IDENTIFICATION OF THE TRITROPHIC INTERACTIONS IN THE LOCAL AGROECOSYSTEMS

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BACHELOR OF SCIENCE

in

ZOOLOGY

(2015-18 batch)

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CERTIFICATE

This is to certify that the dissertation entitled **'Identification of the Tritrophic Interactions in the Local Agroecosystems'** is an authentic record of the work done by a group of nine students of B. Sc Zoology, 2015-18 batch under my supervision as partial fulfillment of the requirements for the award of the Degree of **Bachelor of Science** in **Zoology** and this report has not been submitted earlier for the award of any degree or diploma or any other similar titles anywhere.

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DECLARATION

We do hereby declare that this dissertation **'Identification of the Tritrophic Interactions in the Local Agroecosystems'** is a bona fide report of the project work carried out by us, under the supervision and guidance of Dr. Jasin Rahman V.K, Asst. Professor, Department of Zoology, TKM College of Arts and Science, Kollam as a partial fulfillment of the requirements for the award of the Degree of **Bachelor of Science** in **Zoology**.

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DEDICATED TO OUR PARENTS AND TEACHERS....

INTRODUCTION

Agriculture makes the spine of the economy and survival of India. About 600 million people directly or indirectly depend on agriculture for their livelihoods. Various sorts of amateur agricultural practices without proper guidance and organization are done by rural people to meet the daily need of agricultural produce. They go for chemical strategies to protect the crop from pests and diseases despite the health hazards of the same. Agroecosystems make up large areas in our country and contribute to considerable variety of natural habitats for diverse kinds of organisms. But conservation of biodiversity in agroecosystems has not yet been focused much as on natural ecosystems. Large percentage of areas is used for various kinds of agriculture, nurseries and gardens in India. Even if the primary habitat of many organisms is in natural areas, most species interact with these agricultural systems in one or other ways such as for habitats or for foraging and breeding.

Maintaining high biodiversity in agroecosystems makes agricultural production more sustainable and economically viable. Agricultural biodiversity ensures, for example, pollination of crops, biological crop protection, maintenance of proper structure and fertility of soils, protection of soils against erosion, nutrient cycling, and control of water flow and distribution. In this context, promoting agricultural practices with promising strategies for economical and sustainable agriculture becomes necessary. Scientific cropping patterns and integrated pest management strategies are the essential ones to be practiced in agriculture to maintain the beneficial fauna and control the pest populations in agroecosystems. They comprise planting compatible crops in terms of pests, natural enemies and nutrient requirements in nearby plots, biological pest and weed control measures, and reduction of synthetic chemicals and fertilizers.

In order to execute the strategies for conservation of biodiversity, it is essential that all species which are highly associated with the agroecosystem are properly understood and identified scientifically. Long term sustainable conservative measures may have to take into account the type of balance that exists within a community. This can only be assessed by the proper identification of the various tri-trophic interactions, i.e., species inhabiting the area comprising the food stuff/crop plants, the primary consumers and their natural enemies. Every species differs from its related species in food preference, breeding season, tolerance to various environmental factors, resistance to predators, pathogens, etc. Such information is required for effectively implementing a pest management programme without destroying the diversity and richness of beneficial and neutral fauna in an agroecosystem. So attempts were made to identify and document various tri-trophic interactions existing in the agroecosystems in the study areas.

OBJECTIVES

- To observe and scientifically identify the fauna associated with various agricultural crops
- To figure out the tri-trophic interactions existing in various agroecosystems
- To create an awareness of conserving biodiversity in agroecosystems

