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Reduction of hazardous impact of chemical control from agricultural crops by utilization of different insect biolures

Ruchika Kataria and Dolly Kumar

Abstract
Management of insect pests damaging the economically important crops without insecticides is growing importance amongst the farmers and researchers. Physical, Mechanical, Chemical and Biological control are various strategies for controlling the pests. Out of all the plans; ecofriendly biolures are useful in reducing the population of insect pests, minimizing the use of chemicals. The objectives of this work are: i. Screening of insect pests in the agricultural fields around Vadodara. ii. Isolation, Identification and characterization of the pheromones of those insects, which are damaging the economically important crops. iii. Once, synthesized, performing of laboratory and field trials. An increase in use of pheromonal traps will reduce the load of insecticides from the agricultural fields of not only Vadodara, Gujarat but the rest of the country also, and will be an important contribution towards the on-going Integrated Pest Management programmes.

Keywords: Insecticides, insect pest, pheromones, ecofriendly, IPM

Introduction
Overwhelmingly, farmers in both developed and under developing countries depend on synthetic insecticides, to control insect pest problems spending of the order of 9,000,000,000 US$ per annum [1, 2]. In India, there are approximately 145 pesticides are registered for use and 90,000 metric tons of technical grade pesticides are used annually to control the insect pests [3, 4]. 51% of food commodities of our country are contaminated with pesticide residues [5, 6]. Gujarat is in 5th place in India consuming around 3649 tons of pesticide per annum (Directorate of Plant Protection Quarantine and Storage, 2001). Cork *et al*. (2003) [1] reported that insecticides also kill non-target arthropods, typically insects involved in pollination and important predators such as spiders and ground beetles. According to Devillers *et al*. (2002) [7] honey bees during their foraging activity are contaminated by pesticides. The population of insect's pest such as aphids, sugarcane stem borer, tree and leaf hoppers, whiteflies, red cotton bugs, leaf footed bugs *etc*., were on rise in the two `years study time-period. Kumar, D. & Naidu, B. (2010) [8] have observed an increase in population of pests due to the uncontrolled use of dimethoate and carbofuran for aphids and jassids; fenvelarate and deltamethrin for serious pests like cotton bollworm and tobacco cutworm or cotton leafworm in the agricultural fields of Vadodara rendering the pests resistant to pesticides. Hence there is an urgent need to minimize the use of pesticides and incorporate integrated pest management (IPM) practices which include number of alternatives like biological, cultural, mechanical, pheromonal and chemical control in the biological systems.
The objectives of the present study are; 1. Assessment of insect pests in the agricultural fields of Vadodara and explore about their methods of control with special emphasis on the use of bio-lures. 2. Isolation and characterization of the pheromones of major insect pests which are damaging the economically important crops.
To fulfill the above objectives an extensive survey of the agricultural fields in and around Vadodara was done for a period of two years from January 2007 to December 2009. The assessment report showed that agricultural fields having economically important crops like cotton, maize, castor, wheat, sorghum, sugarcane, brinjal, ladies-finger, cauliflower, cabbage *etc*., were being damaged by a wide range of insect pests. These insects were controlled by using different categories of insecticides such as synthetic pyrethroids, organophosphates, organochlorines and carbamates.

According to the market survey of availability of pesticides and interviewed with local shop retailers and farmers in Vadodara indicated that there were very few bio-lures are present and those available are less popular amongst farmers. Usually, there are more than 90% of farmer's dependence on insecticides for the control of insect pests in the agricultural fields of Vadodara. This gloomy picture of indiscriminate usage of pesticides had motivated us towards isolation and characterization of bio-lures of the major insect pests namely aphids.

Materials and Methods

In western India, Vadodara is one of the largest cities in the eastern part of the state of Gujarat, which is located at 22º11' N latitude and 73º 07' E longitude. The whole district covers an area of 7,794 square km. This study was conducted at Entomology Division, Department of Zoology, M.S. University of Baroda, for a period of two years from January 2007 to December 2009. The agricultural fields located in Vadodara region were selected in all the four directions on the basis of accessibility and location of ecoregion (As given in Table 1). The economically important crops which were severely damaged by various insect pests were accessed and examined to know the extent of damage to the crops. The different stages of insect pests were collected from the crops. Later, Insects were identified in the laboratory using standard manuals. During field surveys, the interviews with the farmers and locals were conducted to know about their different ways of controlling the insect pests in the agricultural fields.

