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

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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

		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

	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

		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

		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

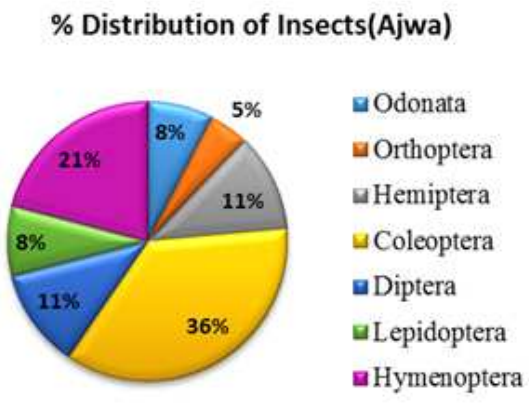

Figure 1: % Distribution of Insects in Sites I.

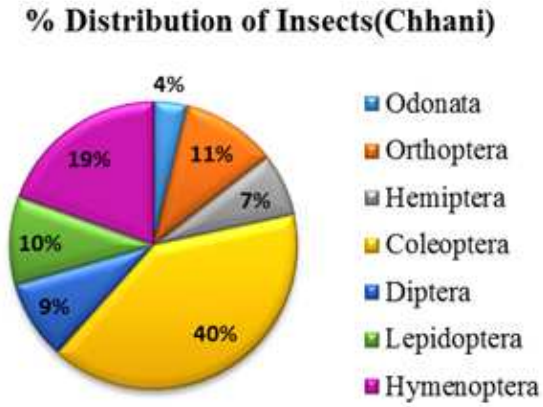

Figure 2: % Distribution of Insects in Sites II.

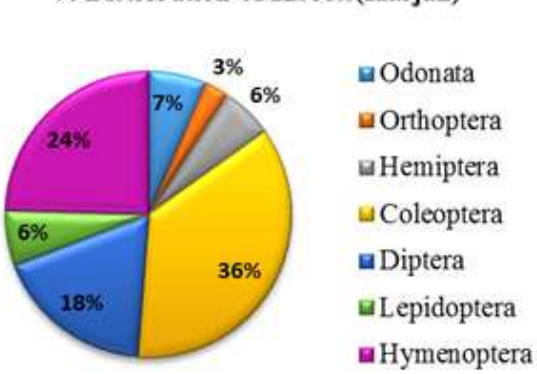

Figure 3: % Distribution of Insects in Sites III.

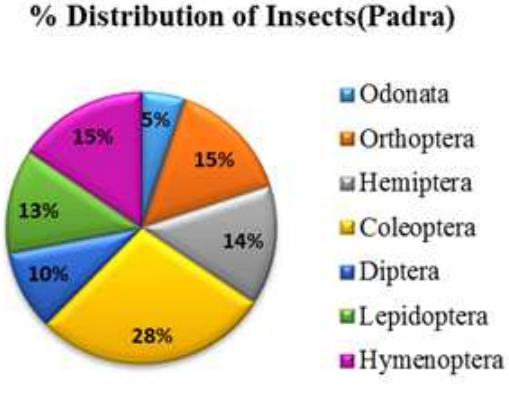

Figure 4: % Distribution of Insects in Sites IV Sites.

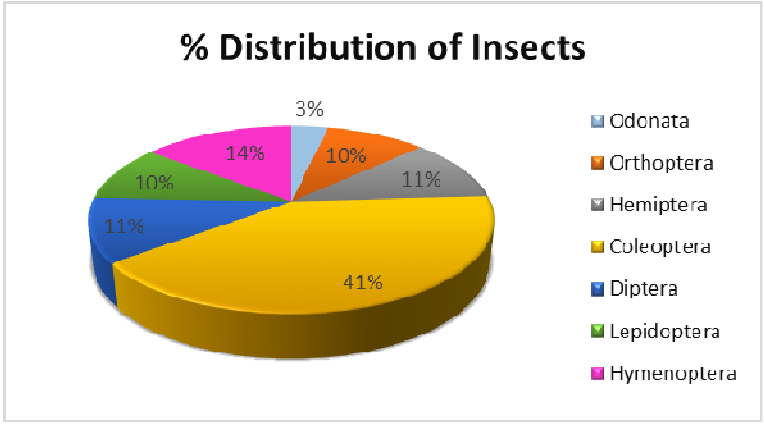

Figure 5: Percentage Distribution of Insects in the Four Sites of Vadodara.

