CHAPTER 2

INSECT COMMUNITY OF GIR PA: SEASONAL CHANGES IN COMPOSITION AND ABUNDANCE

INTRODUCTION

Insects dominate terrestrial ecosystem in terms of species, biomass, number of individuals, and ecological roles (Rickleft *et al.*, 1984; Wilson, 1987, 1988). Approximately 80% of all described metazoan species are insects (Samways, 1992). Their global distribution is highly biased, with over 50% living on less than 7% of the earth's surface in tropical rain forests (Samways, 1994). Of about 1.4 million species of invertebrates that have been described, 0.75-1 million are insects (Wells *et al.*, 1983). Hammond (1992) recorded 9,50,000 species, although lower figures around 7,50,000 and 7,90,000 (May, 1990a) are generally quoted. According to various sources if all species of insects were described, that figure would rise to well over 90% (Adis, 1990; May, 1990a, b). It has been estimated that only about 5% of species have been described and significant information is thought to exist on less than 1% of these (Raven 1990). Insects are generally little valued economically (IUCN, 1983). Small size and the associated lack of information contribute to this situation (Samways, 1994).

Insects have existed from carboniferous time, some 300 million years ago. During this vast period of time many major groups of animals have lived and became extinct from the earth, but the insects have remained and have thrived. Prehistory and history have played major roles in determining insect distributions and abundances (Samways, 1994). Retraction of faunas during the Pleistocene glaciations in the northern hemisphere, retreated to climatic refugia in the tropics and in modern times, fragmentation of the landscape with increasing intensive and extensive urbanization have all determined present insect population patterns and species distribution.

Ancient Sanskrit literature refers to different kind of Insects like 'Patanga', 'Bhramara', 'Pipilika', 'Makshika', etc. The early naturalist from Aristotle onwards have known insects well and divided these in various groups. The earliest insect worker in India was perhaps Mandavya referred to in story of Mahabharata, who had the habit of collecting and pinning insects. Laksha, the product of Lac insect, is the

subject of another popular story of Mahabharata. However, entomology in modern India can be traced from the middle of 18th century, with arrival of Christian missionaries, and subsequent establishment of the East India Company (Z.S.I, 1991).

E. P. Stebbing a forest entomologist started studies on forest insects, in a serious and systematic way, back in 1900. Compiling all the information available up to 1898, he published the pamphlet entitled "Injurious Insects of Indian Forest" in 1899. Lefroy and Howlett (1909) in the monumental book 'Indian Insect Life' reported 25,700 insect species indicating the vastness of insect fauna of India. In 1914, Stebbing published another book entitled " Indian Forest Insects of Economic Importance – Coleoptera", which was pioneering work on wood boring beetles and has contributed much to our knowledge on forest insects from India and neighboring countries. Another studies by Beeson contributed to the knowledge on coleopterans and other forest insects when he published the book entitled "The Ecology and Control of Forest Insects of India and the neighboring countries", in 1941. Mathur *et al.* (1954 -1961) compiled and published 10 volumes describing various aspects of insect pests affecting more than 2000 forest plant species. Over 16,000 species of insects are included in these volumes, as associated with forest trees, which are nearly one quarter of the 67,000 species of insects recorded from all habitats in India. The other notable works by the forest entomologist are the studies on taxonomy of timber beetles by Stebbing (1914) and Gardner (1941); Termites by Roonwal (1954) and Psyllids by Mathur (1975). The forest research institute at Dehradun, maintains a fabulous collection of forest insects consisting of about 17,000 authentically identified specimens (Roonwal *et al.*, 1950).

Apart from the above general studies, a few faunistic studies have been made recently in specific forest areas. Larsen (1987, 1988) carried out studies on butterflies of Nilgiri Mountains. Ananthkrishnan and Seastedt in 1984 and 1988 respectively, worked on insects of forest leaf litter community. Scientists of Z.S.I. (1988) conducted four faunistic explorations of insects of Silent Valley. Cherian (1985) has reported insect fauna from the disturbed forests of Idukki covering the hydel project reservoir and its catchment area.

Mathews (1990) studied the butterflies of Silent Valley and also the insect fauna of disturbed and fragmented forests of Malayatoor. The Insect taxonomic diversity in

the reserve forests and forest plantation of Uttara Kanada was studied by Gadagkar and his coworkers (1990). Few dedicated workers have contributed towards understanding the taxonomy and ecology of Lepidoptera. Muthukrishnan (1990), Pandian (1976, 1986), Selvasundaram, (1992), Uniyal and Mehra (1996) worked on diversity of butterflies in high altitude grazing pasture in Greater Himalayan National Park.

Insects are by far most valued in conservation for their ecological roles. They are key components in the composition, structure and function of ecosystem (Hafernik, 1992; Ricklefts *et al.*, 1984; Wilson, 1987). They are abundant herbivores and detritivores influencing directly and indirectly elemental cycling and net primary productivity (Seastedt and Crossely, 1984). Insects are increasingly used as indicators of biogeographic zones, areas of endemism, community richness, diversity, naturalness, typicalness and centers of evolutionary radiation in conservation planning (Kremen, 1992; Kremen *et al.*, 1993). However, terrestrial insects are considered as bioindicators (Chakravarthy, 1997; McGeoch, 1998).

The study of insects has unique task of understanding 80% of the species on earth, of which perhaps 85% remain undescribed. About 1/3rd of the world's crop production depends on pollination by insects either directly or indirectly. Of the overall pollination in the world, most of it is by insects (Costanza *et al*; 1997). They contribute to nutrient cycling in terrestrial ecosystem along with related arthropods.

Any discussion on biodiversity would be incomplete without reference to insects because they contribute at least three- fourth of all described forms of life. No one knows the total number of species of insects on earth for sure, but estimates vary from one to thirty million, of which 7,51,000 species of insects has been authentically described (Wheeler, 1990). According to the estimates made by Z.S.I (1980), in India we have 67,000 species of described insects. However the taxonomic knowledge of the group is still inadequate, particularly with reference to National parks and Sanctuaries except in southern parts of India. But, overall the diversity of insect species is very vast and unexplored (Samways, 1994.).

In Gujarat no systematic studies on insects have been carried out barring few isolated works on certain groups. However, biology of insect pests of various crops was conducted by different workers. Vazirani (1973, 1977) reported some water insects of Gujarat whereas Prasad and Thakur studied odonata species of Gujarat in

1984. Ghosh recorded Neuropterans of Gujarat in 1990. Sabnis and Amin, (1992) recorded about 250 species of insects belonging to several order from Narmada valley in Gujarat region during the faunal survey conducted during the year 1990 – 1992. Butterfly fauna of Jessore Sloth Bear Sanctuary was carried out by Suresh and co-workers in 2001. Thus, studies on insect are by and large scanty in Gujarat particularly in National parks and Sanctuaries in comparison to other states of India. Therefore, a study on the diversity and seasonal variation of insects along with temporal variations in the relative density of different orders of class insecta was carried out in Gir PA.

Class insecta includes 32 orders, of which 29 are reported from India. The classification of insects is followed according to Borror (1992). A brief description of various orders of class inscta and their significance in forest ecosystem is been reviewed as follows.

Thysanura includes the silverfish and bristletails. They are herbivorous or detritivorous. In forests, these forms are found under stones, under tree barks or ground. Diplurans are herbivorous and are found in damp moist ground and in leaf litter. Collembola including springtails are small group of insects, which are ecologically important as they play a vital role in enrichment of the soil. They are minute soil insects feeding on decaying organic debris in humus. Ephemeropterans commonly called as mayflies, have no direct importance to forested ecosystem as they spend major part of their life cycle in fresh water ecosystem during egg and larval stages. Adults and nymphs are important food source for many fresh water fishes (Besson, 1941).

Dragonflies and damselflies forming a very small but clearly defined order of Insecta called Odonata. Economically they are of great importance in destroying mosquitoes and other noxious flies. They are also considered as ecological indicators (Borrer, 1998). Orthopterans are songsters. They are largely plant feeders. Some are omnivoresand some are scavengers. Mantids are the only insects that "Look over their shoulders". These insects are highly predaceous and feed on a variety of insects. Cockroaches are primarily tropical insects generally found under leaf litter (Boror, 1998). Isoptera includes termites, which are considered as pest due to damage caused by them to wood materials. They also help in recycling dead trees and other plant material into nutritive substances. Termites are important "ecosystem

engineers" (De Oliveira, 1992) but the role played by them is poorly acknowledged in the key paper by Jones *et al.*, (1994). Their nest represents important structural elements of many ecosystems, which affect plant growth (De Oliveira, 1992) and influence diversity and composition of plant and animal communities (Redford, 1984). Termites are important "gap – makers" which renews the forest (Doscent Bulletin, 2004) and play a very important role in soil ecology. They transport and mix soil and organic material from different horizons, and also aid in the breakdown of cellulose and other organic material, therefore aiding in soil fertility (Amund *et al.*, 1988).