1. Study Sites: Figure (1) Table (1)

Studies were conducted in all the four directions of Vadodara and agricultural fields were located within 80 kms from the city center. These sites were included in various numbers of crops including cereals, cash crops and vegetables *etc.* [2]

a. North Site (Channi): Cotton, Sorghum, Castor, Pigeon pea, Potato, Brinjal, Radish and Cauliflower.
b. West Site (Timbi): Wheat, Castor, Peral millet, Paddy, Jowar and Spinach.
c. East Site (Waghodia): Cotton, Castor, Sugarcane and Brinjal.
d. Southeast Site (Dabhoi): Wheat, Paddy, Maize, Sorghum, Castor and Pigeon pea.
e. South Site (Ankleshwar): Cotton, Maize, Pigeon pea, Cabbage and Beans.

2. Collection methods & sampling techniques

The insect collection was carried out depending upon the different seasons in which crops were grown. The collection was made by using different collection techniques such as sweeping and hand-picking methods. In sweep net method; each quadrat was swept several times. Every sweep was repeated after a gap of 10 minutes. 10 sweeps were performed each time. In hand – picked methods, large sized caterpillars, mealybugs, aphids and bugs were collected manually. During the sampling period of two years, each year was divided into two phases: Phase 1 (January to April) and Phase 2 (September to December). There was no study was conducted in the month of May (due to high temperatures) and in June-July (due to rainy season). Each phase had four sampling periods and each study site were visited twice a month. The sampling was done twice on each day; once in the morning hours (7 am to 9 am) and second time in the evening hours (5pm to 7pm). The large insects were killed using killing jars with potassium cyanide powder. The tiny insects like aphids were transferred in the vials having 70-90% ethyl alcohol. Later, insects were brought to the laboratory, mounted those insects on slides and then observed and identified [2].

3. Identification

The identification and labeling of the insect pest which damaging the economically important crops were done using standard taxonomic literature and manuals. A stereomicroscope, Leica MPS 60 Ø28/8x/MPS was used for identification and photographic record. Photography was done using a Canon digital Camera (Power Shot ISI – 120, 12x optical Zoom). The collected insects were identified with the help of standard keys available in Leffroy (1909) [9], Borrer *et al*. (1992) [10], Richard and Davies (1997) [11] and Ananthkrishnan and David (2004) [12]. The identified samples were confirmed by the Entomology Department of Indian Agriculture Research Institute (IARI), PUSA, New Delhi and Anand Agricultural University, Anand, Gujarat. Kataria, R and Kumar D (2012) [2] have also reported the assessment of the incidence and occurrence of sucking pests in the agricultural fields of Vadodara.

4. Assessment of incidence and severity damage of insect orders

The assessment of incidence and severity of damage of insect orders on various crops was done as per 1-4 scale of infestation given by Nag rare and his co- workers (2011) [13, 14] from Central Institute for Cotton Research, Nagpur.

4.1 Scale infestation

1. **Grade:** Scattered appearance of few insect pests on the plants
2. **Grade:** Severe infestation of insect pest on any one branch of the plants
3. **Grade:** Severe infestation of the insect pest on more than one branch or half portion of the plants
4. **Grade:** Severe infestation of insect pests on the whole plants.

The percentage of incidence was calculated by using suitable formula [2, 15]:

Percentage Incidence (PI) = No. of infested plants/ Total plants observed X 100

Severity Index (SI) = Sum of total grade points (1-4 infestation Grade) of the infested plants/ Total No. of infested plants observed.

