Cicadellidae), on rice in Sri Lanka, *Bulletin Entomological Research*. **81**: 161-167.

Ganguli, J.L.1996. Studies on the yellow stem bober, *Scirpophaga incertulas* walker (lepidoptera: pyralidae) on rice in Chhattisgarh. *Ph.D.thesis*, Indira Gandhi Agricultural University Raipur, Chhattisgarh (India). pp. 122-123.

Gangurde, S. 2004. Aboveground arthropod pest and predator diversity in irrigated rice (*Oryza sativa* L.) production systems of the Philippines. *Journal of Tropical Agriculture.* **45** (1): 1–8.

Garg, V. 2012. Monitoring of rice insect pest and their natural enemies during *Kharif* season at Raipur. *M.Sc.(Ag.) thesis*, Indira Gandhi Agricultural University Raipur, Chhattisgarh (India).p. 88.

Girish, V P. 2010. Studies on insect pests and their predators in upland rice ecosystem. *M.Sc.(Ag.) thesis*, Univ. of agricultural sciences Dharwad, Karnatka (India).p.73.

Gomez, K.A. and Gomez, A. 1985. Statistical procedure for agriculture research. A wibey-Inter Sci.Publication John and sons, Newyork.

Grist, D. H. and Lever, R. J. 1969. Pests of Rice, Longmans, Green, London. pp. 520-601.

Gupta, M. and Pawar, A.D. 1989. Biological control of rice leafhoppers and planthoppers in Andhra Pradesh, *Plant Protection Bulletin (Faridabad)*. **41** (1-2): 6-11.

Gururaj, K., Pasalu, I.C., Varma, N.R.G. and Dhandapani, N. Quantification of natural biological control in rice ecosystem for possible exploitation in rice IPM. *Indian-Journal-of-Entomology*. **63** (4): 439-448.

Hachiya, K. 1995. Egg parasitoid of small brown planthopper, *Laodelphax striatellus* Fallen (Hemiptera, Delphacidae) in Hokkaido, Japan, *Japanese Journal of Applied Entomology and Zoology*. **39** (1): 89-90.

Harinkhere, J.P., Kandalkar, V.S. and Bhomik, A.K. 1998. Seasonal abundance and association of light trap catches with field incidence of rice leaf folder, *Cnaphalocrocis medinalis* G. *Oryza*. **35** (1): 91-92.

Hassan, A. 1994. Studies on the mosquito fauna of Kerian District with emphasis on the mangrove swamp ecotype. *Ph.D. Thesis*, Univ. Malaya, Kuala Lumpur, Malaysia.pp. 167-170.

Hazarika, S. H. 1952. Destructive insects of Eastern Pakistan and their control. *EPG Press,* Dacca. p.9.

Heckman, C.W. 1979. Rice field ecology in North East Thailand. *Monographs of Biology*. **34** (1): 228.

Heinrichs, E.A. 1994. Insect pests of rice plant - Their biology and ecology. In : Biology and management of rice insects, Willey Eastern Ltd., India & IRRI , Manila , Philippines. pp- 363-487.

Hesler, L.S., Grigarick, A.A., Oraze, M.J. and Palrang, A.T. 1993. Arthropod fauna of conventional and organic rice fields in California. *Journal of Economic Entomology*. **86** (1): 149-158.

Hidaka, K. 1997. Community structure and regulatory mechanism of pest populations in rice paddies cultivated under intensive, traditionally organic and lower input organic farming in Japan. *Biological Agriculture and Horticulture*. **15** (1): 35-49.

Hirai, K. 1993. Recent trends of insecticide susceptibility in the brown planthopper, *Nilaparvata lugens* Stal. (Homoptera: Delphacidae). *Appl. Entomol. Zool*. **28**: 339-346.

Huang, S.H., Cheng, C.H. and Yang, H.Y. 2008. Investigation on the occurrence of rice stem borers in central Taiwan. *Plant protection bulletin, Taipei.* **50** (2): 37-46.

Isahaque, N.M.M and Rahman, A. 1983. Seasonal abundance of rice stem borer, *Scirpophaga incertulas* Walk. in Assam. *Pesticides*. **17**:1, 25-27.

Israel, P. and Rao, K. 1961. The Incidence of gundhi bug and steps for its control. *Proc. Rice Conf.,* Cuttack. pp. 297-99.

