

CHAPTER V

CONCLUSION, SIGNIFICANT FINDINGS AND RECOMMENDATIONS

CONCLUSION

- Vadodara is surrounded by more than 500 Agricultural fields and almost 62 community gardens making Vadodara extremely rich on flora (Table 4 a & b).
- The agriculture fields of Vadodara are full of economically important crops such as Cotton, Castor , Wheat , Maize , Jowar , Bajra, Tobacco, Pigeon pea, Chickpea , Sugarcane, Brinjal, Cabbage , Cauliflower, Radish , Beans , Banana , Mango , Guava, etc.
- Urban or Agro-ecosystems in and around Vadodara are full of insect biodiversity. There are around 382 insects (Naidu, B., 2008) of which 50 insects are pests (Table 5).
- It is the prime responsibility of a researcher to document the flora and fauna of the local areas and keep a record on the population of insects and factors which are affecting it. Hence, it is our responsibility to conserve them.
- Not all insects are pests, hence it is important for us to sustain the diversity of insects as well as at the same time get rid of only those insects which are harmful for the crops.
- The high rise buildings and multiplexes are taking away the sheen from the green environment of urban sites. Same is true for Agricultural fields where improper management of insects cause increase in its population beyond the economic threshold. Their control day by day is becoming difficult. Biorational alternatives are been exercised but, our research clearly stated that there are voids in agriculture field and

urban community garden. Hence farmers are not left with many options but to use highly toxic insecticides.

- Vadodara in agricultural field organophosphates such as Methyl parathion (Folidon), Chlorpyrifos (Dursban) etc. are dominating. These are broad spectrum insecticides.
- The harmful effects of the indiscriminate uses of insecticides for controlling the insect pests have been discussed in Chapter 1.
- Useful insects like predator (*Cheilomenes sexmaculata*, *Scymnobiis sordidus*, etc.), parasitoids (*Trichogramma chilonis*, *Aenasius bambawalei*, etc.) and pathogens (*Bacillus thuringiensis*, *Verticillium lecanii*, etc.); Other biocontrol agents – spiders, vertebrate (Insectivorous Birds); Air, water, soil and Health of the non- target animals including man all are under the influence of insecticides used in the agricultural fields.
- Our three years research (April 2008 – April 2011) shows that the use of biorational alternatives was less popular amongst farmers of Vadodara as compared to chemical control. So, this indicates the need of implementing biorational control measures in agricultural fields of Vadodara.
- The complete biorational alternative in the agricultural fields was seen only for *Helicoverpa armigera*, *Spodoptera litura*, *Erias vitella* and *Scirpophaga excerptalis*.
- Channi agricultural fields located within 20 Km from Vadodara city in the northern direction had crops of Cotton, Sorghum, Castor, Pigeon pea, Potato, Brinjal, Radish and Cauliflower. In these fields use of inter-cropping such as the chick pea plants are used as inter-crop for protecting it from *Helicoverpa armigera* and *Lampidus boiticus* in the agricultural fields of wheat were seen. They are also using botanicals such as eco-neem for control of lepidopteron and whiteflies pest.

- Varanama which is located 17 Km from Vadodara city in southern direction had crops of Cotton, Castor, Sugar cane, Ladies finger, Pigeon pea, Cauliflower. Black loamy soil was the characteristic of this field. Here crop rotation are seen, for example Cauliflower and Cabbage crops are rotated by non-cruciferous crops such as Chick pea and Potato to divert insect pests like Diamond Back Moth, Cabbage looper, Cabbage aphid, Whitefly etc.
- Waghodia which is located 20 Km from Vadodara city in eastern direction had crops such as Cotton, Castor, Sugarcane and Brinjal. The use of trap-crops is also seen amongst the farmers such as row of chickpea were placed at the hedges of cotton plantation area so that the insect pests get diverted from major plant. The use of Triochoard is popular amongst Vadodara farmers for controlling pests such as *Helicoverpa armigera* and *Spodoptera litura*.
- Dabhoi fields located 35 Km from Vadodara city in southeast direction. Field surveyed had crops of Wheat, Paddy, Maize, Sorghum, Cotton, Castor and Pigeon pea. Mechanical control such as hand picking where eggs and caterpillars of *Earias insulana*, *Helicoverpa armigera* and *Spodoptera litura* are handpicked and removed. Biolures which are having a potential of trapping large (around 1000/trap) number of insects are less frequently used.
- The number of pheromonal lures was lacking in Vadodara market which is just only 6. Overall in India only 13 bio lures are present.
- The biocontrol agents released in field is just one (use of Triochoard).
- As stated above mechanical control and cultural control is prevalent in almost all the fields but is not sufficient so as to replace the insecticides.

