# Publications

- Paulson, L., Pandya, P., Thakkar, B. and Parikh, P. (2018). Isolation of Pathogenic Bacteria from M. domestica and the effect of Antibiotics, Captured from Vadodara City, Gujarat. Journal of Entomology and Zoology Studies. 6(4), 1369-1377.
- Paulson, L., Thakkar, B., & Parikh, P. H. (2020). Diversity of Agriculturally Important Insect in and around Vadodara, Gujarat, India. 10. 15–28.
- Paulson, L., & Parikh, P. H. (2020). Diversity of pests and its infestation in agroecosystem of Vadodara. *Int. Res. J. of Science & Engineering*, *A9*.

# Conferences

- I have participated in **oral presentation** in the "International Conference on Conservation of Biodiversity (ICCB19), organized by Yazhli global multidisciplinary research organization. (28th November 2019)
- I have participated in **oral presentation** in the 10th International Congress of Environmental Research (ICER - 19), organized at Adi Shankara Institute of Engineering and Technology, Kalady, Kerala, India in collaboration with Journal of Environmental Research and Development. (19- 21 December 2019)
- I have participated in **oral presentation** in E- Conference on "Emerging Trends and Challenges in Life Sciences (ETCLS – 2020)" organized by Department of Botany, Indraraj Arts, Commerce and Science College Sillod Dist. Aurangabad (MS) India. (18th & 19th June 2020)

# Workshop Attended

I have attended one-day training programme in phylogenetic Analysis in R & D Lab of Athmic Biotech Solutions Pvt Ltd on 23rd December, 2019.

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# DIVERSITY OF AGRICULTURALLY IMPORTANT INSECT IN AND AROUND VADODARA, GUJARAT, INDIA

**LINTA PAULSON, BHUMI THAKKAR & PRAGNA PARIKH**

*Division of Entomology, Department of Zoology, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, India*

***ABSTRACT***

***Insects are the most species-rich group on earth and play numerous crucial roles in ecosystem functioning and the global economy. The conservation of insect diversity is a topic of global importance. Herbivorous insects damage 18% of world agricultural production. Pests are major challenges to agriculture practice security. Characteristics of the agricultural community influence the insect in general and pest populations in particular. However, the nature of these interactions remains poorly understood within community complexities. The present work examines how the species diversity and the topology of linkages in species' abundances affect pest abundance in agricultural fields around Vadodara city, Gujarat. The study inventoried insect diversity and their host plant distribution of pest species. A total of 283 species belonging to 83 families of 7 orders were reported of which 128 were insect pests. Of the 7 orders, only four orders have the pest representative. Diversity indices indicated that of all the orders, Coleoptera was the most dominant group with a maximum number of pest species, followed by Hemiptera, next in the order was Lepidoptera followed by Orthoptera. The present work is the first of its kind to report the agricultural important insects and the pest status in and around Vadodara.***

***KEYWORDS: Insects, Agricultural Pest & Diversity***

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Original Article

## 1. INTRODUCTION

The most diverse and plenteous invertebrate on the planet is insects. Insects have been used as landmark studies in many areas like biomechanics, climate change, developmental biology, ecology, evolution, genetics and physiology. Because of their diverse and varied characters, they are familiar to the public and their conservation is a challenge (Jalali and Ojha, 2015). Globally there are approximately 5.5 million insect species of which around 1.5 million species are beetles (Stork 2018). Approximately some 63,760 species of insect less than 658 families representing 29 orders and three classes are known in India. Of these, eight orders constitute the bulk 94% of the insect fauna and the remaining 21 orders are signified by small numbers (6% of species) which represents nearly 7% of global insect diversity (Joshi *et al.,* 2016; Sankarganesh, 2017). Gujarat has a record of 1446 species belonging to 147 families of orders Orthoptera (Thakkar, *et al.,* 2015), Coleoptera (Thakkar and Parikh, 2016), Lepidoptera (Kataria and Kumar, 2012; Kumar, 2015; Bhatt and Nagar, 2017), Hemiptera (Kumar and Naidu, 2010; Kataria and Kumar, 2012), Hymenoptera (Thakkar and Parikh, 2018), Diptera (Parikh and Sonavane, 2008), Odonata (Parikh, and Sonavane, 2010; Rathod *et al.,* 2016; Patel *et al.,* 2016; Patel and Ghetiya, 2018) and overall a wide range insect fauna (Chandra, 2011). The work to date has been focused on the general diversity of insects; however, there is very scanty information available with regards to agriculturally important insect diversity study

in Vadodara.

Insects are vital for human existence, because crops cannot be formed without the ecological functions delivered by them. Insect diversity and composition are largely dependent on vegetation and any change in the habitat is likely to have an impact on their distribution and relative abundance (Kerchev *et al.,* 2012; Patil *et al.*, 2016). Being the major part of the agriculture ecosystem, insects are most apparent as pests or potential pests. Agriculture fields are comparatively more in danger to insect pest infestation due to the threat of varied climatic situations. The larvae of insects are a voracious feeder and cause heavy damage to agriculture crops. Dhaliwal *et al.,* (2015)reported that in India agriculture is currently suffering an annual loss of about US$. 36 billion due to insect pests. Insect pests are linked to different agriculture crops, vegetables, woody plants, and ornamental plants. Almost 50% of insect species are a pest (Schoonhoven *et al.,* 2005), of which as reported by Losey and Vaughan, (2006) 18 % are herbivorous species that forage on plants in one or another way. Mono-cropping of certain crops is one of the major issues for increased pest infestation. A key motivation of the present study is to fill up the lacunae of the Diversity of agriculturally important Insects with special reference to the pest status. An attempt is made to explore the existence of general insect occurrence in agriculture fields in and around Vadodara district of Gujarat.

## 2. MATERIAL AND METHODS

A preliminary survey was carried out for the presence of agriculture fields based on the crop pattern and type. Taking into the consideration of the accessibility and location, four sites were selected i.e. Ajwa (22.3751° N, 73.3851° E), Chhani (22.3633° N, 73.1658° E), Karjan (22.0535° N, 73.1202° E) and Padra (22.2394° N, 73.0848° E) areas of the Vadodara district and these four sites were visited twice a month from August 2017 to August 2019. The primary mode of research was the direct observation and photo documentation along with that insects were collected manually by pitfall trap wherein small Plastic cups filled with a mixture of 70% Ethyl alcohol and Glycerin were buried up to the rim in the ground so that passing insects may fall. The light trap method was employed to collect the nocturnal insects, wherein a halogen bulb was kept at the study site and the insect thus attracted were collected in the plastic container. Sweep nets were employed for catching the flying insects and the beating umbrella method was used for collecting the insects from the trees. The collected samples were preceded for further identification procedures and the specimens were narcotized by exposure to cyanide vapors for maintaining their original color. Following the standard protocols of pinning each specimen was pinned for further identification. Identification was done by using standard reference books and published articles. The identified collections were stored in insect cabinets, containing naphthalene balls wrapped in paper and pinned at one corner of the cabinet. The specimens identified were confirmed by comparing with the authentic specimens at the Department of Zoology, Faculty of Science, The Maharaja Sayajirao University of Baroda and Bombay Natural History Society, Mumbai. The pest species were confirmed with the specimen of Anand Agriculture University, Anand, Gujarat.

### 2.1 Data Analysis

Data Analysis was done based on their abundance and habit through Shannon Wiener diversity indices, Evenness indices as well as Marglef's indices for richness by using PAST 3.X software.

## 3. RESULTS

Table 1 represents the checklist of the collected species with their presence / absence status as well as their ecological role. A total of 283 species belonging to 7 orders and 83 families were recorded during the study period. Members of order

Coleopteran were found to be the most dominant with 115 species belonging to 23 families, followed by Hymenoptera with 41 species belonging to the 8 families, followed by Hemiptera with 31 species belonging to 17 families. Diptera was recorded with the 31 species from the 15 families and Lepidoptera was recorded with 28 species belonging to 13 families. Order Orthoptera with 27 species belonging to 5 families and order Odonata with 10 species and 3 families were also found (Table 1). All the four agricultural fields are enriched with the insect species of different orders. Site wise distribution pattern of insects has been depicted in figure 1-4.

