Diversity of Coleopteran Fauna in *kharif* Pulses

खरीफ दलहनों में भृंग जीवो की जैव विविधता

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Thesis

Master of Science in Agriculture

(Entomology)

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MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
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Thesis

Submitted to the

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Master of Science in Agriculture

(Entomology)

BY

IRPHAN MOHAMMAD PINJARA

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Maharana Pratap University of Agriculture and Technology
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Diversity of Coleopteran Fauna in *Kharif* Pulses

Irphan Mohammad Pinjara* **Dr. R. Swaminathan****
M.Sc. Scholar **Major Advisor**

ABSTRACT

An investigation on "Diversity of coleopteran fauna in kharif pulses" were carried out at the Department of Entomology, Rajasthan college of Agriculture, MPUAT, Udaipur, during the *kharif* season 2015 with a view to record the species diversity of coleopteran fauna in *kharif* pulses *viz.*, blackgram greengram and cowpea at three locations (College Instructional farm, Farmer's field at Vallabhnagar village and another Farmer's field at Badgaon village). In the experiment the influence of abiotic environmental factors on the coleopteran population was ascertained and a diagnostic key was developed for identification of members of family Curculionidae and Chrysomelidae up to sub-family level. The conducted survey during *kharif* 2015 resulted in the collection of members of 8 families (2 foliage feeding families: Curculionidae and Chrysomelidae, 3 families feeding flowers and pods: Scarabaeidae, Bruchidae and Meloidae and other coleopteran families: Coccinellidae, Staphylinidae and Anthicidae) of Coleoptera. A total of 15 genera were identified from the 8 families (Curculionids: *Myllocerus* and *Cyrtozemia*; chrysomelids: *Aulacophora, Monolepta, Chaetocnema, Luperomorpha, Lema* and Colasposoma; scarabaeids: *Oxycetonia* and *Chiloloba*; bruchids *Callosobruchus*; the meloid: *Mylabris*; coccinellids: *Coccinella, Cheilomenus* and *Illeis*; staphylinids: 3 unidentified genera and Anthicid: one unidentified genus).

Members of the leaf feeding families and those of natural enemies started to appear in the crop field at all three locations from the 29 SMW and prevailed up to the harvest of crop (38 SMW); whereas, the flowers and pod feeding families started to infest the crop from 34 SMW up to crop harvest. Based on relative density the curculionids and chrysomelids were dominant in pulse crops. The location-wise and as per crop Shannon diversity indices ranged from1.72 to 1.54 and was the maximum for the fauna in greengram at the farmer's field of Vallabhnagar (1.72) and lowest for fauna in blackgram at farmer's field of Badgaon (1.54). The population of foliage feeding insects was negatively correlated with the major abiotic factors; whereas, the population of flower/ pod feeders and natural enemies of pestiferous insects evinced a significant positive correlation with major abiotic factors.

Morphological characterization of 3 species of *Myllocerus* (Curculionidae), 7 species of the six chrysomelid genera: *Aulacophora*, *Monolepta*, *Chaetocnema*, *Luperomorpha*, *Lema* and *Colasposoma* (Chrysomelidae), *Mylabris pustulata* Thunberg (Meloidae) and 3 coccinellids: *Coccinella septumpunctata* Linnaeus, *Cheilomenes sexmaculatus* (Fabricius) and *Illeis cincta* (Fabricius) (Coccinellidae) was done and has been described with suitable photographs and line diagrams to depict the taxonomic characters.

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1. INTRODUCTION

Food legumes have been grown by farmers since millennia providing nutritionally balanced food to the people of India (Nene, 2006) and many other countries in the world. Pulses are the major source of protein in the vegetarian diet in our country; besides being a rich source of protein, they maintain soil fertility through biological nitrogen fixation in soil and thus play a vital role in furthering sustainable agriculture (Kannaiyan, 1999). Though pulses are consumed all over the world, their consumption is higher in those parts of the world where animal proteins are scarce and expensive (Ofuya and Akhidue, 2005). The major pulse crops that have been domesticated and are under cultivation include blackgram, chickpea, cowpea, greengram, pigeonpea, lentil, moth bean, and pea. The area covered under pulses in our country in 15.35 per cent of the total cropped area. The states of Rajasthan, M.P, Haryana, Orissa, Maharashtra and Uttar Pradesh together accounts for 83.77 per cent of total area under pulses. Pulses production in India in kharif 2014-15 was 18.40 million tons; however, in order to ensure self sufficiency, the requirement in the country is projected at 50 million tonnes by the year 2050 which necessitates an annual growth rate of 4.2 percent (lCAR Vision, 2050).

About 200 insect pests that belong to 48 families of Coleoptera, Diptera, Hemiptera, Hymenoptera, lsoptera, Lepidoptera, Orthoptera, Thysanoptera, and 7 species of mites of order *Acarina* are known to infest greengram and blackgram. Under severe infestation stem fly may alone cause more than 90 per cent damage to these crops with a yield loss of 20 per cent. Among the coleopteran fauna causing significant damage to the foliage of *kharif* pulses, members of the insect families Chrysomelidae, Curculionidae and Meloidae, better known as leaf beetles, weevils, and blister beetles respectively, are common. The *galerucid* beetle, *Madurasia obscurella* Jacoby may cause damage to the tune of 20-60 per cent. In India the girdle beetle, *Oberiopsis brevis* (Swedenbord), a major pest of soybean, sometimes infests greengram locally (Talekar, 1990).

The foliage feeding insect fauna of Lepidoptera and Hemiptera have been well

documented in literature. With regard to the insect fauna of order Coleoptera, some predatory coleopteran fauna are well known; but, many pestiferous insect fauna of Coleoptera happen to be incompletely documented for *kharif* pulses in Rajasthan. Keeping these facts in view, the present investigation on the species-rich insect order Coleoptera associated with *kharif* pulse crops has been planned out entitled, "**Diversity of coleopteran fauna in *kharif* pulses**" with the objectives: (i) to study the species diversity of coleopteran fauna in *kharif* pulse crops; (ii) to ascertain the influence of environmental factors on the dominant coleopteran fauna; (iii) to develop a field diagnostic key for identifying key coleopteran pest and beneficial fauna on *kharif* pulses based on their morphological characterization.

2. REVIEW OF LITERATURE

The available literature on the present investigation "Diversity of coleopteran fauna in k*harif* pulses" have been reviewed and presented under following sub heads:

2.1 Species diversity of coleopteran fauna in *kharif* pulse crops

The *kharif* season pulse crops (greengram, blackgram and cowpea) infested by the foliage feeding coleopterans include: the weevils, *Cyrtozemia dispar* Pascoe, *Myllocerus undecimpustulatus maculosus* Desbr., *Myllocerus discolor* Boheman, *Myllocerus viridanus* Boheman, *Episomus lacerata* Fab.; hada beetle, *Henosepilachna* spp., the leaf beetles, *Monolepta signata* Olivier, *Luperomorpha nigripennis* Duvivier, *Colasposoma* sp. and the flea beetle, *Chaetocnema* sp. The blister beetles, *Mylabris phalerata* (Pallas), *M. pustulata* Thunberg and *Lydomorphus ornata* (Cast) cause serious damage to the flowers, especially to the second and third flush during August-September months in most *kharif* pulse crops cultivated in India. The pod and seed feeding insects that cause damage in field as well as storage are the pulse beetle complex: *Callosobruchus chinensis* Linn; *Callosobruchus maculatus* Fab. and *Callosobruchus analis* Fab. that are of common occurrence in India. The predatory coccinellid species include *Coccinella septempunctata* Fabricius, *Menochilus sexmaculatus* (Fabricius), *Illeis cincta* (Fabricius) and *Brumoides suturalis* Mulsant. Some of the common rove beetles *Paederus fuscipes* Curtis, *Dinaraea angustula* (Gyllenhal),and *Philonthus cognathus* (Stephens) have been reported to be associated with pulse crops.

2.2 Foliage feeding coleopteran fauna of pulse crops.

Lefroy (1909) described the general characteristics of suborder Rhynchophora, *viz.*, habit, distribution, host plants and brief morphology of some of the economically important Indian species, which comprise *Tanymecus indicus* Faust that are found abundantly in soil feeding young plants, *T. circumdatus* found on common plants of *kharif* and *rabi* season, *Alcidodes fabricii* (F.) infesting leaves of beans. Various injurious Indian weevils were described by Marshall (1915) who reported that *Pachytychius mungonis* Marshall laid eggs in a hole prepared in seed of greengram (*Phaseolus mungo)* or cowpea, where they caused considerable damage. Of the 342 species of weevils recorded by Marshall (1916), 15 genera and 179 species were reported to be as new. The damage caused to the cultivated plants by

different species was briefly referred to: *Tanymecus indicus* Faust, the adults of which nibble off the young germinating plants of wheat, peas and gram; *Episomus lacerta* F. found on the field beans and on bark of cotton plants; *Myllocerus dorsatus* (F.) feeding on the leaves of sword bean (*Canavalia)*. Ramakrishna Ayyar (1922) recorded 190 species of weevils with their host plants from South India; amongst these weevils approximately over 40 species were of economic importance; *Apion amplum* (Faust) found on greengram (*Phaseolus* spp.) and *Anacardium occidentale* Butani (1980) recorded *Alcidodes collaris* (Pascoe) as a major pest of pigeonpea, country bean, blackgram and greengram. *A. fabricii* (F.) and *A. leopardus* (Olivier) were recorded from blackgram and greengram, and *A. pictus* from country bean.