REVIEW OF LITERATURE

Many studies emphasize the relevance of tritrophic interactions in agroecosystems. Even if the primary habitat of many organisms is in natural areas, most species interact with agricultural ecosystems in one or other ways such as for habitats or for foraging and breeding. So managing these areas will dramatically benefit overall levels of the biodiversity in those areas and contribute to the survival of many species to successfully assume their ecological niche. Agroecosystems are the most at risk of losing biological diversity. During the last decades, worldwide losses of biodiversity have occurred at an unprecedented scale and agricultural intensification has been a major driver of this global change (Matson et al. 1997). Apart from the usual natural factors, biodiversity in agroecosystems is influenced by farming activities such as tillage, irrigation, fertilization, weeding, crop establishment and pesticide application and inherent properties such as monoculture and intensification. The indiscriminate use of synthetic fertilizers can have significant effects on the highly diverse community of soil microorganisms and invertebrates that regulate nutrient cycling in ecosystems (Matson et al. 1997). Some pests and predators are found specifically in agroecosystems. In a study covering four districts in central Kerala, 49 species of spiders were recorded unique to the agricultural ecosystems, and 85 species were shared by both agro and forest ecosystems (Sebastian et al. 2012). For plants, natural enemies can serve as indirect plant defences and can mediate the efficacy of direct defences (Price et al., 1980; Gassmann and Hare, 2005; Dicke, 2000). Exploitation of tri-trophic interactions has the capacity to directly benefit agricultural systems. Significant biocontrol of crop pests can be exerted by the third trophic level, given an adequate population of natural enemies (Cortesero et al., 1999). The widespread use of pesticides or Bt crops can undermine natural enemies' success (Obrycki, 2001; Groot and Dicke, 2002; Poppy and Sutherland, 2004). Natural enemy population thrives when increasing landscape diversity through companion planting, border crops, cover crops, intercropping, or allowing some weed growth for providing nectar or other sugar-rich resources (Wäckers, 2005). Some of the visitors in agroecosystems assume the status of neither pests nor predators, but of pollinators or seed dispersers. It has been found that natural habitats nearby agroecosystems are beneficial to obtain the service of pollinators and alternate food source for natural enemies. Proximity to natural habitats could be beneficial for obtaining pollination services as it has been found that pollination services decline as the distance from a natural habitat increases (Ricketts et al. 2008, Carvalheiro et al. 2010, Garibaldi et al. 2011). Nesting resources could also be important for structuring bee communities through the availability of locations for nesting or nest-building materials (Potts et al. 2005, Chaplin-Kramer et al. 2011). Thus, conserving natural habitats could help maintain naturally occurring pollinator species, ensuring pollination services in agricultural fields (Ricketts et al. 2008, Rader et al. 2009).

STUDY AREA

The study areas include various domestic and commercial agricultural landscapes especially horticultural ecosystems in Kollam District (Plate 1). This district is located on the southwest part of Kerala State and extends from Lakshadweep Sea to the Western Ghats. It is bordered by Trivandrum district on the South, Alapuzha and Pathanamthitta districts in the North, Thirunelveli district of Tamilnadu State in the East and Lakshadweep sea in the west. It lies between North latitudes 8° 45′ and 9° 07′ and East longitudes 76° 29′ and 77° 17′. It has a geographical area of 2491 sq. km which is about 6.48% of the total geographical area of the State. This district has been gifted with sea, lakes, plains, mountains, rivers, streams, backwaters, forest, vast green fields and tropical crop of every variety, both food and cash crop, hence called God's own Capital. The district is drained by three west flowing rivers, Achenkovil, Kallada and Ithikara, originating in the eastern hilly region. These rivers together with their tributaries exhibit dendritic pattern of drainage. The whole district of the study area has a tropical humid climate, with an oppressive summer, plentiful seasonal rainfall and cool winters. Temperature is almost steady throughout the year. The average temperature is around 25° C to 32° C. Summers usually begin from March and extend till May. The rest of the year is generally dry. The monsoons begin by June and end by September. The district receives an average rainfall of about 2555 mm annually. The major source of rainfall is South West monsoon from June to September which contributes nearly 55% of the total rainfall of the year. The North East monsoon season from October to December contributes about 24% and the balance 21% is received during the month of January to May as pre-monsoon showers. Winter is from November to February during which temperature is moderately cool hovering from 18° C to 25° C. The Relative humidity is higher during the monsoon period and it is higher all through the year during the morning hours. Ecologically Kollam district belongs to Agasthyamalai Biosphere Reserve. The vegetation consists of typical southern subtropical flora. Though the rural areas are gifted with many undisturbed habitats, most areas are on the threat of unscientific construction activities and destruction of wetlands and rain groves.