SIGNIFICANT FINDINGS

1. The study revealed that 49 insect species of insects are pests in urban and agricultural fields of Vadodara which are damaging the major crops such as Cotton, Castor, Sugar cane, Pigeon pea, Ladies finger, Brinjal, Radish, Cauliflower, Wheat, Maize, etc.
2. The maximum number of insect pest identified are from the orders Hemiptera and Lepidoptera having 16 and 13 species respectively.
3. Minimum insect pests are from the Orders Orthoptera and Thysanoptera having 2 species each whereas from the order Diptera only 1 insect species has been found damaging the crops.
4. To control these insect pest organophosphates such as Methyl parathion (Folidon), Chlorpyrifos (Dursban) are mainly used among farmers of Vadodara.
5. In Vadodara the maximum pesticides are spread in cotton field for control of pests.
6. In Vadodara, five different species of mealybugs belonging to three different families were collected and identified.
7. They are Hemipteran *Phenacoccus solenopsis*, *Maconellicoccus hirsutus* Green, 1903 and *Ferrisia virgata* Cockerrel, 1893 from the family Pseudococcidae; Homoptera *Ceroplastes ceriferus* Fabricius, 1798 from the family Coccidae and *Icerya purchasi* Maskell, 1878 from the family Monophlebidae.
8. Out of this the *Phenacoccus solenopsis* is the major mealybug species infesting all crop plants.
9. *Phenacoccus solenopsis* infestation show many symptoms such as leaves some times with bunchy tops, withering and yellowing of leaves. This symptom gives farmers as indicator for infestation of mealybug. With the help of this scientist can identify those crops which are full of insect pests and need biorational alternative to control measures.

10. *Phenacoccus solenopsis* shared a mutual interaction with *Monomorium Pharaonis* Linnaeus, *Monomorium minimum* Buckley; *Camponotus compressus* Fabricius and *Tapinoma melanocephalum* Fabricius ants.
11. The presence of ants increases the population of mealybug, *Phenacoccus solenopsis*.
12. 6 different biocontrol agents of *Phenacoccus solenopsis* were identified which decreases its population.
13. Due to the presence of ants, the population of biocontrol agent gets affected which gives inverse positive impact on mealybug population.
14. *Camponotus compressus* move adult mealybugs from one plant to other by holding it in its mouth. Hence, *Camponotus compressus* usually acts as one of the reason of *Phenacoccus solenopsis* dispersion from one plant to other in cotton, okra and ornamental plants.
15. *Phenacoccus solenopsis* infestation started appearing in the month of August which progressively increases with the advancement of crop growth. The highest level of *Phenacoccus solenopsis* population was seen in the month of February. This shows that the infestation of mealybug is dominant for 7-8 month in a year.
16. In Vadodara 31 host plant species were recorded from 17 different families which were infested by *Phenacoccus solenopsis*. Host plant species belonging to family Malvaceae (16%), Solanaceae (13%) and Asteraceae (10%) were found as preferred hosts of mealybugs in Vadodara.
17. The rearing and breeding of *Phenacoccus solenopsis* was in general done at 20-25°C under a photoperiod of 16L: 8D at humidity of 70-75% RH. The life cycle in the laboratory gives an insight into the stage which maximally damages the economically important crops. In the fields a larval stage prior to the (damaging stage) should be controlled by biorational alternatives. This will improve the quality of the crop as well as minimize the use of insecticides.