**Table 1: Checklist of Insect Diversity of Four Sites of Vadodara**

| Order | Family | Scientific Name | I | Ii | Iii | Iv | Habit |
|---|---|---|---|---|---|---|---|
| Odonata | Coenagrionidae | *Enallagma geminatum* | + | | | + | Bioindicator |
| | | *Ischnura aurora* | | + | + | | Bioindicator |
| | | *Ischnura hastate* | + | | | + | Bioindicator |
| | Gomphidae | *Ictinogomphus australis* | | + | + | | Bioindicator |
| | Libellulidae | *Bradinopyga geminate* | | | + | | Bioindicator |
| | | *Celithemis eponina* | | | + | | Bioindicator |
| | | *Crocothemis servilia* | + | + | | + | Bioindicator |
| | | *Orthetrum Sabina* | | | + | | Bioindicator |
| | | *Pantala flavescens* | + | | + | + | Bioindicator |
| | | *Rhyothemis variegate* | | + | + | | Bioindicator |
| Orthoptera | Acrididae | *Acrida conica* | + | + | + | + | Pest |
| | | *Acrida exaltata* | + | | | + | Pest |
| | | *Acrida ungarica* | | + | | | Pest |
| | | *Aiolopus thalassinus* | | | | + | Pest |
| | | *Hieroglyphus banian* | | | | + | Pest |
| | | *Melanoplus femurrubrum* | + | + | + | + | Pest |
| | | *Metaleptea brevicornis* | + | | | + | Pest |
| | | *Orphulella pelidna* | + | | | | Pest |
| | | *Oxya hyla hyla* | | + | | | Pest |
| | | *Oxya hyla intricate* | | + | | | Pest |
| | | *Schistocerca gregaria* | | + | + | | Pest |
| | | *Trilophidia annulata* | + | | | + | Pest |
| | | *Xenocatantops humilis* | | | | + | Pest |
| | Grylidae | *Acheta domesticus* | | + | | | Scavenger |
| | | *Gryllodes sigillatus* | + | | + | | Scavenger |
| | | *Gryllus bimaculatus* | | + | | + | Scavenger |
| | | *Gryllus domesticus* | + | | | + | Scavenger |
| | | *Loxoblemmus doenitzi* | + | | + | | Scavenger |
| | | *Teleogryllus oceanicus* | | + | | + | Predator |
| | Gryllotalpidae | *Gryllotalpa Africana* | | + | + | | Scavenger |
| | Pyrgomorphidae | *Poikilocerus pictus* | | + | | | Pest |
| | Tettigoniidae | *Amblycorypha rotundifolia* | | | | + | Pest |
| | | *Mecopoda elongata* | | | + | | Pest |
| | | *Neoconocephalus velox* | | | | + | Pest |
| | | *Sathrophyllia sp.* | | + | | | Bioindicator |
| | | *Scudderia furcuta* | | | | + | Pest |
| | | *Trigonocorypha unicolor* | | + | | + | Pest |
| Hemiptera | Aleryrodidae | *Aleurodicus disperses* | | | + | + | Pest |
| | Aphididae | *Aphis gossypii* | | | + | + | Pest |
| | Cicadellidae | *Empoasca decipiens* | + | + | + | + | Pest |
| | Coccidae | *Drepanococcus cajani* | + | + | + | + | Pest |
| | | *Phenacoccus madeirensis* | + | + | + | + | Pest |
| | Coreidae | *Acanthocephala femorata* | | + | | | Pest |
| | | *Cletomorpha Benita* | + | | | | Pest |
| | | *Cletus punctiger* | + | + | + | + | Pest |

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|---|---|---|---|---|---|---|---|
| | | *Homoeocerus signatus* | + | | | + | Pest |
| | Derbidae | *Pamendanga sp.* | + | | | | Pest |
| | | *Proutista moesta* | + | + | + | + | Pest |
| | Dictyopharidae | *Rhynchomitra microrhina* | + | | | | Pest |
| | Dinidoridae | *Coridius janus* | + | + | + | + | Pest |
| | | *Leptocentrus moringae* | + | + | + | + | Pest |
| | Lophophidae | *Pyrilla perpusilla* | + | + | | + | Pest |
| | Lygaeidae | *Lygaeus kalmia* | | | + | | Predator |
| | Membracidae | *Acanthuchus trispinifer* | + | | + | | Pest |
| | | *Oxyrachis tarandus* | | + | | + | Pest |
| | Pentatomidae | *Bagrada hilaris* | + | | | | Pest |
| | | *Eysarcoris guttiger* | + | | | + | Pest |
| | | *Halyomorpha halys* | + | + | + | + | Pest |
| | | *Nezara viridula* | | | + | | Pest |
| | | *Palomena prasina* | | | + | | Pest |
| | | *Megacopta cribraria* | + | + | + | + | Pest |
| | | *Plautia affinis* | + | + | | | Pest |
| | | *Eocanthecona furcellata* | | + | | | Predator |
| | Pseudococcidae | *Phelanococcus sp.* | + | | | | Pest |
| | Pyrrhocoridae | *Dysdercus koenigii* | + | | | + | Pest |
| | | *Dysdercus cingulatus* | | | + | | Pest |
| | Reduviidae | *Melanolestes picipes* | | + | | | Predator |
| | Rhyparochromidae | *Myodocha serripes Olivier* | + | | | + | Predator |
| Coleoptera | Anobiidea | *Lasioderma serricorne* | | | + | | Scavenger |
| | Anthicidae | *Formicomus sp.* | + | | | | Pest |
| | Aphodidea | *Rhyssemus sp.* | + | | | | Scavenger |
| | Attelabidea | *Paratrachelophorus sp.* | + | | | | Pest |
| | Brenthidae | *Amorphocephalus coronatus* | | + | | + | Predator |
| | Buprestidae | *Acmaeodera viridaenea* | + | | + | | Pest |
| | | *Agrilus acutus* | | + | | | Pest |
| | | *Sternocera chrysischrysidoides* | + | | | + | Predator |
| | | *Sternocera sternicornis aequisignata* | + | + | + | | Predator |
| | | *Psiloptera coerulea* | + | | | | Scavenger |
| | Cantharidae | *Cantharis livida* | | | + | | Predator |
| | | *Rhagonycha fulva* | + | + | | + | Predator |
| | Carabidae | *Anthia sexguttata* | + | | + | | Bioindicator |
| | | *Bembidion conforme* | + | | + | | Bioindicator |
| | | *Calosoma maderae* | | | + | + | Bioindicator |
| | | *Craspedophorus saundersi* | | + | | | Pest |
| | | *Brachinus crepitans* | | + | | | Predator |
| | | *Brachinus exhalans* | + | | | + | Predator |
| | | *Chlaenius bimaculatus* | + | | | | Predator |
| | | *Cicindela oregona* | + | | | | Predator |
| | | *Neocollyris andrewesiregia* | | | + | | Predator |
| | | *Pheropsophus catoire* | + | + | | | Predator |
| | | *Pheropsophus verticalis* | | | + | | Predator |
| | | *Pterostichus aethiops* | | + | | + | Predator |
| | | *Pterostichus oblango punctata* | | | + | | Predator |
| | | *Drypta lineola* | | | + | | Scavenger |
| | | *Microcosmodes symei* | + | | | | Scavenger |
| | Cerambycidae | *Acanthophorous serraticornis* | | | + | + | pest |
| | | *Batocera rufomaculata* | + | | | + | pest |
| | | *Celosterna scabrator* | + | | | | pest |
| | | *Dectes texanus* | | + | | | Pest |
| | | *Derobrachus hovorei* | | + | | | pest |
| | | *Prionus californicus* | | + | | | pest |