Member of order Dermaptera (earwigs) are commonly encountered in vegetation, in various living and more or less decayed parts of herbs and trees. Very little is known about ecology. The adults are largely carnivorous and probably omnivorous, feeding on small soft-bodied insects and spiders. Embiopterans are webspinners and are not of much economic importance, neither these are beneficial nor harmful to forestry (Imms,). Hemipterans are a large and widely distributed group of insects. Most species are terrestrial, but many are aquatic. The terrestrial species are destructive pest as plant sapsuckers. Few species are predatory, feeding on various noxious insects. For this reasons they are sometimes used in the control of insect pests (Zahradnik, 1999). Aquatic and semi aquatic forms are predatory and sarcophagus and thus perform an important role in energy transformation (Basu, 1982). All Homopterans are plant feeders and many species are serious pests, some species transmit plant diseases. However, few homopterans are beneficial and serve as source of shellac, dyes or other materials (Borror, 1992).

Lepidopterans are the "Scaly – winged" insects. Butterflies are considered to be the flagship species of insect conservation (New *et al.*, 1995; Smateck, 1996). They are found practically in all types of habitat. According to a rough estimate there are some 40,000 species distributed throughout the world. As regards number of species, they rank second after the beetle, worldwide (Zahradnik, 1999). The Lepidopterans are of great economic importance being both injurious and beneficial. The larvae of most species are phytophagous, and many are serious pests. Natural silk is byproduct of one of the member of this order. However, they play a very important role as plant pollinators.

The faunistic records of lepidopterans from India are given by Linnaeus (1767). The butterfly fauna of India is rich with over 1500 sp., which is close to 7% of total butterfly sp. in the world. Lepidopterans are known to be predatory and parasitic. Predators of lepidopterans are reptiles, birds and bats. Among invertebrates, spiders, mantids, ants, bugs, tiger beetles, and ground beetles are threat to lepidopterans. While the dipterans and hymenopterans are the chief parasites.

The Diptera constitutes one of the largest orders of insects, and its members are abundant, almost everywhere. Some of the dipterans are blood sucking and are serious pests of humans and vectors of animal diseases and important pests of cultivated plants. Many flies are useful as scavengers while others are important predators or parasites of various insect pests and others aid in pollination of useful plants and noxious weeds (Dutta, 1992).

The ubiquitous hymenopterans are highly specialized insects. Thousands of species are yet to be discovered. The tremendous diversity of the hymenopterans reflects their ecological importance. Hymenopterans in general have a beneficial role and are the best pollinators. The economic value of the pollinating insects is enormous. The hymenoptera is very interesting group in terms of its biology, for it exhibits a great diversity of habits and complexity of behavior culminating in the social organization of the wasps, bees and ants. The bees have been well known in India from time immemorial (Ghosh, 1936)

OBSERVATIONS

During the current study spanning two years covering all the seasons one could observe/ identify 238 species of insects which are hierarchically organized and listed as follows. However, hundred and ten species of coleopterans that are collected/identified during the current study are not included here since they are specially treated in a later chapter (Chapter 3).

PHYLUM: ARTHROPODA

Class: Insecta

Order: Thysanura

Family: Lepismetidae

1. *Lepisma scacchirina*
2. *Lepisma collaris*

Order Diplura

Family: Compodeidae

3.Unidentified

Family: Japygidae

4. Unidentified

Order: Collembola

Family: Poduridae

5. *Achorutes armatus*

Order: Ephemeroptera

Family: Ephemeridae

6. Unidentified 1

Order: Odonata

Family: Protoneuridae

7. *Disparoneura quadrimaculata*

Family: Lestidae

8. *Lestes viridulus* (Rambur)

Family: Libellulidae

9.*Brachythmis contaminata* (Fabr.)

10. *Trithemis aurora* (Burmester)

11.*Trithemis pallidinervis*

12. *Pentala flavensis* (Fabr.)

13.*Onychothemis testacea* (Ris.)

Family: Platycnemidae

14. *Copera marginipes*

Family: Coenagriidae

15. *Protosticta stevensi*

16. *Argia spp.* (Darper)

17. *Enallagama spp.* (Blutes)

18. *Pseudocopera trotteri*

19. *Ceriagrion olivaceum*

20. *Ceriagrion spp.*

21. *Aciagrion occedentalis*

22. *Pseudagrion laidlawi*

Order: Orthoptera

Family: Acrididae

23. *Cyrtacanthacris latarica*
24. *Indomeru noxius*
25. *Pachyacris venosa*
26. *Acrida indica*
27. *Acrida turrita*
28. *Heterairs insignis*
29. *Thisoicetrus dorsatus*
30. *Thisoicetrus littorolis*
31. *Catantops innotobile*
32. *Gastromargus spp.*
33. *Gastromargus transverses*

Family: Pyrgomorphidae

34. *Poecilorus pictus* (Fabr.)
35. *Atractomorpha crenulata*

Family: Gryllidae:

36. *Gryllus bimaculatus* (De Geer)
37. *Gryllus domesticus*
38. *Teleogryllus mitratus* (Burmeister.)
39. *Oecanthus indicus* (Sauss.)
40. *Neombius spp.*

Family: Tettigonidae

41. *Sathrophylia rugosa* (Linn.)
42. *Mecopoda elongata* (Linn.)
43. *Marsimus carinatus*
44. *Sathrophylla spp.*
45. *Conocephalus indicus* (Redt.)
46. *Holochlora albida*
47. *Liogryllus bimaculatus* (Deg.)

Order: Mantodea

Family: Mantidae

48. *Gongylus gongyuliodes* (Linn.)
49. *Rhombodera woodmmasoni* (Werner)

50. *Deiphobe infusecata*

51. *Deiphobe ocellata*

52. *Hierodula coarctata* (West.)

Order: Phasmida

Family: Phasmatidae

53. *Schizocephala bicornis*

54. *Carausis spp.*

Order: Blattaria

Family: Blattidae

55. *Periplaneta Americana* (Linn.)

56. *Blatta germanica* (Linn.)

Order: Dermaptera

Family: Labiduridae

57. *Lebidura bengalensis*

Family: Forficulidae

58. *Forcipula indica* (Brindal)

59. *Forcipula trispinosa* (Dhrn.)

Order: Isoptera

Family: Termitidae

60. *Odontotermus obesus.*

61. *Nasutitermus spp.*

62.*Microtermes obesi*

Order: Embioptera

Family: Embiidae

63. *Embia spp.*

Order: Hemiptera

Family: Pyrrhocoridae

64. *Physopelta schlanbaschi* (Fabr)

65. *Antilochus coquiberti* (Fabr.)

66. *Dysdercus singulatus* (Fabr.)

Family: Pentatomidae

67. *Antestia anchora*

68. *Pladostrmum taurua* (Fabr.)

69. *Erthensia spp.*

70. *Erthensia fullo* (Thumb)
71. *Eusarcocoris montivagus*
72. *Plausia spp.*
73. *Placosternam dama*
74. *Melanophara dentate*
75. *Halyomorpha picus*
76. *Halys dentatus* (Fabr.)

Family: Reduviidae

77. *Canthesancus gulo* (Stal.)
78. *Catamiarus breripennis* (Serv)
79. *Harpactor costalis* (Sal.)
80. *Harpactor fusipes* (Fabr.)
81. *Brassivola hystrix*

Family: Belostomatidae

82. *Lithocerus indicus* (Lep. & Serv.)

Family: Nepidae

83. *Laccotraphes rubber* (Linn.)
84. *Laccotraphes maculates*
85. *Ranatra filiformis* (Fabr.)

Family: Coreidae

86. *Anoplocemis phasiana* (Fabr.)
87. *Anoplocemis compressa* (Fabr.)
88. *Acanthocephala femorata* (Fabr.)

Family: Notodentidae

89. *Enithares templetoni* (Kirby.)

Family: Hydrometridae

90. *Hydrometra vittata* (Stal.)
91. *Petillia lobipes* (West)
92. *Homoeocerus prominulus* (Pal.)

