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DIVERSITY OF PESTS AND ITS INFESTATION IN AGROECOSYSTEM OF VADODARA

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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 (Dhaliwal *et al.,* 2010). 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 (Srivastava, 2017), 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 (Dhaliwal *et al.,* 2015; Rathee and Dalal, 2018). 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 (Karthika *et al.,* 2016). 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.

Materials and Methods

Site Selection
Vadodara is located at 220 11' N latitude and 730 07' E longitude, 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

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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.

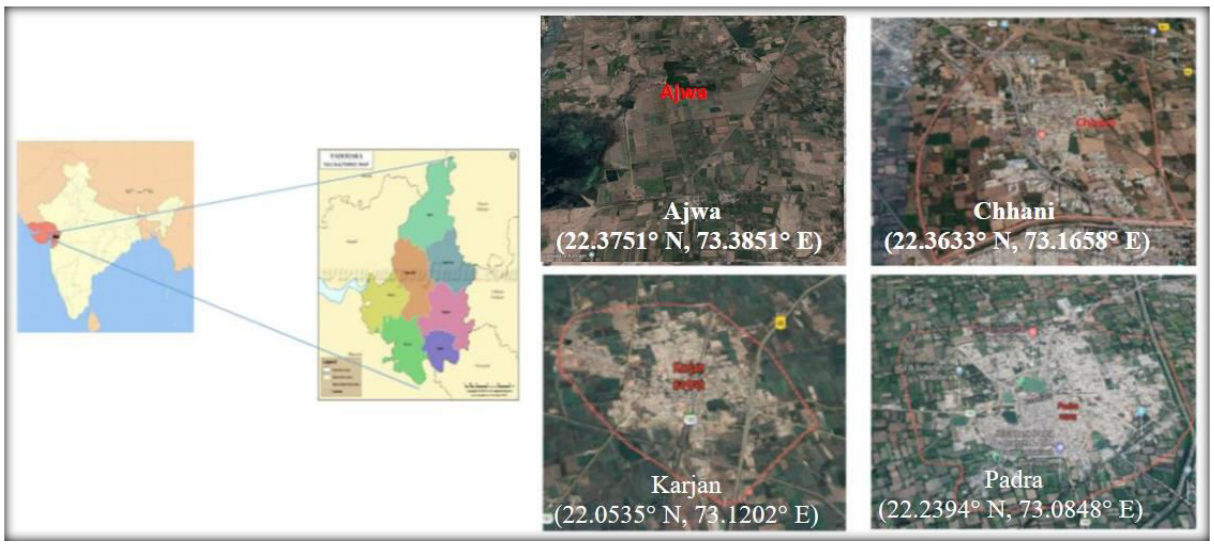

Fig. I: Map of Study area

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 onebranch
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.
(Berger, 1980)

Result

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Table I represents an annotated order wise list of pests observedin 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).

