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Entomofauna assessment of *Vigna radiata* Agro-ecosystem of Eastern Odisha, India

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Abstract
The investigation was carried out in Cuttack and Jagatsinghpur districts in the year 2018 with collection of data by several methods. Four months of study and survey yielded 52 insect species out of which 19 were found damaging the productivity of the pulse field. Although the insect pest population was high in the studied field but the damage caused by them was not significant because the beneficial insects are playing a crucial role in controlling the pest and increasing the yield indirectly. The pest species of Cuttack was found higher than Jagatsinghpur. *Aphis craccivora, Euchrysops cnejus and Empoasca kerri* were found to be the most abundantly present pest of Eastern Odisha. The incidence of Coleopteran pest was higher than the other 4 orders. Along with the pests, 23 beneficial insects were found which help in increasing the productivity of the pulse field in several ways. Ladybird beetle, Dragonfly and Praying mantis were found to be the most abundant beneficial insect of the field. The dominancy of beneficial insect was seen in the surveyed greengram field. Some predatory and parasitoid beneficial insects have the controll over the pest population. Ten neutral insects were also seen, which don't have any significant role in the studied agroecosystem. A new insect species named *Cossyphus depressus* was found from the field which was never reported before from Odisha.

Keywords: Green gram, insect, pest, coleoptera, beneficial insect

Introduction
Insects are air-breathing mostly terrestrial and rarely aquatic arthropods [1]. They belong to Class Insecta of Phylum Arthropoda which includes all animals with segmented bodies, segmented legs and exoskeleton. Scientists have identified nearly a million different species of insects and many more left to be discovered. The average number of insects in one square mile is more than all people of the Earth [2]. Increasing knowledge of the damage done by insects, and the role they play in transmission of animal, plant and human diseases, emphasises the necessity for correctly identifying these organisms and knowing more about their life habits [2]. The Class Insecta or Hexapoda is studied under a classification system with approximately 30 orders.

From the farmers' point of view usually insects are classified in 3 groups, depending on their behavior in the farm: Pests, Beneficial insects & Neutral insects. Pests are insects or small animals which damage crops or food supplies.

There are many insects found on agriculture land those are not threat to the crop production but beneficial to the farmers in different aspects, as natural enemies, pollinators, productive insects, scavengers, weed killer and soil builders. Insect predators and parasitoids that attack and feed on other insects, particularly on insect pests of plants are considered natural enemies. Through this type of feeding, natural enemies contribute to a type of pest regulation referred to as natural biological pest control. Natural enemies responsible nearby 33% of the natural pest control in cultivated systems [3]. Many insects feed upon unwanted weeds. In many cases the occurrence of these insects has contributed much towards eradication of the weeds. Insects which live in soil make tunnels, creating channels for smaller organisms, water, air, and roots to travel through. Insects improve soil aeration, and earthworm activity can enhance soil nutrient cycle, the soil physical properties, such as soil structure and tilth and activity of other beneficial soil organisms [3]. Insect-mediated pollination is an essential step in reproduction for the majority of the world's flowering plants, including numerous cultivated plant species [3].

If an insect is neither a pest and nor beneficial then it is called as a neutral insect. In a pulse field a cockroach can be considered as a neutral insect as it doesn't harm the crop.

Pulses, the food legumes, have been grown by farmers since millennia providing nutritionally balanced food to the people of India [4] and many other countries in the world. Mung bean is one of the most important pulse crops, grown from the tropical to sub-tropical areas around the world [5-8]. The green gram is also known as golden gram, mung bean, Haricot mungo, mungo and moong bean [9]. In India, the name green gram is more commonly used than mung bean [10].

It is an erect plant which is highly branched and is about 60 to 76 cm tall [11]. Mung bean roots are deep rooted just like the roots of black eye. The leaves are tri-foliate like other legumes. The pale yellow flowers are borne in clusters of 12–15 near the top of the plant. Flowers will eventually develop into small, thin cylindrical pods and, often, cylindrical seeds covered with a white rough layer. Pod colour varies from black and brown to pale gray when mature. Pods are 7.5 cm to 10 cm long, each having 10 to 15 seeds. There are several pods clustered at a leaf axil, with typically 30 to 40 pods per plant. The pods turn darker in colour as they mature.

Mung bean is low in calories and rich in fiber [12]. It is an important source of protein and several essential micronutrients. The composition of mature mung bean seeds per 100 g edible portion is: water 9.1 g, energy 1453 k.J (347 kcal), protein 23.9 g, fat 1.2 g, carbohydrate 62.6 g, [6, 12, 13] dietary fibre 16.3 g, Ca 132 mg, Mg 189 mg, P 367 mg, Fe 6.7 mg [14], Zn 2.7 mg, vitamin A 114 IU, thiamin 0.62 mg, riboflavin 0.23 mg, niacin 2.3 mg, vitamin B6 0.38 mg, folate 625 µg and ascorbic acid 4.8 mg. Among pulses, mung bean is favoured for children and the elderly people because of its easy digestibility and low production of flatulence [15]. Green gram is drought tolerant and gives reasonable yields with as little as 650 mm of rainfall [16-18]. It has the unique ability to fix the atmospheric nitrogen (58-109 kg/ha) in symbiotic association with *Rhizobium* bacteria, which not only enables it to meet its own nitrogen requirement but also benefits the succeeding crops [19]. Hence, it is adapted to poor soils [20]. They have miraculous properties like high nutritional value and low water requirements, ability to self-fertilize, improving soil and crops health by fixing nitrogen contents and above all maintaining the health benefits to the people [21-23] and thus play a vital role in sustainable agriculture [24].

It is an important wide spreading, herbaceous and annual legume pulse crop cultivated mostly by traditional famers [25]. Sowing of mung bean mainly occurs during summer when sufficient rain is available for growth but it is sensitive to waterlogging. India has the distinction of being the top producer of this pulse crops in the world. It is the third most important pulse crop with an area of approximately 3.02 million hectares (about 15% of the national pulse crop area) producing 1.50 million tonnes of grain (8.5% of the pulse production in the country) [26, 27]. Mung bean is cultivated in all of the states of India, but top producer states are Odisha, Maharastra and Andhra Pradesh [28].

Mung bean yields are greatly depressed by a complex of biotic and abiotic factors of which insect pests are the most important. Mung bean is attacked by a number of insect pests which cause a heavy loss to crop. An estimated 200 insect pests that belong to 48 families in Coleoptera, Diptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Orthoptera, Thysanoptera, and 7 mites of the order Acarina are known to infest green gram and black gram [29]. In India nearly 60 species of insect pest have been recorded from green gram but only a few are known to cause economic damage and commonly covers large areas [30-32]. On an average 2-2.1 million tonnes of pulses with a monetary value of nearly Rs 6,000 crore are lost annually due to the ravages of insect pest complex [33]. The insect pests of mung bean may differ from area to area, or from season to season within an area. Major insect pests are stemfly, thrips, whitefly, jassid and pod borer [34]. Due to the crop loss, the per capita consumption of pluses has declined from 69 grams/day in 1960-61 to 36 grams/day in 2007-08. For India, the World Health Organization recommends a minimum consumption of 80 grams of pulses per capita /day [35].

Greengram pest predators include spiders, amphibians, birds and some other insect species like ants, dragonflies, beetle etc; however the most important ones are the spiders. One spider can consume about thirty white leaf-hoppers in a day [36]. One peculiarity of spiders is that they never eat greengram and only feed on insects where as insect predators feed both on greengram and insects [36].*Vigna radiata* crop is benefited by pollinators which enhance their yield both quantitatively and qualitatively. Like soybean, Moong bean and other pulses are self-pollinated crop but yield increases by bee pollination have been observed [37].