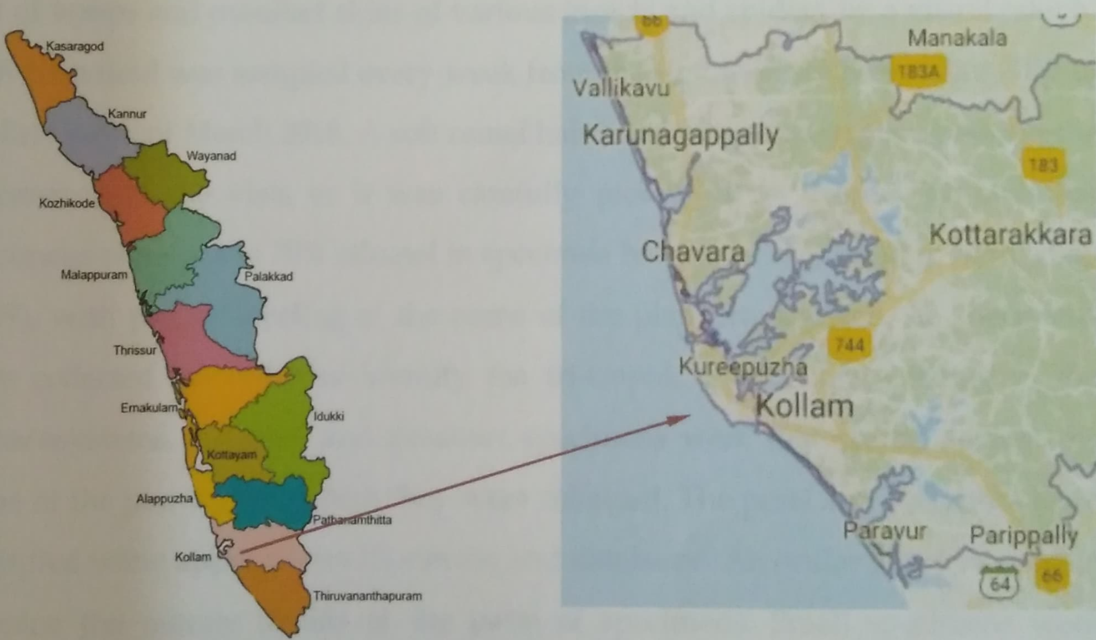

Plate 1. The study area

MATERIALS AND METHODS

Identification of the tri-trophic interactions in local agroecosystems

Various agroecosystems in the local area were regularly visited and the fauna associated with them were either noted or collected. The entire plant parts and the area around each plant were examined for pests, predators, spider webs, nest of wasps and moulted skins of various insects and spiders by a visual search. Each crop field was sampled every week from the first week of November 2017 to the first week of March 2018. A soft camel hair brush was used to gently collect the specimen into the vials or it was carefully picked off by hand. The collected specimens were put in 70% ethanol in specimen bottles, as suggested in Marc et al. (1999), with proper labeling of the name of the plant from which the specimens were collected. In order to identify the tri-trophic interactions existing in the agroecosystems, the pest and predator specimens were first sorted against the name of the plants from which they were collected. The pests and predators were identified using appropriates literatures and databases. An ocular lens was used to examine the minute details of the parts of specimens. Small specimens were identified under microscope. Observations were tabulated and graphs were plotted.

RESULTS AND DISCUSSION

Identification of the tri-trophic interactions in local agroecosystems

A wide array of pests and natural enemies exists in each agroecosystem. Among them most pests are present in more than one crop and are predated by different species of natural enemies, and most natural enemies prey on different types of pests, making a complex food web in each agroecosystem. The pests and natural enemies associated with various crop plants were identified. The tri-trophic interactions identified as existing in the agroecosystems in the study areas are given in Table 1.

The important pests observed in the present investigation in agroecosystems include Leafhoppers, Whitefly, Aphids, Epilachna beetles, Mealybugs and caterpillars of various moths. Ladybird beetles, Praying mantises, Spiders, parasitic and parasitoid wasps and Reduviid bugs of various species constituted major natural enemies. Crops showed difference in hosting pests as well as harbouring natural enemies (Figure 1). Spinach and Brinjal hosted more species of pests (8 each) followed by Tomato (5). Spinach harboured more species of natural enemies (14) followed by Brinjal and Tomato (9 each). Various species of leafhoppers, whiteflies, mealy bugs and aphids were found to cause high infestation in most of the crops. Other insect pests showed either moderate or miner infestation level.