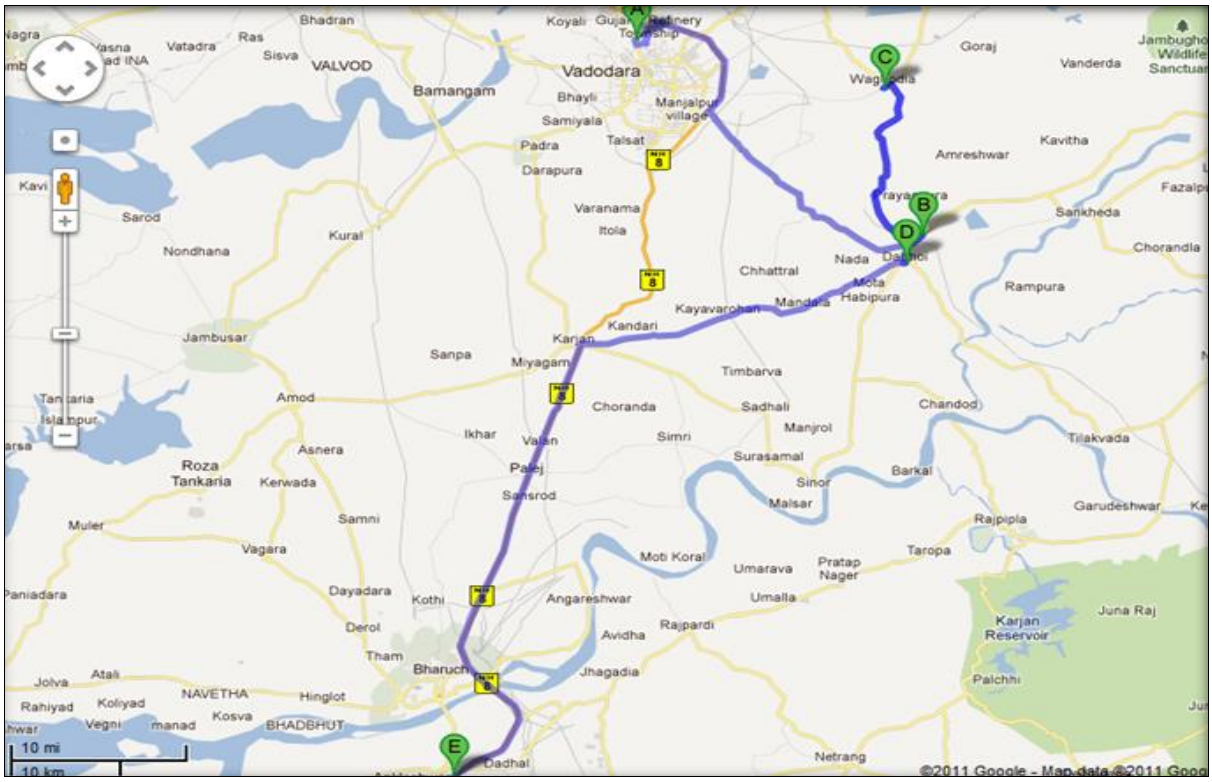
5. Laboratory work being carried out

Many insect pests were recorded which damaging the economically important crops. But our study was focused on the sucking pests especially the aphids.

Aphids: The aphids were appeared in the fields in the month of November until March. They are polyphagous by nature damaging almost all the crops which were mentioned below. The both stages of aphid nymphs and adults were responsible for sucking the sap of the plants/crops and damaged the entire shoot system. They also act as vectors of the mosaic virus. These aphids were reared at 20-25ºC under a photoperiod of 16L: 8D at a humidity of 70-75% RH in laboratory in big plastic containers. After mass rearing of aphids, lures would be extracted from the virgin females of aphids and then will be isolated and identified for making bio-lures.

Table 1: Description of study sites

Sr. no.	Study sites	Distance and Direction from Vadodara	Area in hectare	Soil type	Crops
Agricultural fields					
A	Channi	15 Kms. in the North	4	Black and White mix soil	Cotton, Castor, Pigeon pea, Potato, Brinjal, Cabbage and Radish.
B	Timbi	15 Kms. on the West	2	Medium black	Wheat, Castor, Peral millet, Paddy, Jowar and Spinach.
C	Waghodia	25 Kms. on the East	5	Medium black	Cotton, Castor, Sugarcane and Pigeon pea.
D	Dabhoi	30 Kms. on the Southeast	5	Medium black	Wheat, Paddy, Maize, Sorghum, Castor and Pigeon pea.
E	Ankleshwar	80 Kms. on the South	5	Medium black	Cotton, Maize, Pigeon pea, Cabbage, Beans, Jowar.