Several works have been done by many entomologists to explore the insect pest diversity of mung bean field. Sinha *et al*. (1982) studied the seasonal occurrence of various insect pests on green gram during summer and Kharif in 1980 in North Bihar and reported Galerucid beetle, *Madurasia obscurella*, Pod borer, *Euchrysops cnejus* during summer and *M. obscurella, Empoasca kerri, Aphis craccivora, Mylabris spp., E. anejus*, *Maruca testulalis* and *Bemisia tabaci* during Kharif [38]. Gupta and Singh (1993) studied the insect pests of *V. radiata* in Uttar Pradesh, India, during summer and Kharif, 1978 and 1979. *M. distalis* and *O. phaseoli* appeared first in summer, followed by *M. obscurella* and *B. tabaci*. During the Kharif season, *M. distalis, O. phaseoli* and *M. obscurella* appeared first, being followed by leaf-miners, *B. tabaci* and other insect pests [39]. Sahoo and Patnaik (1994) conducted field studies in Ganjam, India, the following insect pests were record on green gram and black gram: *Madurasia obscurella*, *Luperodes sp., Aphis craccivora, Bemisia tabaci, Megalurothrips distalis, Caliothrips indicus, Cydia ptychora* (Leguminivora ptychora), *Maruca testulalis* and *Helicoverpa armigera* [40]. Borah (1995) reported that the main pests of green gram in Assam, were *Aphis craccivora*, *Amrasca biguttula* and *Bemisia tabaci* [41]. Singh and Kalra (1995) recorded the succession and abundance of insect pests on *Vigna radiata and Vigna mungo* and found 22 and 16 insect pest species, respectively at different stages of growth. The most important insect pests were *Empoasca kerri, Ophiomyia phaseoli, Austroagallia sp., Bemisia tabaci* and *Nysius sp* [42]. Dar *et al*. (2002) studied insect pests of summer crops of mung bean and urd bean in Aligarh, Uttar Pradesh and reported 31 species of insect pests, 20 of which were regular visitors and 11 were sporadic [43].

No significant works have been done in India to explore all the insect fauna of mung bean Agroecosystem. All are emphasising on the pest diversity and neglecting the importance of beneficial insect status. Keeping this fact in mind we have started this survey in Eastern Odisha. Our major goal was to know the insects fauna of mungbean according to their role.

2. Materials and methods

2.1 Study Area

The Odisha state of India has a geographical area of 155,707 sq. km. It is located between 17 47' - 22 34' North and 81 22' - 87 29' East. The state is divided into 30 administrative

districts. Jagatsinghpur and Cuttack are the coastal districts of Odisha. The present work was carried out in 2 Districts of Odisha; Jagatsinghpur & Cuttack.

Jagatsinghpur lies between 19° 58' & 20° 23'N latitude and between 86° 30' & 86° 45' E longitudes. The economy of the district is largely agriculture oriented. The climate of this district is characterised by high humidity, nearly all the year round, oppressive summer and good seasonal rainfall. The average annual rainfall in the district is 1514.6 mm.

Cuttack district is situated in the eastern part of Odisha and lies between north latitudes 20^0 00' & 20^0 40' and east longitudes 84^0 52' & 86^0 01'. The district is characterized by tropical monsoon climate having three distinct seasons in a year, viz, winter, summer and rainy seasons. Lowest and the highest temperatures recorded for the districts are 7.5 ^{0}C and 42 ^{0}C respectively. The normal annual rainfall is 1501.3 mm with the average of 1587.4 mm.

Four moong bean fields were selected for study; two of Jagatsinghpur dist and two of Cuttack dist.

Table 1: Geographical coordinates of the Studied Mung bean Field

Field No	District	Place	Coordinates
1	Jagatsinghpur	Salijanga	20.3268828 N 86.2290086 E
2	Jagatsinghpur	Ramachandrapur	20.3248366 N 86.2323888 E
3	Cuttack	Siuli	20.3603621 N 86.1322442 E
4	Cuttack	Siuli	20.3606035 N 86.1323780 E