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

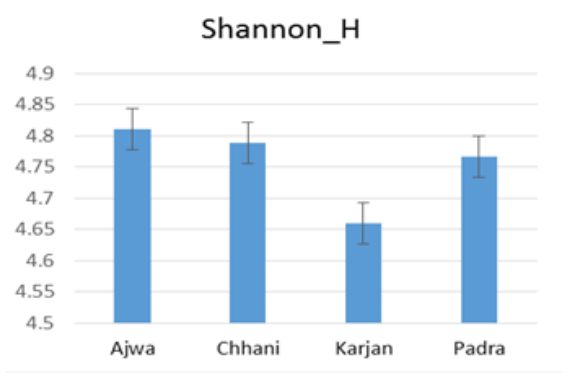

Figure 6: Diversity Indices (Shannon_H) of Insect Species in Four Sites.

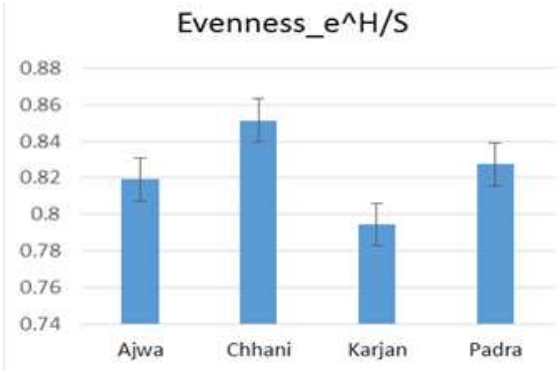

Figure 7: Species Evenness Indices (Buzas and Gibson's) of Insect Species in Four Sites.

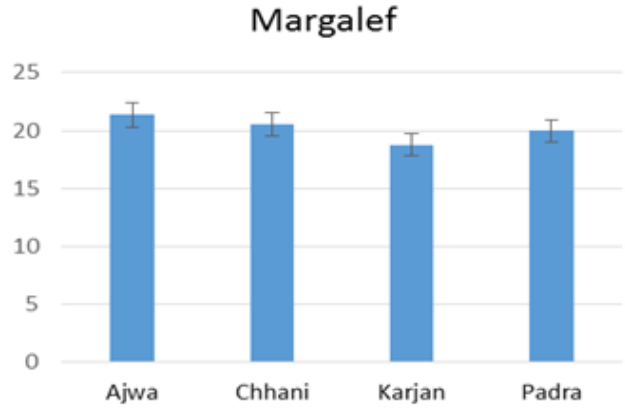

Figure 8: Richness Indices (Margalef) of Insect Species in Four Sites.

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.

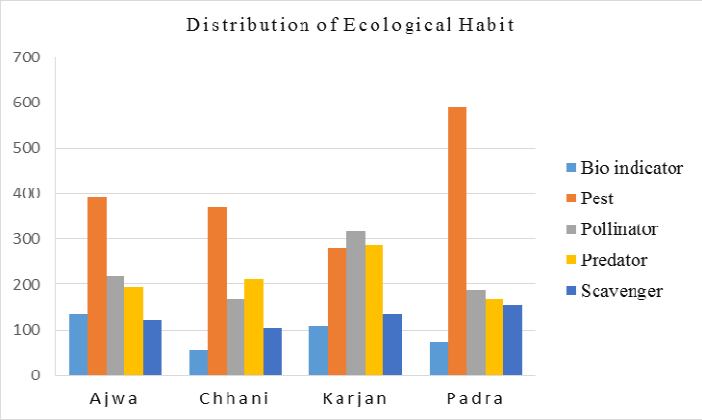

Figure 9: Comparative Distribution of Ecological Habit of Four Sites.

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 2nd 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.

6. ACKNOWLEDGEMENT

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