CHAPTER 3

MATERIALS AND METHODS

A reconnaissance survey in and around Vadodara city was made for site selections. Four different types of habitats were selected on the basis of ecological factors, flora, type of soil, surrounding environment and Anthropogenic activities, to get an insight of the best possible insect diversity. Study was conducted during the period 2005 to 2007.

Study area at a glance

Sir Sayajirao Gaekwad III (1875-1939) had a vision to make the city of Vadodara a centre for education, industry and commerce. The modern city of Vadodara is a tribute to this able administrator. It is also known as the city of arches, domes, colourful gardens, fountains, supreme education and ever increasing industries. It is a pleasant, medium sized city worth visiting for tourists and researchers more specifically insect lovers.

Geographical location

Vadodara District is in the eastern part of the state of Gujarat in western India. The district is bound by Panchmahal and Dahod districts to the north, Anand and Kheda districts to the west, Bharuch and Narmada districts to the south, and the state of Madhya Pradesh to the east. The tallest point in the region is Pavagadh hill. The Mahi river passes through the district. Vishwamitri river flows through the city of Vadodara.

The city of Vadodara,in the western part of the district, is the administrative headquarter. It is located at 22°11' N latitude and 73°07' E longitude. Vadodara District covers an area of 7,794 sq km.

Climate of study area (Annexure -1)

The climate of Vadodara is semiarid type characterized by dry and increasingly hot summer from end of February to June, warm monsoon from July to September, and a dry and cold winter from October to early February. The climatic factors of greater importance affecting the insect population are rainfall, temperature and relative humidity.

Rainfall

The monsoons arrive every year in the later half of June and continue till September. July and August receive the heaviest downpour.

Temperature

One of the most characteristic features of Vadodara is the great extremes of temperature. The heat during the summer (March- June) is intense with the temperature rising as high as 43.3 degree centigrade in May. June – September is warm monsoon, while winter sets in the month of November and continues till middle of February. December and January are the real cold months, when the temperature drops down. In January mean maximum and mean minimum temperatures are 30 and 13 degree centigrade respectively.

Relative humidity

Minimum during the month of December (31%) and maximum during monsoon, specially in the month of July (92%).

Study sites (Figures 3-16)

Selection was made on the basis of ecological factors, flora, type of soil, surrounding environment and anthropogenic activities.

The sites were selected:

1. Agricultural fields: all around Vadodara.
2. Two community gardens: Sayajibaug and Lal baug.
3. Fragmented habitat: M.S. University campus and Laxmivilas palace compound.
4. Residential areas: New residential area of Ellorapark and old city area of Navabazaar.

Location, details of the study sites, geographical location and the flora of the areas is given in Maps (Figure 1 and 2) and Tables (2 and 3).

Abbreviations used in Renyi's Ordering Graphs:

A — Agricutural fields

CG — Community Gardens

F — Fragmented Habitats

R — Residential Area

Collection and preservation

Sampling

The study was performed from January 2005 till December 2007. Insects have been collected at all times of the year and seasons. Each study area was visited twice per month in the morning from 7 A.M to 9 A.M and evening from 5 P.M to 7 P.M on the same day. Collection was done for one hour while the other was utilized for labeling. Agricultural fields were visited only in the morning hours which were solely spent on collection, labeling of those insects was done in laboratory.

At all the sites, except agriculture fields, quadrates of 10x10 m were laid but in fields 10x 5 m quadrates were laid to decrease sampling error as number of fields visited (4) were more than other sites (2).

Sweep net method was used for collecting insects. In this method each quadrant was searched until whole quadrate is covered numerous times and net is swept. This was repeated with a time gap of 10 minutes. 10 sweeps were done each time.

Collection

Hand collection was done by picking the insect and transferring it into a Poison bottle. This method involved searching and collecting in different microhabitats. The search was carried in grass, shrubs, flowers, leaf litter, bare ground, base of roots of trees, under stones, in field margins, tree trunks etc.