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|---|---|---|---|---|---|---|
| | *Xylotrechus stebbingi* | + | + | | | Pest |
| Chrysomelidae | *Chrysolina fastuosa* | + | + | | | Bioindicator |
| | *Altica sp* | + | + | + | + | Pest |
| | *Aspidomorpha miliaris* | | | | + | Pest |
| | *Aulacophora lewissi* | + | + | + | + | Pest |
| | *Aulacophora nigripennis* | + | + | + | + | Pest |
| | *Aulocophora foveicollis* | + | + | + | + | Pest |
| | *Cassida circumdata* | + | | + | + | Pest |
| | *Cassida sp.* | | + | + | + | Pest |
| | *Chiridopsis bipunctata* | | | | + | Pest |
| | *Chrysochus cobaltinus* | | + | + | | Pest |
| | *Clytra laeviuscula* | + | + | | | Pest |
| | *Oides palleata* | | | + | | Pest |
| | *Podagrica fuscicornis* | + | + | | | Pest |
| | *Sindia clathrata* | + | + | + | | Pest |
| | *Chrysolina coerulans* | | + | + | + | Predator |
| Cicindelidae | *Polydrusus formosus* | | + | | | pest |
| | *Cicindela ocellata* | + | | | + | Predator |
| Coccinellidae | *Adalia bipunctata* | | | + | | Predator |
| | *Adonia variegate* | | + | | + | Predator |
| | *Anegleis cardoni* | + | | + | + | Predator |
| | *Brumoides suturalis* | + | | | | Predator |
| | *Cheilomenes sexmaculate* | | + | + | | Predator |
| | *Chilocorus circumdatus* | + | + | | | Predator |
| | *Chilocorus nigritus* | + | | | | Predator |
| | *Coccinella repanda* | | + | | | Predator |
| | *Coccinella septumpunctata* | + | | + | + | Predator |
| | *Coccinella transversalis* | | + | | + | Predator |
| | *Coccinella undecimpunctata* | | | | + | Predator |
| | *Epilachna ocellata* | + | + | + | + | Pest |
| | *Harmonia expallida* | | + | + | | Predator |
| | *Harmonia octomculata* | | | | + | Predator |
| | *Henosepillachna vigintioctopunctata* | | + | | + | Predator |
| | *Menochilus sexmaculatus* | + | | + | | Predator |
| | *Propylea dissecta* | | | | + | Predator |
| Curculionidae | *Brachyderes incanus* | | + | | + | Predator |
| | *Cosmopolites sordidus* | | + | | + | Pest |
| | *Hypera postica* | | | + | | Pest |
| | *Myllocerus subfasciatus* | | + | + | + | Pest |
| | *Myllocerus viridanus* | + | + | + | + | Pest |
| | *Notaris scirpi* | | | + | | Predator |
| | *Odoiporus longicollis* | | + | | + | Predator |
| Dermestidae | *Dermestes sp.* | | | + | | Scavenger |
| Dysticidae | *Cybister tripunctatus* | + | | + | | Predator |
| | *Eretes sticticus* | | + | | + | Predator |
| Elateridae | *Lanelater fuscipes* | + | | | + | Pest |
| | *Agriotes ustulatus* | | + | | | Predator |
| Lampyridae | *Luciola anceyi* | | | | + | Pollinator |
| Lemophloeidae | *Cryptolestes pusillus* | + | | | | Pest |
| Meloidae | *Lytta caraganae* | + | + | + | + | Pest |
| | *Mylabris pustulata* | + | + | + | + | Pest |
| | *Mylabris variabilis* | | + | + | | Pest |
| | *Psalydolytta rouxi* | + | | + | + | Pest |
| Nitidulidea | *Glischrochilus quadripuntatus* | | | + | | Scavenger |
| Scarabaeidae | *Anomala bengalensis* | + | | | | Scavenger |
| | *Aphodius fossor* | | | + | | Scavenger |
| | *Cetonia funesta* | | + | | | Pest |

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|---|---|---|---|---|---|---|---|
| | | *Chiloloba acuta* | + | + | + | + | pest |
| | | *Copris incertus* | + | | | | Scavenger |
| | | *Copris Numa* | | | + | | Scavenger |
| | | *Cyclocephala pasadenae* | + | | | | Scavenger |
| | | *Gymnopleurus cyaneus* | | + | | | Scavenger |
| | | *Gymnopleurus miliaris* | + | | | + | Scavenger |
| | | *Heliocopris bucephalus* | | + | | | Scavenger |
| | | *Heliocopris gigas* | + | | + | + | Pest |
| | | *Holotrichia reynaudi* | + | | + | | Pest |
| | | *Onthophagus gazella* | | + | | | Scavenger |
| | | *Onthophagus lemur* | + | | | + | Scavenger |
| | | *Onthophagus Taurus* | | | + | | Scavenger |
| | | *Oxycetonia jucunda* | | + | + | + | Pest |
| | | *Oxycetonia versicolor* | + | + | + | + | Pest |
| | | *Phyllophaga nebulosa* | + | | | | Pest |
| | | *Phyllophaga obsolete* | + | + | | | Pest |
| | | *Protaetia alboguttata* | + | + | + | + | Pest |
| | | *Protaetia aurichalcea* | | | + | | Pest |
| | | *Protaetia squamipennis* | + | + | + | + | Pest |
| | | *Scarabaeus erichson* | | + | | + | Scavenger |
| | Silvanidea | *Oryzaephilus surinamensis* | + | | | | Pest |
| | Staphylinidae | *Ocypus brunnipes* | | | | + | Predator |
| | | *Paederus riparius* | + | | | + | Scavenger |
| | Tenebrionidae | *Zophosis punctata* | + | | + | | Scavenger |
| Diptera | Anthomyiidae | *Delia antique* | | + | | + | Pollinator |
| | Bombyliidae | *Xenox tigrinus* | + | | + | + | Pollinator |
| | Calliphoridae | *Calliphora veratotoria* | | + | + | | Scavenger |
| | | *Chrysomya megacephala* | | | + | + | Scavenger |
| | Chloropidae | *Oscinella frit* | + | | | | Pest |
| | Culicidae | *Aedes albopictus* | | + | | + | |
| | | *Culex quinquefasciatus* | + | | | | |
| | | *Culex pipiens* | | | + | | |
| | Diopsidae | *Ropalidia marginata* | | + | | | Predator |
| | Dolichopodidae | *Condylostylus longicornis* | | | | + | Predator |
| | Drosophilidae | *Gitona distigma* | + | + | + | + | Pest |
| | | *Drosophila melanogaster* | + | | | | Pest |
| | Lauxaniidae | *Homoneura flavofemorata* | + | + | + | + | Pest |
| | | *Minettia flaveola* | | | | + | Scavenger |
| | Muscidae | *Atherigona soccata* | | + | | + | Pest |
| | | *Musca domestics* | | | + | | Scavenger |
| | | *Musca autumnalis* | + | | | + | Scavenger |
| | Psychodidae | *Chloromyia Formosa* | | + | + | | Scavengers |
| | | *Hermetia illucens* | + | + | + | | Scavengers |
| | | *Psychoda alternate* | + | | | | Scavengers |
| | Sacrophagidae | *Sacrophaga bullata* | | | + | + | Scavenger |
| | | *Sacrophaga sp.* | | | + | + | Scavengers |
| | Syrphidae | *Meliscaeva cintella* | | + | + | | Pollinator |
| | | *Syrphus ribesii* | | + | + | | Pollinator |
| | Tabanidae | *Tabanus eggeri* | + | | | | Pest |
| | | *Philoliche sp.* | + | | + | | Pollinator |
| | Tephritidae | *Bactrocera cucurbitae* | + | | + | + | Pollinator |
| | | *Bactrocera curvifera* | | | | + | Pollinator |
| | | *Bactrocera dorsalis* | + | + | + | | Pollinator |
| | | *Bactrocera tryoni* | + | + | + | | pest |
| | | *Diarrhegma modestum* | + | + | + | + | Pest |
| Lepidoptera | Crambidae | *Cnaphalocrocis madinalis* | + | | + | | Pest |