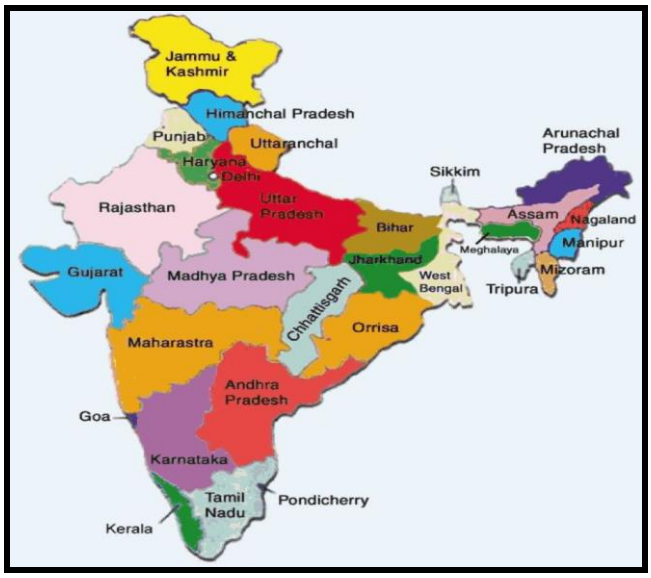


Fig 1.1: Map of India

Fig 1.2: Map of Odisha

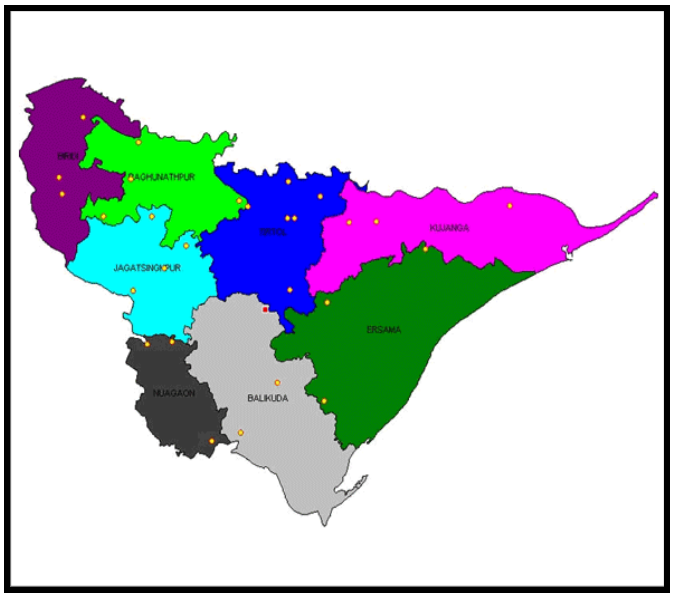


Fig 1.3: Map of Jagatsinghpur

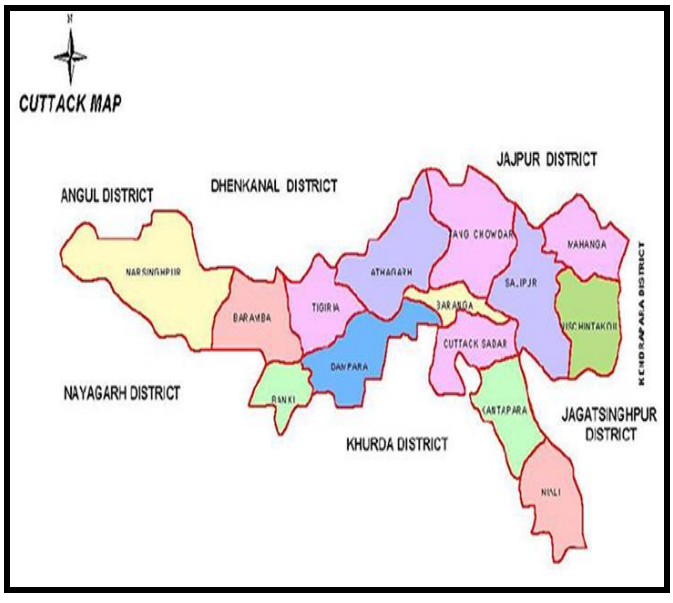


Fig 1.4: Map of Cuttack

Fig 1.5: Google map showing Greengram field studied of Jagatsinghpur Area

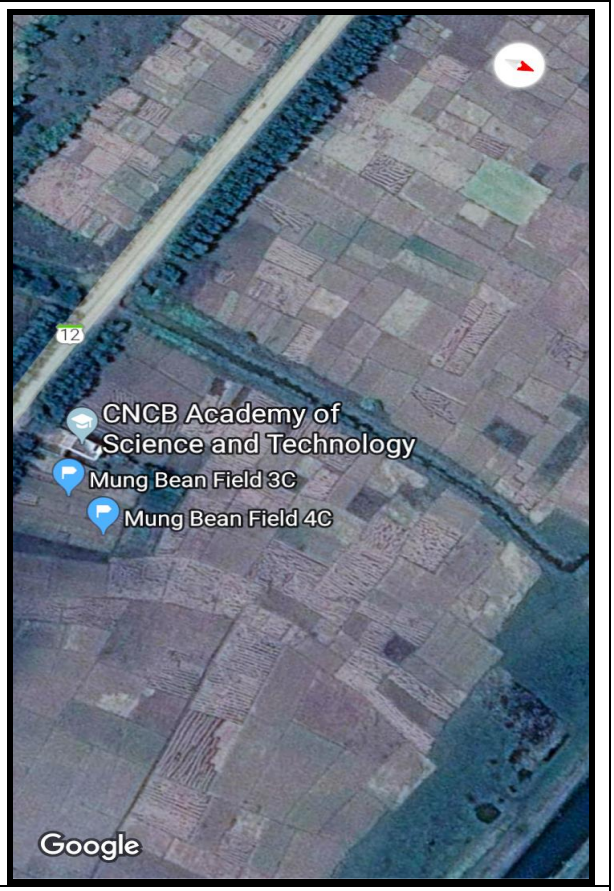


Fig 1.6: Google map showing Greengram field studied of Cuttack Area

2.2 Methodology

The study was conducted for four months; from December 2018 to April 2018. Four moong bean fields were selected for study; 2 of Cuttack district and 2 of Jagatsinghpur district. Random sampling was conducted in every plot to record the incidence of insect in different time. Observations were recorded at weekly intervals, starting when the crop was 15 days old, till crop maturity.

Specimens were collected by 6 methods; Active sampling and hand picking, pitfall trap, sweep-net technique, aerial net, light trap and yellow pan water traps. Some specimens were observed but unfortunately failed to capture hence not photographed. Sampling was done both at night and day in order to capture both nocturnal and diurnal insects. Investigation was also continued in the morning and evening to catch the crepescular insects. Small insects, specially the soft bodied ones are collected by hand with the help of a forecep. Soft camel hair brush was also used for hand collection. Many specimens were collected by sweep-net method using an insect collecting net of 35 cm diameter, attached to a steel stick. Aerial net was used to collect free-living insects like, Lepidoptera. Specimens captured were placed in a wide-mouthed killing jar containing alcohol. When the specimens in the jar were dead, they were preserved in small glass Homeopathic vials with 10% formaline. Paper packets are used to keep Lepidopteran, Odonates and many other insects. Some smaller insects were visualised under a binocular microscope. Specimens were photographed by using NIKON D5600 DSLR camera. The species were identified by using taxonomic key. Only those species with confirmed identification are listed in this paper.

Fig 2.1: Pitfall trap installed in the mung bean field

Fig 2.2: Insect collection by Sweep net technique

Fig 2.3: Light trap installed in the field

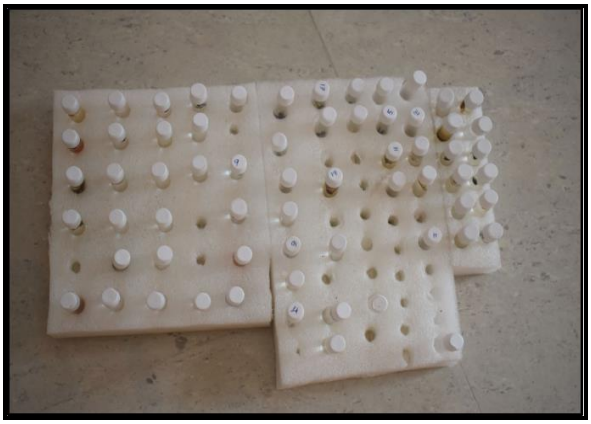


Fig 2.4: Insect specimen preserved in small glasss homeopathic vials

3. Results and Discussion

The study yielded 52 insect species. From the survey and assessment work, it was found that the entomofauna of the agro-ecosystem of Eastern Odisha belongs to 2 Divisions, 12 Orders, 38 Families and 50 genera. The systematic position of each insect species is given in Table 2. The scientific names & common names along with taxonomic authority and nature of insect are given in Table 4. No insects of Sub-class Apterygota was recorded. All insects found were belonging to the Sub-class Pterygota. Under Sub-class Pterygota, out of the two division, Division Endopteryogota dominates over Division Exopteryogota with 33 number of species. The species account of the two division in percentage is given in Figure: 3.1. Seven Exopterygotan and five Endopterygotan orders were found. In Exopterygota, Order Orthoptera and Hemiptera dominate over other with five species each while Order Phasmatodea and Dermaptera have the least number of species (one species each) (Fig 3.2). In Endopterygota, Order Coleoptera has the highest number of species (11) while Order Neuroptera contains only a single species (Fig 3.3). Overally from all the 12 orders found, Coleoptera dominates over other 11 orders.

The mung bean insect diversity of Cuttack and Jagatsinghpur were found to be similar. 42 insect species were found from Cuttack while Jagatsinghpur yielded 39 insect species. The species found from the 4 green gram fields studied is given in

Table 3. The mung bean fields of Cuttack has a greater pest population (17 pests) than that of Jagatsinghpur (14 pests). Species like *Orosius orientalis, Nezara virudle, Crytozemia dispar, Mylabris pustulata and Spodoptera exigua* were only restricted to Mung bean fields of Cuttack. Two insect pests named *Hoplasoma unicolor and Monolepta signata* were found only from Jagatsinghpur.

