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**Research Article**

# BIODIVERSITY OF INSECTS IN ORGANIC AND CHEMICAL VEGETABLE FIELDS IN TIRUVALLUR DISTRICT, TAMIL NADU, INDIA

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## ABSTRACT

Insect diversity study was carried out in vegetable fields from January-2012 to December 2013 one organic and one chemical vegetable field were selected. Among the different orders Coleopteran was found to have high diversity. Order Odonata and Coccinellidae contained 16 and 13 species respectively. Both organic and chemical farms supported the same number of insect orders. Among the two different farming practices, organic field recorded higher number of taxa during January-June in the year 2012. Maximum number of individuals was collected from organic field. Maximum number of individuals from all taxa was collected during July – December 2012 in organic field. The other season (January-June 2012) also recorded high number of total individuals from organic field. In chemical field very low number of individuals was collected during January-June and July to December in both the year. In the present study maximum insect abundance and total number of individuals were recorded in organic fields. The study proved that organic farming practices can help in the population build-up of natural enemies and pollinators.

**Key words:** Diversity, Pattabiram, Shannon's index, Panchakavya, *Epilachna*, Simpson index.

## INTRODUCTION

Agricultural intensification and structural changes in the agricultural landscapes in recent years have led to the over exploitation of agrochemicals, which in turn have caused a decline in farmland biodiversity. A long term use of synthetic pesticides and fertilizers during the past 50 years has resulted in degradation of soil quality. Soil health is an important criterion for improving the agricultural productivity. The invention of synthetic fertilizers and pesticides has led to overexploitation of these chemicals by farmers with an aim to get very high productivity and profit. Starting from the green revolution time in 1960s in India farmers are largely relying on chemicals alone. Due to this over application of synthetic chemicals in soil, the sustainability has been lost and farmers have to load heavy quantities of synthetic fertilizers in the soil each time whenever they grow crops. In chemical farming, chemical plant protectants and chemical fertilisers are very common.

Organic farming is a method of farming system which primarily aims at raising crops using organic wastes and other biological materials along with beneficial microbes (biofertilizers) for increased sustainable production without spoiling the soil health. For thousands of years farmers are using organic wastes as fertilizers. Organic wastes do not spoil the soil health and soil microorganisms. *United States Department of Agriculture* (USDA) study team defines organic farming as 'a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives, etc.) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection' (Lampkin *et al.*, 2012). Food and Agricultural Organization states: (FAO) 'Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs' (Jahanban and Davari, 2012).

In recent years public is much aware of the side effects of chemicals in the environment and human health. Farmers are also realising that

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organic farming is better solution for sustainable development. Whenever there is a shift from one method of cultivation practice to another, it will lead to a change in the biodiversity in the agroecosystem. Recently ecologists have tried to understand the effect of organic farming practices on the population, distribution and species richness of beneficial and harmful insects (Youngberg *et al.,* 1984; Isart and Llerena, 1996). In India, especially in Tamil Nadu, very limited works have been done on this aspect. Hence the present study was undertaken to analyse the impact of organic farming and chemical farming practices on insect diversity in vegetable fields in Tiruvallur District of Tamil Nadu.

## MATERIALS AND METHODS

**Study area:** The study was conducted in two different villages in Tiruvallur District, Tamil Nadu. Organic farm was maintained in Vayalanallur village. In organic farm, the farmer applied only organic fertilizers like farm yard manure, vermicompost and biofertilizers. The farmer was continuously following organic farming practices for the previous ten years in the same field. Botanical pesticides such as neem-based commercial formulations and crude extracts of neem seed kernel and leaves of neem, *Calotropis* and *Vitex* were used as pesticides. 'Panchakavya; a natural formulation was used as plant growth promotor as well as pesticide.

The chemical farm, in which chemical fertilizers and chemical pesticides were applied, was located in 'Pattabiram' village. In this farm, the farmer followed chemical method of pest control and crop management. Synthetic fertilizers like Urea and Diammoniam phosphate were applied in the farm.

In each organic and chemical farm, one acre field area was selected for insect sampling.

**Insect collection:** Insects were sampled using sweeping net, hand picking method and beating sheet. All the collected insects were killed by ethyl acetate vapour and sorted out into families. Small and soft bodied insects were preserved in 70% ethanol and large insects were mounted by pins. All the insects were identified up to species level by following the identification keys as mentioned in Chapter-I. Some insects were identified with the help of experts.