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|---|---|---|---|---|---|---|---|
| | | | *Hellula undalis* | + | + | + | | Pest |
| | | | *Leucinodes orbonalis* | | + | | + | Pest |
| | | | *Noorda blitealis* | + | + | | + | Pest |
| | | | *Noorda moringae* | + | + | | + | Pest |
| | | | *Protrigonia zizanialis* | | + | | + | Pest |
| | | | *Scirpophaga incertulas* | | | + | + | Pest |
| | | Erebidae | *Asota caricae* | | + | | | Pest |
| | | | *Spilosoma oblique* | | + | + | | Pest |
| | | Eupterotidae | *Eupterote germinate* | | + | | + | Pest |
| | | | *Eupterote mollifera* | | + | | + | Pest |
| | | Gelechiidae | *Pectinophora gossypiella* | + | | + | | Pest |
| | | Lymantridae | *Euproctis lunata* | + | + | | | Pest |
| | | Noctuidae | *Helicoverpa armigera* | + | + | + | + | Pest |
| | | | *Spodoptera litura* | + | + | + | + | Pest |
| | | Nolidae | *Earias insulana* | + | | + | | Pest |
| | | | *Earias vitella* | + | | + | | Pest |
| | | Nymphalidae | *Danaus chrysippus* | + | + | + | + | Pest |
| | | | *Danaus genutia* | + | | | | Pest |
| | | | *Hypolimnas misippus* | | | | + | Pest |
| | | | *Junonia almanac* | | + | + | | Pest |
| | | Papilionidae | *Pachliopta aristolochiae* | | + | | | Pollinator |
| | | Pieridae | *Eurena hecabe* | + | + | + | + | Pest |
| | | | *Anthocharis cardamines* | | | + | | Pest |
| | | | *Delias eucharis* | | | + | | Pollinator |
| | | Plutellidae | *Plutella xylostella* | + | + | | + | Pest |
| | | Pyralidae | *Euzophera perticella* | + | + | + | | Pest |
| | | Pyrausdtidae | *Scripophaga incertulas* | + | + | | + | Pollinator |
| | Hymenoptera | Apidae | *Amegilla cingulata* | + | | + | + | Pollinator |
| | | | *Amegilla zonata* | + | + | | | Pollinator |
| | | | *Apis cerana* | + | + | | | Pollinator |
| | | | *Apis dorsata* | + | + | + | + | Pollinator |
| | | | *Apis florae* | + | + | + | + | Pollinator |
| | | | *Colletes daviesanus* | + | + | + | + | Pollinator |
| | | | *Tetraloniella braunsiana* | | | | + | Pollinator |
| | | | *Xylocopa aestuans* | + | | + | + | Pollinator |
| | | | *Xylocopa micanus* | + | + | + | + | Pollinator |
| | | | *Xylocopa pubescens* | + | + | | + | Pollinator |
| | | | *Xylocopa verginica* | | + | + | + | Pollinator |
| | | | *Xylocopa violaceae* | | | + | + | Pollinator |
| | | Chrysididae | *Chrysis angolensis* | + | + | | | Pollinator |
| | | Formicidae | *Solenopsis Invicta* | + | | | + | Pollinator |
| | | | *Oecophylla longinoda* | + | | + | + | Predator |
| | | | *Formica fusca* | + | + | + | + | Predator |
| | | | *Oecophylla smaragdina* | | + | + | + | Predator |
| | | | *Opisthopsis haddoni* | + | | + | + | Predator |
| | | | *Podomyrma gratiosa* | | + | | + | Predator |
| | | | *Tetraponera rufonigra* | + | + | + | + | Predator |
| | | | *Camponotus pennsylvanicus* | + | + | | | Scavenger |
| | | Halictidae | *Agapostemon virescens* | + | | | + | Pollinator |
| | | | *Holictus scabiose* | + | | | | Pollinator |
| | | | *Holictus sp.* | + | | | | Pollinator |
| | | | *Nomia sp.* | | + | | + | Predator |
| | | Ichneumonidae | *Ichneumon sp.* | + | | | | Pollinator |
| | | Melittidae | *Melitta leporine* | | + | | | Pollinator |
| | | Sphecidae | *Chalybion californicum* | | | + | + | Pollinator |
| | | | *Delta dimidiatipenne* | + | + | + | + | Pollinator |
| | | | *Ectemnius cavifrons* | + | | | | Pollinator |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Larra anathema* | + | + | + | + | Pollinator |
| | | *Sceliphron caementarium* | | | + | + | Pollinator |
| | | *Sceliphron spirifex* | | | + | | Pollinator |
| | | *Sphex pennsylvanicus* | + | + | + | | Pollinator |
| | Vespidae | *Abeja carpintera* | | + | | + | Pollinator |
| | | *Eumenes sp.* | | | | + | Pollinator |
| | | *Orange potter wasp* | + | + | | | Pollinator |
| | | *Polister Carolina* | | + | + | | Pollinator |
| | | *Ropalidia marginata* | + | | + | + | Pollinator |
| | | *Vespa crabro* | + | + | | | Pollinator |
| | | *Vespa tropica* | + | | + | + | Predator |

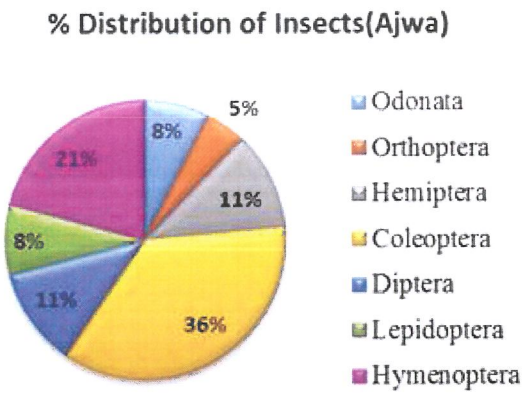


**Figure 1: % Distribution of Insects in Sites I.**

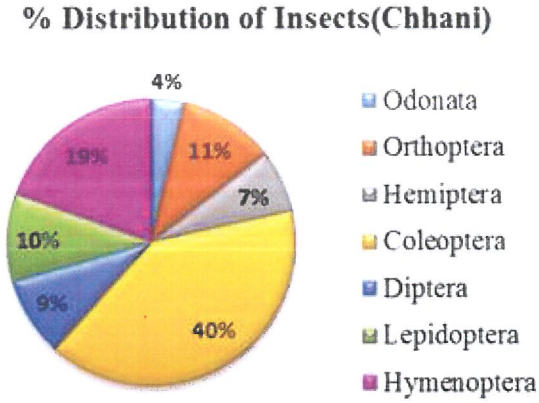


**Figure 2: % Distribution of Insects in Sites II.**

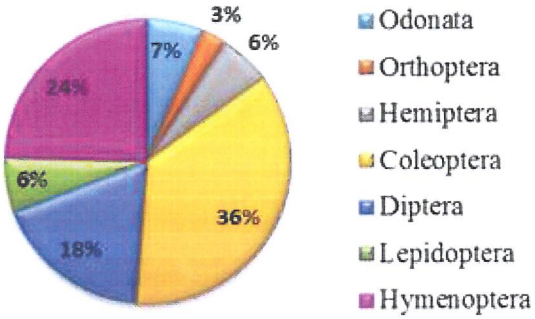


**Figure 3: % Distribution of Insects in Sites III.**

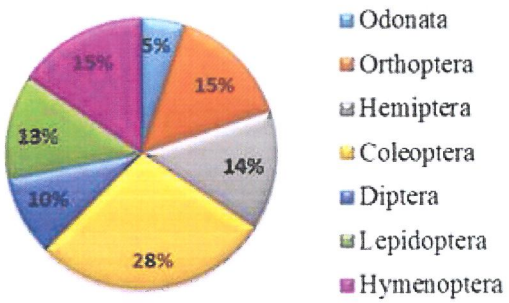


**Figure 4: % Distribution of Insects in Sites IV Sites.**

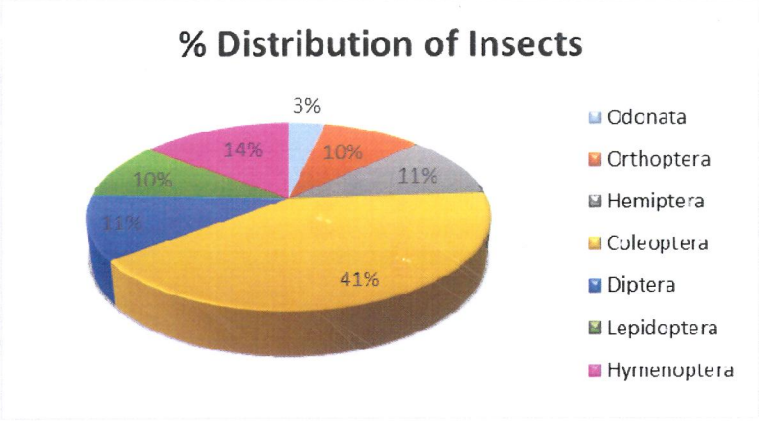


**Figure 5: Percentage Distribution of Insects in the Four Sites of Vadodara.**

An analysis of the total number of the individuals collected exhibited marked variations. The relative density of individuals of various orders was also studied. The percentage distribution of the Insect is being presented in Figure 5. During the current study the Shannon Weiner indices (Species' diversity), Marglef's indices (Species' richness) and Buzas and Gibson's indices (Species' evenness) were computed using the data to facilitate comparison between the sites. Amongst the four sites considering the total diversity and richness, Site I (Ajwa) had maximum, followed by Site IV (Padra) and followed by Site II (Chhani) compared to that of Site III (Karjan) depicted in Figures 6 and 7. As far as the evenness is concerned, Site II (Chhani) was found to have more evenly distributed species compared to the other three sites in figure 8.