Study Sites - A. Channi B. Timbi C. Waghodia D. Dabhoi E. Ankleshwar

Fig 1: Selected study sites in Vadodara

Results and Discussions

The appreciable number of insect pest orders was reported in the present study suggest that Vadodara has a good assemblage and has a rich biodiversity of insects. There are large number of agricultural fields of 2-5 hectares surrounding the whole city of Vadodara. An extensive survey of agricultural fields was done in and around the Vadodara district for a period of two years (January 2007 to December 2009) which states that there is a diversity of 300 species of insects within the agricultural fields of Vadodara [16]. There are total 29 insect orders which are the key to identifying and understanding the insects. Out of 29 insect orders, 7 orders are dominant in the agro-ecosystem of Vadodara district are recorded in our present studies.

Insect pests were identified for the purpose of assessing the incidence and severity of damage on economically important crops by the insect pests. The infestation based on the presence or absence of insect pests and the severity using one to four (1-4 Grade) scale of infestation. Similarly, Vennila *et al*., (2010) [17] also reported the assessment of incidence and severity of damage of mealybugs on cotton crop. The assessment showed that agricultural fields of Vadodara having economically important crops like Cotton, Castor, Wheat, Maize, Sorghum, Pigeon pea, Chickpea, Brinjal, Ladies Finger, Beans, Cauliflower, Cabbage *etc*., were being damaged by a wide range of insect pests. Out of 300 species of insects; 49 species of insects are pests (Table 2). This number of insect pests, we could report from the collection and identification of insects collected and identified from the severely damaged crops. The maximum numbers of insect pests were identified are from the orders Hemiptera (33%) and Lepidoptera (27%) having 17 and 13 species respectively (Fig 2). Coleoptera (18%) is having 9 insect pest species. Minimum insect pests are from the Orders Orthoptera (4%) and Thysanoptera (4%) having 2 species, each whereas from the order Diptera (2%) only 1 insect species has been found damaging the crops. The maximum severity of insect pests was observed in the order Hemiptera, Lepidoptera and Coleoptera. The occurrence of insect pests was observed in the month of September till April in all the two consecutive years in the agroecosystem of Vadodara.

Our focus of studies is based on the sucking pests specially Aphids. In order Hemiptera, *Aphis gossypii*, *Aphis craccivora*, *Aphis nerii*, *Aphis fabae*, *Aphis brassicae* and *Myzus persicae* (Family: Aphididae) are considered as a serious threat to the economically important crops of the agricultural fields of Vadodara [2]. These species of aphids are attacking various plants, infesting leaves, stems, fruits and roots and damaged to almost all agricultural crops and alternative host plants because of their polyphagous feeding habits [18].

Based on field surveys, through personal interviews with farmers and local residents, we found the following alternatives other than insecticides prevalent in the agricultural fields of Vadodara: Cultural control, Biological control, Mechanical control, Chemical control and Biorational control. Out of all, some of the control practices are very common in agricultural fields. These are the important tactics in the field of Integrated Pest Management.

Cultural Control practices like crop rotation and removing crop residues are generally preferred by farmers of Vadodara. For example; Cauliflower and Cabbage crops are rotated with non-cruciferous crops such as Chickpea and Potato to divert insect pests like Diamond Back Moth, Cabbage looper, Cabbage aphid, Whitefly etc.

Use of Trichocards as Biological control method is popular amongst Vadodara farmers for controlling pests such as *Helicoverpa armigera* and *Spodoptera litura*. Farmers are releasing this card in small pieces which are stapled on the inner side of a leaf in the morning to avoid direct sunlight. These cards are released into the fields of Cotton, Cauliflower, Castor *etc.* where Trichogramma will parasitize on the Lepidopteran eggs and finally kill them controlling a large population of insect pests. 5-8 cards/ha are released, each card having around 1000 eggs. The time when cards are released into the fields, insecticide is recommended for not to be sprayed.