The proportion of plants, herbivores and natural enemies observed is given in Figure 2. The 35 species of pests observed from 16 species of plants were found

Table 1. The Tri-trophic interactions existing in local agroecosystems

Sl. No.	Common name of pests	Scientific name of pests	Natural enemies
I	**BITTERGOURD** *Momordica charantia*		
1	Aphids	*Aphis malvae*	Ladybird beetle, Praying mantis, Spider, Red ant, Dragon fly
2	Red pumpkin beetle	*Aulacophora foveicollis*	Braconid wasp, Spider
3	Caterpillar		Praying mantis, Birds
4	Fruit fly		Wasps, Birds
II	**BRINJAL** *Solanum melongena*		
1	Epilachna beetle	*Epilachna vigintioctopunctata*	Praying mantis
2	Mealy bug	*Centrococcus insolitus*	Parasitoid wasp
3	Whitefly	*Trialeurodes vaporariorum*	Parasitoid wasp, Ladybird beetle, Dragon fly
4	Eggplant lace bug	*Urentius* sp.	Ladybird beetles, Spider
5	Ash weevils	*Myllocerus* sp.	Birds
6	Leaf hopper	*Amrasca biguttula biguttula*	Praying mantis
7	Aphids	*Myzus persicae, Aphis gossypii*	Lady beetles, Praying mantis, Lacewings, Syrphid flies, and various Parasitic wasps
8	Grasshopper		Praying mantis, Birds
III	**CABBAGE** *Brassica oleracea*		
1	Aphids	*Lipaphis erysimi, Brevicoryne brassicae*	Lady bird beetles, Praying mantis
2	Cabbage looper	*Trichoplusia* sp.	Tachinid flies, Ants, Lady bird beetles
3	Diamond Back Moth larva	*Plutella xylostella*	Parasitoid wasps (*Diadegma semiclausum*)

IV	**CHILLI** ***Capsicum annum***		
1	Mealy bug		Lady bird beetle, Lacewings, Reduviid bug
2	Whitefly		Spider, Praying mantis
3	Horned treehopper		Parasitoid wasp
4	Red cotton bug	*Dysdercus cingulatus*	Predatory bug
V	**COW PEA** ***Vigna unguiculata***		
1	Aphids	*Aphis craccivora*	Parasitoid wasps
2	Leaf footed plant bug	*Leptoglossus* sp.	Birds, Spiders
3	Stink bug	*Nezara* sp.	Parasitic wasps, Tachinid flies
4	Leaf miner	*Liriomyza* sp.	Parasitic wasp (*Diglyphus isaea*), Lacewings, Lady bird beetle, Spider, Praying mantis
VI	**CUCUMBER** ***Cucumis sativus***		
1	Leaf beetle	*Aulacophora* sp.	Reduviid bug, Parasitoid wasps
2	Cucumber moth larvae	*Diaphania indica*	Parasitic wasps, Lacewing larvae
VII	**CURRY LEAF** ***Murraya koenigii***		
1	Scales		Ants
2	Mealy bug		Lady bird beetles (*Cryptolaemus montrouzieri*/ Mealybug destroyer)
3	Brown stink bug	*Euschistus* sp.	Parasitoid wasps (egg parasitoid)
VIII	**GOOSEBERRY** ***Emblica officinalis***		
1	Aphids	*Setaphis bougainvilleae*	Red soldier beetle (*Rhagonycha fulva*)
2	Whitefly	*Trialeurodes rara*	Spider, Praying mantis
3	Mealy bug	*Ferrisia virgata*	Lady birds, Lacewings

IX	**IVY GOURD** *Coccinia grandis*		
1	Aphids		Lady bird beetles
2	Thrips		Lacewing larvae
3	Whitefly		Lady bird beetles, Spider
X	**LADIES FINGER** *Abelmoschus esculentus*		
1	Mealy bug	*Ferrisia virgata*	Lady bird beetle (*Cryptolaemus montrouzieri*)
2	Leaf hopper	*Amrasca biguttula biguttula*	Praying mantis
3	Whitefly		Lady bird beetles, Ants
XI	**PUMPKIN** *Cucurbita moschata*		
1	Red pumpkin beetle	*Aulacophora foveicollis*	Braconid wasp, Spider
2	Leaf miner	*Liriomyza* sp.	Parasitic wasp (*Diglyphus isaea*), Lacewings, Lady bird beetle, Spider, Praying mantis
XII	**SNAKEGOURD** *Trichosanthes cucumerina*		
1	Aphid	*Aphis gossypii*	Lady bird beetle
2	Epilachna beetle	*Epilachna vigintioctopunctata*	Praying mantis
3	Red Pumpkin Beetle	*Aulacophora foveicollis*	Braconid wasp, Spider
XIII	**SPINACH** *Spinacia oleracea*		
1	Amaranthus weevil	*Hypolixus truncatulus*	Spider, Lacewing, Reduviid bug, Pentatomid bug, Praying mantis, Wasps, Ants
2	Grasshopper		Praying mantis, Spiders
3	Aphids	*Aphis* sp.	Parasitoid wasps, Tiny Black Beetle (*Stethorus punctillum*), Red ant, Spider, Lacewing, Praying mantis, Reduviid bug