**Table 2: Diversity Indices of Four Sites of Vadodara**

| Indices | Sites | | | |
|---|---|---|---|---|
| | Ajwa | Chhani | Karjan | Padra |
| Shannon_H | 4.811 | 4.788 | 4.66 | 4.766 |
| Evenness_e^H/S | 0.8192 | 0.8514 | 0.7945 | 0.8274 |
| Margalef | 21.36 | 20.52 | 18.76 | 19.95 |

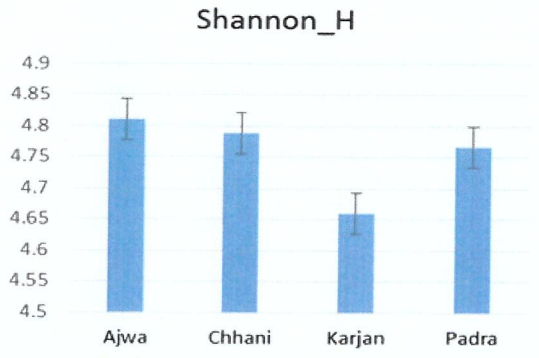


**Figure 6: Diversity Indices (Shannon_H) of Insect Species in Four Sites.**

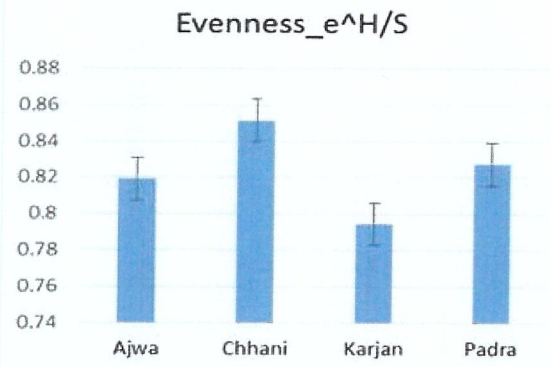


**Figure 7: Species Evenness Indices (Buzas and Gibson's) of Insect Species in Four Sites.**

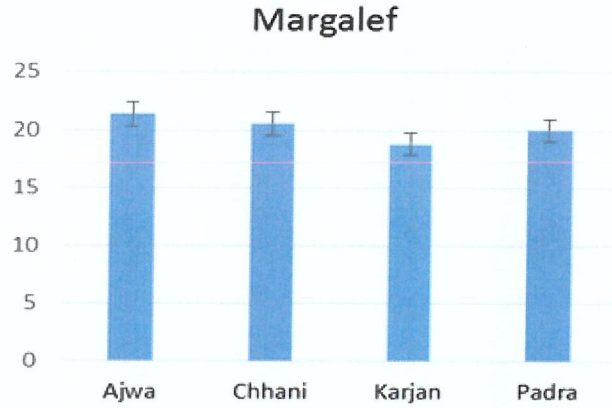


**Figure 8: Richness Indices (Margalef) of Insect Species in Four Sites.**

Based on the ecological role of the insects the collected species were categorized as Bioindicators, Pests, Pollinators, Predators and Scavengers. When the site-wise distribution pattern was studied it revealed that Site IV (Padra) had the highest number of the pest species followed by Site I (Ajwa), Site II (Chhani) and Site III (Karjan). Predators were found maximum in number at Site III (Karjan) whereas the Bio-indicator species were found more in number at Site I (Ajwa) in figure 9.

As far as the pest status is concerned only five insect orders were having pests. The maximum numbers of pests were from order Coleoptera (49) > Hemiptera (27) > Lepidoptera (25) > Orthoptera (19) > Diptera (8). A total of 283 insect species, of which 129 were pest species found inclusively in four sites and the main crops of these sites were cabbage, cowpea, spinach, onion, bitter gourd, sponge gourd, ivy gourd, pomegranate, ladies finger, guar bean, tomato, millet, banana, sweet potato, paddy, fodder grass, maize, sugarcane, cotton, brinjal, pigeon pea, drumstick, lemon tree and mango tree in various season.

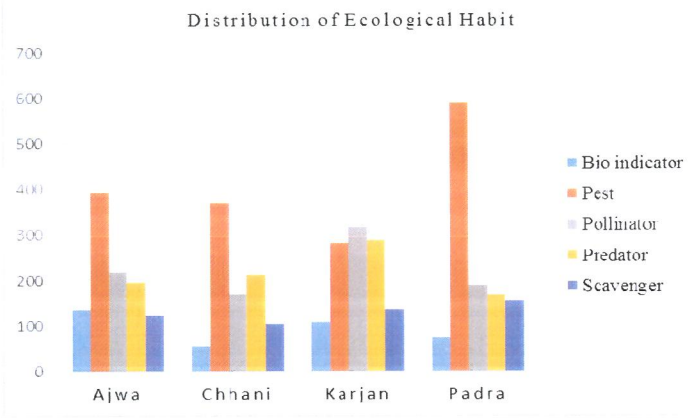


**Figure 9: Comparative Distribution of Ecological Habit of Four Sites.**

## 4. DISCUSSIONS

The appreciable numbers of Insect species reported at Ajwa site and the present study suggest that the area of Ajwa has a good healthy environment. Their presence was more prevalent in the presence of more optimum growth of all types of vegetation (Hahs *et al.,* 2009; Lambert *et al.,* 2016; El-Sabaawi, 2018). Coleoptera was reported to be the most dominant of all the Orders. Family Scarabaeidae was identified as the most dominant in the selected sites. The members belonging to this family were performing a series of ecological functions such as nutrient cycling, soil aeration, parasite suppression, secondary seed dispersal, and bioturbation (Thakkar and Parikh, 2016). Family Coccinellidae was ranked 2$^{nd}$ in case of diversity and was reported as the most predacious. Members of the Carabidae family were reported as the bioindicators of environmental changes. This is due to the habitat and presence of a good assemblage of vegetation on the site Ajwa as compared to other study sites. These three families were also reported to be very dominant based on the regional data of Gujarat by Thakkar and Parikh (2016).

Hemiptera was found with good diversity at the Padra site and most of its species such as Lygaeidea, Pentatomidae, Reduviidae, Membracidae and Coreidae were found to be pests. More number of pests was also recorded in Padra as compared to any other study site. Karjan was reported to have a good number of Hymenopterans which play the role as pollinator, parasite and predator, and also includes agriculturally important species that play a role as the biocontrol agent. The abundance of parasitic and predatory Hymenoptera can prevent the undue increase of noxious species. Pollinators are a key component of global biodiversity which provide services to crops and wild plants. Insects from the order Lepidoptera also play an important role in the pollination. In the present study, 13 families with 28 species were reported from the order Lepidoptera, in which family Nymphalidae and Papilionidae comes under schedule-1 and family Pieridae comes under schedule-2 (Gandhi and Kumar, 2015). The presence and abundance of butterflies mark the importance of the plant resources available on the site and show a healthy and suitable environment for insect diversity.

However, many species of the Lepidoptera order are a serious pest in the larvae stage (Salunke and More, 2017). Orthoptera is one of the most important groups of herbivorous insects living in the grassland systems. In the present study, 5 families with 27 species were recorded. More abundance of Orthopterans was seen on the Padra site. Order Diptera was reported with 15 families in which some have positive and some have a negative ecological effect. Various species of fruit flies cause damage to fruit and other plant crops, i.e. family Tephritidae (Gaimari, 2017). Overall, plant-herbivore interactions represent one of the most widespread and dominant ecological interactions in the conservation of natural and semi-natural habitats in landscapes to increase and protect insect resources which may be useful to improve insect pollination. Plant–herbivore interactions also play a pivotal role in ecosystem functioning (Stam *et al.,* 2014, Turcotte *et al.,* 2014).

However, the present study has the span of two years in which deals with the Species distribution, diversity, richness, evenness, ecological role and pest status of insects in four selected areas of Vadodara district. This study is considered to be the first from Vadodara district since there has been no notable work done on this aspect. Hence, the seasonal and long term studies further in this region will throw more light on the ecology and diversity of Insects. A long term study is needed to observe the species occurrence of insect diversity and their interaction with the environment, to get better and comprehensive information.

## 5. CONCLUSIONS

This work concludes that Ajwa was the most dominant site in terms of insect diversity and richness among the four selected sites. The good number of the insects in this site was not surprising as this area is dominated by grasslands as well as plenty of vegetation. The results which were being presented in this report might be the first comprehensive list of insects in these areas. It is an obvious fact that insects contribute much to the ecological welfare therefore the insect conservation has been recognized as vital for a sustainable world because of their critical role in the conservation of the ecosystem. This study is also derived that the pest status of insects are also high in the agricultural fields due to several adaptations. An extensive study is needed to observe the species occurrence in all seasons and their interaction with the environmental changes. It is also a fact that acquiring more information on community structure, abundance and distribution to determine appropriate levels of protection needed for the ecosystem process for better results. However, this study will throw more understanding to the existing knowledge of the entomologists of Vadodara, Gujarat and India as well. Hopefully, there will be further research studies on insect biodiversity and taxonomy in this area, for better and comprehensive information on those aspects to be documented for future reference.