Mechanical control such as hand picking where eggs and caterpillars of *Earias insulana*, *Helicoverpa armigera* and *Spodoptera litura* are hand-picked and removed. This is very simple and common techniques to control insect pests. Some farmers are preferred to use the water sprays to wash out the tiny insects. On the other side, Biolures which are having a potential of trapping large (around 1000/trap) number of insects are less frequently used. Farmers of Vadodara are unaware about the use of biolures in the fields. Moreover, there are only 8 biolures which are commercially available in the market in Vadodara (Table 3). This is negligible compared to the availability of a wide variety of insecticides.

Generally, farmers of Vadodara city mainly dependent on the various types of Insecticides such as Organophosphates (Endosulphan, Chlorpyriphos, Parathion), Synthetic pyrethroids (Cypermethrin, Deltamethrin) and Carbamates (Aldicarb, Carbaryl, Carbofuran) are used for spraying the crops in the fields for the control of insect pests and to prevent the yield loss. The judicious use of pesticides plays a major role in plant protection [19]. Usually, the farmers believed on instinct output and not aware about the long-term effects of the pesticides. Due to indiscriminate use of chemicals caused pest resistance, resurgence of pests, residues in food, water, air and soil, elimination of natural enemies and disruption of ecosystem [20]. Spraying of the insecticides is done once in 10 to 15 days, depending upon the appearance of insects on the crops within the fields. Usually, farmers invest Rs.2000 to 3000/- for each spray which is much more than the cost of biolures. Due to long- term effects of pesticides, the Karnataka government has banned the use of pesticides such as spraying of endosulphan in the cashew fields of South Karnataka has led to a trail of deformities such as visual impairment, mental retardation, weak limbs and pelvic bones (The Week, June 6, 2010). Previously, farmers are mainly focused on the use of mechanical, cultural and chemical controls but the present studies focused on the use of biorational controls such as Bio-lures.

The present study revealed that Bio-lures should be popularized. Semiochemical-based pest management programs comprise three major approaches that are being used to provide environmentally friendly control methods: mass trapping, lure and kill and mating disruption [21]. There are approximately 10 number of biolures present commercially in the Vadodara Market. As bio-lures are eco-friendly, cost effective and control the pest by monitoring the insect pest population, mass trapping and mating disruption. If in a field of one hectare, 10 traps are placed. Each trap costs are Rs.30/35. The cost of all the 10 traps will be around Rs. 300-450 per hectare, which is comparatively less than the cost of insecticides. Moreover, biolures are eco-friendly, does not disrupt the natural or introduced populations of beneficial predators and parasites which are integral components of Integrated Pest Management (IPM). The gloomy picture of heavy dependence on insecticides has motivated us to isolate and identify bio-lures of the major dominant pests. Out of the all the insect orders, aphids are one of the dominant pests and its very difficult to control them due to its polyphagous nature and high reproductive rate (Fig 3). Still, there is no biolure present for aphids in Indian market. This is the first study reported by us regarding to the bio-rational approach for aphids which are helpful for the aphid management. Once the chemical nature of these pheromones is known they can be corroborated by behavioral studies in laboratory as well as in fields. The pheromone research calls for continued efforts of enlightened researchers and policy makers. The controlling the insect pest with minimum pesticide is the need of the hour and add advantages in the field of Integrated Pest Management (IPM) programs.