Orthoptera Species	
Acoryphaglaucopsis(Fabricius, 1798)	*Omocestusviridulus*(Linnaeus, 1758)
Acridaconica(Fabricius, 1781)	*Orphulellapelidna*(Burmeister, H., 1838)
Acridaexaltata(Walker, F., 1859)	*Oxyahylahyla*(Serville, 1831)
Acridaungarica(Herbst, 1786)	*Oxyahylaintricata*(Stål, 1861)
Acrida willemsei	*Schistoceragregaria*(Forskål, 1775)
Acrotylushumbertianus	*Schistocera sp.*
Aiolopusthalassinus(Fabricius, 1781)	*Sphingonatus sp.*
Calliptamus sp.	*Trilophidiaannulata*(Thunberg, 1815)
Phlaeobainfumata	*Xenocatantops humilis*(Serville, 1838)
Choroedocus robustus (Serville, 1838)	*Acheta domesticus*(Linnaeus, 1758)
Chorthippuscurtipennis	*Chrotogonus sp.*
Euthystriabrachyptera	*Poekiloceruspictus*(Fabricius, 1775)
Hieroglyphus banian (Fabricius, 1798)	*Amblycorypharotundifolia*(Scudder, 1862)
Locustamigratoria(Linnaeus, 1758)	*Neoconocephalusvelox*(Rehn &Hebard, 1914)
Melanoplusfemurrubrum(De Geer, 1773)	*Ducetia japonica* (Thunberg, 1815)
Metalepteabrevicornis (Johannson, 1763)	*Scudderiafurcata*(Brunner von Wattenwyl, 1878)
Omecestussp.	*Trigonocorypha unicolor*(Stoll,1787)
Hemiptera Species	
Aleurodicusdisperses (Russell, 1965)	*Acanthuchustrispinifer*(Fairmaire, 1846)
Aphis gossypii(Glover, 1877)	*Oxyrachistarandus*
Empoascadecipiens(Paoli, 1930)	*Agonoscelisnubilis*(Fabricius, 1775)
Drepanococcuscajani(Maskell, 1891)	*Bagradahilaris*(Burmeister, 1835)
Phenacoccusmadeirensis(Green, 1923)	*Eysarcorisguttiger*(Scopoli, 1763)
Acanthocephalafemorata(Fabricius 1775)	*Halyomorphahalys*(Stål, 1855)
Cletomorphabenita(Kirby, 1891)	*Nezaraviridula*(Linnaeus, 1758)
Cletus punctiger(Dallas, 1852)	*Nezaraantennata*
Homoeocerussignatus(Walker, 1871)	*Palomenaprasina*(Linnaeus, 1761)
Pamendanga sp.	*Megacoptacribraria*(Fabricius, 1798)
Proutistamoesta(Westwood, 1851)	*Plautiaaffinis*(Dallas, 1851)
Rhynchomitramicrorhina(Walker, 1851)	*Planococcus sp.*
Coridiusjanus(Fabricius, 1775)	*Dysdercuskoenigii*(Fabricius, 1775)
Pyrillaperpusilla(Walker, 1851)	*Dysdercuscingulatus*(Fabricius, 1775)
Leptocentrusmoringae	
Coleoptera Species	
Lasiodermaserricorne(Fabricius, 1792)	*Cosmopolites sordidus* (Germar, 1824)
Formicomus sp.	*Hyperapostica*(Gyllenhal, 1813)
Apionclavipes	*Mylloceruspdorsatus*(Fabricius, 1798)
Paratrachelophorus sp.	*Mylloceruspsubfasciatus*(Guerin-Meneville, 1843)
Acmaeodera sp.	*Mylloceruspundecimpustulatus*(Faust,1891)
Acmaeoderaviridaenea(Eschscholtz, 1829)	*Mylloceruspviridanus*(Fabricius,1775)

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Agrilusacutus(Thunberg, 1787)	*Polydrususformosus*(Mayer, 1779)
Craspedophorussaundersi(Chaudoir, 1869)	*Sitophilus oryzae*(Linnaeus, 1763)
Acanthophorusserraticornis(Olivier, 1795)	*Lanelaterfuscipes*(Fabricius, 1775)
Batocerarufomaculata(De Geer, 1775)	*Cryptolestespusillus*(Schönherr, 1817)
Celosternascabrator(Fabricius, 1793)	Horia sp.
Dectestexanus	*Lytta caragana* (Pallas, 1798)
Derobrachushovorei (Santos-Silva, 2007)	*Mylabriscichorii*(Linnaeus, 1767)
Macrotomapalmate (Fabricius)	*Mylabrispustulata*(Thunberg, 1821)
Prionuscalifornicus(Motschulsky, 1845)	*Mylabrisvariabilis*(Pallas, 1782)
Trachysida sp.	*Psalydolyttarouxi*(Castelnau 1840)
Xylotrechusstebbingi(Gahan 1906)	*Cetoniafunesta*(Poda, 1761)
Alticacyanea	*Chilolobaacuta*(Wiedemann, 1823)
Aspidomorpha miliaris (Fabricius, 1775)	*Cyclocephalapasadenae*(Casey, 1915)
Aulacophoralewisii(Baly, 1886)	*Heliocoprisgigas*(Linnaeus, 1758)
Aulacophoranigripennis(Motschulsky, 1857)	*Holotrichiareynaudi*(Blanchard, 1851)
Aulocophorafoveicollis(Lucas, 1849)	*Oryctesnasicornis*(Linnaeus, 1758)
Cassidacircumdata	*Oryctes rhinoceros*(Linnaeus, 1758)
Cassida sp.	*Oxycetoniajucunda*(Falderman, 1835)
Chiridopsisbipunctata(Linnaeus, 1767)	*Oxycetonia versicolor* (Fabricius, 1775)
Chrysochuscobaltinus(LeConte, 1857)	*Phyllophaga nebulosi* (Polihronakis, 2007)
Clytralaeviuscula(Ratzeburg, 1837)	*Phyllophaga obsolete* (Blanchard, 1851)
Metrionabicolor(Fabricius,1981)	*Phyllophaga sp.*
Monoleptasignata	*Protaetiaalboguttata*(Vigors, 1826)
Oidesbipunctata(Fabricus, 1781)	*Protaetiaaurichalcea*(Fabricius, 1775)
Oidespalleata(Fabricius, 1781)	*Protaetiasquamipennis*(Burmeister, 1842)
Podagricafuscicornis(Linnaeus, 1767)	*Oryzaephilussurinamensis*(Linnaeus, 1758)
Sindiaclathrata(Olivier,1808)	*Gonocephalum sp.*
Epilachnaocellate (Redtenbacher, 1977)	*Tenebrio molitor*(Linnaeus, 1758)
Cleonus sp.	