**Diversity analysis:** Total number of individuals collected under each insect family was recorded. The biodiversity indices namely richness, Hill`s number (N0), Margalef index (R1), Menhinick index (R2), Simpson`s index (λ), Shannon`s index (H`), Hill`s diversity N0. 1 (N1), Hill`s diversity No.2 (N2) and Evenness indices (E1 to E5) were derived from data collected from both organic and chemical farms. PAST software was used to calculate the diversity indices.

## RESULTS

### Species composition

The vegetable fields in Tiruvallur District recorded 10 insect orders irrespective of farming practices. The insect orders collected were: Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Orthoptera, Lepidoptera, Mantodea, Neuroptera and Odonata. Among the different orders, Coleoptera was found to be the most diverse group of taxa, which included both phytophagous and predatory insects. Order Odonata and Predatory ladybird beetles (Coccinellidae) contained 16 and 13 species, respectively. Both organic and chemical farms supported the same number of insect orders. But the number of families and lower taxa such as genera and species was not the same between organic and chemical farms. Total number of taxa was generally found to be higher in the year 2012 in both organic and chemical fields. Among the two different farming practices, organic field recorded higher number of taxa during January-June in the year 2012. In the next season of the year 2012 or in the next year (2013) there was no difference found in the total number of taxa present between organic and chemical fields.

### Diversity in the year 2012

The total number of taxa, collected from organic and chemical fields, was 130 and 127, respectively during Januray-June and 121 and 121, respectively during July-December (Table 1). Maximum number of individuals was collected from organic field. Maximum number of individuals from all taxa (4701) was collected during July-December in organic field (Figure 1). The other season (January-June) also recorded higher number of total individuals (3266) from organic field. In chemical field very low number of individuals was collected during January-June (2929) and July to December (2090) (Table 2, Figure 2).

In organic field, relative abundance of natural enemies was more and in chemical field relative abundance of phytophagous insects was high. In the first season (Januray-June of 2012) relative abundance of ant was maximum (8.72) in organic field ladybird beetles (6.79), prey mantis (6.5), hoverflies (6.21) and stink bugs (6.30) abundances were also higher in the same field (Table 3). In chemical field, *Epilachna* beetles, leaf beetles and aphids showed maximum relative abundance in all the seasons of both years (Figure 4). In general, ants and ladybird beetles showed very high relative abundances in organic field.

There were no significant differences in Evenness and Shannon-Wiener indices between organic and chemical fields.

**Diversity in the year 2013**

In the year 2013, the total number of individuals collected from organic field was 4489 and 5241 in January-June and July-December, respectively (Figure 3). In chemical field, 3447 and 2914 individuals were collected during January-June and July-December, respectively (Table 4). The population of natural enemies such as predatory insects and parasitoids increased in the organic field, which was evident from the relative abundance data (Table 3). The results revealed that the populations of whiteflies, thrips, and dipteran flies increased in brinjal and okra fields, where chemical agricultural practices were followed. As like the year 2012, the relative abundances of natural enemies were more in organic farms and phytophagous insects were more in chemical fields. In the first season (January-June) of the year 2013, the relative abundance of ants (9.93) and predatory ladybird beetles (8.19) was higher than other group of insects. But in chemical farm, the same season showed that *Epilachna* beetles (8.23) and aphids (7.77) were more abundant (Table 3). During the period from July-December, the relative abundance of ladybird beetles (10.07) and aphids (6.48) was high.

**Table 1.** Total number of species (species richness) recorded under insect groups/families registered from organic and chemical agroecosystems in Tiruvallur District during the years 2012 and 2013.