Three types of insects were recorded according to the role they play in the mungbean field; Insect Pests, Beneficial Insects and Neutral Insects. The percentage of insects of different categories is given in Fig 3.4. Abundant beneficial insects were found to be present in the sampled mung bean field than that of Insect pests. Some neutral insects were also recorded which don't have any significant role in the *Vigna radiata* agroecosystem. Nineteen insect pests were found damaging the pulse field. The name of the insect pest and their targeted plant part along with reference is given in Table 6**.** Some pictures of the pest taken during study is also given. The resulted insect pests were found to targeting pods, stem, foliage, leaves and flowers and hence adversely affecting the productivity of mung bean. Out of the 19 insect pests 9 belong to the division Exopterygota and 10 to the division Endopterygota. Exopterygotan pests belong to 2 orders; Orthoptera & Hemiptera while Endopterygotan pest belong to 3 Orders; Coleoptera, Lepidoptera & Diptera. Most of the pests found were belonging to Order Coleoptera. The number and percentage of insect pests according to their order is given in Fig 3.5 and Fig 3.6 respectively. *Aphis craccivora, Nezara viridule, Euchrysops cnejus and Empoasca kerri* were found to be the most abundantly present pest. The population of Green stink bug (*Nezara viridule*) was found to be at its peak at the time of harvest. *Euchrysops cnejus* population was high during the flowering stage and started to decline later.

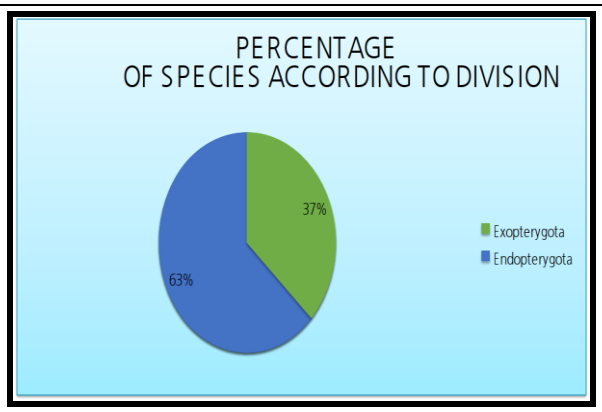


Fig 3.1: Pie Chart Showing Percentage of Species present in 2 Division of insects

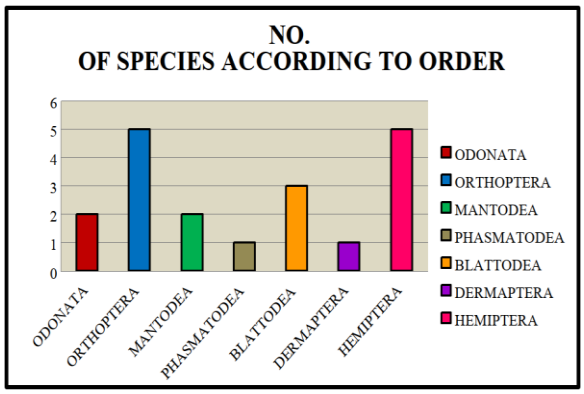


Fig 3.2: Bar Chart Showing number of Species present in the orders of division Exopterygota

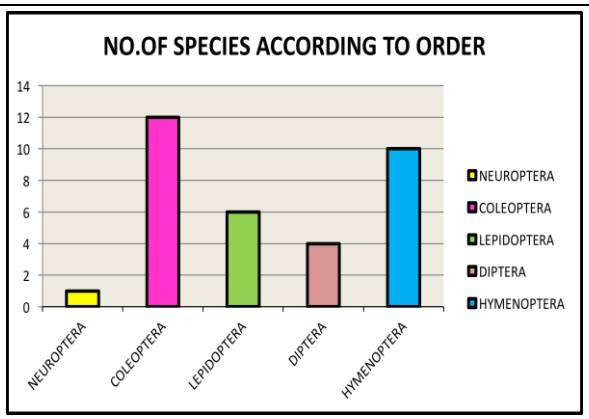


Fig 3.3: Bar Chart Showing number of Species present in the orders of division Endopterygota

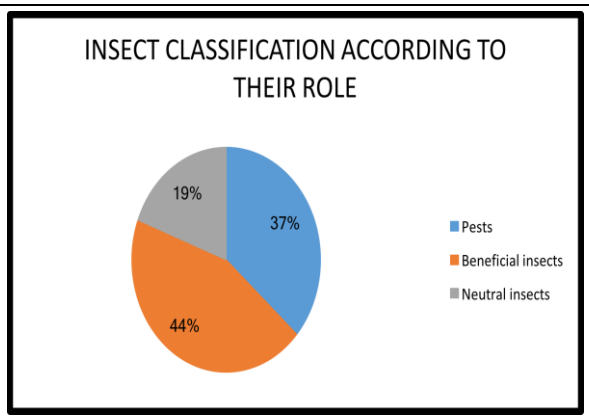


Fig 3.4: Pie chart showing percentage of insects with different roles

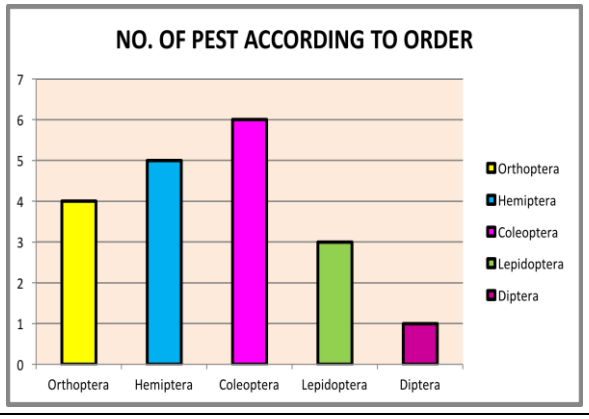


Fig 3.5: Bar chart showing order-wise insect pest numbe**r**

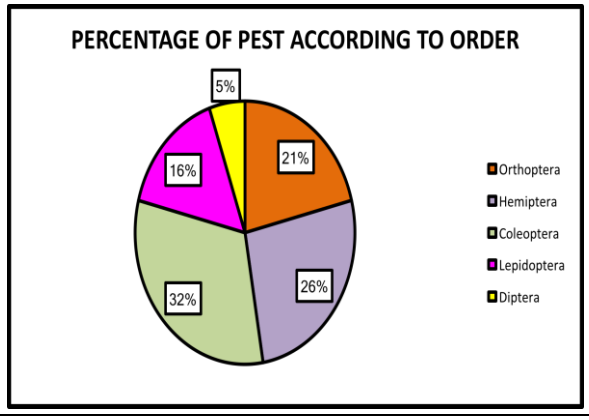


Fig 3.6: Pie-chart displaying insect pest percentage according to order

A total 23 beneficial insects were found. These beneficial insects increase the mung bean production directly or indirectly. They play an important role in controlling the insect pest population in the field. Many insects help in increasing the soil fertility. Although the mung bean is a self-pollinating plant but some insects contribute to pollination in some extent. The list of the beneficial insects along with their services is given in Table 7. Ladybird beetle (*Coccinella transversalis*), Dragonfly and Praying mantis (Mantis religiosa) were found to be the most abundant beneficial insect of the field. Some beneficial insects' figures are also given. (Fig 5.1-5.13).

The dominancy of beneficial insect was seen in the surveyed greengram field. Some predatory and parasitoid beneficial insects have the controll over the pest population.

Ten neutral insects were also seen. *Cossyphus depressus* was found from the field which was never reported before from Odisha [44]. The pictures of the neutral insects are also given. (Fig 6.1 - 6.8)

In the Mung bean agro-ecosystem of Eastern Odisha species like Ladybird beetle and Aphids are of common occurrence. But species like *Mylabris pustulata* are few. *Gonocephalum sp*. are rarely seen due to their burrowing secretive habits but they are abundant inside the soil. *Spodoptera exigua* are present abundantly but unfortunately not photographed.