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## AUTHOR'S PROFILE

**Prof. Pragna Parikh, Education Details: B.Sc (Zoology); M.Sc (Zoology); Ph. D (Zoology),**

**Prof. Pragna Parikh** is working in the field of Biodiversity from the past 30 years and her research group has provided vital insights into the Morphological and Molecular taxonomy, as well as the Physiological changes and the biopesticidal effects on the various Insects. State of Gujarat is very rich in various fauna as it encapsulates four major bio-geographical zones of India, but very less work is done which is focused on the diversity especially of the insects. Insects are the major players in governing the food chain and food web of an ecosystem. The studies in her lab are ranging from biodiversity to effect of neonicotinoids on insect non-neuronal cell line. The author has published more than 25 research articles in the different fields of Insect diversity and insect physiology in various national and international journals. The author is a life member of Indian Science Congress Association (ISCA), Society of Reproductive Biology and Comparative Endocrinology, member of Editorial Board of Bionano Frontier and International Society of Science and Technology Bombay, India. In 2008, the author was also invited at University of Lethbridge, Alberta, Canada for insect identification as an expert.

**Sr. Linta Paulson, Education Details: B.Sc (Microbiology); M.Sc (Zoology); Ph. D (Zoology, Pursuing),**

**Ms. Linta Paulson** a recipient of **Gold Medalist** at the Masters level from The Maharaja Sayajirao University of Baroda, Vadodara with specialization in Entomology. Presently she is working for her Ph.D, on Insect diversity of Agricultural fields of Vadodara district biodiversity, its molecular characterization with special reference to the Agricultural pests and trying to understand the insect-plant interaction.

**Miss. Bhumi Thakkar, Education Details: B.Sc (Bio-Tech); M.Sc (Forensic Science); Ph. D (Zoology, Thesis Submitted),** Since 2014 Miss. Bhumi Thakkar is working in the field of Insect biodiversity which involves its Ecology, Ethology and Molecular characterization and has published 5 research articles in field of insect biodiversity in various national and international journals.

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# Diversity of pests and its infestation in agroecosystem of Vadodara

**Paulson Linta and Parikh Pragna***

Division of Entomology, Department of Zoology, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara. 390002.
*Corresponding author Email :php59@yahoo.co.in

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## Abstract

Pests are one of the most challenging threats to the agricultural ecosystem. The occurrence and infestation severity of pests was studied in the agroecosystem of the Vadodara district for two years. The maximum numbers of potential pests were observed from orders like Coleoptera, Orthoptera, Lepidoptera, and Hemiptera. In the present study, a total of 163 pest species were recorded, where order Coleoptera was represented with the highest number of 69 species belonging to 16 families, order Orthoptera with 34 species belonging to 4 families, Lepidoptera with 31 species representing 12 families and Hemiptera with 29 species represented by 13 families. The present study provides scientific data about the assessment of incidence and infestation severity of pest insects in the agroecosystem of Vadodara, which will provide baseline information to farmers in monitoring and managing the control of pest in and near Vadodara district.

**Keywords:** Insects, pest, agroecosystem, Vadodara

## Introduction

Insects comprise the most diverse and successful group of multicellular organisms on the planet, and in natural ecosystems, phytophagous insects coexist in a complicated relationship with plant communities. Pests are the most significant threats to agricultural yield and the health and wealth of human beings, inflicting enormous losses to the potential agricultural production. Insect pests are a significant concern for farmers globally, and more than 10,000 species of insects have recorded damaging crops [1]. Despite using various control methods, the control of agriculture pests continues to be critical for farmers.

One-fifth of the world's crop productions are damaged by pests annually [2], and the crop loss by pests reach as high as 60-70%. Agriculture is currently suffering a yearly loss of about 36 billion USD in India due to insect pests [3-4]. This massive crop loss is a reason behind the farmer to use an enormous amount of pesticides.

Among the many challenges in supporting crop productivity and nutritional security, direct and indirect damages by insect pests is of paramount importance. The population of insect pest outbreaks has enormous potential to damage the agricultural economy. It is crucial to recognize the early signs of pests and its damage to deal with the problem [5]. Keeping in view the importance and the damage caused by insect pests, the objective of the present work was to survey pests and its infestation in the agriculture fields of Vadodara district.

## Methodology

**Site Selection**

Vadodara is located at 220 11' N latitude and 730 07' E longitudes, in the eastern part of Gujarat in western India and covers an area of 7,794 sq km. A preliminary study was carried out for the presence of agriculture fields based on the crop pattern and type. Further, taking into consideration the accessibility and location, four sites were selected i.e., Ajwa (22.3751° N, 73.3851° E), Chhani (22.3633° N, 73.1658° E), Karjan (22.0535° N, 73.1202° E) and Padra (22.2394° N, 73.0848° E) areas of Vadodara district (Fig.1). All four sites were visited twice a month from August 2017 to August 2019, and the entire study period was classified into three distinct seasons: winter, winter, and Rainy season.

**Insect collection**

Along with the direct observation and photo documentation, pest species were collected manually and transferred in plastic jars. Sampling was carried out from the herb and shrub layers of the vegetation using a scientific method like sweeping net, handpicking, pitfall trap, and light trap. The collected insects were transferred into that contained cotton soaked in ethyl acetate. Then they were transported to the laboratory where the insects were stretched, pinned and preserved in wooden insect boxes. The identified specimens were confirmed by comparing with the authentic specimens at the Department of Zoology, Faculty of Science, The Maharaja Sayajirao University of Baroda and Bombay Natural History Society, Mumbai.

**Assessment of Damage rating / visual severity score of Pests**:

The infestation of insect pests on agricultural fields of selected sites on various crops was assessed as per the scale given by Nagrare and his co-workers in the year 2011. (Central Institute for Cotton Research, Nagpur).

**Damage rating / visual severity score for Pest**

1. Grade: 0 –20% of foliage consumed/ indecently seen
2. Grade: 21–40% of foliage consumed/ Scattered appearance of few individuals on the plant
3. Grade: 41 – 60% of foliage consumed/ Severe infestation of individuals on any one branch of the plant
4. Grade: 61 – 80% of foliage consumed/ Severe infestation of individuals on more than one branch
5. Grade: 81–100% of foliage consumed/ Severe infestation of individuals on the whole plant.

**The formulae are shown as follows used for estimations:**

**Percentage incidence (PI) =** Number of infested plants / Total plant observed X 100.

**Severity index (SI) =** Sum of total grade points (1-5 infestation grade G-I to G-V, respectively) of the infested plants / Total number of infested plants observed. **[6]**

## Results and Discussions

Table I represents an annotated order wise list of pests observed in the present study. A total of 163 pest species belonging to 4 orders (Coleoptera, Hemiptera, Orthoptera and Lepidoptera) were recorded during the study period (2017 - 2019). Members of order Coleopteran were found to be the most dominant with 69 pest species spread in 16 families, next in order of the

number of representatives was Order Orthoptera with 34 species belonging to 4 families. Lepidoptera was recorded with 31 species spread in 12 families and last in the order of number of pest species was Hemiptera with 29 species represented by 13 families. Year wise occurrence of the pest was higher in year 2017- '18 (Table: II).