| Insect Group | Year 2012 | | | | Year 2013 | | | |
|---|---|---|---|---|---|---|---|---|
| | Jan - June | | July-Dec. | | Jan.-June | | July-Dec. | |
| | Organic | Chemical | Organic | Chemical | Organic | Chemical | Organic | Chemical |
| Ladybird beetles | 13 | 10 | 13 | 11 | 13 | 8 | 13 | 11 |
| Carabidae | 12 | 4 | 11 | 5 | 8 | 4 | 10 | 4 |
| Syrphidae | 4 | 3 | 4 | 2 | 5 | 3 | 4 | 2 |
| Sting bug | 8 | 6 | 8 | 5 | 7 | 5 | 7 | 4 |
| Hover fly | 6 | 4 | 6 | 4 | 6 | 4 | 5 | 4 |
| Dragonflies | 16 | 11 | 15 | 11 | 16 | 10 | 15 | 11 |
| Green lacewings | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Ants | 18 | 15 | 18 | 12 | 17 | 14 | 18 | 13 |
| Prey mantids | 3 | 2 | 3 | 2 | 3 | 1 | 3 | 2 |
| Jassids | 4 | 6 | 4 | 6 | 2 | 4 | 3 | 5 |
| Green leaf hopper | 5 | 6 | 3 | 6 | 3 | 6 | 4 | 6 |
| Whiteflies | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Aphids | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Hodded hopper | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Vegetable bug | 4 | 6 | 4 | 6 | 3 | 6 | 5 | 6 |
| Epilachna beetle | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Leaf beetle | 8 | 14 | 7 | 12 | 8 | 12 | 7 | 13 |
| Flea beetle | 2 | 3 | 2 | 4 | 2 | 3 | 2 | 3 |
| Flower beetle | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 3 |
| Grasshoppers | 6 | 8 | 4 | 8 | 5 | 8 | 3 | 6 |
| Semilooper | 5 | 7 | 5 | 6 | 4 | 6 | 4 | 7 |
| Red spider mites | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| S.F. borer | 1 | 3 | 1 | 2 | 1 | 3 | 1 | 2 |
| Fruit fly | 4 | 6 | 3 | 6 | 3 | 6 | 2 | 6 |
| Field cricket | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Total number of taxa | 130 | 127 | 121 | 121 | 116 | 116 | 113 | 117 |

**Table 2.** Diversity indices for insects present in organic field and Chemical field in Vayalanallur village in the year 2012.

| Number of individuals | | Organic field | | Chemical applied field | |
|---|---|---|---|---|---|
| | | First season (Jan-June) | Second season (Jul-Dec) | First season (Jan-June) | Second season (Jul-Dec) |
| | | 3266 | 4701 | 2929 | 2090 |
| Richness | R1 | 2.96 | 2.83 | 3.006 | 3.13 |
| | R2 | 0.43 | 0.36 | 0.46 | 0.54 |
| Diversity | Simpson (1-D) | 0.95 | 0.94 | 0.94 | 0.95 |
| | Shannon (H) | 3.10 | 3.09 | 3.08 | 3.12 |
| | N1 | 22.23 | 21.98 | 21.95 | 22.64 |
| | N2 | 20.34 | 20.01 | 19.73 | 20.99 |
| Eveness | E1 | 0.96 | 0.96 | 0.95 | 0.96 |
| | E2 | 0.88 | 0.87 | 0.87 | 0.90 |
| | E3 | 0.92 | 0.91 | 0.91 | 0.94 |
| | E4 | 0.013 | 0.013 | 0.013 | 0.013 |
| | E5 | 0.033 | 0.033 | 0.033 | 0.032 |

**Table 3.** Relative abundance of different insect groups/families recorded in organic and chemical fields in the years 2012 and 2013.