Insects like Coleopterans and Hemipterans are collected manually. Some nocturnal insects were collected using light traps which were placed in the corridors of Zoology Department. Some were caught under street light at night and field moths were collected in the morning hours but in inactive condition. Aquatic insects were collected using the same aerial net.

Preservation

Insects were killed using killing jars with potassium cyanide powder. While catching, insects were confined to the end of the net, grasping the end of the net from outside just below the insect .Then the killing jar was reached inside and the net was emptied into the jar. The lid was placed and the net slowly removed. Since many of the insects like Hymenopterans have stings, care was taken by transferring them to the killing jar only when the insect was dead. Tiny insects like aphids were collected using vials having 70-90% ethyl alcohol, brought to the laboratory, mounted on slides and then observed and identified. Larger insects were pinned on metathorax a little right to the middle by using entomological pins on thermocol sheets .They were preserved in wooden insect boxes with naphthalene balls . Identification and labeling was done using standard taxonomic literature.

Identification

Insects collected from above sampling methods were separated from other organisms, sorted out into families using identification keys available in Borror (1992), then identified to species level using Lefroy (1909), Wynter–Blyth (1957) and Ananthkrishnan (1981,2004) .The sequence of insect orders is according to Imms General Textbook of Entomology, Volume 2 Ed.10. More than 90% identification was done by me and the taxon which remained unidentified was confirmed by experts from the Entomology division of Indian Agriculture Research Institute, ((IARI), PUSA,New Delhi.), Anand Agriculture University (Anand) and Navsari Agriculture University (Navsari,Gujarat)

Data analysis

The raw data of all the sampled sites from the field diary of the three consecutive years was transferred in an electronic format in spreadsheet layout

(Microsoft excel). The data was finally analyzed to calculate important value indices from all the sampling sites.

The Percentage composition of the orders of well represented families was calculated.

The diversity indices were calculated by the aid of computer software - species diversity and richness-version 2.65 www.irchouse.demon.co.uk

The following indices were estimated for collected data:

1. **Shannon-Weiner index (H)**: The richness of species within habitats was calculated using Shannon-Weiner index (H) of alpha diversity index.

H= $P_i \log_e P$

Where Pi is the proportion of individual in i^{th} species. The higher value of H, greater is the uncertainty. This implies higher diversity and evenness of the community as biological community value of H does not exceed 5. It ranges from 4 (most diverse) to 0 (least diverse).

2. **Equitability or Evenness (J)** refers to the pattern of distribution of the individuals between the species in a specific habitat. In our study this was done for all the four habitats. If H is the observed Shannon-Wiener index, the maximum value this could take is log(S), where S is the total number of species in the habitat. Therefore the index is:

J = H/log(S).

This index is high if a community has many species and their abundances are evenly distributed; index is low if the species are few and their abundances are unevenly distributed.

3. **Berger –Parker index**: It is simple measure of the numerical importance of the dominant species. The Berger-Parker Index accounts for both richness and relative abundance, presents the proportional importance of the most dominant species, and is simple and easy to calculate Let

d = Nmax/N,

Where Nmax is the number of individuals in the most abundant species and N is the total number of individuals in the sample.

The Berger-Parker index is then simply 1/d. so that increase in the index value follows an increase in species diversity or a decrease in dominance. It ranges from 0 (most diverse) to 1(least diverse).

4. Diversity of species was found using **Renyi diversity** ordering graph.

5. For measuring rate and extent of change in species along a habitat gradient, other β diversity indices like Whittaker's, Cody's and Wilson and Shmida index are caculated.

a. Whittaker index $\beta_w = S/\alpha - 1$

Where, S is the total number of species and α is the average species richness of the sample.

b. Wilson and Shmida index $\beta_T = g(H) + l(H)/2 \alpha$

its value ranges from 0 (least diverse) to 1(most diverse) .If the value obtained for diversity is in close proximity to one, the greater is richness of the species in community.