Verma and Henry (1988) studied the incidence of insect pests on 24 varieties of mungbean (*Vigna radiata*) in Rajasthan during July-September 1985. On an average, 10.8 and 16.8 individuals of the curculionids, *Myllocerus maculosus* Desbr. (*M. undecimpustulatus*) and *Cytrozemia cognata* Marshall were recorded per 10 plants, respectively. The incidence of *M. u. maculosus* was highest on the cultivars ML 26/10-3, ML131 and P101, while that of *C. cognata* did not differ significantly among cultivars. Eight species of insects which cause considerable damage to red kidney beans were noticed by Abrol *et al.* (2006). *Alcidodes signatus* (Boheman), a bean gall weevil and *Cyaneolytta coerculea* (Pfaff), a blister beetle were recorded for the first time as serious pests from Jammu. Ramamurthy (2007) reviewed the faunistic, ecological, biogeographical and phylogenetic aspects of Curculionidae acting as gall inducers and associates in plants from Oriental and eastern Palearctic. The key species like cotton stem weevil *Pempherulus affinis* (F.), amaranthus stem weevil, *Hypolixus truncatulus* (F.), bean gall weevil, *Alcidodes signatus* (Boheman), and sesbania stem weevil, *Alcidodes bubo* (F.) and their role as gall inducers was elucidated. Shanas and Ramamurthy (2009) carried out studies on the genus *Episomus* from India and nearby countries. This study provided an annotated checklist of 106 species known from the world, and a key to the 20 known species. Azam *et al.* (2009) recorded the bionomics of *Alcidodes signatus* (Boheman) as a pest of red kidney bean *Phaseolus vulgaris* L. Eliakira *et al.* (2014) reported that the population of bean leaf beetle [*Cerotoma trifurcata* (Forster)] significantly damaged leaves of cowpea more in intercrop than in sole cowpea, results showed that intercropping increased severity of the damage caused by *C. trifurcata* to the cowpea with rating scales of 8 in sole cowpea and 9 in cowpea-

maize intercrop.

2.3 Flower and seed feeding coleopteran fauna of pulse crops.

Beetles of the family Bruchidae are important pests of stored pulses throughout the world. In India C. *maculatus* and *C. chinensis* are the most serious pests of pulses (Lefroy, 1909). Seeds of pulses are heavily damaged by pulse beetles (bruchids) in storage. Pingale (1953) has recorded that green gram when holed by bruchid beetles failed to germinate. The pulse beetles attack the pods of pulses in the field from where they are carried to godown. They completely destroy the endosperm of seed leaving only seed coat, thus the seed loses their viability *Callosobruchus chinensis* Linn; *Callosobruchus maculatus* Fab and *Callosobruchus analis* Fab are the more common species of pulses beetle found in India (Raina, 1970). Arora (1977) worked out the taxonomy of Bruchidae (Coleoptera) of Northwest India. Singh and Van emden (1979) investigated the insect pests of grains and indicated C. *maculatus* as a primary pest of cowpea and other legumes worldwide, both in fields and stored seeds. Leelavathy (1982) did an extensive *study* on *C. analis. Callosobruchus maculatus* infests seeds of wild and cultivated legumes especially *Vigna radiata* (Mitchell, 1983). *Callosobruchus maculatus* has been reported as one of the major pests of stored cowpea in the tropics (Raja *et al.,* 2001). This pest multiplies rapidly under warm humid conditions and causes serious damage within a short time. Zaghloul and Mourad (1997) studied the effect of some environmental factors on *C. chinensis* infesting mungbean in Egypt, according to their report, egg parasitism, egg disappearance and infertility were the limiting factors for the development of *C. chinensis*. Several bruchid species attack cereals and pulses in store and cause a loss of 10-15 percent with a germination loss ranging from 50 - 92 percent (Adugna Haile, 2006).

“Blister beetles”, or "Oil beetles", are classified in the family Meloidae. The family, with about 120 genera and 3000 species, represents a monophyletic, cosmopolitan family of phytophagous beetles. Patnaik *et al.* (1993) studied the seasonal incidence of *Mylabris pustulata* Thunberg in northern and southern Orissa. Beetle activity begun in both regions with the initiation of flowering of pigeon pea in September and continued until the end of December. In northern Orissa, beetle incidence reached the peak during the first half of October and in southern Orissa, peak incidence was observed during the 2nd and 3rd week of October. Balikai (2000) observed severe infestation of *M. pustulata* on pigeonpea, *Digitaria singuinalis* and *Stylosanthes hamata* during August to December. Singh *et al*. (2012) observed that in case of the blister beetle both maximum and minimum temperatures had positive correlation with the population build up in cowpea.

Vikrant *et al.* (2013) studied the population dynamics of insect pests of blackgram when cultivated sole and when niger was intercropped as a barrier crop against blister beetles. The maximum mean population of blister beetle was 2.75 per plant in the sole crop of blackgram and 2.50 per plant in blackgram with niger. Pawar *et al*. (2014) recorded temporal and intraday abundance variations of blister beetle (*Mylabris phalerata*) on greengram under regular and late sown condition. The abundance of blister beetle and crop phenology revealed population from bud initiation stage with a peak during flowering and early pod formation stage, clearly indicating its preference for the buds and flowers. Higher abundance of blister beetle adults during pod formation stage was attributed to second flush of greengram. The beetle population decreased when the crop reaches physiological maturity.

Sharanabasappa and Basavana Goud (2004) conducted survey for the incidence of *Apion amplum* on greengram and recorded that the per cent pod and seed damage in different talukas varied from 18.50 (Ron) to 48.30 (Bailhongal) and 26.30 (Ron) to 61.50 (Bailhongal), respectively. In Kundagol and Dharwad, the per cent pod and seed damage recorded was 39.80 and 44.60, 47.60 and 53.50, respectively. Patil and Nithya Chandran (2012) recorded the pestilence activity of the seed weevil, *Apion amplum* (Faust) (Apionidae: Coleoptera), which gained a major pest status on greengram and blackgram and was maximum when the crop was sown in first fortnight of July (4.57 and 4.70 weevils/plant) as compared to that when sown in second fortnight of July.

2.4 Beneficial coleopteran fauna in pulse crop ecosystem

The family Coccinellidae comprises 5200 described species worldwide (Hawkeswood, 1987). Later, Iperti and Paoletti (1999) reported that of the coccinellids reported globally, about 90 percent are known to be predaceous on different insect/acarine pests. Flemming (2000) reported 4000 predatory species of coccinellids including more than 300 species from Indo-Pak subcontinent. Thirty six true aphidophagous coccinellids with 16 incidental or doubtful species and 16 unidentified species of predaceous coccinellids have earlier been reported from India by Agarwala and Ghosh (1988). Omkar and Pervez (2000) reviewed the distribution records and prey range of 119 coccinellid predators belonging to 13 tribes from India. The authors also mention about some ladybeetles like *Scymnus, Nephus, Cryptogonous. Micraspis, Coleophora, Oenopia* etc. Poorani (2002) published a checklist of the Coccinellidae of Indian sub-region in which she described 79 genera and 400 species of ladybeetles along with their distribution in the subcontinent.

Irshad (2001) published a review summarizing the distribution, host range, ecology and biotic potential of 71 species of predaceous coccinellids from Pakistan. Inayatullah *et al.* (2005) conducted an extensive survey of different district Poonch of Azad Kashmir, Pakistan, which revealed 16 species of coccinellids in genera belonging to four subfamilies; Coccinellinae, Chilocorinae, Scymninae and Epilachninae from the area. The subfamily Coccinellinae was represented by 13 species; whereas as the subfamilies Chilocorinae, Scymninae and Epilachninae were represented by single species each. Khan Imamullah *et al.* (2006) carried out an extensive survey of predatory coccinellid beetles in district Chitral, Pakistan during 2001. Twelve different species belonging to 9 genera of 3 tribes and 3 subfamilies occurred in the area. Eight species namely, *Coccinella septempunctata* Linnaeus*, Hippodamia variegate* (Goeze)*, Calvia punctate* (Mulsant)*, Adalia tetraspilota* (Hope)*, Adalia bipunctata* L. *Aiolocaria hexaspilota* (Hope), *Macroilleis hauseri* Mader and *Oenopia conglobata* L. belonging to Coccinellinae; three species i.e., *Chilocorus rubidus* (Hope), *Chilocorus circumdatus* (Gyllenhal)and *Priscibrumus uropygialis* (Mulsant) belonging to Chilocorinae and one species i.e., *Halyzia tschitscherini* Semenow of Psyloborini were collected during the survey. Rekha *et al.* (2009) studied the diversity of predatory coccinellids in agro ecosystems comprising cereals, pulses and vegetables, besides a comparative study in weeded and partially weeded irrigated rice and cowpea ecosystems in Madurai District of Tamil Nadu. A total of 9 species of predatory coccinellids were recorded. Most abundant species found were *Coccinella transversalis* Fabricius, *Menochilus sexmaculatus* Fabricius and *Brumoides suturalis* Mulsant. Rank abundance values revealed that C. *transversalis, Micraspis discolor* F. and *B. suturalis* were the dominant taxa in weeded and partially weeded rice ecosystem. *M. sexmaculatus, C. transversalis* and *B. suturalis* were the dominant taxa in weeded and partially weeded cowpea ecosystem.

Pushpendra *et al.* (2010) conducted an extensive survey of predatory and mycophagous coccinellid beetles (Coleoptera: Coccinellidae) in Dehradun District, India, over a period of two years (July 2005 to June 2007). A total of 4382 specimens of coccinellids were collected at four different sites representing four different ecosystems having altitudes from 310m to 640m within the Dehradun. Twenty five species were identified and 14 species were recorded for the first time from district Dehradun. Elmira *et al.* (2011) studied the biodiversity and distribution of lady bird beetles from seven region of Iran. *Hippodamia variegata* (Goeze) 63.68 percent (n=998) and *Coccinella septempunctata* Linnaeus 31.07 percent (n=487) were recorded as more abundant species and were widely distributed on all the regions. The maximum and minimum diversity species were obtained in Solan (Simpson's diversity index = 0.58) and Salehabad (Simpson's diversity index = 0.36) regions

respectively. Rahamat ullah *et al.* (2012) conducted survey in District Dir Lower, over a period of two years. Specimens of coccinellid beetles were collected from four major localities *viz*; Maidan, Jandool, Timergara and Adenzai. Identification of these beetles showed that 14 different species in 12 genera belonging to sub-families Coccinellinae, Chilocorinae, Scymninae and Epilachninae were present in the selected area. Alia Hayat and Muhammad Rafique Khan (2013) studied the biodiversity (diversity, abundance, richness and evenness) and species composition of Ladybird Beetles from Mirpur Division of Azad Jammu and Kashmir, Pakistan. A total of fifty one species from 6 subfamilies were recorded from the study area. Diversity was calculated by using Shannon-Wiener's diversity index and Simpson's index. Richness was calculated by Margalef's and Menhinick's Indices and evenness was calculated by Shannon-Wiener's Equitability Index, Pielou's index and Nakamuras's R-I index. The calculated values of diversity indices showed that highest diversity was recorded from district Bhimber and lowest from district Kotli.