Out of the 6 methods employed in insect collection, Simple observation technique was the most convenient one. Majority of species can be known just by simple observation. Sweep net technique, pitfall trap, light trap and water trap are also useful in insect collection. Pitfall trap with sugar is a useful technique to attract the species belonging to Family Formicidae. Aerial net technique was found useful in capturing moth, butterfly, dragonfly and damselfly. The species name and the most convenient way of its collection are given in Table 5**.**

Although the insect pest population was high in the studied field but the damage cause by them was not significant. It is because the beneficial insect are playing a crucial role in controling the pest and increasing the yield indirectly.

Table 2: Species systematic position

Division	Order	Family	Genus	Species
Exopterygota	Odonata	Libellulidae	*Diplacodes*	*spp.*
		Coenagrionidae	*Ischnura*	*spp.*
	Orthoptera	Gryllotalpidae	*Gryllotalpa*	*spp.*
		Gryllidae	*Gryllus*	*bimaculatus*
		Pyrgomorphidae	*Chrotogonus*	*spp.*
		Acrididae	*Attractomorpha*	*crenulata*
			Oxya	*velvox*
	Mantodea	Mantidae	*Amantis*	*spp.*
			Mantis	*religiosa*
	Phasmatodea	Phasmatidae	*Carausius*	*morosus*
	Blattodea	Termitidae	*Odontotermes*	*horni*
		Blattidae	*Periplaneta*	*americana*
		Ectobiidae	*Blattella.*	*spp*
	Dermaptera	Forficulidae	*Forficula*	*auricularia*
	Hemiptera	Cicadellidae	*Empoasca*	*kerri*
			Orosius	*orientalis*
		Pentatomidae	*Nezara*	*viridule*
		Alydidae	*Riptortus*	*pedestris*
		Aphididae	*Aphis*	*craccivora*
Endopterygota	Neuroptera	Ascalaphidae	*Ascalaphus*	*sinister*
	Coleoptera	Coccinellidae	*Coccinella*	*transversalis*
		Curculionidae	*Cyrtozemia*	*dispar*
			Myllocerus	*discolor*
		Meloidae	*Mylabris*	*pustulata*
		Elateridae	*Melanotus*	*spp.*
		Tenebrionidae	*Cossyphus*	*depressus*
			Gonocephalum	*spp.*
		Carabidae	*Pheropsophus*	*spp.*
			Nebria	*livida*
		Lampyridae	*Luciola*	*praeusta*
		Chrysomelidae	*Hoplasoama*	*unicolor*
			Monolepta	*signata*
	Lepidoptera	Papilionidae	*Papilio*	*demoleus*
		Lycaenidae	*Euchrysops*	*cnejus*
		Noctuidae	*Spodoptera*	*exigua*
			Helicoverpa	*armigera*
		Erebidae	*Amata*	*passalis*
		Nymphalidae	*Danaus*	*genutia*
	Diptera	Muscidae	*Musca*	*domestica*
		Syrphidae	*Ischiodon*	*scutellaris*
		Calliphoridae	*Lucilia*	*sericata*
		Agromyzidae	*Ophiomyia*	*phaseoli*
	Hymenoptera	Apidae	*Apis*	*florea*
				dorsata
		Formicidae	*Paratrechina*	*longicornis*
			Camponotus	*radiatus*
				compressus
			Meranoplus	*bicolor*
			Monomorium	*pharaonis*
			Pheidole	*watsoni*
		Braconidae	*Aphidius*	*colemani*
		Vespidae	*Polistes*	*olivaceus*

Table 3: Table showing Species presence in different sampled field (P-Present)

Species Name	JSPUR 1	JSPUR 2	CUT 1	CUT 2
Diplacodes spp	P	P	P	P
Ischnura spp.	P	P	P	P
Gryllotalpa spp.		P		
Gryllus bimaculatus	P	P	P	
Chrotogonus spp.	P		P	
Attractomorpha crenulata	P	P	P	P
Oxya velvox	P	P	P	P
Amantis spp.	P			P
Mantis religiosa			P	
Carausius morosus			P	
Odontotermes horni	P		P	
Periplaneta americana			P	P
Blattella. spp.				P
Forficula auricularia	P	P	P	
Empoasca kerri	P	P	P	P
Orosius orientalis			P	P
Nezara viridule			P	
Riptortus pedestris	P		P	
Aphis craccivora	P	P	P	P
Ascalaphus sinister	P			
Coccinella transversalis	P	P	P	P
Cyrtozemia dispar			P	
Myllocerus discolor	P		P	
Mylabris pustulata			P	
Melanotus spp.	P	P	P	
Cossyphus depressus	P			
Gonocephalum spp.	P	P	P	P
Pheropsophus spp.			P	
Nebria livida	P		P	
Luciola praeusta	P	P	P	P
Hoplasoama unicolor	P			
Monolepta signata	P			
Papilio demoleus	P			P
Euchrysops cnejus	P	P	P	P
Spodoptera exigua				P
Helicoverpa armigera	P			P
Amata passalis			P	
Danaus genutia	P			
Musca domestica	P		P	
Ischiodon scutellaris	P	P		P
Lucilia sericata	P			
Ophiomyia phaseoli	P		P	
Apis florea	P		P	P
Apis dorsata	P			
Paratrechina longicornis	P	P	P	
Camponotus radiatus			p	
Camponotus compressus	P	P	P	P
Meranoplus bicolor	P			
Monomorium pharaonis	P			
Pheidole watsoni			P	
Aphidius colemani	P		P	P
Polistes olivaceus	P		P	P

Table 4: Species scientific name along with English name, Taxonomic Authority and Nature of insect.

Sl No	Scientific Name	English Name	Taxonomic Authority	Nature
1	*Diplacodes spp.*	Dragonfly	Kirby,1889	Beneficial
2	*Ischnura spp.*	Western golden dartlet Damselfly	Charpentier,1804	Beneficial
3	*Gryllotalpa spp.*	Mole cricket	Latreille,1802	Beneficial
4	*Gryllus bimaculatus*	Field cricket	DeGeer,1773	Pest
5	*Chrotogonus spp.*	.Grasshopper	Uvarov,1938	Pest
6	*Attractomorpha crenulata*	Tobacco grasshopper	Fabricius,1793	Pest
7	*Oxya velvox*	Short horned grasshopper	Fabricius, 1787	Pest
8	*Amantis spp*	Praying mantis	Tos, 1915	Beneficial
9	*Mantis religiosa*	Praying mantis	Linnaeus,1758	Beneficial
10	*Carausius morosus*	Stick insect	Sinety,1901	Neutral
11	*Odontotermes horni*	Termite	Wasmann,1902	Beneficial
12	*Periplaneta americana*	Cockroach	Burmeister,1838	Neutral
13	*Blattella. spp*	Brown cockroach	Caudell	Neutral
14	*Forficula auricularia*	Ear wig	Linnaeus,1758	Beneficial
15	*Empoasca kerri*	Green leaf hopper	Walsh,1802	Pest
16	*Orosius orientalis*	Brown leaf hopper	Distant,1918	Pest
17	*Nezara viridule*	Green stink bug	Linnaeus,1758	Pest
18	*Riptortus pedestris*	Bean bug	Fabricius,1775	Pest
19	*Aphis craccivora*	Black legume aphid	C.L.Koch,1854	Pest