Janjua, N. A. 1957. Insect pests of paddy in Pakistan. *Agric Pakista*. **8** (1): 5-18.

Jayakumar, S. and Sankari, A. 2005. Spider population and their predatory efficiency in different rice establishment techniques in Aduthurai, Tamil Nadu. *Journal-of-Biopesticides*. **3** (1): 20-27.

Kajimura, T., Maeoka, Y., Widiarta, I.N., Sudo, T., Hidaka, K., Nakasuji, F., and Nagai, K. 1993. Effect of organic farming of rice plants on population density of leafhoppers and planthoppers. I. Population density and reproductive rate. *Japanese J. Appl. Entomol. Zool.* **37**: 137-144.

Kalode, M. B. and Pasalu, I. C. 1986. Pest management in rice. *Indian Farming.* **9**: 31-34.

Kamala, G., Ramasubbarao, V. and Rajasekhar, P. 2002. New record of leafhoppers associated with rice ecosystems of Andhra Pradesh, India. *Pest Management and Economic Zoology.***10** (1): 51-56.

Kandibane, M., Raguraman, S. and Ganapathy, N. 2005. Arthropod guilds in irrigated rice ecosystem. *Crop-Research-Hisar*. **30** (3): 360-363.

Karthikeyan, K., Sosamma, J. and Purushothaman, S.M. 2010. Incidence of insect pests and natural enemies under SRI method of rice cultivation. *Oryza.* **47** (2): 154 – 157.

Karthikeyan, K., Sosamma J. and Puvaraj, M. 2008. Incidences of pests in the SRI and normal system of rice cultivation. In : *Extended summaries of the Third National Symposiun on System of Rice Intensification in India-Policies, Institutions and Strategies for Scaling up.* 1-3 December, 2008. Tamil Nadu Agricultural University, Coimbatore. pp. 90-91.

Kasyanov, A.I. 2010. Coccinellids in rice systems of the Krasnodar Krai. *Zashchita-i-Karantin-Rastenii*. **7**: 23-24.

Katti, Gururaj, Pasalu, I.C., Padamakumari, A.P., Padamavathi, C., Jhansilakshmi, V., Krishnaiah, N.V., Bentur, J.S. Prasad, J.S. and Rao, Y.K. 2007. Biological control of insects-pest of rice. *Oryza*. **44** (7): 125-127

Kerketta, M.S., Dubey, A.K. and Kaushik, U.K. 1990. Light trap studies of two rice plant hoppers, *Nilaparvata lugens* and *Sogatella furcifera* in relation to field population. *Oryza*. **27** (4): 503-506.

Khaire, V. A. and Dumbre, R. B. 1984, Seasonal incidence and chemical control of brown plant hopper in Konkan region. *J. Maharashtra Agric. University*. **9** (1): 106-107.

Khan, A. A. and Mishra, D.S. 2006. Abundance of arthropod fauna in rice ecosystem. *Environment-and-Ecology*. **24** (1): 97-101.

Khan, M.M.H. and Alam, M.I. 2007. Influence of management practices and growth stages of rice on the abundance and diversity of insect pests and natural enemies. *Annals-of-Bangladesh-Agriculture*. **11** (2): 21-32.

Khan, Z.R., Litsinger, J.A., Barrion, A.T., Villanueva, F.F.D., Fernandez, N.J. and Taylor, L.D. 1991. World bibliography of rice stem borers 1974-1990. International Rice Research Institutre and International Centre of Insect Physiology and ecology. pp. 196-198.

Kittur, S. U., Kaushik, U. K. and Prophaly, D. J. 1985. The role of phototropism in controlling the major pests of Rice. In: *Behavioural and Physiological Approaches in Pest Management*, 1984-85. Ed. Ragupathy, A. and Jayaram, Coimbatore, India. pp. 100-103.

Kraker, J. D., Huis, A.V., Heong, K.L., Lenteren J.C. and Rabbinge, R. 1999. Population dynamics of rice leaf folders (Lepidoptera: Pyralidae) and their natural enemies in irrigated rice in the Philippines. *Bulletin of Entomological Research.* **89**: 411-42**.**

Krishnaiah, N.V., Prasad, A.S.R., Rao, C.R., Pasalu, I.C., Zaheruddeen, S.M., Varma, N.R.G., Lakshmi, V.J. and Lakshminarayanamma, V. 2006. Population dynamics of rice brown plant hopper, *Nilaparvata lugens* in Godavari Delta of Andhra Pradesh State. *Indian-Journal-of-Plant-Protection.* **34** (2): 158-164.