3. MATERIALS AND METHODS

The materials used and methodology adopted during the present investigation on, "*Diversity of coleopteran fauna in kharif pulses"* that was conducted at the Instructional farm of Rajasthan College of Agriculture, Udaipur, two farmer's fields: (one at village Badgaon and the other at Vallabhnagar) and Department of Entomology RCA during the crop season '*kharif* 2015', have been presented in this chapter under suitable sub-headings:

3.1 Surveillance and collection of coleopteran fauna in *kharif* pulses

The cultivated pulse crops (greengram, blackgram and cowpea) at the Instructional Farm of Rajasthan College of Agriculture, MPUAT, Udaipur and the two farmer's field one at village Badgaon and the other at Vallabhnagar, were observed for pestiferous and beneficial coleopteran (beetles and weevils) fauna during July to December, 2015. The collection was made from three different spots of the crop area selecting 10 plants at random, from each of the cultivated pulse crop at weekly intervals. In all 30 plants were sampled at one time in each crop.

Standard sampling procedures for the different insect pests and natural enemies were followed making use of insect sweep net, aspirator, and hand picking as per requirement. The abiotic factors of the environment during the period of study were recorded from the meteorological station at the Instructional Farm for analyzing the impact of these factors on the population of the major pestiferous and beneficial coleopteran fauna.

3.2 Study of population dynamics of coleopteran fauna

a) The foliage and flower feeding coleopteran fauna including adult leaf beetles, chafer beetles and weevils and blister beetles were observed and collected during early hours (7 am to 9 am) of the day on the 10 selected plants and expressed as mean numbers per plant.

b) Blister beetles were observed from 10 plants at random, maintaining an observation period of 2 minutes per plant between 10 am to 12 noon soon after initiation of flowering (mid-August). The data were expressed as mean numbers of blister beetles per plant.

c) The natural enemies of pestiferous insects belonging to order Coleoptera, the coccinellids and staphylinids were observed visually and counted. The collection was made by sudden

trapping from the same 10 plants per replication randomly tagged, during early hours of the day as mentioned earlier.

d) Estimation of the relative population density of the pestiferous coleopteran fauna in the different pulse crops was made and expressed as a percentage. Shannon-Weiner and Simpson Diversity Indices were also computed.

The statistical analyses made towards estimating the species richness and diversity indices included estimation of mean density, relative density, Simpson's and Shannon Diversity Index. The population of coleopteran insect fauna associated with *kharif* pulses was correlated with the abiotic factors of the environment. For correlation studies, weekly average values of the environmental factors and the population data were taken into consideration. To work out the correlation coefficients (r) the following standard statistical formula given by Karl Pearson (1973) was adopted:

$$r = \frac{\Sigma xy - \frac{\Sigma x . \Sigma y}{N}}{\sqrt{\left\{\Sigma x^2 - \frac{(\Sigma x)^2}{N}\right\}\left\{\Sigma y^2 - \frac{(\Sigma y)^2}{N}\right\}}}$$

Where,

r = Co-efficient of correlation
N =Number of observations
x = Mean population
y = Independent variable

The correlation co-efficient (r) values were tested for significance as follows:

$$t = \frac{r}{\sqrt{1 - r^2}}\sqrt{n - 2} \quad with\ (n - 2)d.f$$

Mean density:

Mean density ——

Where,

Xi = Number of insects or natural enemies in i^{th} sample

N = Total Number of plants sampled.

Relative density (RD %) = $\left[\frac{\text{Number of individual of one species}}{\text{Total number of individual of all species}} \times 100\right]$

Diversity Indices:

Simpson's index:

$$D = \frac{1}{\sum_{i=1}^{s} P_i^2}$$

Where:

- *S* is the total number of species in a community (i.e., Species richness)
- p_i is the relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community: n_i/N
- n_i is the number of individuals in each species; the abundance of each species
- *N* is the total number of all individuals

Shannon index:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

Where

- *S* is the number of species. Also called species richness
- p_i is the relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community: n_i/N
- n_i is the number of individuals in each species; the abundance of each species
- *N* is the total number of all individuals

3.3 Faunal sorting and morphological characterization

The field collected coleopteran insect fauna were killed with ethyl acetate in a jar, processed and preserved, both dry as well as in wet preservation media (70% alcohol) they, were sorted out into respective families with the help standard taxonomic references. The major insect fauna of Coleoptera were classified up to generic and species levels, characterized morphologically and identified. Photographs of specific taxonomic characters were taken under the sterozoom binoculars (Carl Zeiss Stemi 2000 C) and necessary line diagrams for key taxonomic characters were drawn with the help of drawing tube attached to the binoculars (Nikon SMZ 1500). Linear measurements of smaller body parts for taxonomic purposes were taken with the software Axio-Vision Rel. 4.8 and the larger parts on a cm-graph paper. The weevils and blister beetles were dissected out by following the technique described by Smith (1979) for studying genitalia. Each perfectly dried and preserved specimen was used for the study. The specimen was kept in a moist chamber for two days to relax. This greatly reduces the chances of damage to the specimen while handling and enhance the maneuverability of the specimen. The relaxed specimen was gently supported on rubber block on its back and a fine needle was inserted between the metacoxa and first visible abdominal segment. Severing the connecting membrane and the abdomen was gently separated. The abdomen was then transferred to a test tube containing a few milliliters of 10 percent caustic potash and boiled for two to five minutes for clear digestion. The digested abdomen was transferred to cavity block containing water and washed repeatedly, before the final washing it was lift in the dilute acetic acid for a minute to remove traces of caustic potash. Abdomen thus cleared was dipped in glycerin in a cavity block to remove water before placing it in a drop of glycerin on a glass slide for dissection. In the case of male aedeagus and associated structures were pulled out through a slit made on the lateral side of the abdomen. From weevils spicules and tegmen were gently detached from aedeagus and from blister beetle aedeagus spicule and tegmen were separated to facilitate detailed observation, while dissecting female of weevils, first the abdomen was opened by making a slit on the lateral and the tergites were moved to one side. The spermatheca could be located inside the abdominal cavity and the spiculum gastrale were separated with extreme care. The abdomen after dissection glued on the point next to the specimen ventral side up. After studying the genitalia along with its associated structures were transferred in to a drop of glycerin inside an arthropod

micro vial using a minute dissecting needle. The vial was stoppered with a neoprene stopper, pinned through the stopper, and positioned below the data lables.

The leaf beetles were identified at the biosystematics laboratory of Department of Entomology, Rajasthan College of Agriculture, Udaipur, using the key provided in Insecta: Coleoptera: Chrysomelidae 2000 by (C.R. Basu) ZSI, Calcutta; the identifications were consulted by Dr. K. D. Pratapan, Insect Taxonomist (Chrysomelidae) at Department of Entomology, Kerala Agriculture University, velyani, Trivandrum.

The weevils were identified using the key provided in Coleoptera (R. G. Booth, M. L. Cox and R.B. Madge) up to sub species level; later, the identification were confirmed and validated at NPC, IARI in consultation with Insect Taxonomists (Curculionidae) at Division of Entomology, Indian Agricultural Research Institute, New Delhi.

The morphologically characterized and identified specimens have been presented in plates and the key taxonomic characters have been represented through the line diagrams in figures

4. RESULTS

The results obtained under different objectives of the investigations on "*Diversity of coleopteran fauna in kharif pulses"* carried out during the crop season '*kharif* 2015', have been presented in this chapter under suitable sub-headings:

4.1 Species diversity of coleopteran fauna in k*harif* pulses

4.1.1 Diversity of foliage feeding/ defoliator coleopteran fauna

The comparative diversity of coleopteran fauna in pulses sampled from three different locations *viz*; college instructional farm, farmer's field Badgaon and farmer's field Vallabhnagar based on the estimated diversity indices has been presented in the Table (1). The Shannon's diversity index values were recorded maximum at Vallabhnagar in all three crops i.e., blackgram, greengram and cowpea compared to the other two locations, ranging from 1.66 to 1.72 with the highest 1.72 recorded in greengram followed by that in cowpea (1.71) and blackgram (1.66). At the college instructional farm the diversity recorded was maximum in cowpea (1.62) followed by that in blackgram (1.59) and greengram (1.56). The diversity index at the farmer's field of Badgaon village was recorded maximum in greengram (1.64) followed by cowpea (1.60) and blackgram (1.54). The diversity index was lowest at the farmer's field of Badgaon village in blackgram (1.54). The Simpson's diversity index values ranged highest from 5.16 in cowpea to 4.77 in blackgram at Vallabhnagar farmer's field. At farmer's field Badgaon the Simpson's diversity value ranged from 4.47 in greengram to 4.04 in cowpea. At college instructional farm the Simpson's values ranged from 4.77 in blackgram to 4.01 in greengram.

4.1.2 Family wise abundance of coleopteran fauna in *kharif* pulses

(A). Blackgram

It is evident from Table (2) that the relative density of chrysomelids in blackgram was maximum at the college instructional farm (38.56%), followed by curculionids (33.99%) and coccinellids (18.30%). At the farmer's field in village Badgaon the relative density of coleopteran fauna was recorded highest for curculionids (34.25%), followed by that for

chrysomelids (31.05%). At the farmer's field in village Vallabhnagar in blackgram the highest relative density was recorded for curculionids (33.0%) followed by that for chrysomelids (31.65%) and meloids (10.77%). The members of the family Chrysomelidae and Curculionidae started to infest the crop from 29th SMW in blackgram at all three locations and prevailed until the harvest of the crop. The members of family Bruchidae, Scarabaeidae and Meloidae appeared from 34th SMW or later and prevailed up to the harvest of the crop at all three locations; whereas, the members of the family Coccinellidae prevailed throughout the crop season at all the three locations.