Family: Lygaeidae

93. *Acanthaspis trimaculata*
94. *Spilostethus hopes*
95. *Sydnus mccan*
96. *Dieches leucocerus* (wlk.)
97. *Pamera vincta* (Say.)

Family: Gerridae

98. *Gerris spinole* (Leth.)

Order: Homoptera

Family: Cicadidae

99. *Platypleuro octogultata* (Fabr.)

100. *Platypleuro mackinnoni*

Family: Fulgoridae

101. *Pyrilla perpusilla* (Wlk.)

Family: Cicadellidae

102. *Ledra spp.*

103. *Ldocerus atkinsoni*

104. *Neophotettix bipunctatus* (Fabr.)

Order: Neuroptera

Family: Mymeleontidae

105. Unidentified 1

Family: Crysopidae

106. Crysopa spp.

Order: Mecoptera

Family: Panorpidae

107. Unidentified 1

Order: Lepidoptera

Family: Papilionidae

108. *Pachliopta aristolochiae*

109. *Papilio demoleus* (Linn.)

110. *Papilio polytes* (Linn.)

111. *Graphium nomius*

Family: Danaidae

112. *Danus crysippus* (Linn.)

113. *Danus plexipus* (Linn.)

114. *Danus genutia* (Scramer.)

115. *Tirumala limniace* (Butler.)

116. *Euploea core* (Cramer)

Family: Satyridae

117. *Melantis leda*

118. *Melantis phedima* (Stall.)

119. *Melantis ismence*

120. *Ypthima asterope* (Moore.)

Family: Pieridae

121. *Delias euchari* (Drury)

122. *Cepora nerissa*

123. *Anapheis aurota*

124. *Ixias Marianne* (Cramer)

125. *Ixias pyrene* (Linn.)

126. *Colotis eucharis*

127. *Colotis danane* (Fabr.)

128. *Colotis etrida* (Boisduval)

129. *Calotis estalis*

130. *Catopsilia Pomona* (Fabr.)

131. *Catopsilia pyranthe*

132. *Eurema blanda*

133. *Eurema laeta*

134. *Eurema hecabe* (Linn.)

135. *Terias libythea* (Fabr.)

Family: Nymphalidae

136. *Byblia ilithyia* (Drury)

137. *Ariandne ariadne* (Frusthorfem)

138. *Phalanta phalanta* (Dry)

139. *Junonia orithya* (Linn.)

140. *Junonia hierta* (Fabr.)

141. *Junonia alamana*

142. *Junonia lemonas*

143. *Hypolimnas misippus*

144. *Euthalia nais* (Forster)

Family: Lycaenidae

145. *Catochrysops strabo*

146. *Azanus jeasons*

147. *Rapala airbus*

148. *Castalius rosimon*

149. *Tarucus nara*

150. *Spindasi vulcanus* (Fabr.)

151. *Lampides becticus*

Family: Agaristidae

152. *Aegosera bimacula*

Family: Bombicidae

153. *Antheraea paphia* (Linn.)

Family: Eupterotidae

154. *Eupterote udanta*

Family: Geometridae

155. *Hyposidra talaca* (Wlk.)

156. *Biston verianaria*

157. *Boermia meti*

158. *Sterrha sacraria*

Family: Sphingidae

159. *Marumba dyras*

160. *Marumba indicus*

161. *Acharontia lachesis*

162. *Agnosia orneus*

163. *Psillogramma menophron*

164. *Nephele didyma*

Family: Noctuidae

165. *Calesia satellitia*

166. *Phalena raya*

167. *Ophederes fulloniea*

168. *Ophederes maternal*

169. *Fodina stola*

170. *Ophiusa algira*

171. *Psimala guadriponnis*

172. *Hyblaea puera*

Family: Notodontidae

173. *Antheua servula*

Family: Pyralidae

174. *Pygospila tyres*

175. *Synpomis passalis*

176. *Sameodes cancellatis*

177. *Caprina conehylelis*

Family: Hypsidae

178. *Hypsa ficus*

179. *Hypsa conies*

180. *Digama cribraria*

Family: Lymentridae

181. *Lymenpris viola*

Family: Arctiadae

182. *Utetheisa pulchella*

183. *Alphaea biguttata*

184. *Deiopia pulchella*

Family: Lasiocampidae

185. *Trabala Vishnu*

Family: Uranidae

186. *Micronia aculeate*

Order: Diptera

Family: Mucidae

187. *Lucilia spp.*

188. *Musca domestica* (Linn.)

Family: Tabanidae

189. *Tabanus striatus* (Fabr.)

190. *Pangonia longirostris*

Family: Culicidae

191. *Anopheles spp.*

192. *Anopheles spp.*

193. *Culex spp.*

Family: Sarcophagidae

194. *Sarcophaga lineatocollis* (Macq.)

Family: Bombylidae

195. *Bombylias orientalis* (Macq.)

196. *Exoprosopa spp.*

Family: Syrphidae

197. *Helophilus bengalensis*

198. *Microdon stilbodies*

Family: Asilidae

199. *Promachus rufipes*

Family: Nemestrinidae

200.*Hirmoneura annandaei*

Family: psycodidae

201.*Phlebotomus argentipes*

Order: Hymenoptera

Family: Formicidae

202.*Oecophylla smaragdina* (Fabr.)

203. *Camponotus sericerus* (Fabr.)

204. *Camponotus Comressus* (Fabr.)

205. *Leptogenys assamensis* (Forel)

206. *Anochetus taylori* (Forel)

207. *Polyrhachis clypeata* (Mary.)

208. *Tetraponera (Tetraponera) rufonigra* (jerdon)

209. *Tetraponera (Tetraponera) nigra* (jerdon)

210. *Myrmicaria brunnea* (Saunders)

211. *Meranoplus bicolor* (Geur.)

212. *Lophomyrmex quadrispinosus* (Jerdon)

213. *Cataulacus latus* (Forel)

214. *Pheidole spp.*

215.*Crematogastor spp.*

216. *Heranoplus bicolor*

Family: Sphecidae

217. *Bembex spp.*

Family: Eumenidae

218. *Eumenes spp.*

Family: Pompilidae

219. *Pompus analis*

220. *Pseudogenia honesta*

Family: Vespidae

221. *Ropalidae spp.*

222. *Icaria terrugine (Fabr.)*

223. *Polites herbroeus* (Sausseure)

Family: Xylocopidae

224.*Xylocopa aestuans* (Linn.)

225.*Xylocopa teneiccic*

Family: Apidae

226.*Apis (Macropis) florae* (Fabr.)

227.*Apis dorsata* (Fabr.)

228.*Apis indica* (Fabr.)

229.*Anthidium pulchellum (Klug.)*

Family: Chrysididae

230.*Chrysis oculata* (Fabr.)

231.*Stiribum spp.*

Family: Sphegidae

232. *Sceliphron coromandelicum*

233.*Sceliphron salsette*

234.*Stizus primaticus*

235.*Ammophila lavigata* (Smits)

Family: Scoliidae

236.*Elis reticulata*

237.*Elis grossa*

Family: Braconidae

238.*Iphiaulax spp.*

During the present study nineteen orders, seventy six families and two hundred and thirty eight species of insects other than coleopterans have been recorded (Figure 2.1). An analysis of the total number of individuals belonging to various orders collected during each season exhibits marked temporal variation (Table 2.1). On the whole maximum number of individuals was encountered during monsoon. However, a definite decline in the number was observed during winter. An aberrant swam of ephemeropterans nevertheless, altered this trend during the year 2001. The individual number declined to minimum during summer (Table 2.1). Relative density

of individuals of various orders was also studied. Members of order Lepidoptera predominated during winter and summer. However, during monsoon relative density of hemiptera was the highest closely followed by hymenoptera (Table 2.2).

Apterygotans are represented by orders, Thysanura, Diplura and Collembola. These orders showed monsoon dominance during the tenure of the study however they were in good numbers in year 2001 than in year 2000 (Figure 2.2 – 2.4). Two families and two species represented Diplura. Whereas, Thysanura is represented by 1 family and 2 species and Collembola represents one species.

Pterygotes were represented by 16 orders. They were more abundant during year 2001 than during the year 2000. Ephemeroptera was encountered during winter 2001 in a huge swarm (Figure 2.5). The single family Ephemeridae with single species is recorded from this order. Odonates were commonly sighted near water points, rivulets etc. they were noticed more in winter than any other season (Figure 2.6). Five families and sixteen species are reported from the study area during the current study. Twenty five species belonging to four families were recorded and identified from order Orthoptera. This order showed declining trend from monsoon to summer during the studies (Figure 2.7).