Photography

The photographs have been taken using SONY DIGICAM DSC H2 version 6 megapixel resolution ,12 x zoom and NIKON COOLPIX L4 version ,6 megapixel resolution, 3 x zoom. Some photographs of insects are taken directly at the study site and some are taken in the lab. (Photographs were modified using Microsoft picture manager software).
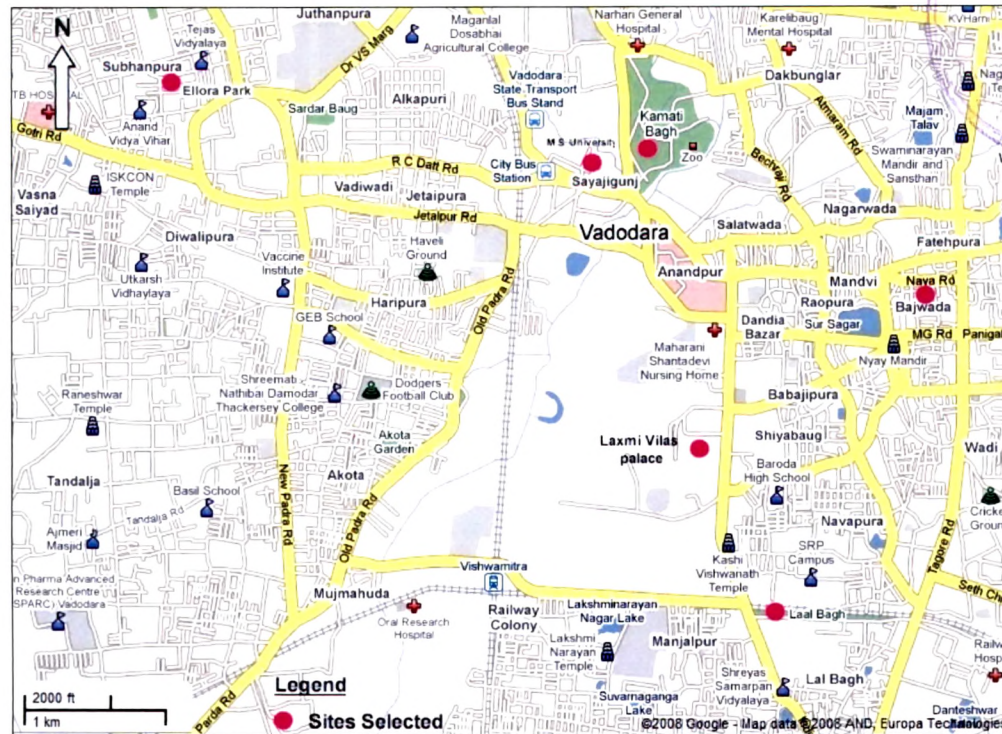
Map of study sites

Figure 1 Map of Vadodara showing urban study sites

Figure 2 Map of Vadodara showing rural study sites

Table 2 Description of study sites

Sr. no.	Study sites	Distance and Direction from Vadodara	Area in hectare	Soil type	Type of site
Agricultural fields					
1	Padra	15 Kms. in the southwest	3.23	Yellow sandy loam	Cultivated fields with large trees and hedges
2	Waghodia	15 Kms. on the east	4.50	Medium black	
3	Savli	25 Kms. on the north	2.50	Yellow sandy loam	
4	Dabhoi	30 Kms. on the southeast	4.80	Medium black	
Community gardens					
1	Lal Baug		3.6	Yellow sandy loam	Garden with pond & swimming pool
2	Sayaji Baug		40	Deep black, yellow sandy loam	Garden with river Vishwamitri passing through it
Fragmented habitats					
3	M.S.University Campus	Within Vadodara city	48	Yellow sandy loam	Buildings, Botanical garden, Cricket ground, Dense vegetation inside and surrounding the campus
4	Laxmivilas palace compound		286	Deep black	Palace with Dense vegetation and play ground.
Residential area					
5	Ellora park		90	Yellow sandy loam	Construction sites,roads and pavements,residential houses.patches of vegetation in private compounds
6	Navabazaar		85	Deep black	

Source: Municipal Corporation of Vadodara, Park and garden Dept.Sayajibaug.