(B). Greengram

In greengram the maximum relative density was recorded at the college instructional farm for chrysomelids (47.88%), followed by that for curculionids (27.27%) and coccinellids (13.94%). At the farmer's field in village Badgaon highest relative density was recorded for chrysomelids (36.36%) followed by that for curculionids (17.65%) and coccinellids (16.58%). At the farmer's field in village Vallabhnagar highest relative density was recorded for curculionids (29.80%) followed by that for chrysomelids (25.10%) and coccinellids (16.08). The members of family Chrysomelidae and Curculionidae began to infest the crop from 29th SMW and prevailed up to harvest of the crop at all three locations. The bruchids, scarabaeids and meloids were observed from 33rd SMW or later and prevailed up to harvest of crop at all three locations; whereas, the coccinellids prevailed throughout the crop season at all three locations.

(C). Cowpea

On cowpea the maximum relative density of coleopteran fauna was recorded at farmer's field in village Badgaon for chrysomelids (45.51%) followed by that for curculionids (12.57%) and coccinellids (11.98%). At the college instructional farm the highest relative density was recorded for chrysomelids (35.06) followed by that for curculionids (34.42) and coccinellids (18.83%). At the farmer's field in village Vallabhnagar the highest relative density was recorded for chrysomelids (34.53%) followed by that for curculionids (25.11%) and meloids (10.76%). Members of the

family Chrysomelidae at the college instructional farm appeared from 31st SMW and prevailed throughout the crop season; whereas, the members of family Curculionidae appeared from 29th SMW. The curculionid and chrysomelid fauna at farmer's field at village Badgaon and Vallabhnagar were found throughout the crop season. The members of Bruchidae, Scarabaeidae and Meloidae appeared after 33rd SMW or later at all three locations; whereas, the members of Coccinellidae at the college instructional farm and farmer's field in village Badgaon were observed throughout the crop season starting from 29th SMW up to 38th SMW; however, at farmer's field in village Vallabhnagar the coccinellid population appeared from 29th SMW and prevailed up to the 36th SMW.

4.2 Influence of abiotic factors of environment on population of coleopteran fauna

4.2.1 Influence on foliage feeding coleopteran fauna

The mean population of curculionids at the college instructional farm (Table: 3) on blackgram crop registered a significant negative correlation with relative humidity (r_2= -0.45); whereas, the population of chrysomelids registered a significant negative correlation with the mean atmospheric temperature and relative humidity (r_1= -0.44, r_2= -0.29 respectively). On greengram the mean population of curculionids evinced a significant negative correlation with relative humidity (r_2= -0.28); whereas, the mean population of chrysomelids had a significant negative correlation with mean atmospheric temperature (r_1= -0.54) and relative humidity (r_2= -0.34). On cowpea crop the mean population of chrysomelids shows significant negative correlation with relative humidity (r_2= -0.49).

At the farmer's field of Badgaon village (Table: 4) on blackgram the mean population of curculionids and chrysomelids did not show any significant correlation with mean atmospheric temperature and relative humidity. On greengram crop the mean population of curculionids had significant negative correlation with relative humidity (r_2= -0.50). The population of chrysomelids also had a significant negative correlation with both the mean atmospheric temperature (r_1= -0.34) and relative humidity (r_2= -0.57). On cowpea crop the population of curculionids did not evince any significant correlation with mean atmospheric

temperature and relative humidity. The population of chrysomelids had a significant negative correlation with mean atmospheric temperature (r_1= - 0.40) and relative humidity (r_2= -0.30).

4.2.2 Influence on population of coleopteran fauna infesting floral parts

At the college instructional farm (Table: 6) on blackgram the population of bruchids had a significant positive correlation with relative humidity (r_2= 0.96). The scarabaeid population also had a significant positive correlation with mean atmospheric temperature (r_1= 0.97). The meloid population had a significant positive correlation with relative humidity (r_2= 0.96). on greengram crop the population of bruchids had a significant positive correlation with mean atmospheric temperature (r_1= 0.92) and significant negative correlation with relative humidity (r_2= -0.74). The scarabaeid population had a significant positive correlation with relative humidity (r_2= 0.67). The meloid population also evinced a significant positive correlation with relative humidity (r_2= 0.82). On cowpea crop the scarabaeid population displayed a significant positive correlation with mean atmospheric temperature (r_1= 0.73).

At the farmer's field of Badgaon village (Table: 7) on blackgram crop the Bruchid population had a significant positive correlation with mean atmospheric temperature (r_1= 0.92) but a significant negative correlation with relative humidity (r_2= -0.73). The scarabaeid population had a significant positive correlation with relative humidity (r_2= 0.88) and likewise the meloid population also exhibited a significant positive correlation with relative humidity (r_2= 0.55). on greengram the population of bruchids had a significant positive correlation with mean atmospheric temperature (r_1= 0.73). while, the scarabaeid population depicted a significant negative correlation with relative humidity (r_2= -0.88). The meloid population had a significant positive correlation with relative humidity (r_2= 0.47). In cowpea crop the population of bruchids did not have any significant correlation with mean atmospheric temperature and relative humidity. The scarabaeid population had a significant negative correlation with mean atmospheric temperature (r_1= -0.63); whereas, the

population of meloid registered a significant positive correlation with mean atmospheric temperature (r_1= 0.52).

4.2.3 **Influence on population of natural enemies of pestiferous insects**

The natural enemies observed on all the three pulse crops at all the three locations included the predatory lady bird beetles belonging to family Coccinellidae. At the college instructional farm (Table: 9) on blackgram crop the coccinellid population had a significant positive correlation with mean atmospheric temperature (r_1= 0.71) and relative humidity (r_2= 0.47). In greengram the coccinellid did not show any significant correlation with mean atmospheric temperature and relative humidity; whereas, on cowpea the coccinellid population had a significant positive correlation with mean atmospheric temperature (r_1= 0.60) and similarly with relative humidity (r_2= 0.55). The coccinellid on blackgram and cowpea showed significant positive correlation with both mean atmospheric temperature and relative humidity at the college instructional farm.

At the farmer's field of Badgaon village (Table: 10) the population of coccinellid on blackgram crop had a significant positive correlation with mean atmospheric temperature (r_1= 0.36) and relative humidity (r_2= 0.33). On greengram the coccinellid population evinced a significant negative correlation with relative humidity (r_2= -0.44). In cowpea the coccinellid population did not show any significant correlation with mean atmospheric temperature and relative humidity.

4.3 Characterization and identification of collected specimens.

4.3.1 Diagnostic key and descriptive characters for family Curculionidae.

The taxonomic key used for identification up to sub family level of the curculionids, collected during this investigation has been presented below.

4.3.1.1 Diagnostic key for identification of weevil specimens up to sub-family level.

1. Mandibles with conspicuous scar on outer surface, rostrum usually short and thick, pro-tibiae without a stout apical process……..ADELOGNATHA 2

   Mandibles without a scar, rostrum usually long and slender, pro-tibiae sometimes with a stout apical process……..PHANEROGNATHA 3

2. Antennal scrobes narrow, elongate, lateral, sharply defined, not visible from above, curved so that the scape usually rests below eye when retracted next to head……BRACHYDERINAE

   Antennal scrobes wider and indistinctly defined posteriorly, visible from above, scape usually passing over middle of eye when retracted next to the head……..OTIORHYNCHINAE

3. Tarsi with third segment bilobed……...4

   Tarsi with third segment entire or slightly emarginate……..9

4. Rostrum free, not received into deep, median, sternal channel. Procoxae usually contiguous, their cavities usually confluent…..... 5

   Rostrum received into deep, median, sternal channel in repose. Procoxae usually widely separated……..... CRYPTORHYNCHINAE

5. Metasternum shorter than first abdominal sternite along midline. Pronotum with postocular lobes……..... RHYPAROSOMINAE

   Metasternum about as long as, or longer than first abdominal sternite along the midline. Pronotum with or without postocular lobes 6

6. Antennal funicle usually with second segment longer than the first……7

   Antennal funicle usually with first segment longer than the second……8

7. Rostrum short and stout or flattened, rather quadrate in cross-section…….GONIPTE RINAE

   Rostrum more elongate, usually cylindrical, round in cross-section……...……CLEO NINAE

8. Procoxae contiguous, their cavities confluent. Rostrum with antennal scrobe lateral, straight, longitudinal, parallel to upper and lower rostral surfaces, ending anterior to eye. Eyes usually convex. Pronotum without postocular lobes……..... ANTHONOMINAE

   Procoxae separated by moderately broad, prosternal process, their cavities not confluent. Rostrum with antennal scrobe lateral, oblique. terminating in front of eye on ventral surface of rostrum. Eyes usually weakly convex, almost flat. Pronotum usually with postocular lobes..... HYLOBIINAE

9. Antennal scape not extending behind posterior margin of eye, usually fitting into scrobe. Two basal abdominal sternites separated by a well-defined suture, length of metasternum equal to or less than their combined length. Pygidium not exposed ……... ERIRHININAE

   Antennal scape extending behind posterior margin of eye for some distance, not fitting into the short antennal scrobe. Two basal

abdominal stetnites fused, the suture between them indistinct or absent medially. metasternum longer than their combined length. Pygidium exposed…….. RHYNCHOPHORINAE

4.3.1.2 Description of identified species of family Curculionidae.

Sub-family: Otiorhynchinae

Genus: *Myllocerus* Schoenherr, 1826: Body colour piceous, the legs being a shade lighter. Grayish-white scales over the body. The antennae and thorax piceous black in colour. Head transverse with dorsally visible scrobes. Antennae measuring about 3.3 mm., in length and possessing dark clubs. Funicle seven jointed with two basal segments longer than the rest. Elytra sub-oblong in shape and measuring about 4.2 mm in length, much broader than the prothorax at shoulders and measuring about 1.5 mm. in width at the base. Outer margins of elytra sub-parallel and ten distinct striae present on each elytra. Hind legs femora may be unidentate, bidentate or tridentate. The three pairs of legs measuring 4.0 mm., 2.1 mm. and 4.4 mm. in length respectively. Male genitalia consist of the aedeagus, tegmen and the spiculum gastrale. The female genitalia consist of spermatheca and spicules. (Figure- I and II)

1. *Myllocerus undecimpustulatus* Marshall, 1916: (Plate-I)

Male genitalia: Aedeagus with penis having a broad apex, length: breadth ratio 3:1, apical process conical, not protruding; internal sac elongate, basal and apical pieces cylindrical, middle conical, middle and apical pieces well chitinised with papillae and tubercles, basal piece less chitinised, flagellum distinct, internal sac valves reniform; apophyses one and a half times as long as penis, apices rounded (Fig. I-6); tegmen with dorsal piece slender, parameres absent, menubrium with apex rounded (Fig. I-7); Spiculum gastrale less than twice as thick as apophyses, base constricted, apex slightly curved with a leaf like chitinous piece, basal prongs sub-equal, apices rounded (Fig. I-8).