IX	**IVY GOURD** *Coccinia grandis*		
1	Aphids		Lady bird beetles
2	Thrips		Lacewing larvae
3	Whitefly		Lady bird beetles, Spider
X	**LADIES FINGER** *Abelmoschus esculentus*		
1	Mealy bug	*Ferrisia virgata*	Lady bird beetle (*Cryptolaemus montrouzieri*)
2	Leaf hopper	*Amrasca biguttula biguttula*	Praying mantis
3	Whitefly		Lady bird beetles, Ants
XI	**PUMPKIN** *Cucurbita moschata*		
1	Red pumpkin beetle	*Aulacophora foveicollis*	Braconid wasp, Spider
2	Leaf miner	*Liriomyza* sp.	Parasitic wasp (*Diglyphus isaea*), Lacewings, Lady bird beetle, Spider, Praying mantis
XII	**SNAKEGOURD** *Trichosanthes cucumerina*		
1	Aphid	*Aphis gossypii*	Lady bird beetle
2	Epilachna beetle	*Epilachna vigintioctopunctata*	Praying mantis
3	Red Pumpkin Beetle	*Aulacophora foveicollis*	Braconid wasp, Spider
XIII	**SPINACH** *Spinacia oleracea*		
1	Amaranthus weevil	*Hypolixus truncatulus*	Spider, Lacewing, Reduviid bug, Pentatomid bug, Praying mantis, Wasps, Ants
2	Grasshopper		Praying mantis, Spiders
3	Aphids	*Aphis* sp.	Parasitoid wasps, Tiny Black Beetle (*Stethorus punctillum*), Red ant, Spider, Lacewing, Praying mantis, Reduviid bug

4	Whitefly		Lady bird beetles, Ants
5	Flea Beetle	*Phyllotreta cruciferae*	Parasitoid wasps
6	Golden tortoise beetle	*Charidotella sexpunctata*	Parasitoid wasps, Lady bird beetle
7	Leaf miner	*Phyllocnistis* sp.	Parasitic wasp (*Diglyphus isaea*), Lacewings, Lady bird beetle, Spider, Praying mantis
8	Leaf eating Caterpillar	*Spoladia recurvalis*	Parasitoid wasps, Praying mantis, Assassin bugs, Lacewings, Dragonflies
XIV	**STAR FRUIT** *Averrhoa carambola*		
1	Horned Treehopper	*Leptocentrus taurus*	Parasitoid wasp
2	Aphid		Lady bird beetle
XV	**STAR GOOSEBERRY** *Phyllanthus acidus*		
1	Eggplant lace bug	*Urentius hystricellus*	Ladybird beetles, Spider
XVI	**TOMATO** *Solanum lycopersicum*		
1	Mealy bug	*Phenacoccus* sp.	Lady bird beetle, lacewings
2	Aphid	*Aphis* sp.	Lady bird beetle
3	Whitefly	*Bemisia* sp.	Lady bird beetle (*Delphastus pusillus*), Spider
4	Leaf miner	*Liriomyza* sp.	Parasitic wasp (*Diglyphus isaea*), Lacewings, Lady bird beetle, Spider, Praying mantis
5	Blue stink bug	*Zicrona* sp.	Parasitic wasp, Tachinid flies, Birds