| Insect Group | Year 2012 | | | | Year 2013 | | | |
|---|---|---|---|---|---|---|---|---|
| | Jan - June | | July-Dec. | | Jan.-June | | July-Dec. | |
| | Organic | Chemical | Organic | Chemical | Organic | Chemical | Organic | Chemical |
| Ladybird beetles | 6.79 | 2.38 | 8.55 | 2.29 | 8.19 | 2.93 | 10.07* | 6.48 |
| Carabidae | 6.18 | 3.00 | 7.82 | 3.11 | 6.12 | 2.32 | 8.18 | 2.60 |
| Syrphidae | 4.19 | 2.25 | 5.48 | 2.29 | 6.63 | 3.71 | 6.12 | 4.18 |
| Sting bug | 6.30 | 2.90 | 5.29 | 3.30 | 6.14 | 4.29 | 5.76 | 3.22 |
| Hover fly | 6.21 | 2.73 | 4.80 | 3.39 | 4.87 | 2.26 | 5.30 | 2.47 |
| Dragonflies | 4.89 | 2.32 | 6.04 | 2.77 | 5.70 | 2.43 | 6.63 | 1.88 |
| Green lacewings | 3.24 | 1.33 | 3.31 | 1.57 | 6.32 | 1.76 | 6.23 | 2.02 |
| Ants | 8.72 | 3.82 | 6.93 | 3.58 | 9.93 | 4.20 | 7.93 | 3.84 |
| Prey mantids | 6.58 | 1.29 | 5.70 | 1.38 | 5.07 | 3.24 | 4.54 | 1.88 |
| Jassids | 3.98 | 2.49 | 3.82 | 3.11 | 3.23 | 4.32 | 2.90 | 4.22 |
| Green leaf hopper | 5.05 | 5.97 | 4.78 | 4.64 | 4.12 | 5.27 | 3.28 | 5.55 |
| Whiteflies | 5.35 | 7.78 | 5.46 | 6.12 | 3.51 | 7.04 | 3.60 | 6.31 |
| Aphids | 4.28 | 7.34 | 4.40 | 5.16 | 3.85 | 7.77 | 3.89 | 6.48 |
| Hodded hopper | 1.99 | 2.90 | 1.80 | 4.21 | 1.60 | 2.72 | 1.94 | 3.15 |
| Vegetable bug | 3.52 | 5.18 | 3.80 | 5.59 | 3.07 | 5.01 | 2.93 | 4.39 |
| Epilachna beetle | 1.95 | 9.38 | 1.76 | 7.46 | 2.80 | 8.23 | 2.63 | 5.35 |
| Leaf beetle | 3.33 | 6.28 | 3.14 | 7.27 | 2.62 | 4.84 | 1.86 | 6.03 |
| Flea beetle | 2.29 | 5.66 | 2.02 | 6.60 | 1.98 | 5.01 | 1.29 | 5.25 |
| Flower beetle | 1.80 | 2.38 | 2.29 | 2.63 | 2.02 | 2.58 | 2.44 | 2.60 |
| Grasshoppers | 2.35 | 4.43 | 2.87 | 3.11 | 2.18 | 3.53 | 2.06 | 4.04 |
| Semilooper | 2.26 | 5.63 | 1.80 | 5.98 | 1.75 | 4.20 | 2.38 | 4.52 |
| Red spider mites | 2.51 | 4.37 | 3.36 | 6.60 | 2.85 | 5.10 | 2.70 | 5.25 |
| S.F. borer | 2.69 | 2.69 | 1.95 | 3.11 | 2.40 | 2.58 | 2.34 | 2.71 |
| Fruit fly | 2.54 | 3.51 | 1.91 | 2.29 | 2.09 | 3.30 | 2.06 | 4.15 |
| Field cricket | 0.88 | 1.87 | 0.78* | 2.34 | 0.82 | 1.21 | 0.82 | 1.30 |

**Table 4.** Diversity indices for insects in organic and chemical-applied vegetable agroecosystems in Tiruvallur District during the year 2013.

| Number of individuals | | Organic field | | Chemical applied field | |
|---|---|---|---|---|---|
| | | First season (Jan-June) | Second season (Jul-Dec) | First season (Jan-June) | Second season (Jul-Dec) |
| | | 4489 | 5241 | 3447 | 2914 |
| Richness | R1 | 2.85 | 2.80 | 2.94 | 3.00 |
| | R2 | 0.37 | 0.34 | 0.42 | 0.46 |
| Diversity | Simpson (1-D) | 0.94 | 0.94 | 0.95 | 0.95 |
| | Shannon (H) | 3.07 | 3.05 | 3.12 | 3.14 |
| | N1 | 21.57 | 21.21 | 22.79 | 23.13 |
| | N2 | 19.16 | 18.59 | 21.10 | 21.93 |
| Evenness | E1 | 0.95 | 0.94 | 0.97 | 0.97 |
| | E2 | 0.86 | 0.84 | 0.91 | 0.92 |
| | E3 | 0.89 | 0.8 | 0.94 | 0.96 |
| | E4 | 0.013 | 0.014 | 0.013 | 0.012 |
| | E5 | 0.034 | 0.034 | 0.032 | 0.031 |