Female genitalia: Spermatheca with proximal arm longer and stouter than cornu; nodulus tubular, base closely appended to proximal arm; ramus very small; cornu with sides tapering, apex curved and pointed (Fig. I-9). Spicule with base slender, apex rounded (Fig. I-10).

2. *Myllocerus discolor* Marshall, 1916: (Plate-II)

Male genitalia: Aedeagus with penis broad at apex, length: breadth ratio 3:1, apical process distinct, not protruding; internal sac almost conical, apices broadly rounded (Fig. II- 6); tegmen with dorsal piece slender, parameres absent, menubrium with apex rounded (Fig. II-7), Spiculum gastrale stout, apex pointed, with a small, chitinous flap, basal prongs sub equal, apices bluntly rounded (Fig. II- 8).

Female genitalia: Spermatheca with proximal arm at least twice stouter than cornu, their junction constricted; nodulus constricted, almost conical, deflected; ramus small; cornu very minute with apex curved (Fig. II- 9), Spicule very slender, variously curved, apex spatulate (Fig. II- 10).

3. *Myllocerus dorsatus* (Fabricius) (Plate-III)

Male genitalia: Aedeagus with penis rounded and pointed at apex, length: breadth ratio 3:1, apical process absent; internal sac cylindrical, medial area intensely chitinised; apophyses twice longer than penis, slender (Fig. III-6). Tegmen with dorsal piece slender, parameres absent, menubrium slender, slightly longer than penis (Fig. III- 7), Speculum gastrale at least twice as thick as apophyses, apex deflected, narrowed and pointed, basal prongs unequal, apices rounded (Fig. III- 8).

Female genitalia: Spermatheca with proximal arm sub-equal to cornu but comparatively stouter than cornu, the junction between the two distinctly constricted; nodulus cuboidal, continuous with proximal arm; ramus triangular, rounded; cornu inwardly curved with the apex narrow and pointed (Fig. III- 9), Spicule elongate with its apex broad and bluntly rounded (Fig. III- 10).

4.3.2 Diagnostic key and descriptive characters of collected insects of family Chrysomelidae.

The taxonomic keys used for identification up to sub family level of the Chrysomelids, collected during this investigation have been presented below.

4.3.2.1 Diagnostic key for identification of specimen up to sub-family level.

1. Head with vertex projecting strongly forward and mouth directed posteriorly below, and often partly hidden by the prosternum ……....16

   Head with vertex not projecting and with mouth directed forward and downward…… ……...2

2 (1). Antennae closely inserted on front of head; elytra not very rigid..... 15

Antennae not very closely inserted, separated by frons or vertex; elytron generally rigid..... 3

3 (2). Prothorax not completely margined laterally; eyes prominent and head more or less constricted behind them..... 4

Prothorax completely margined laterally, eyes not very prominent and head not strongly constricted behind them 10

4 (3). Posterior femur generally not strongly dilated, often armed with teeth..... 5

Posterior femur largely and strongly dilated, rarely armed with teeth..... 6

5 (4) Antenna long, with some segments longer than broad..... Sagrinae

Antenna short, rarely reaching beyond humerus, apical segments generaly broader than long, more or less dentate..... **Megalopodinae**

6 (4). Antennal insertions separated by width of frons .....
7

Antennal insertions not separated by width of frons, relatively close.....**Donacinae**

7 (6). Tarsal claws generally bifid or toothed internally; prothorax usually toothed laterally.....8

Tarsal claws simple, not toothed; prothorax never toothed laterally..... **Criocerinae**

8 (7) Side of prothorax with a prominent swelling or with 2-3 distinct teeth.....
9

Side of pro thorax plain, evenly rounded, body rather flat and narrow.....
Orsodacninae

9 (8) Side of prothorax with a prominent swelling anterior to constricted base; body not very flat.....
Zeugophorinae

Side of ptothorax rounded with 2-3 sharp teeth; body rather flattened.....**Synetin ae**

10 (3) Middle three abdominal sternites constricted at middle; subcylindric.....l1

Middle three abdominal sternites not constricted; body more or less ovate or rounded, often strongly convex and constricted anteriorly 13

11 (10) Antenna relatively short and serrate 12

Antenna long and slender, not serrate..... **Cryptocephalinae**

12 (11). Prothoracic pleuron without antennal groove; body surface smooth..... .....**Clytrinae**

Prothoracic pleuron with groove for reception of antenna; body surface rough or tuberculate..... **Chlamisinae**

13 (10). Wing venation not reduced; cabitall veins present; clypeus not divided into two parts..... 14

Wing venetation greatly reduced; cubital veins lacking; clypeus divided into two parts..... **Chrysomelinae**

14 (13). Prothorax as broad as elytra at base; its side grooved for reception of hind leg..... **Lamprosomatlinae**

Prothorax generally narrower than elytra at base, its side not grooved for reception of antenna; abdomen not grooved for reception of hind leg.....**Eumolpinae**

15 (2). Posterior femora not greatly dilated..... **Galerucinae**

Posterior femora greatly dilated..... **Alticinae**

16 (1). Pronotum and elytron with broad marginal expansions, head often covered by the pronotum..... **Cassidinae**

Pronotum and elytron without broad marginal expansion, but often with spines, head never covered..... **Hispinae**

4.3.2.2 Description of identified species of family Chrysomelidae (Plate IV-VII).

A. Sub-family: Galerucinae (Plate:IV)

1. ***Aulacophora foveicollis* Lucas*:*** Antenna extending somewhat beyond the middle of elytron, third segment equal to fourth (Fig. IV-1); Scutellum

impunctate; pro-notum broader than long, surface finely punctate (Fig. IV-2); Elytra completely yellow-brown and shining with fine punctures (Fig. IV-3); tibia with small apical spine (Fig. IV- 4); claw bifid (Fig. IV-5); abdominal sternites black, last visible abdominal segment, which is modified for copulatory purposes (Figs.IV- 6,7); size: length, 6-7.5 mm. breadth. 3.5 mm.

2. ***Monolepta signata* Olivier:** Pronotum without a transverse depression (Fig. IV- 8); third segment of antenna short (Fig. IV- 9); tibia with small apical spine, first segment of the hind tarsus very long (Fig. IV- 10); the claws appendiculate (Fig. IV- 11). Anterior coxal cavity open behind. Head, pronotum, legs and abdominal sternites, reddish brown; antennae black, with three basal segments brown; breast black; elytron black with two yellowish spots, before and behind middle, these spots are completely united with one another, the black color being continuous. Last abdominal sternite divided into three sections (Fig. IV-12); body length 1.00-3.00 mm.

B. Sub-family: Alticinae (Plate:V)

1. ***Chaetocnema basalis*, Baly:** Body small (1.50 mm to 3.50 mm), ovate, narrowed in front and behind, generally dark, often green with bronzy reflections. Dorsal surface usually punctate. Antennae slender, shorter than the body, third onward the segments are nearly equal (Fig. V-1), Elytra broader than pro-thorax at base, attenuated towards the apex, convex, always punctate striate having eleven rows including scutellar and marginal row (Fig. V-2). Elytral epi-pleura with a marginal longitudinal row of punctures (Fig. V-3), prothorax broader than long, usually narrowed in front and punctate (Fig. V-4). Front coxal cavities closed behind.). Femur swollen, Legs with middle and hind tibiae excavated on its outer edge near apex (Fig. V-5).
2. ***Luperomorpha nigripennis* Duvivier:** Body oblong and shiny, antennae long and its segment 2 and 3 are always small (Fig. V-6). Elytra almost parallel-sided, usually with stronger punctures than those of pronotum, and apical part with a few scattered setae (Fig. V-7). Prothorax usually broader than head and almost quadrate, often finely granulate and punctate, pre-

basal impressions absent (Fig. V-8). Front coxal cavities open behind (Fig. V-9). Femur swollen (Fig. V-10), tibia with apical spine (Fig. V-11).

C. Sub-family: Criocerinae (Plate: VI)

1. ***Lema* sp.-I:** Head generally constrict posteriorly (Fig. VI-1); antennae filiform (Fig. VI-2); thorax with sulci (Fig. VI-3). Elytra punctate-striate (Fig. VI-4). Legs elongate, femora moderately thickened (Fig. VI-5), claws united at base as far as the middle (Fig. VI-6).
2. ***Lema* sp.-II:** The head, antennae, pronotum and scutellum are brown. The eyes are black. Prothorax broader than long (Fig. VI- 7); tibia with small apical spine (Fig. VI- 8); claw bifid (Fig. VI-9). The antenna with basal segment somewhat shining; third nearly equal to fourth; each of the four apical segments slightly shorter than each of the immediately preceding segments (Fig. VI- 10); the elytra are wholly brown they have an obsolescent spot on each elytron (Fig. VI-11). Elytra: the puncture fine and not very closely placed.

D. Sub-family: Eumolpinae (Plate: VII)

1. ***Colasposoma* sp. Castelnau, 1833:** Short, oblong and convex, metallic insect, rarely pubescent above. Head deeply inserted in thorax, flat (Fig. VII-1); antenna filiform, terminal joints more or less widened (Fig. VII-2). Thorax transverse, sides more or less rounded, not narrowed in front (Fig. VII-3). Elytrashining, slightly punctate-striate, (Fig. VII-4). Legs robust femora thickened; tibiae sulcate, dilated and curved at apex in the male, simple in the female (Fig. VII-5), Claw bifid (Fig. VII-6). Presternum nearly quadrate, frequently pubescent; anterior margin of thoracic episternum concave (Fig. VII-7).