Both the orders Mantodea and Phasmida are represented by a single family mantidae and Phasmatidae respectively. Mantidae is represented by five different species whereas Phasmitidae with two species. Three families and six species belonging to order Homoptera are identified during the present study. These three orders showed co dominance during monsoon and winter (Figure 2.8 – 2.10). The remarkable observation was that aphids were rarely sighted.

Blattaria is represented by two species belonging to a single family Blattidae. This order is maximally reported during the winter season (Figure 2.11). They are commonly found from the ground leaf litter. Three species belonging to two families are encountered from order Dermaptera. Isoptera was represented by a single family with three species, they were sited through out the year but there prevailed increase in their number during winter season (Figure 2.12). Order Embioptera was monsoon dominate and was represented by a single species (Figure 2.13).

Thirty-five species spread in ten families are identified belonging to order Hemiptera from the study area. This order showed declining trend from monsoon to summer (Figure 2.14). Neuropterans are represented by two families and two species; on the

other hand order Mecoptera is represented by only a single family and single species. Nevertheless, both these orders were showing monsoon preference (Figure 2.15 and 2.16). A large congregation of ant lion larva (doodlebugs) was seen during April to May at site I on the forest floor. Their presence becomes very obvious by the conical traps they make in the soil in large numbers.

Lepidoptera is the most diverse order amongst insecta other than coleoptera, seventy nine species from eighteen families are recorded from the study area. During postmonsoon showers dominance of this order is more and it lasted till late winter (Figure 2.17). Fifteen species of dipterans belonging to nine families are recorded. Members of this order were dominant during winter than any other season (Figure 2.18).

From the order Hymenoptera thirty seven species from nine families are identified. From monsoon to summer a decline in the appearance of the members of this order was apparent (Figure 2.19). However the ant assemblage was found prominently throughout the study area during the entire tenure of the studies.

DISCUSSION AND CONCLUSION

From the above observation it could be concluded that Gir PA harbors a good diversity of insect species (Figure 2.20 – 2.34). The entire study area showed a fairly even distribution of different insect orders both in terms of number of species and individuals. However, there was a significant seasonal variation caused due to climatic change, which potentially affected insects both directly and indirectly through plant associations. Similar observations made by Dennis, (1993) and New, (1995) consolidate the present notion.

The insects' orders of apterygotans *viz.* thysanura, diplura and collembola were found dominant during monsoon season. Their dominance may be due to availability of good decaying materials. Gir PA being a deciduous forest leaf litter formation starts by late December till the end of summer which, in turn provides organic substance for these organisms. Ananthakrishnan, (1989) also observed similar relationship existing between apterygots diversity and humus in forest floor.

Pterygotans are represented by 16 orders of which Dermaptera, Embioptera, Neuroptera and Mecoptera were monsoon dominant. Terrestrial ecosystems are sensitive to climatic change when key processes such as primary production are tightly coupled to rainfall. In turn, vegetation structure is closely linked to temperature

and rainfall seasonality (Scholes, 1990). Climatic variations may be the reason for fluctuation in resource availability on which insect population is directly dependent (Demster and Pollurd, 1986; White, 1993). Ant lion larvae prefer dry situation for making conical traps (Borror, 1992) which is facilitated by dry weather prevailing during the months of April and May in the study area.

A single member of ephemeroptera was encountered in huge swarm during winter in 2001, which happens sometimes without any apparent reason (Borror, 1992).

Odonata was represented by good number of 16 species and were monsoon dominant. Prasad and Varshney (1995) have reported about 48 species and subspecies of odonata from different parts of Gujarat. Odonates spend major part of their life cycle in fresh water ecosystem. Being voracious predators during both immature and adult stages they are important component of fresh water ecosystem and occupy an apex position in the food chain of invertebrates (Tyagi, 1985, 1997). Study area is bestowed with seven perennial rivers and four water reservoirs (Singh and Kamboj, 1996), which serve as refugia for these insects.

A Good diversity of orthopteran species was recorded at the study site. Their presence was more prevalent during monsoon and post-monsoon seasons, which coincides with the optimum growth of all types of vegetation. Studies done by Hazara and co-workers (1993) and Tandon and Hazara also made same type of observations during 1998. Mantoidea and Phasmida orders were co-dominant during monsoon and winter. This increasing trend in population is due to an apparent increase in herbivorous insects during monsoon and post monsoon. These insect groups persist from monsoon till winter. Due to the onset of leaf litter formation, number of animals belonging to order Blattaria increases. Members of this group are omnivores and feed on every thing and any thing they get. Annathakrishnan, (2000) noticed that insects of leaf litter community, being one of the food source for Blattarians, provides them with good opportunity to proliferate.

Bugs and hoppers belonging to hemiptera and homoptera respectively showed a good number of species diversity with distinct seasonal preferences. Being semiarid ecosystem, study area showed poor representation of homopterans like aphids. Diversity of these groups depends not only on vegetational diversity alone but also on temperature and humidity, which are favourable during monsoon. Similar

observations have been made by Ghosh (1993) from arid and semiarid zones of Rajasthan.

Lepidoptera showed highest diversity among insects excluding coleoptera. Seventy nine species are recorded from this order. Their predominance reflects high diversity of the group. Due to their large size and catchy colour they become conspicuous species compared to other groups, which may be reflected as their relatively greater numbers. Lepidopterans are dependent on various complementary resources suits their dominance, thereby, suggests the availability of these sources such as topography for mating, nectar for food and host plants for ovipopsition and subsequent larval growth (Dennis, 1993 and Venkata Ramana *et.al.*,2001). Therefore, appearance related aspects of butterfly biology have led their use as models for understanding the direct impacts of atmospheric pollutants and for predicting the indirect effects of climate change. For the same reasons, butterflies are promoted as monitors of climate change (Dennis, 1993).

Diptera is one of the important orders of insecta. Their occurrence was persistent on dead remains, left over preys of carnivores, in vicinity of excreta of vertebrates thereby suggesting their saprophagous mode of feeding habit. Fifteen species of dipterans were recorded during the current study.

As far as the number of species and family are concerned the second dominant order is hymenoptera. The reason for more common occurrence of hymenopterans may be attributed to the good availability of the host insects, which in turn may be due to increased floristic diversity. They have fascinating diversity in biology exhibiting both, entomophagy and phytophagy. According to studies carried out by Sureshan (1996) they are found to attack a wide range of hosts that include twelve orders of insects and two of arachnids. Ants contributed about 50% of total hymenopteran species at the study site. Ninety percentage of the dead remains of all insects are scavenged by ants and they may play a major role in turn over of soil (Wilson, 1991). This order stands out for its greater diversity, utilizing the environment fully and at the same time controlling other insects as noted down by Wagner *et al.*, (1989). Any increase or decrease in their population is an indication of the population of noxious species or pests belonging to other insect orders (Chhotani and Ray, 1975). Hymenopterans also play a critical role of pollinators in forest ecosystem (Buchmann and Nabhan, 1996).

Thus, from the present study it can be concluded that insect fauna of Gir PA is vast and the availability of a wide range of ecological niches and climatic variations enhance distribution of insects. Moreover, the heterogeneous plant architecture might have supported an appreciable variety of insects' species. The more complex the plant architecture, the more herbivorous insects are supported (Lawton, 1983). In the apparent changelessness of the tropical forests there are however subtle diurnal or temporal variations in weather, which affects insect community structure. Insect population variability is as evident in the tropics as in temperate zones, making monitoring of insect species for presence/absence or abundance important at all latitudes (Samways, 1994). Population of insect species is found attaining maximum level during monsoon season throwing open a plethora of various forms of insects. Availability of humid microhabitats, plentiful of food – in the form of foliage as well as different stages of life forms – may lead to proliferation of these insects during rainy days. Another apparent reason could be the least anthropogenic pressure during rainy season when human interference is at its low ebb. During winter season the environmental scenario changes leading to change in the insect population, which show decreasing trend. Apart from temperature level of humidity was also found decreasing during this period (table I &III) and that might be affecting the insect population negatively. It is evident by slight decline in the insect abundance during winter. Totally foliated trees that are abundant during monsoon starts weathering during winter and that accounts for the lower number of phytophagous insects. Falling of leaves enhances leaf litter formation, which is favourable to insects preferring this stratum of habitat to flourish. Nevertheless, forest fires – a regular forest management practice – play a major role in keeping check on the leaf litter. This state of affairs may be favourable for some groups of insects whereas unfavourable for other group of insects. Moreover, human interference poses major concern during the rest of the year. Seasonal changes leading to summer were remarkably noticeable by a general decrease in insect species richness and abundance. Due to dry condition and defoliated trees during hot season, insect population starts dwindling during summer months. These observations therefore prove beyond doubt that temporal changes affects the composition and abundance of insect community either directly or through altered phenological and edaphic characters at Gir PA a tropical dry deciduous forest.