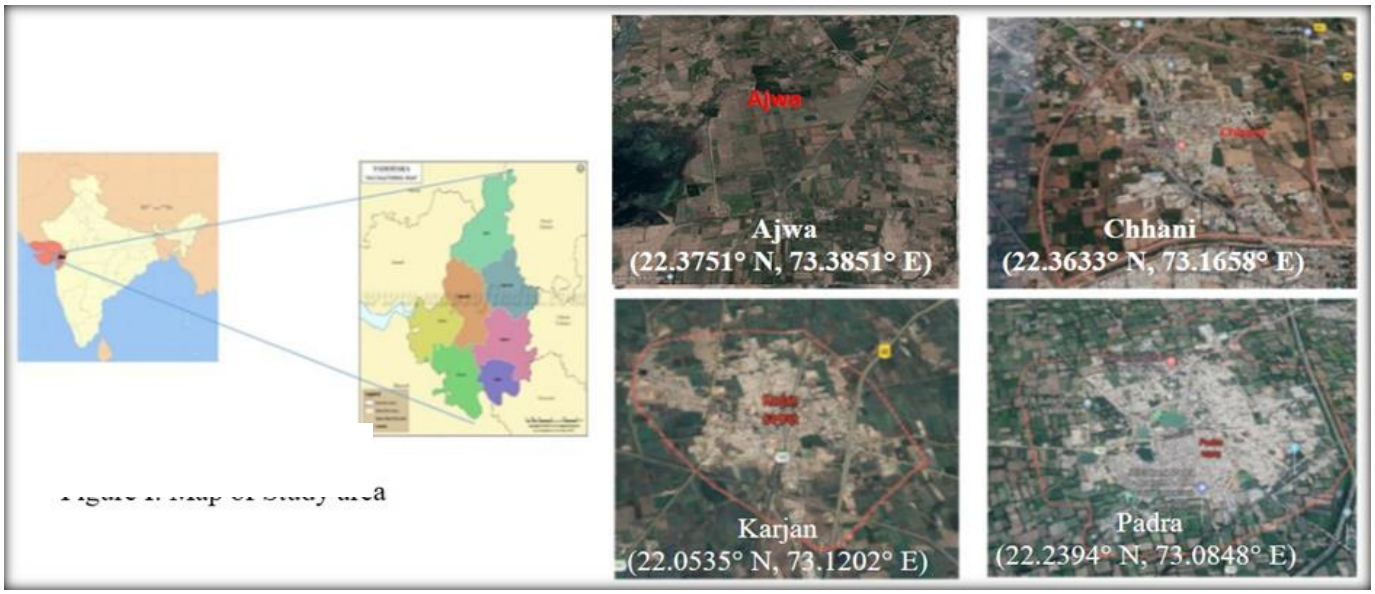


**Figure 1: Map of Study area**

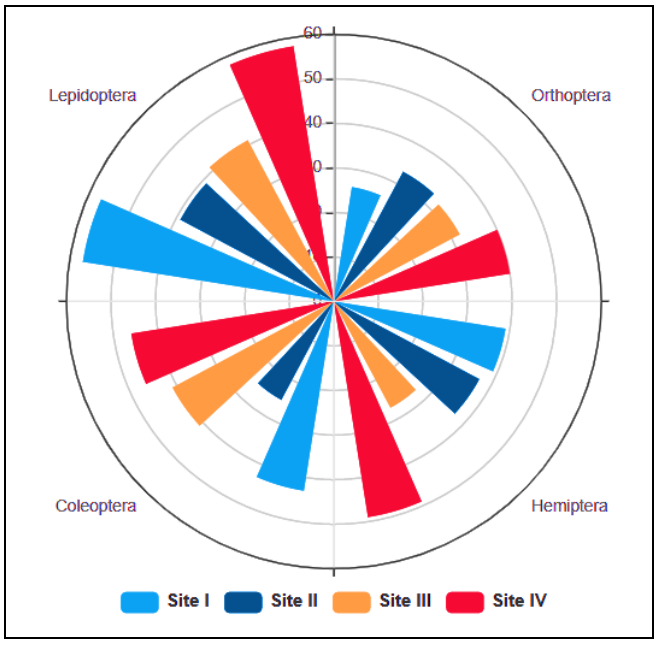


**Figure 2**

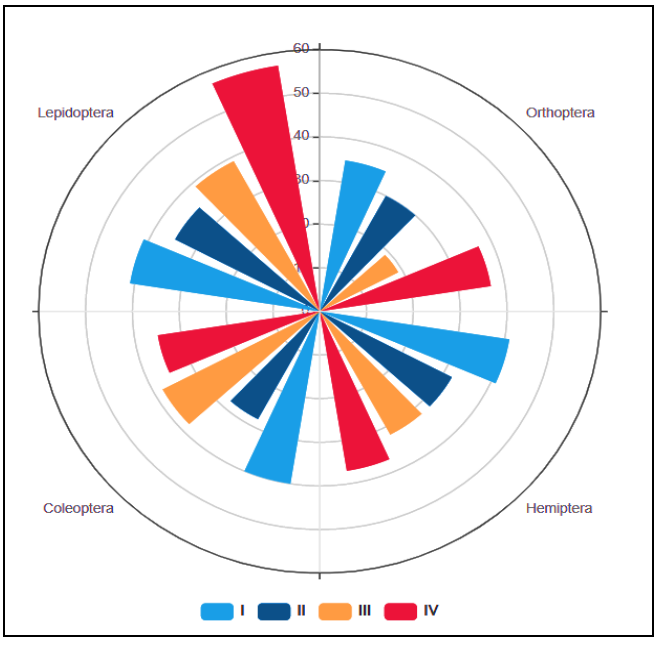


**Figure 3**

**Figure 2: %Incidence of four orders at four Sites in the year 2017- '18**
**Figure 3: %Incidence of four orders at four Sites in the year 2017- '19**

**Table 1: A list of Pest Species of four Orders**

| **Orthoptera Species** | |
|---|---|
| *Acorypha glaucopsis* (Fabricius, 1798) | *Omocestus viridulus* (Linnaeus, 1758) |
| *Acrida conica* (Fabricius, 1781) | *Orphulella pelidna* (Burmeister, H., 1838) |
| *Acrida exaltata* (Walker, F., 1859) | *Oxya hyla hyla* (Serville, 1831) |
| *Acrida ungarica* (Herbst, 1786) | *Oxya hyla intricata* (Stål, 1861) |
| *Acrida willemsei* | *Schistocera gregaria* (Forskål, 1775) |
| *Acrotylus humbertianus* | *Schistocera sp.* |
| *Aiolopus thalassinus* (Fabricius, 1781) | *Sphingonatus sp.* |
| *Calliptamus sp.* | *Trilophidia annulata* (Thunberg, 1815) |
| *Phlaeoba infumata* | *Xenocatantops humilis* (Serville, 1838) |
| *Choroedocus robustus* (Serville, 1838) | *Acheta domesticus* (Linnaeus, 1758) |
| *Chorthippus curtipennis* | *Chrotogonus sp.* |
| *Euthystria brachyptera* | *Poekilocerus pictus* (Fabricius, 1775) |
| *Hieroglyphus banian* (Fabricius, 1798) | *Amblycorypha rotundifolia* (Scudder, 1862) |
| *Locusta migratoria* (Linnaeus, 1758) | *Neoconocephalus velox* (Rehn & Hebard, 1914) |
| *Melanoplus femurrubrum* (De Geer, 1773) | *Ducetia japonica* (Thunberg, 1815) |
| *Metaleptea brevicornis (*Johannson, 1763*)* | *Scudderia furcata* (Brunner von Wattenwyl, 1878) |
| *Omecestus sp.* | *Trigonocorypha unicolor* (Stoll, 1787) |
| **Hemiptera Species** | |
| *Aleurodicus disperses* (Russell, 1965) | *Acanthuchus trispinifer* (Fairmaire, 1846) |
| *Aphis gossypii* (Glover, 1877) | *Oxyrachis tarandus* |
| *Empoasca decipiens* (Paoli, 1930) | *Agonoscelis nubilis* (Fabricius, 1775) |
| *Drepanococcus cajani* (Maskell, 1891) | *Bagrada hilaris* (Burmeister, 1835) |
| *Phenacoccus madeirensis* (Green, 1923) | *Eysarcoris guttiger* (Scopoli, 1763) |
| *Acanthocephala femorata* (Fabricius 1775) | *Halyomorpha halys* (Stål, 1855) |
| *Cletomorpha benita* (Kirby, 1891) | *Nezara viridula* (Linnaeus, 1758) |
| *Cletus punctiger* (Dallas, 1852) | *Nezara antennata* |
| *Homoeocerus signatus* (Walker, 1871) | *Palomena prasina* (Linnaeus, 1761) |
| *Pamendanga sp.* | *Megacopta cribraria* (Fabricius, 1798) |
| *Proutista moesta* (Westwood, 1851) | *Plautia affinis* (Dallas, 1851) |
| *Rhynchomitra microrhina* (Walker, 1851) | *Planococcus sp.* |
| *Coridius janus* (Fabricius, 1775) | *Dysdercus koenigii* (Fabricius, 1775) |
| *Pyrilla perpusilla* (Walker, 1851) | *Dysdercus cingulatus* (Fabricius, 1775) |
| *Leptocentrus moringae* | |
| **Coleoptera Species** | |
| *Lasioderma serricorne* (Fabricius, 1792) | *Cosmopolites sordidus* (Germar, 1824) |
| *Formicomus sp.* | *Hypera postica* (Gyllenhal, 1813) |
| *Apion clavipes* | *Myllocerus dorsatus* (Fabricius, 1798) |
| *Paratrachelophorus sp.* | *Myllocerus subfasciatus* (Guerin-Meneville, 1843) |
| *Acmaeodera sp.* | *Myllocerus undecimpustulatus* (Faust,1891) |
| *Acmaeodera viridaenea* (Eschscholtz, 1829) | *Myllocerus viridanus* (Fabricius,1775) |
| *Agrilus acutus* (Thunberg, 1787) | *Polydrusus formosus* (Mayer, 1779) |