18. After knowing biology of *Phenacoccus solenopsis* it was found that mating activities were predominant during early morning (4-7 am). This information is helpful for conducting behaviour studies.
19. The behavior studies shows that the attractive index is more in male than female which clearly shows that female volatile extract consists of semiochemical which attracts male.
20. The major volatiles which are identified from both confinement and adsorbent methods are: 2, 2, Dimethyl-isopropenyl cyclobutane methyl ester; 3,7,11,15-Tetramethyl-2-hexadecen-1-ol (Diterpenes); 2,6,10,15,19,23-Hexamethyltetracos-2,6,10,14,18,22-hexaene (Triterpenes); Carotene (Tetraterpenes); Hexadecanoic acid and 2-Cyclohexane-1-ol.
21. In this the 2, 2, dimethyl-isopropenyl cyclobutane methyl ester is belonging to sex pheromone.
22. Terpenes such as 3,7,11,15-Tetramethyl-2-hexadecen-1-ol and 2,6,10,15,19,23-Hexamethyltetracos-2,6,10,14,18,22-hexaene are identified from volatile extracts of mealybug and mainly act as kairomones. These kairomones can be used for attraction of female mealybugs for reducing the population of the mealybugs in the fields.
23. For mealybug a lot of organophosphorus chemical is used in the fields but still its control is not effective.
24. Imidacloprid shows less effectiveness against mealybug when applied by using topical method. Whereas Chlorpyrifos is more effective than the Folidon against mealybug.
25. The major predators of *Phenacoccus solenopsis* is *Scymnobius sordidus*. It is having four larval stages. The fourth instar larvae are voracious feeders. This stage feeds on 36.20 ± 3.0 number of mealybug nymph. Larvae are mainly preferred nymph than adult of mealybug.

26. The total number of *Phenacoccus solenopsis* nymph eaten by the larvae of *Scymnobius sordidus* is 61.6 ± 5.81 during its life cycle. Whereas 2.8 ± 0.84 adult *Phenacoccus solenopsis* were consumed during its life cycle.
27. The effect of insecticides which was used for control of mealybug in the laboratory against the fourth instar of predatory larva shows that LC_{50} of Folidon is lesser then the chlorpyrifos and imidacloprid. Therefore folidon is most toxic against predatory larva followed by chlorpyrifos and imidacloprid.
28. The dose which kills the total population of predatory larva is much less then the dose required for control of mealybug.
29. In Vadodara field *Aenasius bambawalei* is found to be the major parasitoid against *Phenacoccus solenopsis*.
30. The effect of insecticides on *Aenasius bambawalei* shown that folidon causing a significantly delay in emergence of adults by 20 days when compared to the other treatment at higher concentration. Similarly, in other two insecticides delay in emergence of parasitoids were seen when compared with control respectively.
31. The body of parasitized mealybug can be easily recognized by absence of wax from its thoracic region as well as the disappearance of two characteristic strips from its abdominal region.
32. The *Aenasius bambawalei* lays its egg in 2nd and 3rd nymphal instar and adult female mealybug.
33. In field the parasitization percentage of *Aenasius bambawalei* recorded ranged between 60-70%. But the population of this biocontrol agent is affected by the uncontrollable use of broad spectrum pesticides in the field of Vadodara.
34. Repellency was recorded by methanol leaf extract in the following order *Azadirachta indica* A. Juss. > *Eucalyptus globules* L. > *Ocimum basilicum* L. against mealybugs.

35. The highest repellency was recorded in case of *Azadirachta indica* A. Juss leaf extract (97.0%) followed by *Eucalyptus globules* L. leaf extract (93.0%). Minimum repulsion was seen in *Ocimum basilicum* L. leaf extract (88.0%) at 10% concentration against mealybug.
36. The botanicals are good alternatives to conventional synthetic insecticides as they are safe, economical, and readily available in many areas of worlds but its application in the field is less as it is less popular amongst farmers.

RECOMMENDATIONS

Insect pests can also be transported by machinery, tools, equipment and soil movement during cultivation and repeated transplanting operations conducted at different times. This causes it easy spread therefore it becomes major pest in the agricultural fields of Vadodara.

The above mentioned management and control measures could be integrated for use by poor resource small scale farmers in Vadodara. Prevention is almost always more (cost-) effective than cure. Therefore incorporating the preventive measures of extension, hygiene and quarantine are essential in any integrated programme. Better hygiene measures, particularly at the nursery level, could be adopted, perhaps in conjunction with some form of quarantine and monitoring system. Boiling-water treatment should especially be included as a major disinfestations technique. Appropriate nutrition, perhaps using manure will also help in producing healthier, more robust plants. For already infested plants, insecticidal plant/seed extracts could be used instead of synthetic insecticides. In future, the use of biocontrol agents and pheromone lures may also become a good reliable option. However, such an integrated approach can only be effective where management techniques are designed to be locally accessible, appropriate and affordable.