Table 3 Checklist of Flora found in study sites of Vadodara

Sr. No	Study sites	Flora
Agriculture fields		
1	Padra	Crop plants : Cabbage(*Brassica oleracea var.campestris*) , Spinach(*spinacia olerecea*), Raddish(*Raphanus sativus*),Paddy *(Oryza sativa)*,pigeon pea(*Cajanus cajan*)
2	Dabhoi	Crop plants: Maize (*Zea maize)*, Wheat *(Triticum aestivum)*, Cotton *(Gossypium Sp.)*
3	Waghodia	Crop plants: Brinjal(*Solanum melongena*), Sugarcane (*Saccharum officinarum*), Paddy *(Oryza sativa)*,Wheat *(Triticum aestivum)*
4	Savli	Crop plants: Castor (*Ricinus communis*), Cotton (*Gossypium sp.)*
	Common in all Fields	Big trees: *Azadirechta indica, Mangifera indica ,Glycine abrus, Tamarindus indicus, Moringa oleifera* Hedges: *Euphorbia neriifolia, E.tirucalli, Capparis decidua, C.zeylacnica, Lawsonia inermis, Annona squamosa, Clerodendrum inermis, Zizyphus mauritiana, Z.oenoplia, Caeselpenia crista, Calotropis procera, Capparis cepiaria, Salvadora persica, Opuntia elatior, Ipomea obscura, Coccinea cordifolia,Ttinospora cordifolia,* Weeds: *Melochia corchorifolia, Ammania baccifera, Jussiaea perennis, Eclipta prostrate, Oryza rufipogon, Portulaca oleracea, Sida alba, Solanum nigrum, Boerhavia diffusa, Amaranthus spinosus, Chenopodium album, Cuscuta chinensis, Setaria tomentosa, Euphorbia geniculata.*
Community gardens		
5	Sayaji baug	Trees: *Ficus bengalensis, Azadirachta indica, Terminalia catappa, Feronia limonia , Aegle marmelos , Butea monosperma , Casuarina equisetifolia, Tamarindus indicus, Polyalthia longifolia, Saraca indica, Dalbergia latifolia ,Mangifera indica, Syzygium cumin., Tabebuia spectabilis* Herbs,Shrubs,Creepers: *Caeselpenia pulcherrima, Commelina nudiflora, Tephrosia purpurea, Hibiscus lobatus, Abutilon indicum, Bougainvillea spectabilis, Ixora , Coccinea ,Tephrosia strigosa, Andropogon annulatus* (common grass) *,Zornia gibbosa,Vinca rosea , Rosa chinensis, Lantana camara, Canna indica, Nerium odorum, Oxalis corniculata, Gaillardia pinnatifida,G.aristata,etc.*
6	Lal baug	Trees: *Tabebuia spectabilis, Butea monosperma, Polyalthia*