TABLE 2.1 Temporal variations in number of individuals of each order during 2000 and 2001

ORDER	MONSOON		WINTER		SUMMER	
	2000	2001	2000	2001	2000	2001
Thysanura	36	59	23	41	1	2
Diplura	18	28	3	6	1	2
Collembola	50	70	11	17	3	9
Ephemeroptera	0	0	0	1000	0	0
Odonata	16	22	22	29	1	2
Orthoptera	101	173	66	106	14	22
Mantoidea	20	31	20	31	3	5
Phasmida	3	5	3	5	0	0
Blattaria	22	34	33	52	12	19
Isoptera	54	64	48	91	23	36
Dermaptera	33	52	6	10	2	3
Embioptera	26	41	5	8	2	0
Hemiptera	156	246	90	141	35	41
Homoptera	56	87	52	85	9	14
Neuroptera	7	12	3	5	0	2
Mecoptera	3	0	0	0	0	0
Lepidoptera	50	88	129	210	53	101
Diptera	54	84	77	121	17	26
Hymenoptera	152	235	99	151	45	71
TOTAL NUMBER	857	1331	690	2109	221	355

TABLE 2.2 Temporal variations in relative density of each order during 2000 and 2001

ORDER	MONSOON		WINTER		SUMMER	
	2000	2001	2000	2001	2000	2001
Thysanura	4.20	4.42	3.33	1.94	0.45	0.56
Diplura	2.10	2.11	0.43	0.28	0.45	0.56
Collembola	5.83	5.24	1.59	0.81	1.36	2.54
Ephemeroptera	0	0	0	47.42	0	0
Odonata	1.86	1.65	3.18	1.37	0.45	0.56
Orthoptera	11.78	12.95	9.56	5.03	6.33	6.19
Mantoidea	2.33	2.32	2.89	1.47	1.36	1.41
Phasmida	0.35	0.37	0.43	0.24	0	0
Blattaria	2.57	2.54	4.78	2.46	5.43	5.35
Isoptera	6.30	4.79	6.96	4.31	10.41	10.14
Dermaptera	3.85	3.89	0.87	0.47	0.90	0.85
Embioptera	3.03	3.07	0.72	0.38	0.90	0
Hemiptera	18.10	18.41	13.04	6.68	15.84	11.55
Homoptera	6.53	6.51	7.54	4.03	4.07	3.94
Neuroptera	0.826	0.89	0.43	0.24	0	0.56
Mecoptera	0.35	0.37	0	0	0	0
Lepidoptera	5.83	6.58	18.69	9.96	23.98	28.45
Diptera	6.30	6.28	11.16	5.73	7.69	7.32
Hymenoptera	17.74	17.59	14.35	7.16	2.36	20