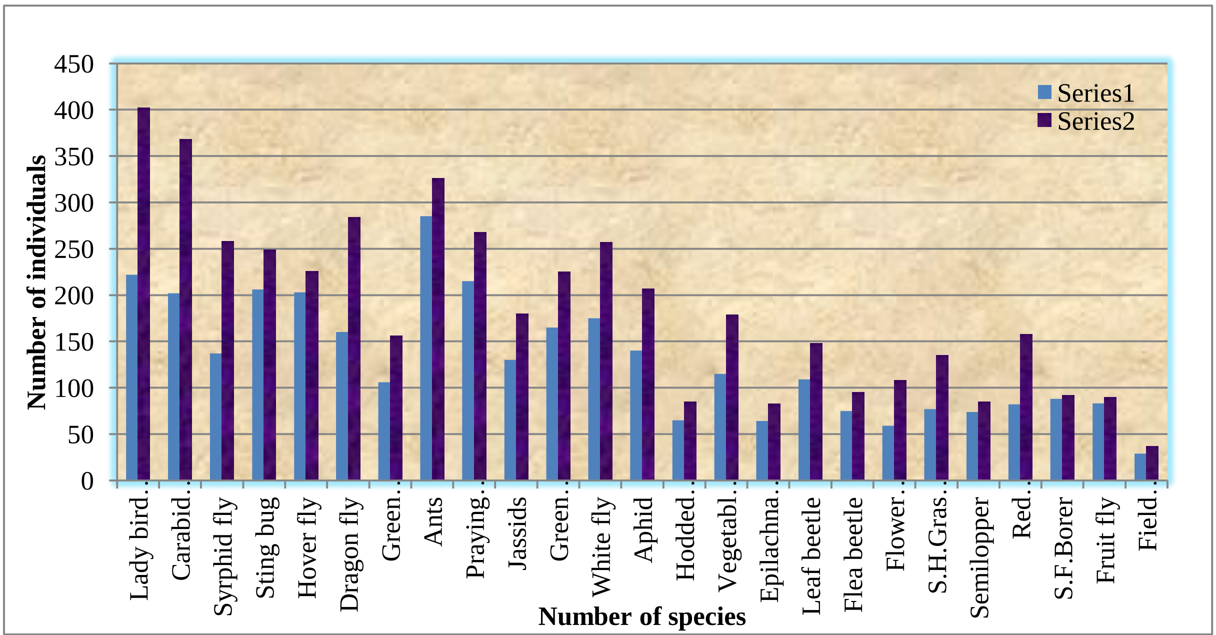


**Figure 1.** Observed Predator and Pest insects in organic field -2012 (Series-1 First season; Series -2 Second season).

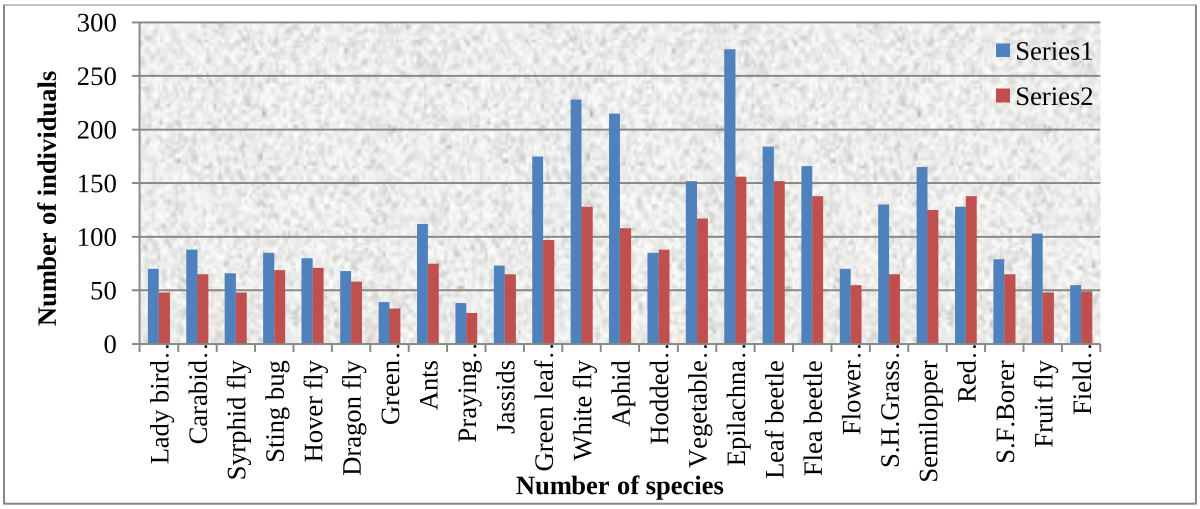


**Figure 2.** Observed Predator and Pest insects in Chemical applied field-2012 (Series-1 First season; Series -2 Second season).