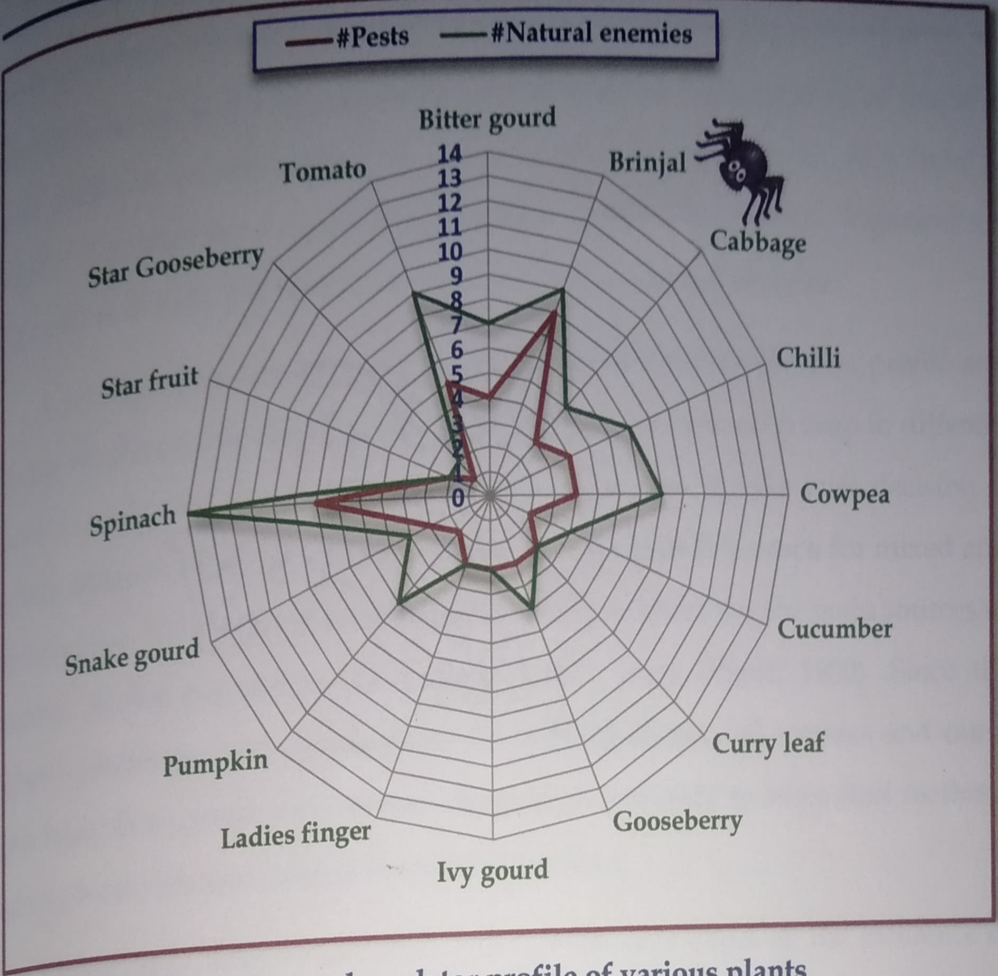

Fig. 1. Pest and predator profile of various plants

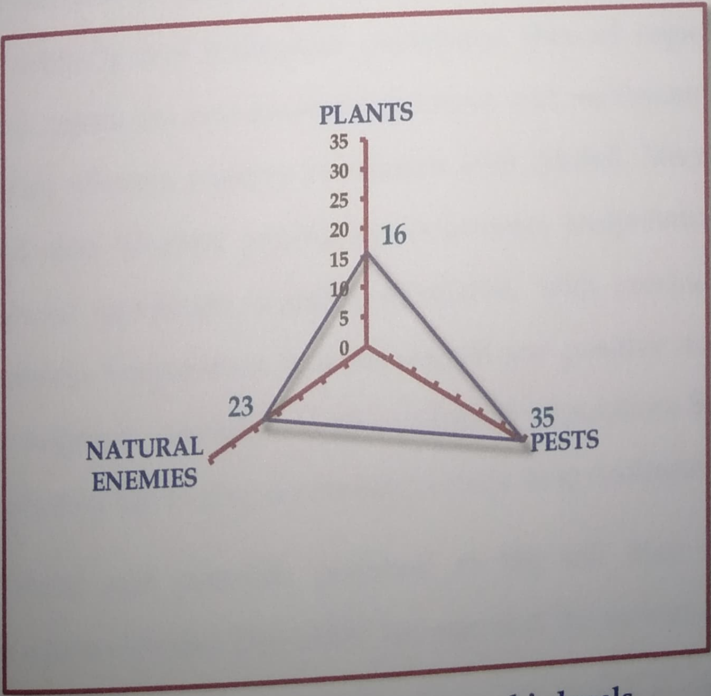

Fig. 2. Proportion of three trophic levels

to be predated up on by 23 species of natural enemies. This number of predator species seems to be less compared to the number of pest species they have to consume. A conservatory aspect in agricultural methods needs to be implemented in the context of very low number in the diversity of natural enemies.