20	*Ascalaphus sinister*	Owlfly	Walker,1853	Neutral
21	*Coccinella transversalis*	Transverse Lady beetle	Fabricius,1781	Beneficial
22	*Cyrtozemia dispar*	Weevil	Pascoe	Pest
23	*Myllocerus discolor*	Weevils	Boheman, 1834	Pest
24	*Mylabris pustulata*	Blister Beetle	Fabricius,1775	Pest
25	*Melanotus spp.*	.Click beetle	Erichson, 1829	Neutral
26	*Cossyphus depressus*		Fabricius,. 1781	Neutral
27	*Gonocephalum spp*	Dusty brown beetle	Chevrolat,1849	Pest
28	*Pheropsophus spp*	Bombardier beetle	Solier, 1833	Beneficial
29	*Nebria livida*	Common ground beetle	Linnaeus,1758	Beneficial
30	*Luciola praeusta*	Firefly	Laporte,1833	Neutral
31	*Hoplasoama unicolor*	Leaf beetle	llliger,1800	Pest
32	*Monolepta signata*	White-spotted leaf beetle	Olivzer,1808	Pest
33	*Papilio demoleus*	Common lime Butterfly	Linnaeus,1758	Beneficial
34	*Euchrysops cnejus*	The gram blue	Fabricius,1798	Pest
35	*Spodoptera exigua*	Small mottled willow moth	Hübner, 1808	Pest
36	*Helicoverpa armigera*	The cotton bollworm	Hubner,1808	Pest
37	*Amata passalis*	Sandalwood Defoliator	Fabricius,1781	Neutral
38	*Danaus genutia*	Striped tiger butterfly	Cramer,1779	Beneficial
39	*Musca domestica*	House fly	Linnaeus,1758	Neutral
40	*Ischiodon scutellaris*	Common Hover fly	Fabricius,1805	Beneficial
41	*Lucilia sericata*	Common green bottle fly	Meigen, 1826	Neutral
42	*Ophiomyia phaseoli*	Bean fly	Tryon,1895	Pest
43	*Apis florea*	Little honey bee	Fabricius,1787	Beneficial
44	*Apis dorsata*	Giant honey bee	Fabricious,1793	Beneficial
45	*Paratrechina longicornis*	Crazy Ant	Latreille,1802	Beneficial
46	*Camponotus radiatus*	Carpenter ant	Forel,1892	Beneficial
47	*Camponotus compressus*	Carpenter ant	Fabricius,1787	Beneficial
48	*Meranoplus bicolor*	Ant	Guerin-Meneville,1787	Beneficial
49	*Monomorium pharaonis*	Pharaoh ant	Linnaeus,1758	Beneficial
50	*Pheidole watsoni*	Spiny Harvester Ant	Westwood,1839	Beneficial
51	*Aphidius colemani*	Parasitic wasp	Haliday,1834	Beneficial
52	*Polistes olivaceus*	Yellow paper wasp	DeGeer,1773	Beneficial

Table 5: Table showing species name and the method of its Capture.

Sl no	Species name	Method of capture
1	*Diplacodes spp*	Aerial net
2	*Ischnura spp.*	Aerial net
3	*Gryllotalpa spp.*	Pitfall trap
4	*Gryllus bimaculatus*	Pitfall trap
5	*Chrotogonus spp.*	Sweep net
6	*Attractomorpha crenulata*	Sweep net, Light trap
7	*Oxya velvox*	Sweep net, Water trap
8	*Amantis spp.*	Light Trap
9	*Mantis religiosa*	Aerial Net
10	*Carausius morosus*	Sweep net
11	*Odontotermes horni*	Pitfall trap
12	*Periplaneta americana*	Water trap
13	*Blattella. spp.*	Pitfall trap
14	*Forficula auricularia*	Observed in the field
15	*Empoasca kerri*	Light trap, Sweep net
16	*Orosius orientalis*	Light trap
17	*Nezara viridule*	Sweep net
18	*Riptortus pedestris*	Sweep net
19	*Aphis craccivora*	Observed in the field
20	*Ascalaphus sinister*	Observed in the field
21	*Coccinella transversalis*	Sweep net
22	*Cyrtozemia dispar*	Pitfall trap
23	*Myllocerus discolor*	Sweep net
24	*Mylabris pustulata*	Observed in the field
25	*Melanotus spp.*	Water trap
26	*Cossyphus depressus*	Pitfall trap
27	*Gonocephalum spp.*	Pitfall trap
28	*Pheropsophus spp*	Water trap
29	*Nebria livida*	Water trap
30	*Luciola praeusta*	Aerial net
31	*Hoplasoama unicolor*	Observed in the field
32	*Monolepta signata*	Water trap
33	*Papilio demoleus*	Observed in the field
34	*Euchrysops cnejus*	Sweep net, Light trap
35	*Spodoptera exigua*	Observed in the field
36	*Helicoverpa armigera*	Observed in the field
37	*Amata passalis*	Aerial net
38	*Danaus genutia*	Observed in the field

39	*Musca domestica*	Water trap,Sweep net
40	*Ischiodon scutellaris*	Observed in the field
41	*Lucilia sericata*	Observed in the field
42	*Ophiomyia phaseoli*	Water trap
43	*Apis florea*	Sweep net
44	*Apis dorsata*	Sweep net
45	*Paratrechina longicornis*	Pitfall trap with sugar
46	*Camponotus radiatus*	Pitfall trap with sugar
47	*Camponotus compressus*	Pitfall trap with sugar
48	*Meranoplus bicolor*	Observed in the field
49	*Monomorium pharaonis*	Pitfall trap
50	*Pheidole watsoni*	Observed in the field
51	*Aphidius colemani*	Water trap, Sweep net
52	*Polistes olivaceus*	Observed in the field