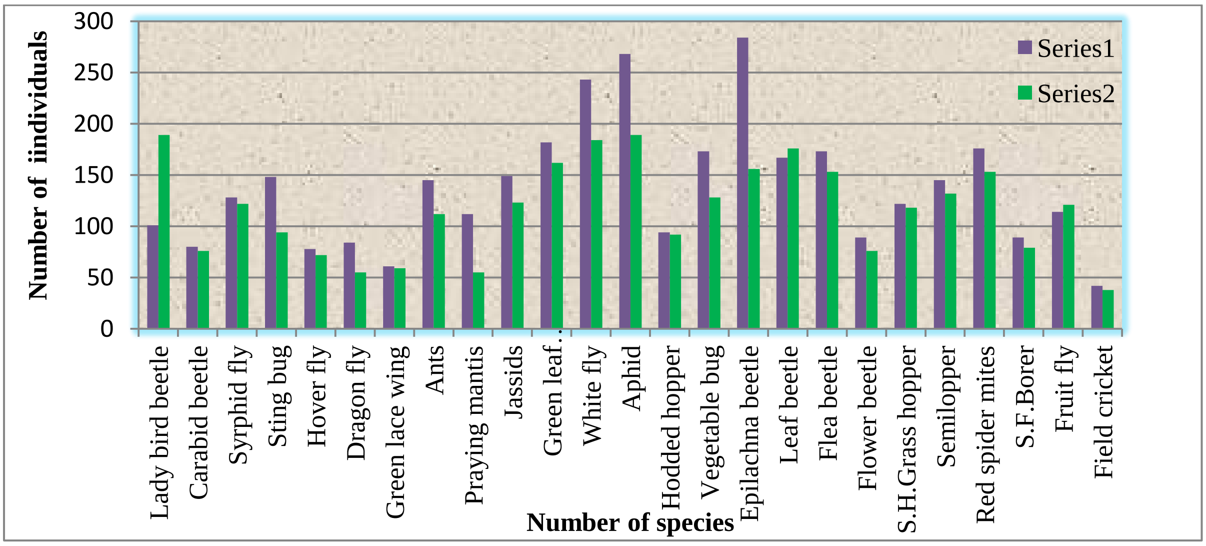


**Figure 3**. Observed Predator and Pest insects in organic field-2013 (Series-1 First season; Series -2 Second season).

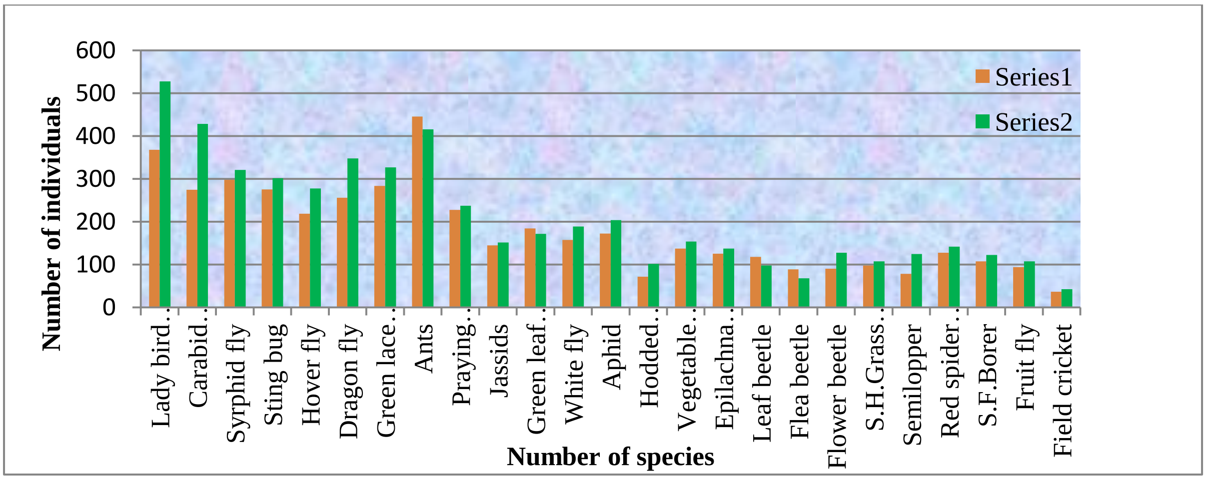


**Figure 4.** Observed Predator and Pest insects in Chemical applied field-2013 (Series-1 First season; Series -2 Second season).