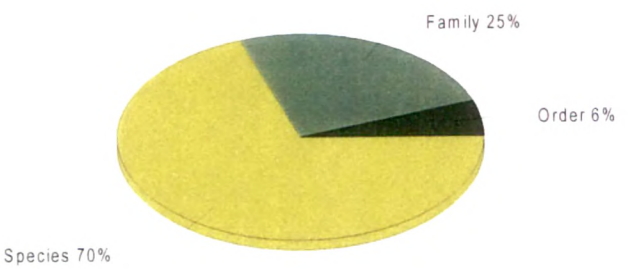

FIGURE 2.1 Composition of class insecta recorded from study area

FIGURE 2.2 Thysanura at study site during 2000-2001

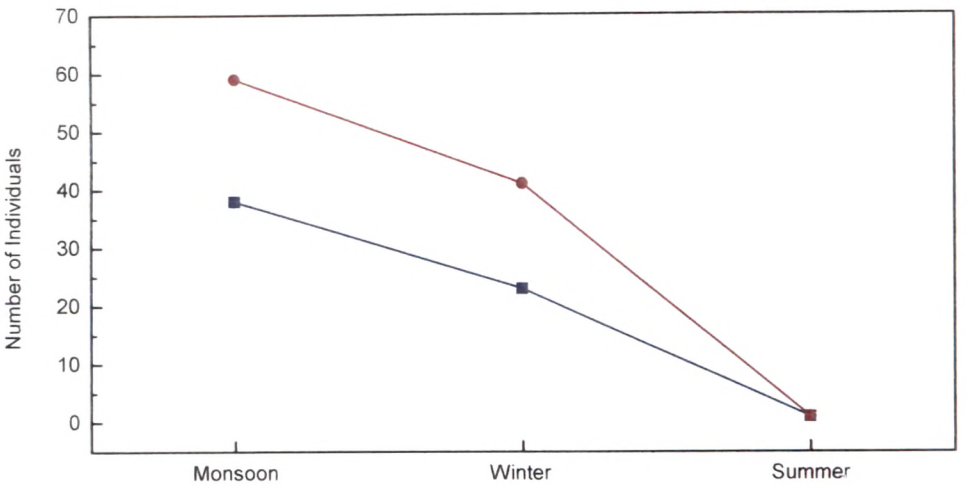

FIGURE 2.3 Diplura at study site during 2000-2001

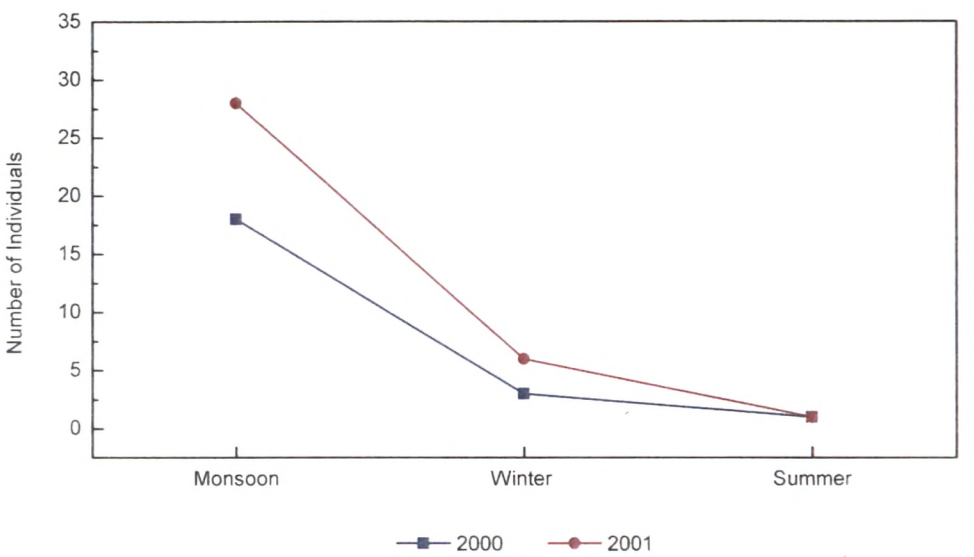

FIGURE 2.4 Collembola at study site during 2000-2001

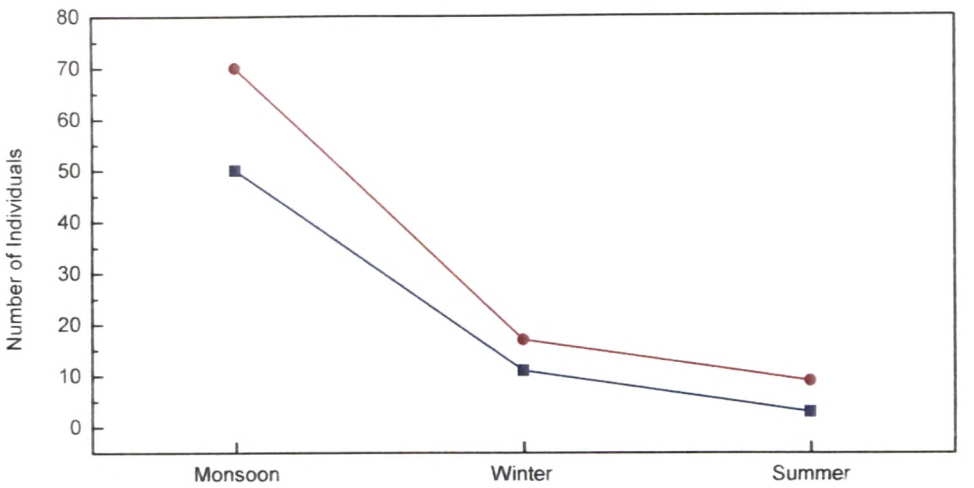

FIGURE 2.5 Ephemeroptera at study site during 2000-2001

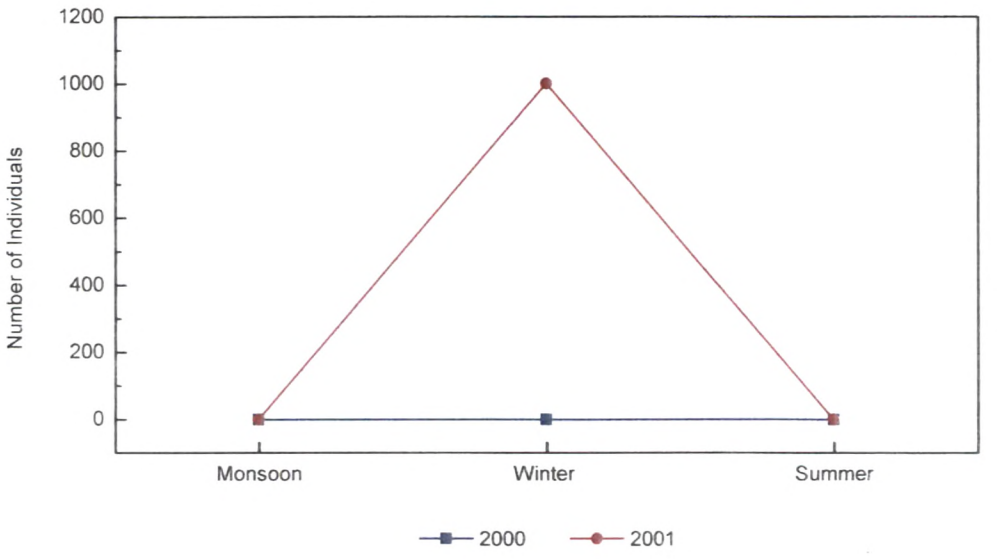

FIGURE 2.6 Odonata at study site during 2000-2001

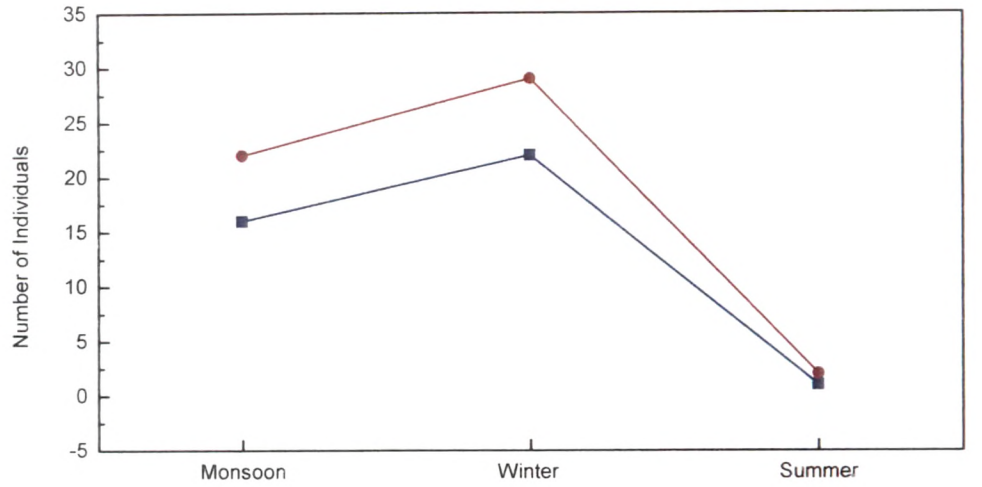