Table 2: Insect pest's severity and the crops they damage in the agricultural fields of Vadodara

Order	Family	Pest Name	Crop	Severity of Pests
Orthoptera	Gryllotalpidae	*Gryllotalpa fossor* (Mole cricket)	Paddy	1
	Acrididae	*Schistocerca gregaria* (Desert locust)	Cotton, Wheat	1
Isoptera	Termitidae	*Microtermes obesi* (Wheat termite)	Cotton, Sugarcane & Wheat	1
		Microtermes mycophagus	Castor, Cotton & Sugarcane	1
		Odontotermes redemanni	Sugarcane & Wheat	1
		Odontotermes obesus	Sugarcane, Cotton, Wheat & Castor	1
		Odontotermes guptai	Sugarcane, Cotton, Wheat & Castor	1
		Odontotermes bhagwathi	Sugarcane, Cotton, Wheat & Castor	1
Hemiptera	Aphididae	*Leptocentrus taurus* (Horned treehopper)	Brinjal	2
		Nephotettix nigropictus (Green rice leafhopper)	Paddy	1
		Aphis gossypii (Cotton aphids)	Cotton, Brinjal	4
		Aphis craccivora (Cow pea aphids)	Chickpea, Bean	4
		Rhopalosiphum maidis (Maize aphid)	Maize, Wheat	3
		Myzus persicae (Green peach aphids)	Cotton, Spinach, Cabbage, Radish, Brinjal	4
	Aleyrodidae	*Bemisia tabaci* (Whitefly)	Cotton, Tobacco, Spinach, Cabbage, Radish, Brinjal	3
	Lophopidae	*Pyrilla perpusilla* (Sugarcane leaf hopper)	Sugar cane, Maize, Wheat, Pea.	2
	Pseudococcidae	*Maconellicoccus hirsutus* (Hibiscus mealy bug)	Cotton, Tomato, Ladies finger	4

	Lygaeidae	*Blissus gibbus*	Sugar cane	1
		Lygaeus militaris (Plant bug)	Cotton	2
		Lygaeus hospes (Lygaeid bug)	Cotton	2
	Coreidae	*Riptortus linearis* (Spined legume bug/ Sap sucking bug)	Chickpea, Bean, Gram	2
		Anoplocnemis phasiana (Coreid bug)	Chickpea, Brinjal	2
		Clavigralla gibbosa (Pod sucking bug)	Chickpea	2
	Pentatomidae	*Nezara Gramineae* (Green plant bug)	Wheat, Paddy, Castor	3
	Psychidae	*Bagrada picta* (Bagrada bug/ Colourful bug)	Cabbage	1
Thysanoptera	Thripidae	*Caliothrips indicus* (Groundnut thrips)	Brinjal, Wheat	2
		Scirtothrips dorsalis (Chilli thrips)	Cotton, Brinjal, Radish	2
Coleoptera	Dynastidae	*Oryctes rhinoceros* (Coconut rhinoceros beetle)	Sugarcane	3
	Melolonthidae	*Holotrichia insularis* (White Grub)	Sugarcane, Paddy	3
		Holotrichia tuberculipennis (Bomboo beetle)	Sugarcane, Paddy	2
		Autoserica insanabilis (Scarab beetle)	Sugarcane, Paddy	3
	Bruchidae	*Callosobruchus maculates* (Bruchid beetle)	Gram	3
	Bostrychidae	*Rhyzopertha dominica* (Lesser grain borer)	Rice, Wheat	3
	Coccinellidae	*Henosepilachna vigintioctopunctata* (Twenty- eight spot lady bird beetle)	Brinjal	4
	Meloidae	*Psaldolytta menoni* (Blister beetle)	Bean	2
		Mylabris pustulata (Orange Blister Beetle)	Bean	2
Diptera	Agromyzidae	*Melanagromyza obtuse* (Pigeonpea pod fly)	Chickpea, Bean	2
Lepidoptera	Yponomeutidae	*Plutella xylostella* (Diamondback Moth)	Cabbage	4
	Pyralidae	*Scirpophaga auriflua* (Sugarcane top shoot borer)	Sugarcane	3
	Gelechiidae	*Platyedra gossypiella* (Pink bollworm)	Cotton	4
	Nymphalidae	*Melanitis leda* (Common Evening Brown)	Paddy, Wheat	3
	Lycaenidae	*Lampides boeticus* (Long-tailed Blue)	Gram, Chickpea	2
	Noctuidae	*Earias insulana* (Spiny bollworm)	Cotton	3
		Trichoplusia ni (Cabbage looper)	Cabbage	4
		Achaea Janata (Castor Semi-looper)	Castor	4
		Helicoverpa armigera (American bollworm)	Cotton, Cabbage, Radish	4
		Spodoptera littoralis (African Cotton Leafworm)	Cotton, Cabbage, Radish	4
		Pericallia ricini (Darth Maul Moth)	Maize, Brinjal	3
	Tipulidae	*Creatonotus gangis* (Hong Kong Tiger Moth)	Paddy, Sugarcane	2
	Arctiidae	*Estigmene lactinea* (Cram hairy caterpillar)	Cotton	2