## DISCUSSION

Biodiversity in agricultural landscapes is affected by many factors such as farming system, field margins, edge zones, habitat islands, hedgerows, natural pastures, wetlands, ditches, ponds and other small habitats (Bengtsson *et al.,* 2005). Biodiversity can be preserved by the restoration and management of small habitats within the agroecosystems (Stopes *et al*., 1995; Baudry *et al*. 2000; Tscharntke *et al*. 2002). In recent years organic farming is given much importance due to the consumer demand and concerns about safe food and safe environment (Maeder *et al*. 2002; Kristiansen 2006).

In the present study predatory insects, parasitic hymenoptera and other beneficial insect populations were more abundant than phytophagous insects in organic field compared to chemical field. This finding is supported by earlier studies by several ecologists. Letourneau and Bothwell (2008) have compared the biodiversity of natural enemies and phytophagous insects between organic and chemical farming systems in the Sacramento Valley. They found that carnivorous insect (predators and parasitoids) richness was higher (37) in organic samples compared to chemical field samples (21). Feber *et al*., (1997) have reported that organic farms recorded significantly high total abundance of butterflies than chemical farms and their findings supported the fact that organic farms were favourable to non-pest species. Gabriel *et al*., (2010) have reported that organic farms supported more insects especially more butterflies compared to chemical farms. Rundlof and Smith (2006) have studied the effect of farming practice on butterfly species richness and abundance on organic and chemical farms in homogeneous and heterogeneous landscape diversity. They found that organic farming and landscape heterogeneity significantly increased butterfly species richness and abundance. Culliney and Pimentel (1986) have reported that phytophagous insect populations were lower in organic farms than chemical fertilizer applied field.

Vandermeer and Perfecto (1995) have recognized two distinct components of biodiversity in agroecosystems. The first component is the 'planned biodiversity'. It is the biodiversity associated with the crops and livestock purposely included in the agroecosystem by the farmer. The second component is 'associated biodiversity', which includes all soil flora and fauna, herbivores, carnivores and decomposers that colonize the agroecosystem from surrounding environments. In organic field, farmers grow intercrops and border crops, which is planned biodiversity. The main purpose of this polyculture or mixed cropping is to completely utilize the soil for productivity. These intercrops/mixed crops attract wasps, pollinators, parasitoids and other natural enemies by providing shade, nectar and pollen. This associated biodiversity, i.e., the natural enemies and pollinators, helps in pest control and pollination in the main crop. The associated biodiversity is conserved in the organic fields by avoiding chemical pesticide sprays.

In this study the total number of taxa was generally found to be higher in the year 2012 in both organic and chemical fields. When the two different farming practices were compared, organic field recorded higher number of taxa during January-June in the year 2012. In the next season of the year 2012 and in the two seasons of the next year (2013) there was no difference in the total number of taxa between organic and chemical fields. So it is not clear whether the farming practice can affect the occurrence of certain species. There was no clear difference in the Evenness between organic and chemical fields. However some workers have documented higher Evenness of natural enemies in organic farms. Crowder *et al.* (2010) have documented high Evenness of predatory insects in organic farms. The higher activity of natural enemies in organic farming systems can be attributed to the reduced use of broad-spectrum pesticides (Letourneau and Bothwell, 2008; Hole (2005).

## CONCLUSION

In the present study maximum insect abundance and total number of individuals were recorded in organic fields. The study also proved that organic farming practices can help in the population build-up of natural enemies and pollinators. However there was no concrete difference in Evenness of insects, Shannon index and Simpson index of diversity between organic and chemical fields. Phytophagous insect populations were very low in number in organic farms. Hence organic farming practices may encourage natural enemies diversity and may not be favourable for pests.

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