4.3.3 Description of species of family Meloidae and Coccinellidae.

A. Family: Meloidae

***Mylabris pustulata* Thunberg:** Body elongate-oblong, blackish with coarse or thick and long black hairs; head large, broad, round posteriorly, fairly punctate

and hairy, eyes large, oval, slightly reiniform behind the antennae; antennae moderately elongate, 11 segmented, clavate apically, segment I slightly arched usually, segment II globular and smallest, other segments moderately variable in shape and length (Fig. VIII-1); labrum transverse (Fig. VIII-2); mandibles strongly developed, broad, narrowed towards apex (Fig. VIII-3); maxillary and labial palpi moderately elongate (Fig. VIII-4 and 5); (pronotum distinctly campanuliform, punctate and with long hairs; slightly concave dorsally with a small longitudinal impression; elytra fairly convex, subparallel, , reddish or orange red with blackish transverse bands and blackish or yellowish spots or patches (Fig. VIII-6); legs moderately elongate, tarsal segments cylindrical, tarsal formula 4-4-5 (Fig. VIII-7); abdomen moderately elongate; last visible sternite with a semicircular or triangular emergination at apex; male genitalia comprised of Aedeagus, spiculum and tegmen. Tegmen with basal piece wide thickly margined at base, parameres moderately wide medially (Fig. VIII-8). Spiculum long, slender and bifurcated at apex (Fig. VIII-9) Aedeagus mostly dorso-ventrally flattened with two ventral and a dorsal hooks which are generally flattened, recurved and pointed at apex (Fig. VIII-10). (Plate- VIII)

B. Family: *Coccinellidae*

1. ***Coccinella septumpunctata* Linnaeus:** Body yellow to reddish testaceous with usually black markings on the, pronotum and elytra (Fig. IX-1). Body rather rounded and convex; Dorsum glabrous; mandibles bifid (Fig. IX-2); maxillary galea conical, apical segment with apex oblique, enlarge and securiform (Fig. IX-3). Anterior margin of clypeus with an anterior projection on each side (Fig. IX-4); antennae inserted very close to the eyes, antennal club compact, the pre-apical segment broader than long (Fig. IX-5); pronotum black except the anterior corner which is flavus and quadrangular (Fig. IX-6); pro-sternum with a pair of carina which hardly extend beyond the level of the front coxae (Fig. IX-7); anterior margin of the mesosternum flat or entire. Meta-sternum and first abdominal sternite with post-coxal plate (Fig. IX-8). Tarsi with segment two lobed beneath (Fig. IX-9), claw bifid (Fig. IX-10). Elytra yellowish brown, each elytron with three small oval black spots- and a common pear shaped scutellar black

spot, totaling to seven spots, in some examples the elytral spots are enlarged and confluent (Fig. IX-11). (Plate: IX)

2. ***Cheilomenes sexmaculatus* (Fabricius):** Dorsum glabrous; Body testaceous yellow to yellowish brown (Fig. X-1). Mandibles bifid (Fig. X-2); maxillary galea conical, apical segment with apex oblique, enlarge and securiform (Fig. X-3). Anterior margin of clypeus with an anterior projection on each side (Fig. X-4); antennae inserted very close to the eyes, short, nearly as long as or shorter than frons, club compact, the pre-apical segment broader than long; the terminal segment pointed at apex (Fig. X-5). Scutellum more than one tenth as wide as pronotum. pronotum with a black band at the base, a little short of the lateral margin, and a transverse-oval, black discal spot connected to the basal black band with a narrow constriction, appearing like a T (Fig. X-6). Meta-sternum and first abdominal sternite with post-coxal plate (Fig. X-7). Tarsi with segment two lobed beneath (Fig. X-8), each tarsal claw with a basal tooth (Fig. X-9). Each elytron with two wavy black bands (one post humeral, one median) and a round black, sub-apical spot, the bands are generally free, not connected with the sutural margin (Fig. X-10); usually not more than *5.0* mm long. (Plate: X)

3. ***Illeis cincta* (Fabricius):** Dorsum glabrous; body yellowish or light testaceous, suborbicular or briefly oval, moderately convex (Fig. XI-1). Mandibles with multi-denticulate tip, inner-margin finely serrated (Fig. XI-2), maxillary galea quadrate, apical segment with apex oblique, enlarge and securiform (Fig. XI-3). Anterior margin of clypeus truncate without any projection on each side (Fig. XI-4). Antennae inserted in front, a little away from the eyes, antennal club loosely segmented, the pre-apical segment longer than broad (Fig. XI-5). Pronotum almost flat, very weakly convex at the disc, lateral sides raised, margined, anterior margin weakly sinuous, without marked post-ocular sinuosity. Corners rounded, generally with a pair of black spots at the base (Fig. XI-6). Prosternum short, without a pair of carina (Fig. XI- 7); mesosternum entire or weakly emarginate; tarsi crypto-tetramerous (Fig. XI-8), claw bifid (Fig. XI-9). Elytra truncated at base, external margin slightly reflexed. (Fig. XI-10); abdomen with six visible. (Plate-XI)

4. 5. DISCUSSION

5. Results of the investigations on diversity of coleopteran fauna in *kharif* pulses have been discussed in the light of the available literature.
6. **5.1 Coleopteran faunal diversity and relative density in pulses.**
7. The present study showed that the insect fauna in *kharif* pulses was diverse in higher and lower levels of taxa. During the investigation 5 pestiferous insects families namely Curculionidae, Chrysomelidae, Bruchidae, Scarabaeidae and Meloidae and 3 beneficial insects family Coccinellidae, Anthicidae and Staphylinidae of Coleoptera was collected from college Instructional farm, farmer's field of Badgaon village and farmer's field of Vallabhnagar village. Among the collected insect pest families, Chrysomelids and Curculionidae were most abundant in blackgram, greengram and cowpea at all three locations. The diversity indices i.e. Shannon-Wiener index and Simpson's index of diversity clearly indicated that the diversity of insect fauna was in good state in pulses field at all three locations. Simpson's index of diversity varied from 4.01 to 5.32.; whereas, Shannon diversity index varied from 4.01 to 5.32. An increase in the value of the index indicates an increase in diversity;
8. The findings of present investigation confirm with the earlier findings of Verma and Henry (1988), who studied the incidence of insect pests on mungbean (*Vigna radiata*) in Rajasthan, during July-September 1985, as the result of their investigation an average, 10.8 and 16.8 individuals of the curculionids, *Myllocerus maculosus* (*M. undecimpustulatus*) and *Cytrozemia cognata* were recorded per 10 plants, respectively. Singh and von Emden (1979) investigated the insect pests of grains and indicated *C. maculatus* as a primary pest of cowpea and other legumes worldwide, both in fields and stored seeds. The study of Vikrant *et al.* (2013) on population dynamics of insect pests of blackgram when cultivated sole and when niger was intercropped as a barrier crop against blister beetles resulted that the maximum mean population of blister beetle was 2.75 per plant in the sole crop of blackgram and 2.50 per plant in blackgram with niger. As Pawar *et al*. (2014) reported blister beetle (*Mylabris phalerata*) on greengram under regular and late sown condition the abundance of blister

beetle and crop phenology revealed population from bud initiation stage with a peak during flowering and early pod formation stage, clearly indicating its preference for the buds and flowers. The beetle population decreased when the crop reaches physiological maturity. Similarly under our investigation the members of weevils, pulse beetles and blister beetles were observed, the weevils prevailed throughout the crop season, whereas pulse beetles and blister beetles were appeared during flowering and pod formation stage. As dominant pests the seasonal mean population of weevils varied from 0.21 to 0.98 per plant and leaf beetles' population varied from 0.59 to 0.94 per plant; whereas, the relative density for weevils varied from 12.57 to 34.42 and for leaf beetles varied from 25.10 to 47.88.

9. From the study on diversity of natural enemy belonging to Coccinellidae family, the findings had shown the similarity with work of Rekha *et al.* (2009) who recorded diversity of predatory coccinellids. *M. sexmaculatus, C. transversalis* and *B. suturalis* were the dominant taxa in weeded and partially weeded cowpea ecosystem. The study of Elmira *et al.* (2011) on biodiversity and distribution of lady bird beetles from seven region of Iran, as the result of their investigation, *Hippodamia variegata* (Goeze) 63.68 percent (n=998) and *Coccinella septempunctata* Linnaeus 31.07 percent (n=487) were recorded as more abundant species and were widely distributed on all the regions. The maximum and minimum diversity species were obtained in Solan (Simpson's diversity index = 0.58) and Salehabad (Simpson's diversity index = 0.36) regions respectively The study of Alia Hayat and Muhammad Rafique Khan (2013) on biodiversity (diversity, abundance, richness and evenness) and species composition of Ladybird Beetles from Mirpur Division of Azad Jammu and Kashmir, Pakistan. The totals of fifty one species from 6 subfamilies were recorded from the study area. Diversity was calculated by using Shannon- Wiener's diversity index and Simpson's index. The calculated values of diversity indices showed that highest diversity was recorded from district Bhimber and lowest from district Kotli. Under the study of our investigation three members of Coccinellidae family i.e., *C. septempunctata, C. sexmaculatus*

and I. cincta were recorded, the seasonal mean density ranged from 0.19 to 0.32 per plant. The relative density ranged from 8.07 to 18.83 percent.

10. **5.2 Characterization and identification of taxa up to generic level in Chrysomelidae**

11. The Fauna of British India volumes on Chrysomelidae, Jacoby (1908), and Maulik (1919, 1926 and 1936) are still the main sources of information on classification of Indian Chrysomelidae. In addition there have been taxonomic studies on oriental leaf beetle, including Indian Chrysomelidae by Kimoto (1970, 1982), Kimoto and Takizawa (1983), Takizawa and Basu (1987), Takizawa and Kimoto (1990), Borowiec (1985, 1990, 1996, 1999 and 2001), Borowiec and Takizawa (1991), Silfverberg (1990), Lopatin (1995) and Swietojanska (2001). Among Indian workers Basu (1985), Basu and Sengupta (1978, 1980 and 1981), Basu and Halder (1987), Pajni and Bansal (1977), Pajni and Singla (1981), Verma (1988) and Prathapan and Konstantinov (2003) were consulted for identification of the chrysomelid genera.