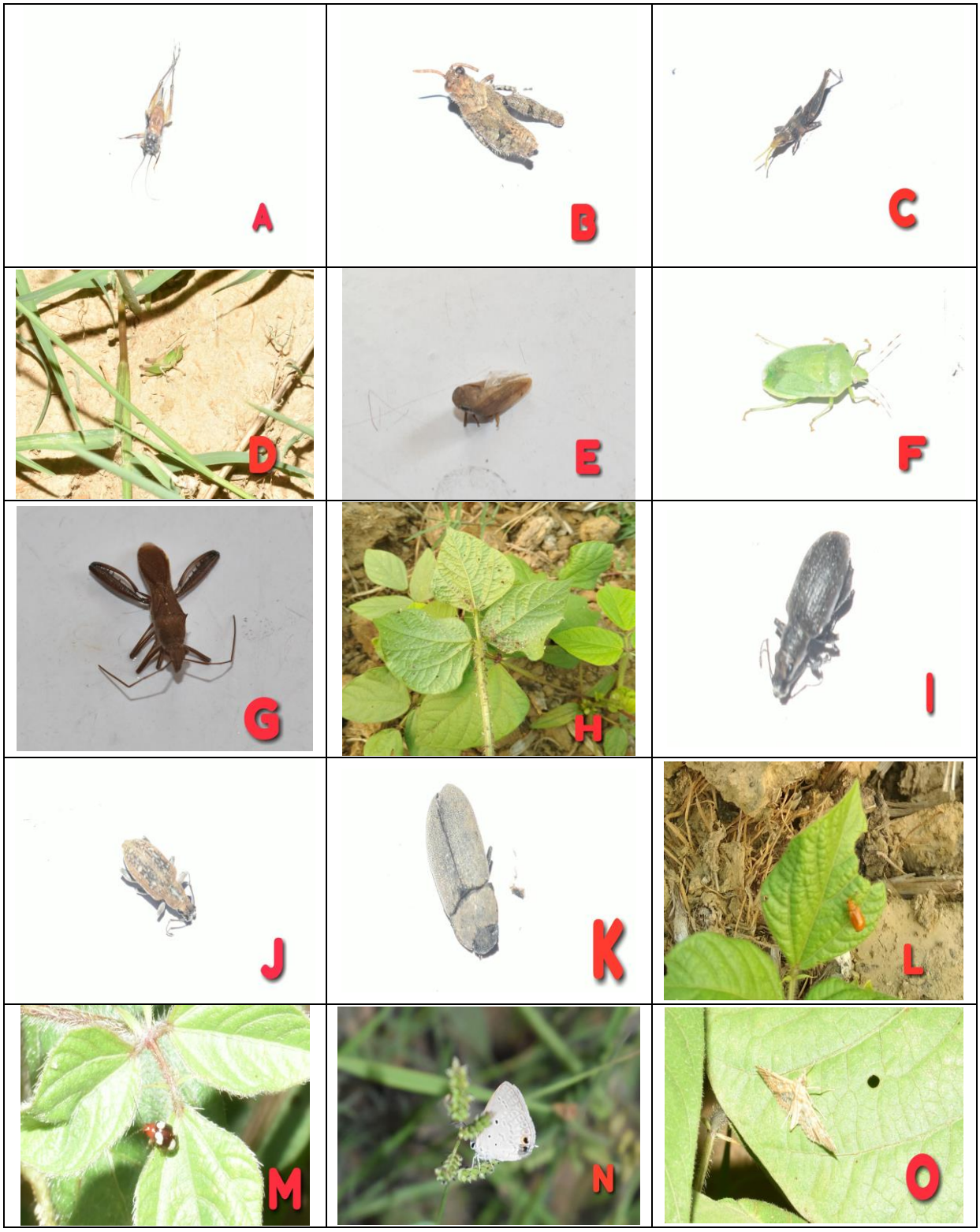
Table 6: List of Insect Pests found and their Targeted plant part with Reference

Insect pest	Plant part affected	Reference
Gryllus bimaculatus	Leaves	
Chrotogonus spp	Pods	45
Attractomorpha crenulata	Leaves	
Oxya velvox	Leaves Flowers Pods	46
Empoasca kerri	Leaves	47
Orosius orientalis	Leaves	
Nezara viridule	Pods	48
Riptortus pedestris	Pods	48
Aphis craccivora	Leaves Stem Flowers Pods	48
Cyrtozemia dispar	Foliage	49
Myllocerus discolor	Foliage	50
Mylabris pustulata	Buds Flowers	48
Gonocephalum spp	Stem	
Hoplasoama unicolor	Leaves	
Monolepta signata	Leaves	
Euchrysops cnejus	Pods	
Spodoptera exigua	Leaves	46
Helicoverpa armigera	Leaves Pods	48
Ophiomyia phaseoli	Stem	51

Table 7: List of Beneficial Insects found and their services to Mung bean field

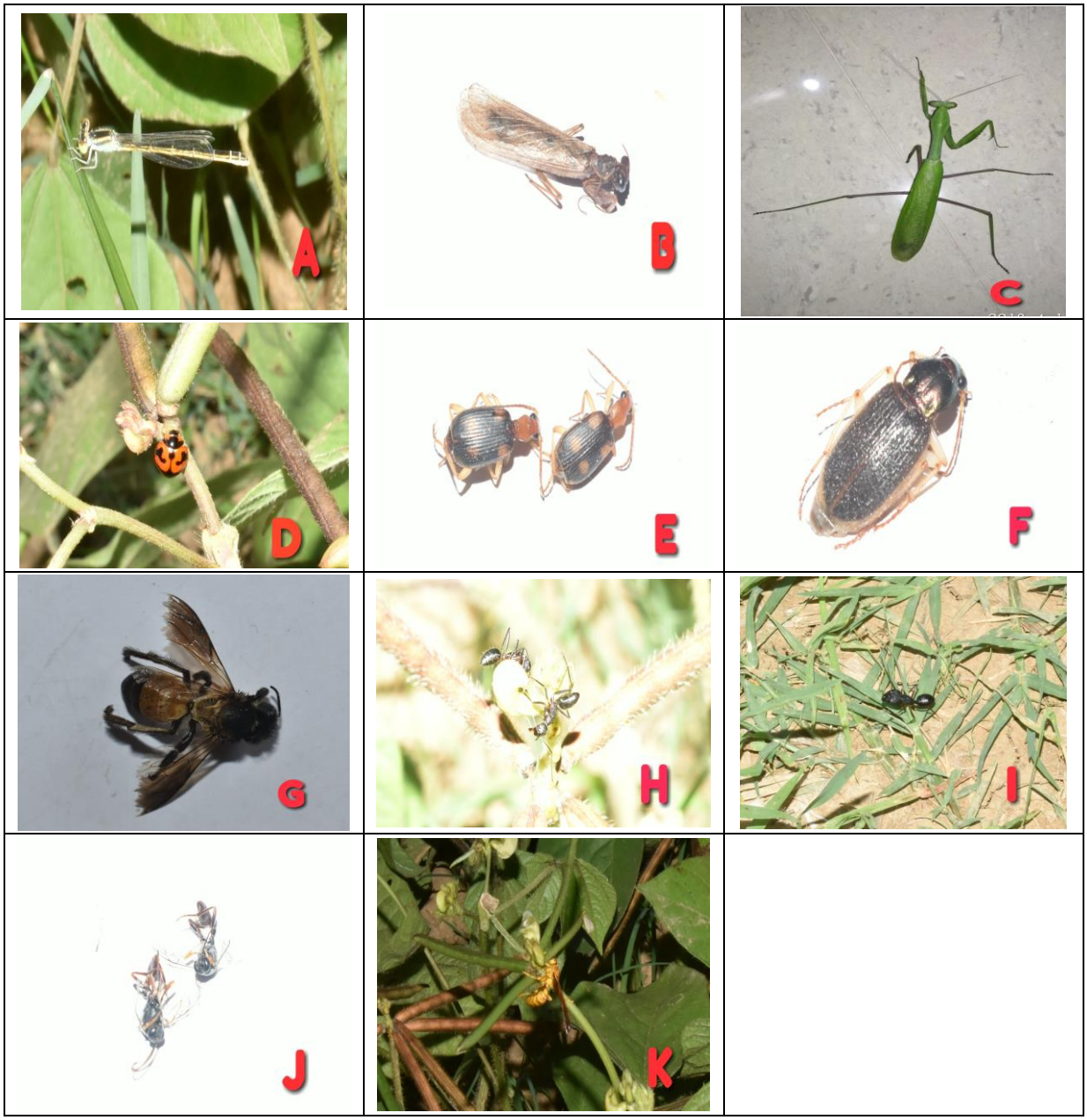
Sl no	Beneficial insect	Services
1	*Diplacodes spp*	Insect pest predator
2	*Ischnura spp.*	Insect pest predator
3	*Gryllotalpa spp*	Soil builder
4	*Amantis spp*	Feed mainly on flies
5	*Mantis religiosa*	Feed on grasshoppers, moths, aphids and flies
6	*Odontotermes horni*	Soil builders
7	*Forficula auricularia*	Predator of aphids, mites, thrips, leafhoppers, caterpillars, insect eggs, and whiteflies.
8	*Coccinella transversalis*	Adult and larvae feed on large numbers of small, soft-bodied insects such as aphids.
9	*Pheropsophus spp*	Insect pest predator
10	*Nebria livida*	Feed on cutworms and root maggots
11	*Papilio demoleus*	Pollination
12	*Danaus genutia*	Pollination
13	*Ischiodon scutellaris*	Feed on aphid, scales, thrips and other small soft-bodied insects in larval stage. Larvae spear aphids with jaws and suck out internal juices.
14	*Apis florea*	Pollination
15	*Apis dorsata*	Pollination
16	*Paratrechina longicornis*	Insect pest predator, Soil Builders
17	*Camponotus radiatus*	Insect pest predator, Soil builders
18	*Camponotus compressus*	Insect pest predator, Soil builders
19	*Meranoplus bicolor*	Insect pest predator, Soil builder
20	*Monomorium pharaonis*	Insect pest predator, Soil builders
21	*Pheidole watsoni*	Insect pest predator, Soil builders
22	*Aphidius colemani*	Females inject their eggs into pests like aphids, flies, beetles and many caterpillars. Larvae grow by absorbing nourishment and ultimately leads to the death of the pest.
23	*Polistes olivaceus*	Predator of caterpillars and beetles