*1 Grade: Scattered appearance of few insect pests on the plant; 2 Grade: Severe infestation of insect pest on any one branch of the plants; 3 Grade: Severe infestation of the insect pest on more than one branch or half portion of the plant; 4 Grade: Severe infestation of insect pests on the whole plants.

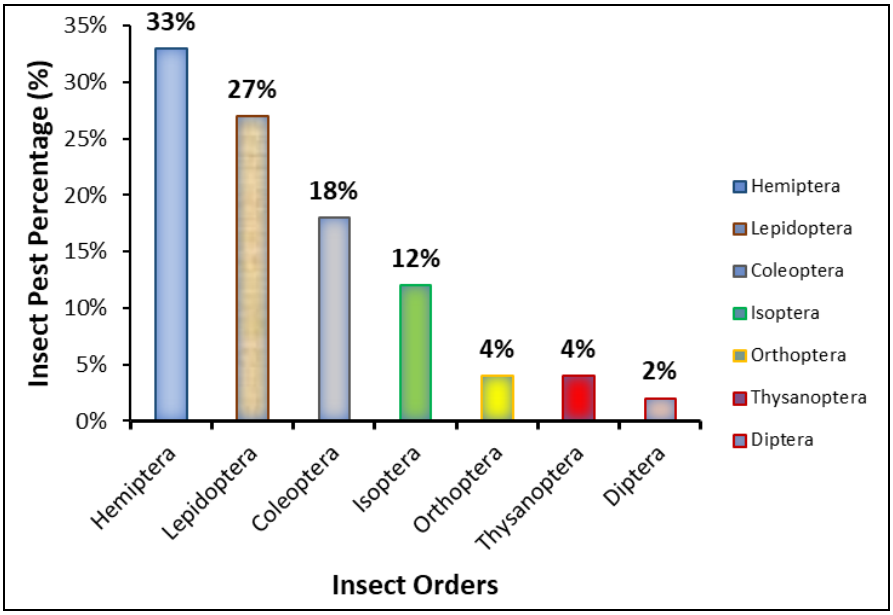


Fig 2: Pest Percentage (%) of insects within the agroecosystem of Vadodara

Table 3: Pheromone lures available in Vadodara market

Order	Pest Names	Lures Recorded In Market
Coleoptera	*Scirpophaga incertulas*	Scirpo –lure
	Rhynchophorus ferrugineus	Orycta-lure
Lepiodoptera	*Helicoverpa armigera*	Heli- lure
	Spodoptera litura	Spodo- lure
	Pectinophora gossypiella	Pectino-lure
	Earias vitella, Earias insulana	Earias-lure
	Chilo infuscatellus	Chilo - lure
	Leucinodes orbonalis	Lucin-O-lure
Diptera	*Batocera dorsalis*	Bacu- lure Cue-lure

Fig 3: Aphid attack on beans in the agricultural fields

Conclusion

Insect pests are the major threat in the agricultural fields of Vadodara. Since, they have a high reproductive rate, their ability to cause severe damage to the economically important crops. Especially, the tiny insects such as aphids hide in cracks and crevices of plants and propensity to spread quickly to cause severe damages to the crops. Many numbers of insects were associated with them. The various control tactics are being used in agricultural fields of Vadodara but it's become a challenge to control these insect pests. In an attempt to find the solutions to reduce the infestations by these pests, the present study emphasized on the knowledge of the evidence of the presence of pheromone that can be further characterized and synthesized for the development of pheromone lures (bio- lures) and traps which add an alternative control against pesticides. It would also useful in providing good scope for the further development of ecofriendly methods for control of various insect pests.

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