12. Jacoby (1908) had described 146 species under 7 genera of the Criocerinae sub-family and 438 species under 51 genera of the Eumolpinae sub-family from the Indian sub-region. Maulik (1919, 1926, and 1936) recorded 152 species under 16 genera of the sub-family Cassidinae, 316 species under 70 genera of the sub-family Alticinae and 440 species under 90 genera of the sub-family Galerucinae, respectively from Indian sub-region. In our study, we collected 6 genera from pulses, belonging to 4 sub-families. Work on morphological characterization of chrysomelid genera from specific cropping systems are scanty, hence it becomes difficult to discuss our work.

6. SUMMARY

The results of the present investigation on **"***Diversity of coleopteran fauna in kharif pulses"* have been summarized in terms of the species richness and abundance besides the morphological characterization of the dominant curculionid and chrysomelid genera. A detailed description of the major coleopteran insect pest of pulses has been presented.

The pulses, blackgram, greengram and cowpea, cultivated at the college Instructional Farm, Udaipur, one farmer's field of Badgaon village and one farmer's field of Vallabhnagar village were observed for pestiferous and beneficial coleopteran fauna. The faunal collection comprised 8 families of order Coleoptera; however, on the basis of relative density values individuals of the family Curculionidae and Chrysomelidae collectively emerged as the dominant pestiferous fauna in all the three crops ranging from 75.15 to 54.01 per cent with the highest (75.15) recorded in greengram, followed by that in blackgram (72.55) at the college Instructional Farm. The other families were relatively less frequent. Computation of the Shannon Diversity index indicated highest values for greengram (1.72) followed by that for cowpea 1.71 at the farmer's field of Vallabhnagar village. Similarly, the Simpson's index values 5.32 and 5.16 for greengram and cowpea, respectively.

The members of the family Chrysomelidae and Curculionidae started to infest the crop from 29th SMW in blackgram at all three locations and prevailed until the harvest of the crop. The members of family Bruchidae, Scarabaeidae and Meloidae appeared from 34th SMW or later and prevailed up to the harvest of the crop at all three locations; whereas, the members of the family Coccinellidae prevailed throughout the crop season at all the three locations. In greengram the members of family Chrysomelidae and Curculionidae began to infest the crop from 29th SMW and prevailed up to harvest of the crop at all three locations. The bruchids, scarabaeids and meloids were observed from 33rd SMW or later and prevailed up to harvest of crop at all three locations; whereas, the coccinellids prevailed throughout the crop season at all three locations. In cowpea the members of the family Chrysomelidae at the college Instructional Farm appeared from 31st SMW and prevailed throughout the crop season; whereas, the members of family Curculionidae appeared from 29th SMW. The curculionid and chrysomelid fauna at farmer's field at village Badgaon and

Vallabhnagar were found throughout the crop season. The members of Bruchidae, Scarabaeidae and Meloidae appeared after 33rd SMW or later at all three locations; whereas, the members of Coccinellidae at the college Instructional Farm and farmer's field in village Badgaon were observed throughout the crop season starting from 29th SMW up to 38th SMW; however, at farmer's field in village Vallabhnagar the coccinellid population appeared from 29th SMW and prevailed up to the 36th SMW.

At college Instructional Farm and Farmer's field of Badgaon village the Population of foliage feeding families i.e., Curculionidae and Chrysomelids, exhibited significant negative correlation with both mean atmospheric temperature and relative humidity. The flowers and pod feeding families i.e., Bruchidae, Scarabaeidae and Meloidae exhibited significant positive correlation with both mean atmospheric temperature and relative humidity. The natural enemies' family of pestiferous insects (Coccinellidae) exhibited significant positive correlation with mean atmospheric temperature and relative humidity in all three crops.

Morphological characterization of three species belonging the genus *Myllocerus* of the family Curculionidae *viz.*, *M. undecimpustulatus*, *M.* discolor and *M. dorsatus*, seven species of six genera: *Aulacophora*, *Monolepta*, *Chaetocnema*, *Luperomorpha*, *Lema* and *Colasposoma* of family Chrysomelidae *viz.*, *Aulacophora foveicollis* Lucas, *Monolepta signata* Olivier, *Chaetocnema basalis* Baly, *Luperomorpha nigripennis* Duvivier, *Lema* sp. 1, *Lema* sp. 2 and *Colasposoma* sp.; one species of family Meloidae *i.e.*, *Mylabris pustulata* Thunberg, and three species of the genera *Coccinella*, *Cheilomenes and Illeis) viz*, *Coccinella septumpunctata* Linnaeus, *Cheilomenes sexmaculatus* (Fabricius) and *Illeis cincta* (Fabricius) of family Coccinellidae have been described in the form of pictures and line diagrams indicating the valid taxonomic characters.

LITERATURE CITED

Abrol, D.P., Ramamurthy, V.V. and Srivastava, K. 2006. Bean gall weevil and blister beetle as new pests on red kidney bean *Phaseolus vulgaris* L. in India. ***Journal of Asia Pacific Entomology,*** 9: 317-320.

Adugna Haile. 2006. On farm storages studies in Eritrea. ***African Journal of Biotechnology,*** 5: 1537-1544.

Agarwala, B. K. and Ghosh, A. K. 1988. Pray records of aphidophagous coccinellids in India. A review and bibliography. ***Journal of Tropical Pest Management*****,** 34: 1-14.

Arora, G. L. 1977. Taxonomy of Bruchidae (Coleoptera) of northwest India- Part I, Adults. ***Oriental insects,*** 7: 1-132.

Azam, M., J. S. Tara., S. Ayri., M. Feroz and V. V. Ramamurthy (2009a). Bionomics of Alcidodes signatus Boheman, a serious pest of red kidney bean Phaseolus vulgaris (Coleoptera: Curculionidae). ***Pest Management in Horticulture Ecosystems***, 15: 93–98.

Balikai, R.A. 2000. Incidence of blister beetle, *Mylabris pustulata* (Thunberg) on different host plants. ***Insect Environment****,* 6: 12.

Basu, C. R. and Sengupta, T. 1978. The Indian species of *Livolia* (Coleoptera, Chrysomelidae, Alticinae). ***Oriental Insects***, **12**: 481-487.

Basu, C. R. and Sengupta, T. 1980. On a new genus and a new species of Alticinae (Coleoptera, Chrysomelidae) from Arunachal Pradesh. ***Record of Zoological Survey of India****,* **76**: 143-146.

Basu, C. R. and Sengupta, T. 1981. Little known Alticinae (Coleoptera: Chrysomelidae) with descriptions of five new species from India. ***Oriental Insects,*** **15**: 262-276.

Basu, C. R. 1985. Insecta: Coleoptera: Chrysomelidae. In fauna of Namdapha: Arunachal Pradesh. ***Records of the Zoological Survey of India,*** **82**: 201-214.

Basu, C. R. and Halder, S. K. 1987. Insecta: Coleoptera: Chrysomelidae. Fauna of Orissa State Fauna Series, No.1, pt. 1: 213-239. Borowiec, L. 1985. Asiatic Cassidinae (Coleoptera: Chrysomelidae) in polish collection. ***Polish Pismo Entomology Bulletin,*** **55**: 25-38.

Borowiec, L. 1990. New record and new synonyms of Asiatic Cassidinae (Coleoptera: Chrysomelidae). ***Polish Pismo Entomology Bulletin,* 59**: 677-711.

Borowiec, L. and Takizawa, H. 1991**.** Notes on Chrysomelid beetles (Coleoptera) of India & its neighbouring areas, Part. 10. ***Japanese Journal of Entomology***, **59**: 637-654.

Borowiec, L. 1996. New records of Asiatic Cassidinae (Coleoptera: Chrysomelidae*). **Annals Upper Silesian Museum, Entomology***, **6-7**: 5-47.

Borowiec, L. 1999. World catalogue of Cassidinae (Coleoptera: Chrysomelidae). Biologica, Wroclaw, 476pp.

Borowiec, L. 2001. New records of Asian and Austropapuan Cassidinae, with a description of five new species of *Cassida* L. from Thailand (Coleoptera: Chrysomelidae: Cassidinae). ***Genus,* 12**: 493-562.

Butani, D.K. 1980. Insect pest of vegetables and their control on cluster beans. ***Pesticides***. 17: 6-13.

Eliakira K., Beatrice Thomas N. and Magreth N. 2014. Effect of cropping systems on infestation and severity of field insect pests of cowpea in Morogoro, Tanzania. ***Modern Research Journal of Agriculture,*** 1: 1-9.

Elmira, A., Jafari, R., Vafai, R. and Shahram, A. 2011. Biodiversity and distribution of predacious ladybird (Coleoptera: Coccinellidae). ***International Research Journal of Applied and Basic Sciences,*** 5: 705-709.

Fleming, R.C. 2000. Lady beetles. Entomological notes No 6. Entomological society. http://insects.unmmz.lsa.umich.edu/MES/notes/entnotes.html.

Hawkeswood, T. 1987. Beetles of Australia. Augus and Robertson, Sydney, Australia.

Hayat, A. and Khan, M. R. 2013. Biodiversity and species Composition of Ladybird Beetles (Coccinellidae; Coleoptera) from Mirpur Division of Azad Jammu & Kashmir, Pakistan. ***Sarhad Journal of Agriculture***, 30: 341-350.

ICAR Vision, 2050. Indian Institute of Pulse Research, Kanpur. Report www.iipr.res.in

Iperti, G. and Paoletti, M. G. 1999. Biodiversity of predacious coccinellidae in relation to bio-indication and economic importance. Special issue: Invertibrate

biodiversity as bio-indicators of sustainable landscapes. ***Agriculture Ecosystem and Environment.*** 74: 323-42.

Inayatullah, M., Hayat, A. and Rafi, M.A. 2005. Species composition, distribution and seasonal occurrence of Coccinellidae (Coleoptera) in District Poonch, Azad Kashmir with new records. ***Sarhad Journal of Agriculture,*** 21: 97-100.

Irshad M. 2001. Distribution, host, Ecology and biotic potential of Coccinellids of Pakistan. ***Pakistan Journal of Biological Science,*** 4: 1259-1263.