**Table 1: Continued…**

| | |
|---|---|
| *Craspedophorus saundersi* (Chaudoir, 1869) | *Sitophilus oryzae*(Linnaeus, 1763) |
| *Acanthophorus serraticornis* (Olivier, 1795) | *Lanelater fuscipes* (Fabricius, 1775) |
| *Batocera rufomaculata* (De Geer, 1775) | *Cryptolestes pusillus* (Schönherr, 1817) |
| *Celosterna scabrator*(Fabricius, 1793) | Horia sp. |
| *Dectes texanus* | *Lytta caragana* (Pallas, 1798) |
| *Derobrachus hovorei (Santos-Silva, 2007)* | *Mylabris cichorii* (Linnaeus, 1767) |
| *Macrotoma palmate (Fabricius)* | *Mylabris pustulata* (Thunberg, 1821) |
| *Prionus californicus (Motschulsky, 1845)* | *Mylabris variabilis* (Pallas, 1782) |
| *Trachysida sp.* | *Psalydolytta rouxi*(Castelnau 1840) |
| *Xylotrechus stebbingi* (Gahan 1906) | *Cetonia funesta* (Poda, 1761) |
| *Altica cyanea* | *Chiloloba acuta* (Wiedemann, 1823) |
| *Aspidomorpha miliaris* (Fabricius, 1775) | *Cyclocephala pasadenae* (Casey, 1915) |
| *Aulacophora lewisii* (Baly, 1886) | *Heliocopris gigas* (Linnaeus, 1758) |
| *Aulacophora nigripennis* (Motschulsky, 1857) | *Holotrichia reynaudi* (Blanchard, 1851) |
| *Aulocophora foveicollis* (Lucas, 1849) | *Oryctes nasicornis* (Linnaeus, 1758) |
| *Cassida circumdata* | *Oryctes rhinoceros* (Linnaeus, 1758) |
| *Cassida sp.* | *Oxycetonia jucunda* (Falderman, 1835) |
| *Chiridopsis bipunctata* (Linnaeus, 1767) | *Oxycetonia versicolor* (Fabricius, 1775) |
| *Chrysochus cobaltinus* (LeConte, 1857) | *Phyllophaga nebulosi* (Polihronakis, 2007) |
| *Clytra laeviuscula* (Ratzeburg, 1837) | *Phyllophaga obsolete* (Blanchard, 1851) |
| *Metriona bicolor* (Fabricius,1981) | *Phyllophaga sp.* |
| *Monolepta signata* | *Protaetia alboguttata* (Vigors, 1826) |
| *Oides bipunctata* (Fabricus, 1781) | *Protaetia aurichalcea* (Fabricius, 1775) |
| *Oides palleata* (Fabricius, 1781) | *Protaetia squamipennis* (Burmeister, 1842) |
| *Podagrica fuscicornis* (Linnaeus, 1767) | *Oryzaephilus surinamensis* (Linnaeus, 1758) |
| *Sindia clathrata* (Olivier,1808) | *Gonocephalum sp.* |
| *Epilachna ocellate* (Redtenbacher, 1977) | *Tenebrio molitor* (Linnaeus, 1758) |
| *Cleonus sp.* | |

**Table 2:** Comparative Occurrence of species in each order during the study period

| Orders | 2017 - '18 | 2018 - '19 |
|---|---|---|
| Orthoptera | 20 | 16 |
| Hemiptera | 19 | 16 |
| Coleoptera | 39 | 36 |
| Lepidoptera | 19 | 17 |

**Table 3: %Incidence (PI) and Severity Index (SI)of four orders at four Sites in the year 2017- '18**

| Sites | Orthoptera | | Hemiptera | | Coleoptera | | Lepidoptera | |
|---|---|---|---|---|---|---|---|---|
| | PI | SI | PI | SI | PI | SI | PI | SI |
| **I** | 26 | 1 | 39 | 1.7 | 43 | 1.5 | 57 | 1.7 |
| **II** | 33 | 1.3 | 37 | 1.6 | 25 | 1 | 39 | 1.6 |
| **III** | 32 | 1 | 27 | 1.3 | 41 | 1.3 | 41 | 1.3 |
| **IV** | 40 | 2.1 | 49 | 1.9 | 46 | 1.5 | 58 | 2.1 |
| **Mean** | | **1.3** | | **1.6** | | **1.3** | | **1.6** |

**Table 4 : % Incidence (PI) and Severity Index (SI)of four orders at four Sites in the year 2018- '19**

| Sites | Orthoptera | | Hemiptera | | Coleoptera | | Lepidoptera | |
|---|---|---|---|---|---|---|---|---|
| | PI | SI | PI | SI | PI | SI | PI | SI |
| **I** | 35 | 1.2 | 45 | 1.5 | 41 | 1.4 | 41 | 1.5 |
| **II** | 30 | 1.1 | 32 | 1.5 | 28 | 1.5 | 35 | 1.5 |
| **III** | 18 | 1 | 32 | 1.1 | 38 | 1 | 39 | 1 |
| **IV** | 38 | 1.5 | 37 | 1.4 | 35 | 1.2 | 57 | 1.4 |
| Mean | | **1.2** | | **1.4** | | **1.3** | | **1.4** |

Although the diversity of Coleopteran pest was maximum (Table. II), the highest Percentage incidence and the Severity Index were recorded maximum with the order Hemiptera and Lepidoptera as compared to the other two orders in both the years (Fig. II & III). The site-wise Percentage Incidence and Severity Index of pest depicted that Site IV had higher occurrence of all the orders compared to the other three Sites (Table III & IV). Year-wise Percentage Incidence and Severity Index of pests were recorded highly significant ($p<0.05$) during the year 2017 - '18 compared to 2018 - '19.

## Discussion

The maximum numbers of pests were from order Coleoptera (69) > Orthoptera (34) > Lepidoptera (31) > Hemiptera (29). An appreciable number of Coleopteran pest in the present study is not a surprise that the area provides a favorable condition for the growth and existence of pests and pests can be found in vegetative foliage, flowers, trees, and their bark, and inside plant tissue in the form of galls [7-10]. They are also beneficial, acting as predators by controlling other insect pests [11]. However, few Coleopterans act as a biocontrol agent and have been successfully used to reduce pestilent flies and parasitic worms [12]. Diversity and population dynamics of Coleopteran pest [13] and predators have been reported by Rattanapun [14]. Agricultural fields comprise of perennial and annual crops; this cultivated habitat harbors a succession of pest species that first use the growing field as a passageway then establish themselves as the crop grows, the temporal and spatial alterations in pest species of Coleoptera are in agreement with the earlier reported works [15-17]

The orders observed in the present study were almost similar to the studies conducted in the agroecosystem. Sathe *et al.*, [18] studied color attractively and the occurrence of some cell sucking pests on crop plants from the Kolhapur region and reported four sap-sucking insect pests. Sathe *et al.*, [19] reported pest species of Brinjal from the Kolhapur region. Diversity and biology and control insect pests from Western Maharashtra and reported 30 species studied by Patil *et al.*,[20]. UlAne and Hussain [21] mentioned Lepidoptera, Hemiptera, Coleoptera, and Orthoptera from major rice-growing areas of the world. Salunke and More [22] reported that in Chandgad Tahsil, the farmers were facing various agricultural insect pests especially in the case of Rice, Red gram, Brinjal and Cowpeas, and observed other pests such as Aphids, Mealybug, and whiteflies are damaging various crops in winter and summer season.

Order Hemiptera and Lepidoptera were shown maximum Percentage Incidence and Severity Index in both the years. Many pest species of both orders have developed resistance to insecticides and have a wide range of hosts. The larvae of these insects are more destructive than adults [23-25]. Our work is parallel to the earlier reported work in various agroecosystems [26-28]. However, the rate of infestation severity was more in the year 2017-18 compared to 2018-19, possibly due to heavy rains; such environmental extremes affect the occurrence, prevalence, and severity of plant diseases and are internally associated with each other [29-32].

## Conclusion

This present study reports the pest diversity in the agricultural field of the Vadodara district. A distinct occurrence of the pest species was observed. A maximum number of pest species were reported from order Coleoptera, followed by Orthoptera, Lepidoptera, and Hemiptera. Incidence and severity index were more in 2017-18 than in 2018-19 due to extreme climate variation. Order Hemiptera and Lepidoptera showed more incidence and severity. The present study can be interpreted as more of a baseline data which will help entomologists and agriculturalists to gain more insights and measures for better yield of the crops. However, there is a need to complement the existing information with additional studies where a detailed understanding of the trophic interaction and population dynamics will affirm how crop pests can be controlled with more directed measures.

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