		longifolia, Saraca indica, Oreodoxa regia. Herbs,Shrubs,Creepers:*Canna indica,Nerium odorum,Tecoma stans, Ixora rubiacea, Hibiscus syriacus ,Ipomea palmate, Cymbopogon martini, Cynodon dactylon, Helianthus annuus, Rosa chinensis,* Aquatic plants: *Hydrilla verticillata, Typha augustata, Vallisnaria spiralis,*
Frangmented habitats		
7	M.S.University campus	Trees: *Pithecellobium dulce, Ficus benghalensis, Santalum album, Couroupita guianensis, Polyalthia longifolia, Saraca indica , Plumeria kubra, Caryota urens, Cassia fistula, Delonix regia* Herbs,Shrubs,Creepers:*Canna indica,Nerium odorum, Tecoma stans, Papavera somniferum, Calendula officinalis, Dianthus, Cosmos, Gaillardia aristata, Caryophyllus, Gerbera, Phlox paniculata, P drumondi, Hibiscus populineus, H.syriacus, Michelia champaca., Annona uncinata, A. sqamosa, A.reticulata,Reseda odorata, Portulaca oleracea, Canna species, Viola odorata,Tamarix gallica, Cynodon dactylon,Nicotiana plumbaginifolia ,Calotropis gigantia, C.procera, Crotalaria juncea, C.medicagenea, Argemone mexicana,etc.* Aquatic plants : *Nymphea stellata,Trapa species,Utricularia stellaris,Hydrilla verticillata,Typha augustata,Vallisnaria spiralis.*
8	LaxmiVilas Palace Ground	Trees: *Casuarinas, Tamarindus indicus,* Azadirachta *indica ,Aegle mermelos ,Feronia lemonia ,Zizyphus jujube.,Butea monosperma,Pongamia pinnata , Pithecelobium dulce ,.Borasus flabellifer,Delonix regia , Morus alba etc* Herbs,Shrubs,Creepers *Tridax procumbens, Commelina nudiflora, Sida acuta, Agave, ,Cassia species, Abutilon indicum, Cymbopogon martini, Urena lobata, Brassica nigra ,Cassia siamea , Acacia nilotica ,Hyphaena indica, Cuscuta species, Sesbania aculeata,etc*
Residential sites		
9	Ellora park(New city)	Trees: *Mangifera indica ,Polyalthia longifolia , Livistona chinensis, Murrya koengii , Azadirechta indica, Moringa oleifera ,Pithecellobium dulce, Terminalia catappa , Cocos nucifera , Achras zapota , Ficus glomerata,Cordia sebestena , Alstonia scolaris, Tecoma stans* Herbs,Shrubs,Creepers :*Rosa chinensis,Lawsonia inermis, Ixora coccinea ,I.arborea, Vinca rosea , Nerium oleander , Calotropis*

		procera, Ocimum sanctum ,Euphorbia neriifolia, Aloe vera , Andropogon annulatus ,A.martinii ,Thevetia peruviana, Quisqualis indica, Pyrostegia, Caeselpinia crista, Achyranthes aspera var porphyristachya ,Bryophyllum calycinum , Datura fastuosa , Bignonia stans, Nyctanthes arbortristis, Chrysanthemum sp. ,Clerodendrum splendens , Mirabilis jalapa,Jasminum sambac, etc.
10	Nava bazaar(old city)	Trees:, *Polyalthia longifolia , Ficus religiosa,* Azadirachta *indica* Herbs, Shrubs, Creepers *Rosa chinensis, Ixora coccinea, I.arborea. Euphorbia neriifolia Linn, Ocimum sanctum ,Vinca rosea, Zizyphus jujube, Pothos, Nerium oleander,Jasminum sambac etc*

Source: Sabnis S.B (1967) and Dave Mona (2002)

PLATE 1   AGRICULTURAL FIELDS

Figure 3 Wheat field in Dabhoi

Figure 4 Sugarcane field in Waghodia

PLATE 2   AGRICULTURAL FIELDS

Figure 5 Field of Radish in Padra

Figure 6 Fields of Castor in Savli

PLATE 3   COMMUNITY GARDENS

Figure 7 Vishwamitri flowing through Sayajibaug

Figure 8 Vegetation of Sayajibaug

PLATE 4   COMMUNITY GARDENS

Figure 9 Lal baug

Figure 10 Pond of Lalbaug

PLATE 5 FRAGMENTED HABITAT (M.S.University)

Figure 11 Department of Zoology, The M.S.University of Baroda

Figure 12 Garden in front of The Zoology Department

PLATE 6 FRAGMENTED HABITATS (Laxmivilas Palace)

Figure 13 Laxmivilas Palace compound

Figure 14 Vegetation of Laxmivilas Palace compound

PLATE 7 RESIDENTIAL AREAS

Figure 15 Lane in new city area

Figure 16 Lane in old city area