Kumar, R.M., Padmavathi, C., Surekha, K., Latha, P. C., Krishnamurthy, P. and Singh, S.P. 2006. Influence of organic nutrient sources on insect pests and economics of rice production in India. *Indian Journal of Plant Protection*. **35** (2): 264-267.

Kumar, S, Khan, M.A., Kumar, A. and Sharma, K. 2008. Biodiversity of natural enemies in Paddy ecosystem and their seasonal dominance. *Annals of Plant Protection Science*.**16** (2):381- 383.

Kumar, V. and Patil, B.V. 2004. Occurrence of minor insect pests of paddy in Tungabhadra project area of Karnataka. *Karnataka Journal of Agricultural Sciences*. **17** (4): 825-826.

Lawanprasert, A., Kunket, K., Arayarangsarit, L. and Prasertsak, A. 2004. Comparison between conventional and organic paddy fields in irrigated rice ecosystem. 4^{th} INWEPF steering meeting and symposium. pp. 1-9.

Li, B.C. and He, J.X. 1991. Investigation of population dynamics of three species of Mymaridae parasitizing the eggs of planthoppers and their utilization and protection, *Natural Enemies of Insects*. **13** (4): 156-161.

Litsinger, J.A., Barrion, A.T and Soikarna, D. 1987. Upland rice insect pests: their ecology, importance and control. *IRRI Research Paper Series, International Rice Research Institute.* 123, 41.

Madhukar, F.J. 2005. A preliminary study of the predatory natural enemy complex of rice ecosystem in Vidarbha region of Maharashtra, India. *International Referred Research Journal*. **2**(22): 25-27.

Mahender, K. R., Raghuveer, R. P., Somasekhar, N., Surekha, K., Padmavathi, C., Srinivas, P. M., Ravindra, B. V., Subba, R. L.V., Latha, P.C., Sreedevi, B., Ravichandran, S., Ramprasad, A.S., Muthuraman, P., Gopalakrishnan, S., Vinod G.V. and Viraktamath B.C. SRI-A Method for sustainable intensification of rice production with enhanced water productivity. *Agrotechnology*. **11** (9):1-6.

Mohan, S. and Janarthanan, R., 1985. Light trap attractant of major pests of rice and a mired predator during the rice growing season. In: *Behavioural and Physiological Approaches in Pest Management, 1970-80*. Eds. Ragupathy, A. and Jayaram., Coimbatore, India, pp. 107-109.

Nagata, T. 1982. Insecticide resistance and chemical control of the rice planthopper *Nilaparvata lugens* Stal. *Bull. Kyushu Natl. Agri. Experi. Stat*. **22**: 49- 164.

Nath, P. and Bhagabati, K.N. 2002. Population dynamics of leafhopper vectors of rice tungro virus in Assam. *Indian Phytopath.* **55** (1): 92-94.

Ngo, T.D. 2007. SRI application in rice production in northern ecological areas of Vietnam. Report from the National IPM Program to Council of Science and Technology, Ministry of Agriculture and Rural Development, Hanoi.

Ngoan, N. D., 1972. Recent progress in rice insect research in Vietnam, *Proc.* of *Symp. On Tropical Agric. Res.,* Japan. **5**: 133-141.

Nyffeler, M., Sterling, W.L. and Dean, D.A. 1994a. How spiders make a living. *Environ. Entomol.* **23**:1357, 1367.

Okuma, C., Lee, M. H. and Hokyo, N. 1978. Fauna of spiders in a paddy field in suweon. *Esakia*. **11**: 81-88.

Ooi, P. A.C. and Shepard, B.M. 1994. Predators and parasitoids of rice insects in biology and management of rice insects, *Wiley Eastern Ltd., India and International Rice Research Institute (IRRI)*, Manila, Philippines.pp.613- 656.

Oyediran, I.O., Ndongidila, A. and Heinrichs, E.A. 1999. Strepsipteran parasitism of white leafhoppers, Cofana spp. (Hemiptera: Cicadellidae) in lowland rice in Cote d'lvoire. *International-Journal-of-Pest-Management*. **46** (2): 141-147.