FIGURE 2.7 Orthoptera at study site during 2000-2001

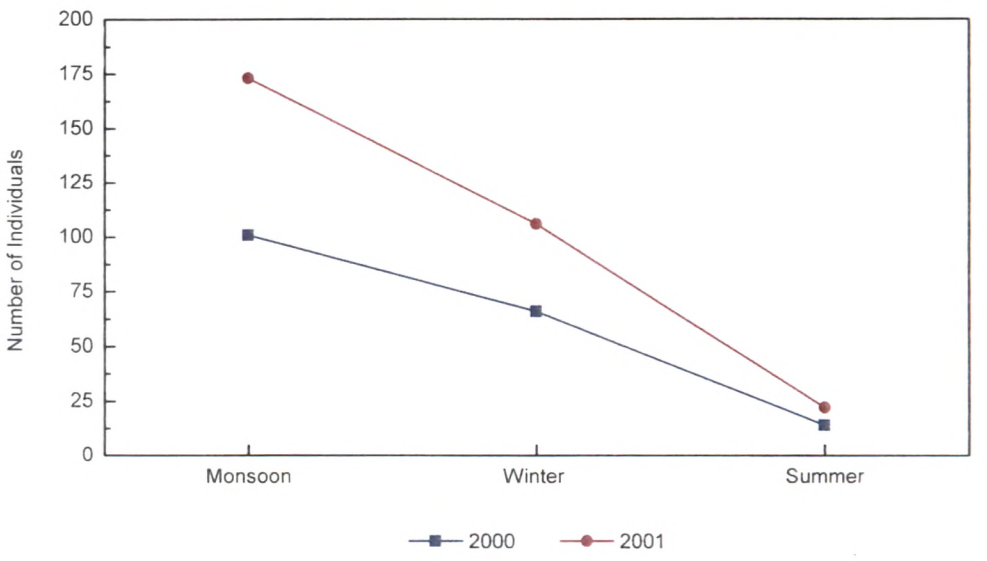

FIGURE 2.8 Mantodea at study site during 2000-2001

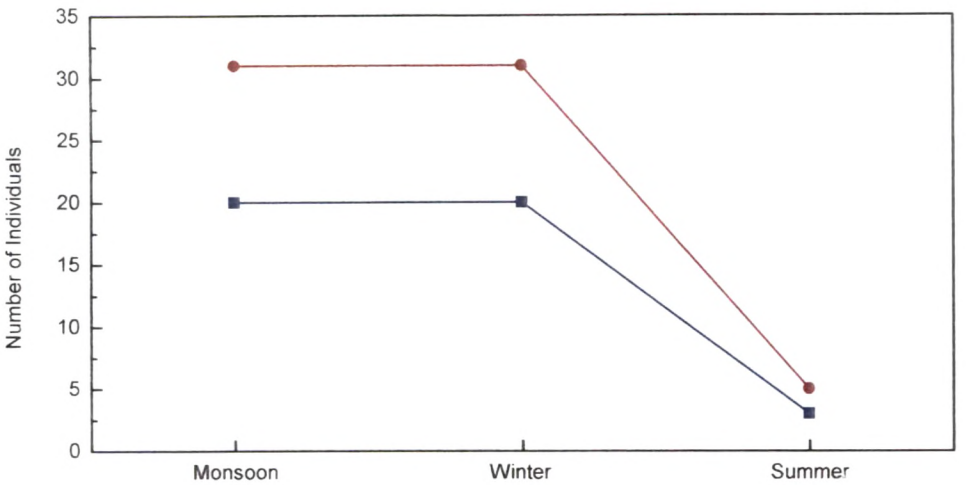

FIGURE 2.9 Phasmida at study site during 2000-2001

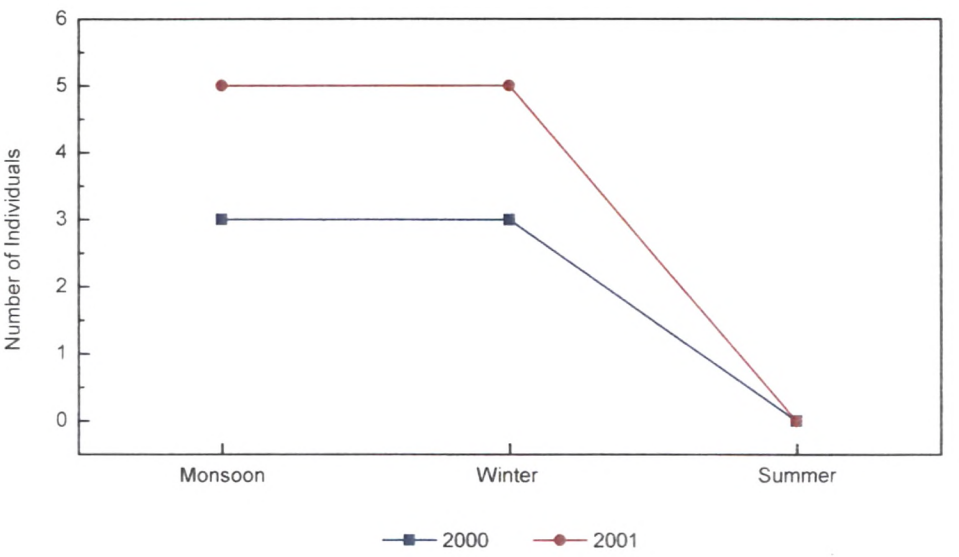

FIGURE 2.10 Homoptera at study site during 2000-2001

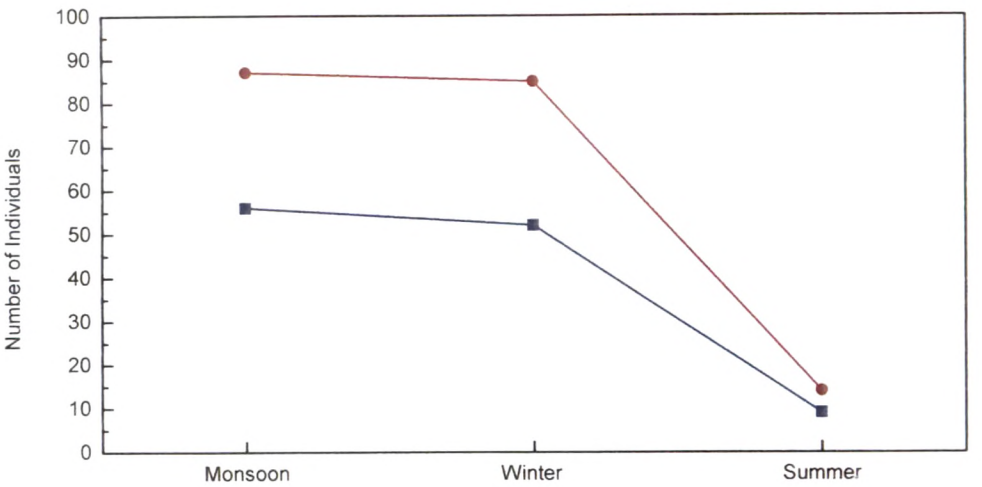

FIGURE 2.11 Blattaria at study site during 2000-2001

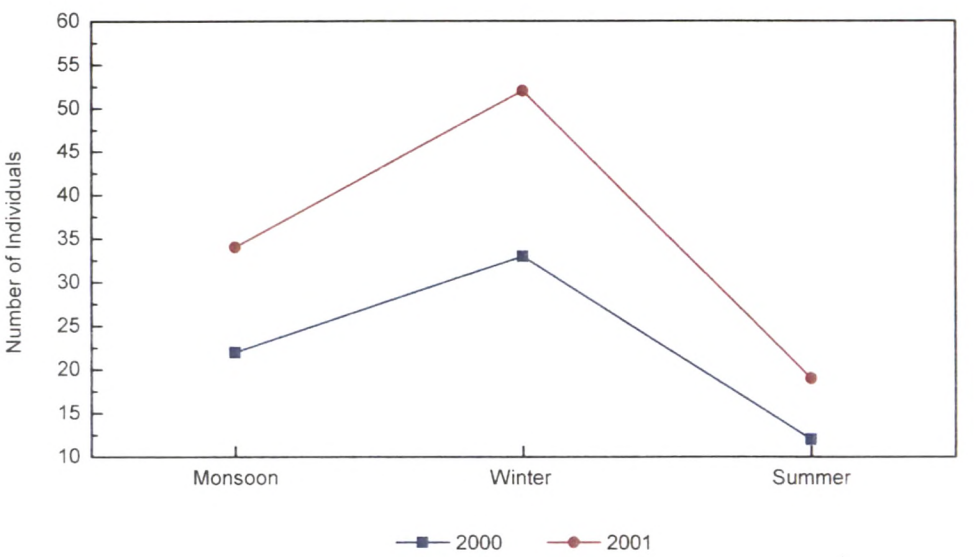

FIGURE 2.12 Isoptera at study site during 2000-2001

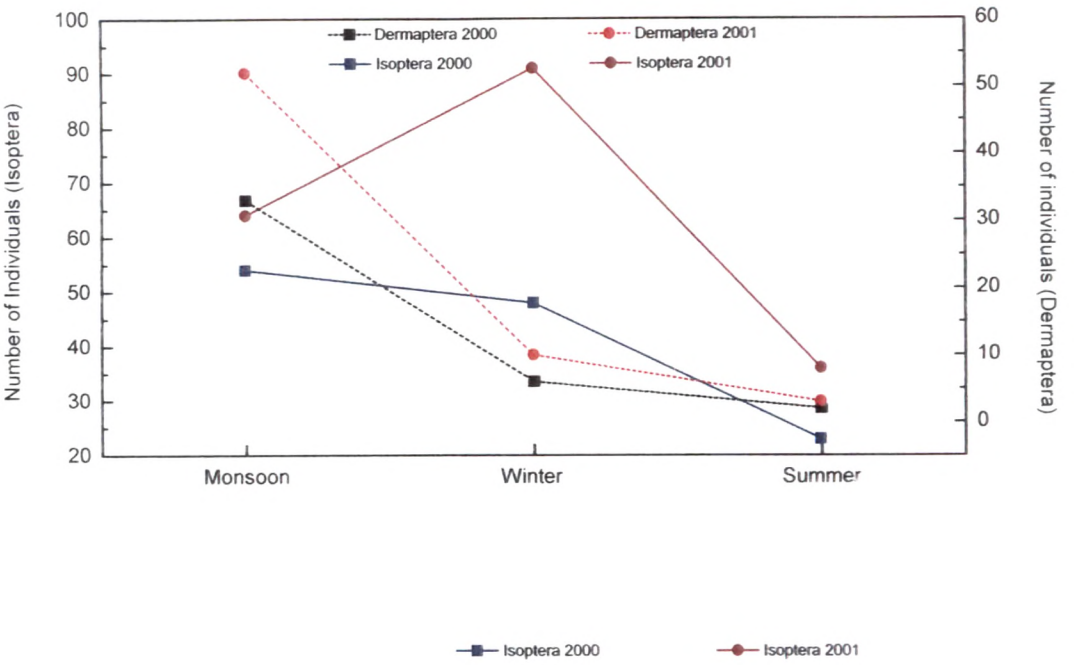

FIGURE 2.13 Embioptera at study site during 2000-2001