Table I: A list of Pest Species of four Orders

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

Table II: Comparative Occurrence of species in each orderduring the study period

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

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

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Incidence and Severity Index of pests were recorded highly significant ($p<0.05$) during the year 2017 - '18 compared to 2018 - '19.

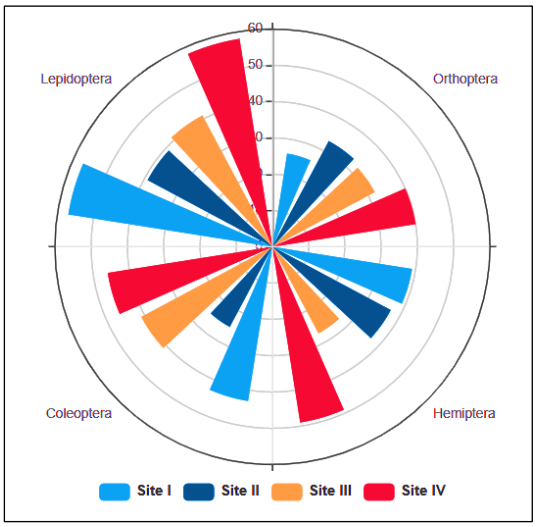

Fig. II: %Incidence of four orders at four Sites in the year 2017- '18

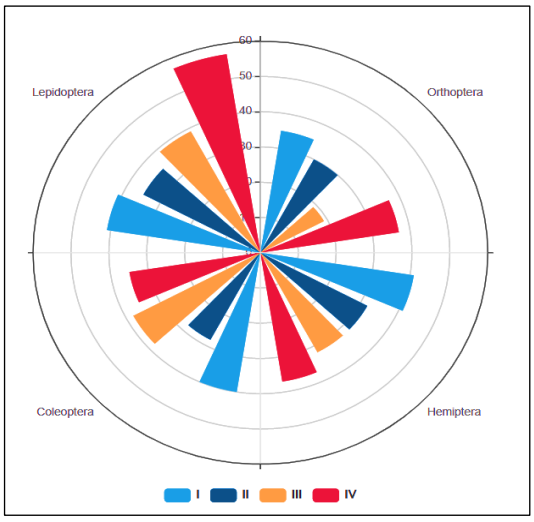

Fig. III: %Incidence of four orders at four Sites in the year 2017- '19

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**

Table IV: % Incidence (PI) and Severity Index (SI)of four orders at four Sites in the year 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 (Gullan and Cranston, 2010; Banerjee, 2014; Singhal *et al.,* 2018, Rossi *et al.,* 2019). They are also beneficial, acting as predators by controlling other insect pests (Brown *et al.,* 2010). However, few Coleopterans act as a biocontrol agent and have been successfully used to reduce pestilent flies and parasitic worms (Kakkar and Gupta, 2010). Diversity and population dynamics of Coleopteran pest (Vician *et al.,* 2015) and predators have been reported by Rattanapun (2012). 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 (Boivin and Hance 2003; French *et al.,* 2004; O'Rourke *et al.,* 2008)

The orders observed in the present study were almost similar to the studies conducted in the agroecosystem. Sathe *et al.,* (2015) 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.,* (2016) reported pest species of Brinjal from the Kolhapur region. Diversity and biology and control insect pests from Western Maharashtra and reported 30 species

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studied by Patil *et al.,* (2016). UlAne and Hussain (2016) mentioned Lepidoptera, Hemiptera, Coleoptera, and Orthoptera from major rice-growing areas of the world. Salunke and More (2017) 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 (Nagrare *et al.,* 2011; Anjorin *et al.,* 2013; Sparks and Nauen, 2015). Our work is parallel to the earlier reported work in various agroecosystems (Singh and Gandhi, 2012; Kataria and Kumar 2012; Manu *et al.,* 2019). However, the rate of infestation severity wasmore in the year 2017-18compared to 2018-19, possibly due to heavy rains, suchenvironmental extremes affect the occurrence, prevalence, and severity of plant diseases and are internally associated with each other (Petzoldt and Seaman 2008; Thornton *et al.* 2014; Zayan, 2019; Raza *et al.,* 2019).

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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