Padhi, G. and Saha, S. 2004. Influence of weather parameters on population fluctuation of rice yellow stem borer, *Scirpophaga incertulas* Walker in light trap catches. *Environment and Ecology*. **22** (3): 504-507.

Padmavathi, C., Kumar, R. M., Subba Rao, L.V., Surekha, K., Prasad, S. M., Ravindra Babu, V. and Pasalu, I.C. 2005. Influence of SRI method of rice cultivation on insect pest incidence and arthropod diversity. Directorate of Rice Research, Rajendranagar, Hyderabad 500030, Andhra Pradesh, India *Oryza*. **46** (3): 227-230.

Padmavathi, C., R. Mahender Kumar, K. Surekha, P.C. Latha, L.V. Subba Rao, M.S. Prasad, V. Ravindra Babu, J.S. Prasad, O.P. Rupela, V. Vinod Goud, I.C. Pasalu and B.C. Viraktamath. 2007. Insect-pest dynamics and anthropod diversity in SRI and conventional methods of rice cultivation. In: *Papers and extended Summaries. SRI India 2007-Second National Symposium on System of Rice Intensification in India –Progress and prospects.* October 3-5, 2007. Agartala, Tripura, India. pp. 89-91.

Painkra, G.P. 2005. Incidence of gall midge, *Orseolia oryzae* Wood Mason in low land rice ecosystem at north zone of Chhattisgarh. *Insect-Environment.* **11**(2):94.

Pathak, M. D. and Khan, Z. R. 1994. Insect pests of rice. *IRRI,* Los Banos, Laguna, Philippines. pp. 77-89.

Pathak, M., Shakywar, R.C., Sah, D. and Singh, S. 2012. Prevalence of insect pests, natural enemies and diseases in system of rice intensification (SRI) and traditional system of cultivation in North East Region. *Annals of Plant Protection Sciences.***20** (2):375.

Prabhuswamy, H. P. 1972. Rice leaf hoppers and plant hoppers in Bangalore area with emphasis on the biology and control of *Zygina maculifrons* (Homoptera: Delphacidae). *M. Sc.(Argi) Thesis*, Univ. Agric. Sci., Bangalore, Karnataka (India).

Prasad, R. and Prasad, D. 2006. Account of insect pests problem in rice ecosystem in Ranchi. *Indian Journal of Entomology*. **68** (3): 240-246.

Pulin, P., Khound, J. N. and Patgiri, P. 1998. Seasonal incidence of rice caseworm *Nymphula depunctalis* (Guen.) in Ahu and Sali rice. *J. Agril Sc. Soc. North East India.* **11**(2): 241-243.

Rai, A.K. and Khan, M.A. 2002. Light trap catch of Insect-pest, *Nephotettix virescens* (Distant) and its relation with climatic factors. *Annals of Plant Protection Science*. **10** (1):17-22.

Rajendra, B. S. 2009. Status of paddy insect pests and their natural enemies in rainfed ecosystem of Uttara Kannada district and management of rice leaf folder. *M.Sc(Agri) Thesis*, Univ. Agric. Sci., Dharwad (India).p.117.

Rajukkannu, K. Ramadass, P. and Jecitha, J. 2007. Keeping the brown planthopper at bay with SRI. LEISA Magazine 23.4, December 2007: p 30-31.

Ravi, G., Rajendran, R., Raju, N., Chozhan, K. and Muralidharan, V. 2007. Insect pest scenario in irrigated rice grown under SRI method of cultivation. In Extended Summaries on Second National Symposium on SRI in India – Progress and Prospects, October 3-5, 2007, Agartala, Tripura. pp. 94-95.

Rawat, S.N. and Diwakar, M.C. 1982. Survey of natural enemies of paddy insect pests in Chhattisgarh (Madhya Pradesh), India. *International-Rice-Research-Newsletter*. **7**: 1, 13-14.

Reddy, A.V., Devi, R. S., Anitha, G. and Reddy, D.V.V. 2007. .Study on the incidence of insect pests and natural enemies as influenced by organic treatments in rice ecosystem. *Journal of Research ANGRAU*. **40** (3): 9-13.

Reddy, M. S., Rao, P. K., Rao, B. H. K. and Rao, G. N. 1983, Preliminary studies on the seasonal prevalence of certain Homoptera occurring on rice at Hyderabad. *Indian J. Entomology*. **45** (1): 20-28.