Plate 1 (Pests)



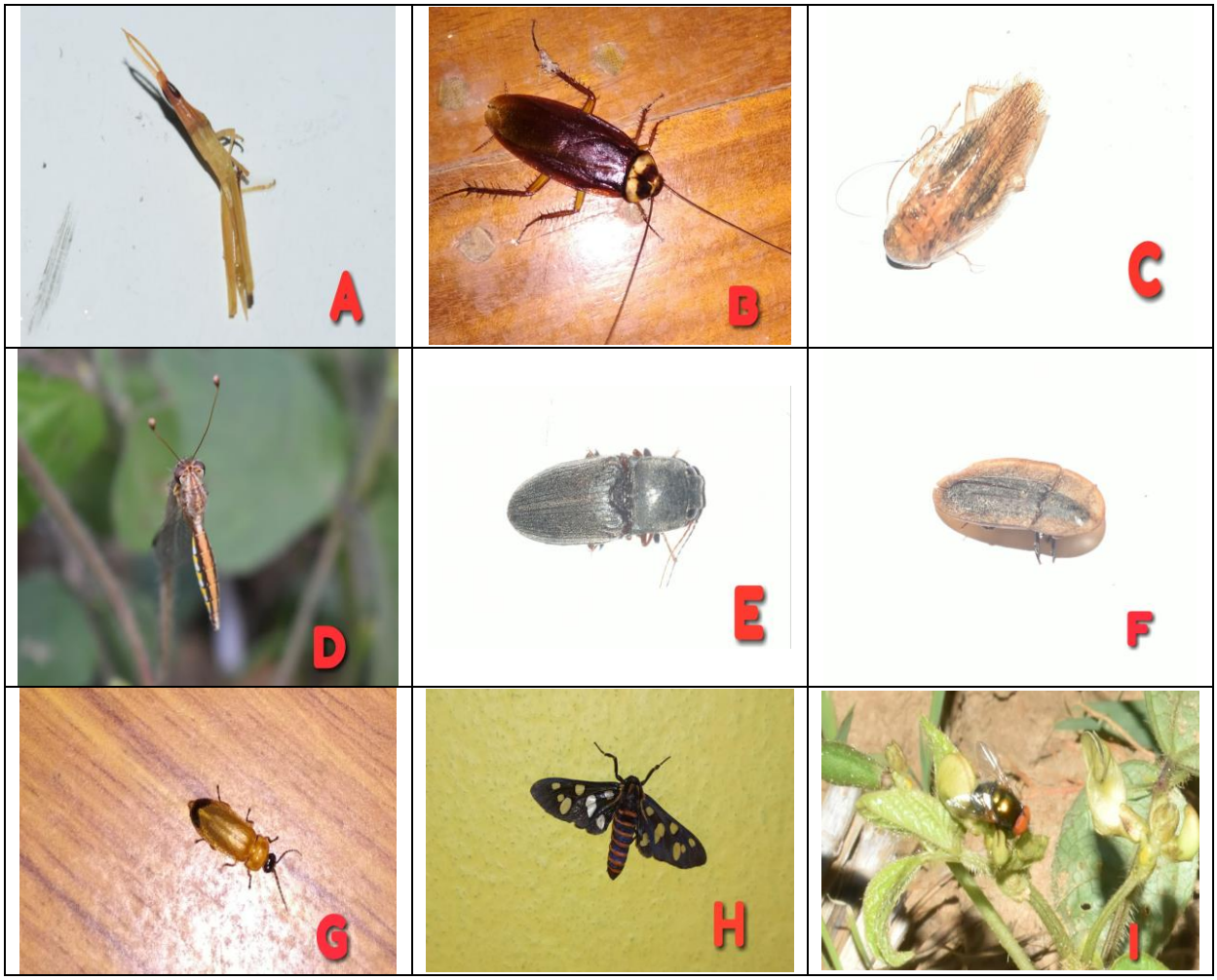
(A-*Gryllus bimaculatus*, B-*Chrotogonus spp*, C-*Atractomorpha crenulata*, D-*Oxya velvox*, E-*Orosius orientalis*, *F-Nezara viridule*, *G-Riptortus pedestris*, H-*Aphis craccivora*, I-*Cyrtozemia dispar*, J-Myllocerus discolor, K-Gonocephalum spp, L-*Hoplasoama unicolor*, M-*Monolepta signata*, N-*Euchrysops cnejus*, O-*Helicoverpa armigera*)

Plate 2 (Beneficial Insects)



(A-*Ischnura spp*, B-*Amantis spp*, C-*Mantis religiosa*, D-*Coccinella transversalis*, E-*Pheropsophus spp*, F-*Nebria livida*, G-*Apis dorsata*, H-*Paratrechina longicornis*, I-*Camponotus compressus*, J-*Aphidius colemani*, K-*Polistes olivaceus*)

Plate 3 (Neutral Insects)



(A-*Carausius morosus*, B-*Periplaneta americana*, C-*Blattella spp*, D-*Ascalaphus sinister*, E-*Melanotus spp*, F-*Cossyphus depressus*, G-*Luciola praeusta*, H-*Amata passalis*, I-*Lucilia sericata*)

4. Conclusion

The present study concluded that in the moong field, both insect pest and beneficial insect are present in a common canopy. Common farmer/people consider all insects as pest and apply pesticide for their eradication. The motive of the farmers is to gain maximum profit so they ignore the importance of the beneficial insects. Insecticide can be an important crop production tool to maximize yield but heavy and indiscriminate use of chemicals also result in negative consequences for the insects those are beneficial to the farmers. Field shared by many beneficial insects positively affect the crop yield so careful decision should be taken to manage the insect pests and awareness should be spreaded among farmers towards the value and role of beneficial insects in the agroecosystem. The loss of a positive insect from the moong-bean field will affect the entire biodiversity of the agro-ecosystem.

Pest specific pesticide should be used which don't have any adverse or negative effect on other insects. Pheromone based trap should be used in the moong field to catch a particular insect pest because pheromone is species specific. More studies and investigation should be done for improvement of pest management approach. Instead of pesticides biological pest control method should be undertaken in the green gram field because many beneficial insects can be used to control the pest.

There was no significant rainfall occurred during the study. More rain fall might have resulted in higher insect population.But unfortunately this link is missing from this study.

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