Jacoby, M. 1908. The fauna of British India including Ceylon and Burma. Coleoptera, Chrysomelidae, 1: xx + 534 pp.

Kannaiyan S. 1999. Bio resource technology for sustainable agriculture. Associated Publishing Company. New Delhi pp: 422.

Kimoto, S. 1970. A list of the Napalese Chrysomelid specimens preserved in Zoolische Sammlung de Bayerischen States, Munchen- ***Khumbu Himal*** 3: 412-421.

Kimoto, S. 1982. The Galerucinae of Nepal, Bhutan and the Northern Territories of India, in the Natural History Museum in Basel, II (Coleoptera: Chrysomelidae). ***Entomological Review of Japan***, 37: 7-24.

Kimoto, S. and Takizawa, H. 1983. Chrysomelid beetles of Nepal collected by the Himalaya Expedition 1979 of the National Science Museum, Tokyo (Part 1). ***Bulletin of Natural Museum Tokyo Series,*** **9**: 83-96.

Khan, I., Din S., Khalil S. K., Rafi M. A. 2006: Survey of predatory coccinellids (Coleoptera: Coccinellidae) in the Chitral District, Pakistan. ***Journal of Insect Science,*** 7: 6

Leelavathy, S. 1982. Studies on stored grain pest: *Callosobruchus analis* (F.), Ph.D. thesis, Madurai, Kamraj University, Madurai.

Lefroy, H. 1909. Indian insect life. Thacker, Spink and company, Calcutta. 839 pp.

Lopatin, I. 1995. New Cryptocephalinae and Chalmisinae from Indian region (Coleoptera: Chrysomelidae). ***Entomologica Basiliensia,*** 18: 455-466.

Marshall, G. A. K. 1915. Part II. Curculionidae. In: Arrow, G. J., Marshall, G. A. K. , Gahan, C. J. & Blair, K. G. Report on the Coleoptera collected by the British Ornitologists' Union

expedition and the Wollaston expedition in Dutch New Guinea. ***Transactions of the Zoological Society of London,*** 20: 497-543.

Marshall, G. A. K. 1916. Coleoptera, Rhynchophora, Curculionidae. In: Shiply, A.E. The fauna of British India including Ceylon and Burma. ***Taylor and Francis, London,*** 15: 367.

Maulik, S. 1919. The fauna of British India including Ceylon and Burma, Chrysomelidae (Hispinae and Cassidinae). Taylor and Francis, London. 439 pp.

Maulik, S. 1926. The fauna of British India including Ceylon and Burma. Coleoptera, Chrysomelidae (Chrysomelinae and Halticinae). xiv + 442 pp.

Maulik, S. 1936. The fauna of British India including Ceylon and Burma. Coleoptera, Chrysomelidae (Galerucinae). xiv + 648 pp.

Mitchell, R. 1983. The evaluation of oviposition tactics in the bean weevil, C. maculatus (Fab.) in a strain of chickpea, *Cicer arietinum* L., ***Journal of Stored Products Research.*** 7: 213-216.

Nene, Y.L. 2006. Indian pulses through the millennia. ***Asian Agri-History,*** 10: 179- 202.

Ofuya, Z.M. and Akhidue, V. 2005. The role of pulses in human nutrition. ***Journal of Applied science and environmental management***. 9: 99-104.

Omkar and Pervez, A. 2000. Biodiversity of predaceous coccinellids (Coleoptera: Coccinellidae) in India: A review. ***Journal of Aphidology,*** 14: 41-66.

Pajni, H. R. and Bansal, R. K. 1977. First report on the chrysomelid fauna of Chandigarh. ***Research Bulletin* (Science) *Punjab University,*** 28: 55-59.

Pajni, H. R. and Singla, S. R. 1981. Secound report on the chrysomelid fauna of Chandigarh and adjoining hilly areas (Coleoptera). ***Research Bulletin* (Science) *Punjab University***, 32: 139-142.

Patil, R.K. and Nithya Chandran 2012. Incidence of Apion amplum (Faust) (Apionidae: Coleoptera) on greengram with its bio–pesticidal management. ***Crop Research*,** 44: 161–167.

Patnaik, H.P., Mohapatra, H.K. and Senapati, B. 1993. Blister beetle incidence and some observations on its ovipositional behavior on pigeonpea in Orisa, India. ***International Pigeonpea Newsletter*,** 18: 27-30.

Pawar, K.S., Dhavan, S.P. and Wadaskar,R.M. 2014. Temporal and intraday abundance variations of blister beetle (*Mylabris phalerata*) on green gram. ***The Bioscan,*** 9:65-69.

Pingale, S. V. (1953) Effect of damage by some insects on the viability and weight of the stored grain. ***Bulletin Central Food Technology Research Institute (Mysore),*** 2: 153-154.

Poorani, J. 2000. An annotated checklist of the coccinellidae (Coleoptera) (excluding Epilachninae) of the India sub region. ***Journal of oriental insects.*** 36: 307-383.

Prathappan, K. D. and Konstantinov, A. S. 2003. The flea beetle genus *Aphthona* Chevrolat (Coleoptera: Chrysomelidae) of Southern India, with descriptions of seven new species. ***Proceeding of the Entomological Society of Washington,*** 105: 154-179.

Pushpendra K. Sharma and Prakash C. Joshi. 2010. New Records of Coccinellid Beetles (Coccinellidae: Coleoptera) from District Dehradun, (Uttarakhand), India. ***New York Science Journal,*** 3: 6

Rahamatullah, Faizul Haq, Habib Ahmad, Mian Inayatullah, Kausar Saeed and Shahroz Khan. 2012. Morphological characteristics of ladybird beetles collected from District Dir Lower, Pakistan. ***African Journal of Biotechnology,*** 11: 9149-9155.

Raina, A.K. (1970) *Callosobruchus* spp. Infesting stored pulses (grain legumes) in India and a comparative study of their biology. Indian Journal of Entomology, 32, 302–310.

Raja, N., Albert, S., Ignacimuthu, S. and Dorn, S. 2001. Effect of plant volatile oils in protecting stored cowpea *Vigna unguiculata* L. Walpers against *C. maculatus* F. (Coleoptera : Bruchidae) infestation. ***Journal of Stored Product Research,*** 37: 127 – 132.

Ramakrishna Ayyar, T. V. 1922. The weevil fauna of South India with special reference to species of economic importance. Agricultural Research Institute, Pusa, Calcutta, ***Bulletin***, 125.

Ramamurthy, V. V. 2007. Faunistic, ecological, biogeographical and phylogenetic aspects of Curculionidae acting as gall inducers and associates in plants from Oriental and eastern Palearctic. ***Oriental insects***, 41: 93-119.

Rekha, B. S., Ramkumar, J., Kandibane, M., Raguraman, S. and Swamiappan, M. 2009. Diversity of coccinellids in cereals, pulses, vegetables and weeded and partially weeded rice-cowpea ecosystems in Madurai District of Tamil Nadu. ***Madras Agricultural Journal,*** 96: 251- 264.

Shanas, S. and V. V. Ramamurthy (2009). A study on the Oriental weevil genus *Episomus* (Coleoptera: Curculionidae). ***Oriental Insects,*** 43: 77–153.

Sharanabasappa and Goud, K.B. 2004. The pest status of *Apion ampulum* (Faust) on greengram. ***Karnataka Journal of Agriculture Sciences***. 17: 600–601.

Silfverberg, H. 1990. Records of Galerucinae (Coleoptera, Chrysomelidae) from the Indian subcontinent Part. 1. ***Entomologica Fennica,*** **21**: 202-207.

Singh, K., Swaminathan, R., Nepalia, V. 2012. Insect Pests of Green Gram Vigna radiata (L.) Wilczek and Their Management, Agricultural Science, http://www.intechopen.com/books/agricultural-science/insect-pests-of-green-gram-vignaradiata-l-wilczek-and-their-management

Singh, S.R. and Van Embden, H.F. 1979. Insect pest of grain legumes. ***Annual review of entomology.*** 24: 225-278.

Smith, E.H. 1979. Techniques for the dissection and mounting of the male (aedeagus) and female (spermatheca) genitalia of the Chrysomelidae (Coleoptera). ***The Coleopterist's Bulletin,*** 33: 93–103.

Swietojanska, J. 2001. A revision of the tribe Aspoidimorphni of the Oriental Region (Coleoptera: Chrysomelidae: Cassidinae) Genus *(Supplement)*. Polish taxonomical society, Wroclaw. 318pp+18colour plates.

Takizawa, H. and Basu, C. R. 1987. Notes on Chrysomelid-beetles (Coleoptera: Chrysomelidae) of India and its neighbouring areas. Part-4. ***Kontyu Tokyo*****,** 55: 266-283.

Takizawa, H. and Kimoto, S. 1990. Notes on Chrysomelid-beetles of S. India preserved in the collection of Staatliches museum of Munich (Coleoptera: Chrysomelidae*).* ***Entomological Review of Japan***, 45: 7-10.

Talekar, N.S. 1990. Insect pests of mungbean and their control. libnts.avrdc.org.tw/ fillltext _pdf/eam0121.pdf

Verma, R. 1988. Chrysomelid fauna of the Chhattisgarh Region. In Sovenir, MAPCOST Symposium on Indian Studies on Chrysomelidae and Bruchidae, Feb. 7-9. Govt. Arts & Science College, Durg.

Verma, S. K., Henry, A., 1988: Intensity of insect pests on mungbean cultivars in arid Rajasthan. ***Annals of Arid Zone.*** 27: 71-74.

Vikrant, Swaminathan, R. and Bajpai, N.K. 2013. Population dynamics of major insect pests of blackgram. ***Indian journal of applied entomology*****,** 27: 16–20.

Zaghloul, O.A. and A.K. Mourad, 1997. Studies on the egg-parasitoid, *Uscana lariophaga* Steffan (Hymenoptera: Trichogrammatidae), with reference to its role in the assessment of cowpea losses due to *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in Egypt. Mededelingen Faculteit Landbouwkundige en Toegepaste Biologische Wetenschappen, ***Univer. Gent.,*** 63: 441-453.