Regannold, J. P., Papendick, R. I., and Parr, J. F. 1990. Sustainable agriculture. *Sci. Amer*. **262**: 112-120.

Riechert S. E., and Bishop, L. 1990. Prey control by an assemblage of generalist predators: Spiders in garden test systems. *Ecology*. **71**: 1441-1450.

Rogel, C.J.G. 2004.The richness of Philippine Rice Fields. *A Public Education Series of the Asia Rice Foundation*. **1**(3): 1-4.

Roy, P, Sinha, P.K., Regupathy, A. and Jayaraj, S. 1985. Utility of light trap data in the control of rice stemborer, *Tryporyza incertulas* (walker). Behavioural and physiological approaches in pest management.pp.1, 92-93.

Sahad, K.A. 1982. Description of new species of *Gonetoserous* Nees and *Anagrus* Haliday from Japan (Hymenoptera: Mymaridae). *Esakia*. **19** (1): 191-204.

Sahad, K.A. 1982a. Biology and morphology of *Gonetoserous sp.* (Hymenoptera: Mymaridae) an egg parasitoid of green leafhopper, *Nephotettix cincticeps* Uhler (Homoptera: deltocephalidae). I. Biology. *Kontya*. **50** (2): 246-260.

Sahu, S., Shatrughnga, R., Sing, K. and Pawan, R. 1996. Host preference and feeding potential of spiders predaceous in insect pests of rice. *Journal of Entomological Research.* **20** (2): 145-150.

Salmah, M.R., Che, S.T.S., Hassan, A. and Ali, A.B. 1993. Influence of physical and chemical factors on the larval abundance of *Neurothemis tullia* Drury) in a rain fed rice field. *Hydrobiologia.* **389** (1): 193–202.

Salokhe, V. M, Kumar, P. and Mishra, A. 2007. Increasing water use efficiency by using mulch under SRI management practices in Northeast Thailand. Second progress report: Participatory action research phases, 1st July – 30th December, 2006, Bangkok, Asian Institute of Technology. pp. 123-125.

Sebastian, P.A., Mathew, M.J. and Murugesan, S. 2002. Spider fauna in the forest and agricultural ecosystems of central Kerala, India. *ENVIS Bulletin: Arthropods and their Conservation in India (Insects & Spiders)*. **14** (1): 159-174.

Shamim, M, Shekh, A.M., Patel, V.J., Dodia, J.F., Korat, D.M. and Mehta, A.M. 2009. Effect of weather parameters on population dynamics of green leaf hopper and white backed plant hopper in paddy grown in middle Gujarat region.*Journal of Agrometeorology*. **11**(2): 172-174.

Shanker, R. and Baskaran, P. 1986. Relative abundance of the three spccics of egg parasitoids of rice brown planthoppr. *IRRNI Ikl*. pp. 34-35.

Sharma, A.K., Barche, S. and Mishra, P. K. 2002. Seasonal Activity of *Sogatella furcifera* H.,*Cnaphalocropcis medinalis* G. and *Mythimna separata* W. in Relation to Weather Parameters in Central India. *Journal of Multidisciplinary Advance Research.* pp.19-29.

Shivamurthappa, 1993. Management of brown plant hopper Nilaparvata lugens Stal. by cultural practices and insecticides and investigation on biotypes in Karnataka. *Ph. D. Thesis*, Uni. Agri. Sci. Bangalore, Karnataka.pp.142-145.

Shukla, B.C., Phoply, D.J., Chandrakar, H.K., Gupta, R., Dubey, V.K., Yadu, Y.K., Rana, D.K., Sharma, S., Rana, N. and Gupta, A. 2008. Through light trap adult catches of different paddy insect pests. Souvenir of National Conference on Pest Management Strategies for Food Security. IGKV, Raipur. pp. 2-3.

Simpson, I.C., Roger P. A., Oficial, R. and Grant I.F. 1993. Impact of agricultural practices on aquatic oligochaete population in rice fields. *Biol.Fertil.Soils.***16**: 27-33.

Singh, B.B. and Singh, R. 2010. Major rice insect pests in northeastern UP. *Int. J. LifeSc. Bt & Pharm. Res.* **3** (1):124-143.