A healthy agroecosystem can be set by understanding the pest profile and probable incidence and succession of pests and predators in each crop in different seasons (e.g., Kumar et al. 2015). This will help farmers to take wise decision in selecting different crops for different seasons and compatible crops for mixed and inter cropping. Natural enemies, parasitoids and predators are the main sources of reduction in the populations of noxious insect pests (Pfadt, 1980). Since the synthetic pesticides used against pests are harmful to natural enemies and cause health hazards in consumers, farmers have to switch over to biocontrol methods adopting botanicals and natural enemies in the field.

Temperature, relative humidity and rainfall have effect on the incidence of the pests and survival of natural enemies in agroecosystems. Singh et al. (2013) reported that whitefly and leafhopper population showed negative correlation with maximum, minimum and mean temperature and maximum and minimum relative humidity whereas positive correlation with rainfall. Meena and Kanwat (2010) reported that Weather parameters (minimum temperature and relative humidity) showed significant negative correlation with coccinellid predators, whereas, maximum temperature had non-significant positive and rainfall had nonsignificant negative correlation with coccinellid population. So Constructing glass/net houses may have effect on the biodiversity in agricultural field.

Heavy metal and pesticide pollution in the soil may also affect the biodiversity in agroecosystem. Das (2000) has reported the serious deterioration of the ecosystem of the Kuttanad, the rice bowl of Kerala as there were high concentrations of heavy metals and organochlorine pesticide residues in water and sediment. This may badly affect the healthy tri-trophic interactions in the agroecosystems and thereby natural control of pests, biogeochemical cycles, rejuvenation of soil etc. Adopting scientific cropping patterns and sustainable developmental and agricultural activities in compliance with the legal and scientific regulations are recommended to accomplish the aim of biodiversity conservation in agroecosystems.

Other beneficial or neutral fauna associated with agroecosystems

Various species of Frogs, Earthworms, Butterflies, Honeybees, Wasps, Ground beetles, Dung beetles etc. constituted other beneficial/neutral fauna in agroecosystems. Butterflies, honeybees and wasps act as good pollinators. The general natural enemies observed consisted of larval and adult ladybird beetles (Coleoptera, Coccinellidae), parasitic wasps (Hymenoptera, Braconidae), syrphid larvae (Diptera, Syrphidae), predatory bugs (Hemiptera, Miridae) and many species of ants.

CONCLUSION

This study makes a database for forming tri-trophic matrix for sowing/planting compatible crops that better facilitate the survival of beneficial fauna in local agroecosystems. Caution can be taken to sow/plant the crops which are infested by same array of pests in a noncontiguous manner so that during harvesting of various crops, the pest will be deprived off undisrupted supply of feeding, breeding and resting places. Similarly, the planting can be done in such a way that the plants that host similar array of natural enemies but with different blooming seasons and crop period in nearby patches so that the predators can migrate from one crop to another when one is harvested. This will facilitate the survival of natural enemies which will bring about efficient natural control of many agricultural pests.

It is highly recommended that people have to practice scientific cropping patterns in order to conserve the biodiversity in these ecosystems. The developmental and agricultural activities in the rural areas should be sustainable and in compliance with the legal and scientific regulations and strict conservatory measures have to be implemented. Highly systematic and long term survey is needed to record the fauna associated with various agroecosystems in detail and people have to be trained on scientific cropping practices to ensure the conservation of biodiversity in agroecosystems.

SUMMARY

- The fauna and tri-trophic interactions existing in various agroecosystems were observed and documented.
- Awareness on the importance of conserving biodiversity of natural enemies in agroecosystems was created.
- The data generated will facilitate the following things during sowing or planting different crops in same agroecosystems.
    - to determine the spacing and timing of sowing/planting various crops in different areas
    - to sow or plant the crops which have same array of pests in non-contiguous plots so that the pests will not get undisrupted feeding, resting and breeding sites throughout the year
    - to sow or plant the different crops whose pest populations are predated up on by same natural enemies in almost nearby rows/plots as intercropping so that once the prey population in a crop is devoured completely, natural enemies can migrate to nearby crops and survive
    - to select suitable trap crops/bio fencing to attract pest population and destroy them without allowing to infest main crops
    - to provision natural areas adjacent to agricultural systems for providing habitat for pollinators and natural enemies, and
    - to plan and execute suitable pest control practices like cultural and biocontrol.