Singh, S.P., Rao, N.S. and Henneberry, T.J. 1993. Leafhoppers and their natural enemies. *Technical Bulletin – Project Directorate of Biological Control, ICAR.* pp. 6, 65.

Siregar, A. Z., Salmah C., Rawi, M. and Nasution, Z. 2008. Abandance and diversity of odonata in Upland rice field at Manik Rambung, North of Sumatera. Proceedings of the 7th IMT-GT UNINET and the 3rd International PSU-UNS Conferences on Bioscience.pp.55-61.

Thakur, A. K., Uphoff, N. and Antony, E. 2010. An assessment of physiological effects of system of rice intensification (SRI) practices compared with recommended rice cultivation practices in India. *Experimental Agriculture*. **46** (1): 77-98.

Tikader, B. K. 1987. Handbook of Indian Spiders. Calcutta, Zoological Survey of India. p. 251.

Tiwari, V. K., Dubey, O. P. and Tiwari, S. K., 2001, Predatory status of paddy pests in Jabalpur region. *Res. Crops*. **2** (3): 375-377.

Uphoff, N. 2011. The system of rice Intensification: An Alternate civil society innovation. *Technikfolgenabschätzung – Theorie und Praxis.* **2** (1):45-52.

Varma, K. and Khan, M.A. 2009. Natural parasitization of *Scirpophaga incertulas* (Walker) eggs in Pantnagar region. *J.Ent.Res*. **33** (3): 49-50.

Varma, N. R. G., Jagadeeshwar, R. and Shanker, C. 2009. Relative Composition of egg parasitoids of Rice Yellow Stem Borer, *Scirpophaga incertulas* Walker, *Journal of Rice Research*. **6** (2): 53-58.

Varma, N.R., Bhanu, K.V. and Reddy, D.R. 2008. Forecasting population of brown plant hopper, *Nilaparvata lugens* Stal. *Journal of Agrometeorology*. pp. 197-200.

Venkatashalu, R. 1996. Ecological studies on spiders in rice ecosystems with special reference to their role as biocontrol agents. *M. Sc. (Agri) Thesis*, Uni. Agri. Sci., Bangalore, Karnataka (India).pp.167-169.

Wahed, A. T. and Satter, A. 1959. Pests of paddy and their control measures with special reference to resistance. *In* “Proceedings of the first international rice breeding training center”. Dacca.pp. 16-28.

Watanabe, T., Wada, T., Mohd, N., Noor, B. and Salleh, N. 1992. Parasitic activities of egg parasitoids on the rice planthoppers, *Nilaparvata lugens* Stal. and

Sogatella furcifera Horvath (Homoptera: Delphacidae), in the Muda Area of Pennisular Malaysia, *Applied Entomology and Zoology*. **27** (2): 205-211.

Way, M. J. and Heong, K. L. 1994. The role of biodiversity in the dynamics and management of insect pests of tropical irrigated rice-a-review. *Bull. Entomol. Research.* **86**: 567- 587.

Xian, L.Z., Ping, Y. X., Luen, H. K. and Cui, H. 2006. Impact of nitrogen fertilizer on natural control capacities of invertebrate predators and parasitoids and its demonstration in rice-based ecosystem. *Acta-Agriculturae-Zhejiangensis*. **18** (2): 128-132.

Young A.P. and Edwards, G.B. 1990. Spiders in United States field crops and their potential effect on crop pests. *J. Araehnol.* **18** (1): 1-27.

Zahirul, I., Heong, K.L., David, C. and Keizi, K., 2012. Invertebrates in rice production systems: status and trends. Commission on genetic resources for food and agriculture, *Res. Crops*. **62** (1):16-51.

Zhang, J., Zheng, X., Jian, H., Qin, X., Yuan, F. and Zhang, R. 2013. Arthropod Biodiversity and Community Structures of Organic Rice Ecosystems in Guangdong Province, China. *Florida Entomologist*. **96** (1): 1-9.

Zhimomi, V. A. and Ao, M. A. 2011. Studies on seasonal abundance and correlation of major groups of insect-pests and their natural enemies in rice ecosystem. *International Journal of Bio resource and Stress Management.* **2** (1): 100-104.

Zhong, P.S., Wu, Y.Q. and Zhong, Z.F. 2010. Dynamics investigation of major natural enemies in organic rice fields. *Southwest China Journal of-Agricultural Sciences*. **23** (4): 1107-1110.