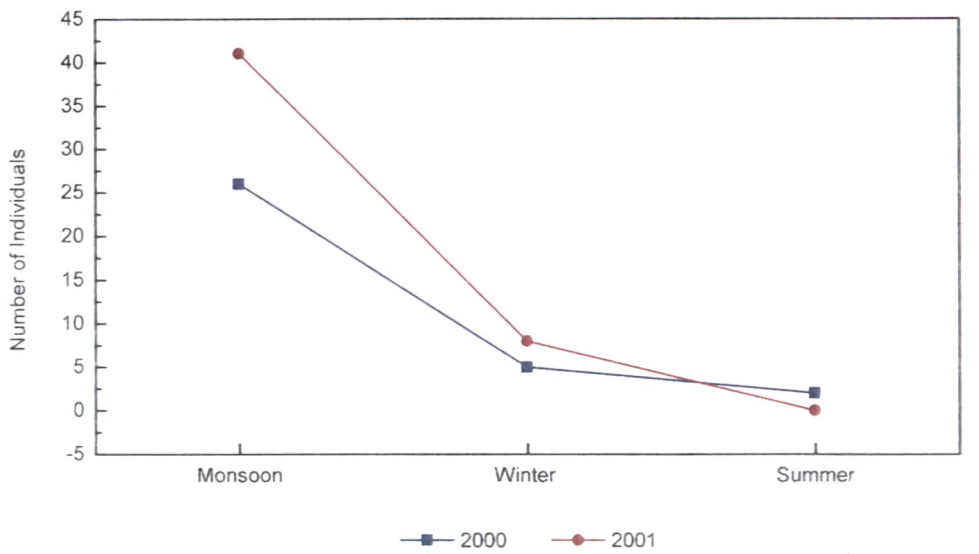

FIGURE 2.14 Hemiptera at study site during 2000-2001

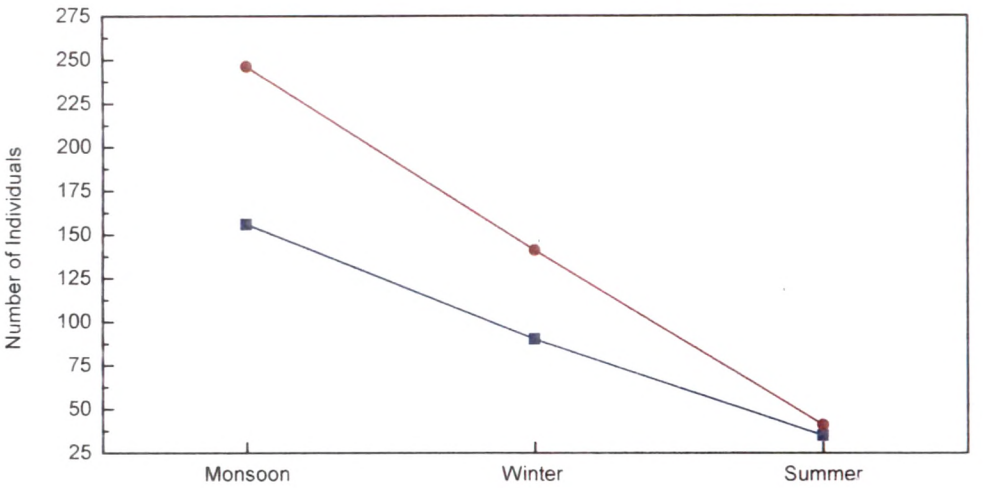

FIGURE 2.15 Neuroptera at study site during 2000-2001

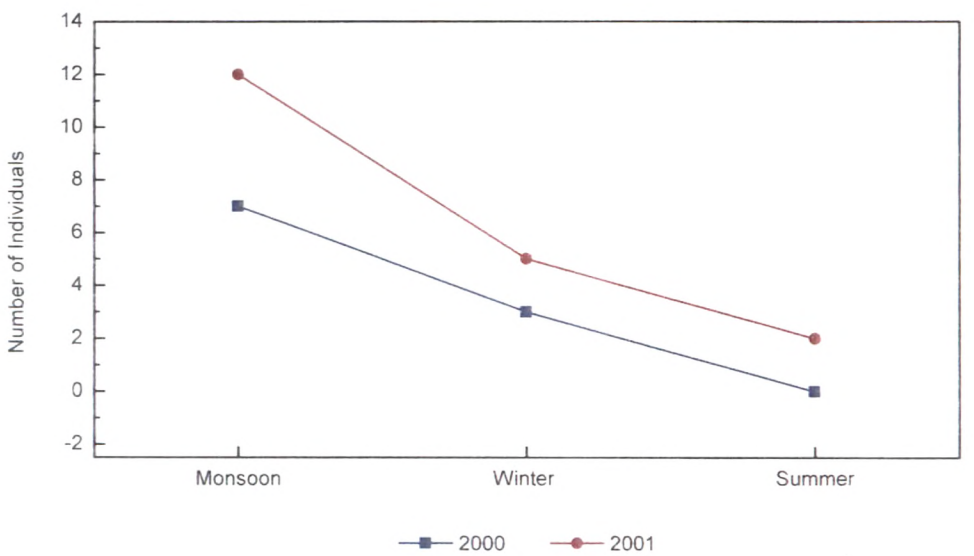

FIGURE 2.16 Mecoptera at study site during 2000-2001

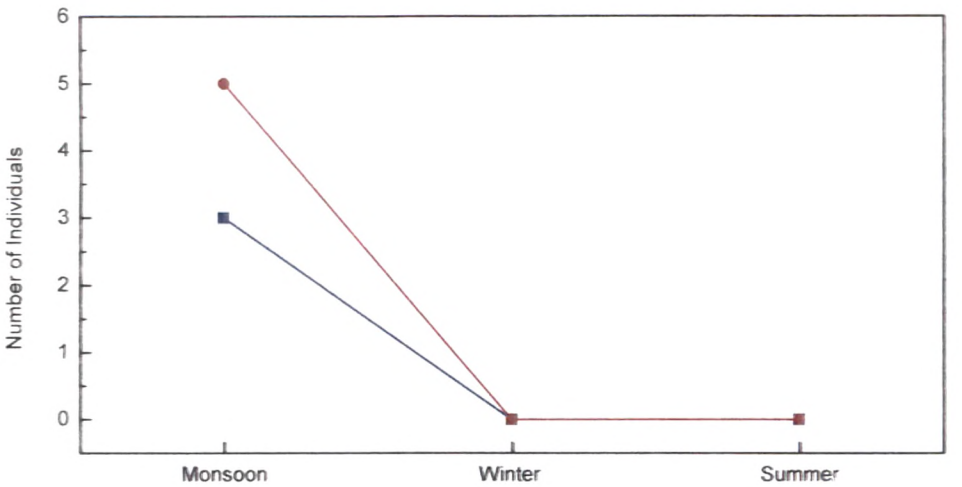

FIGURE 2.17 Lepidoptera at study site during 2000-2001

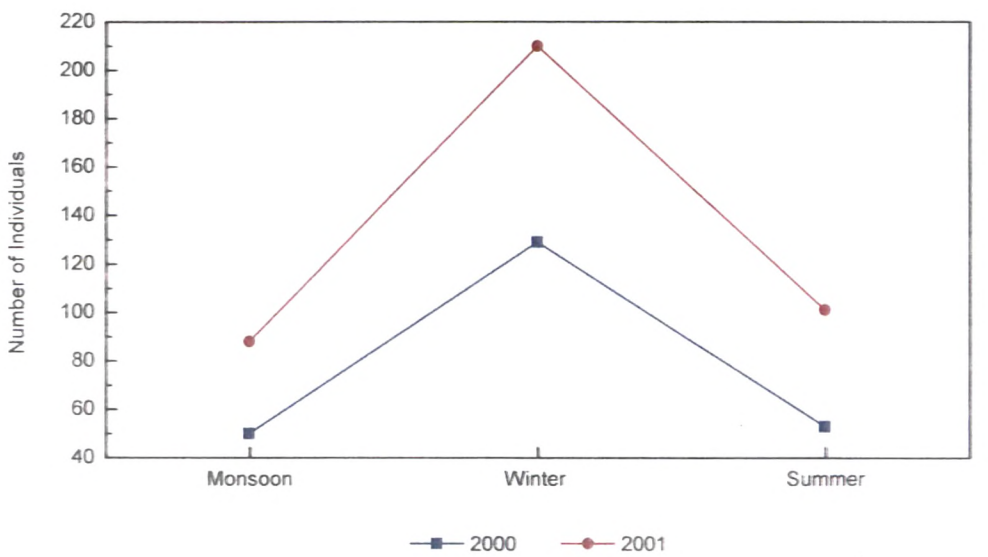

FIGURE 2.18 Diptera at study site during 2000-2001

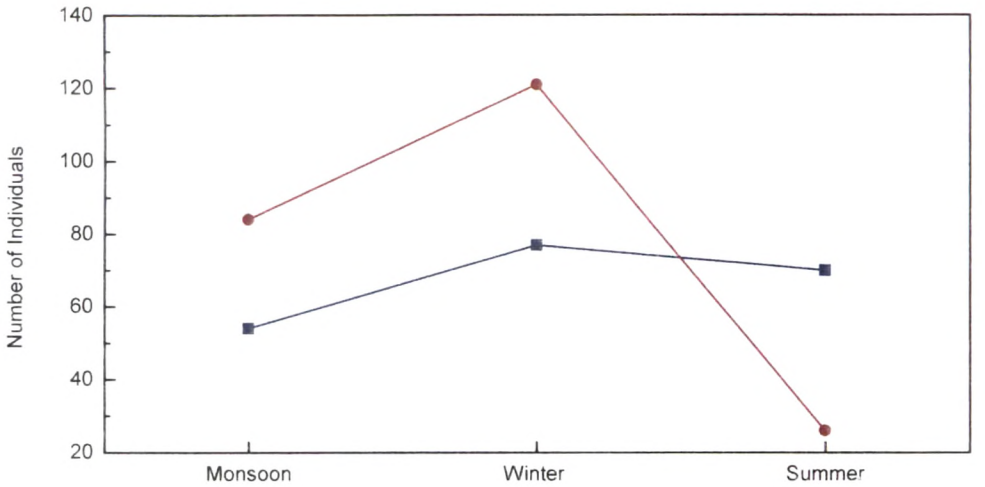

FIGURE 2.19 Hymenoptera at study site during 2000-2001

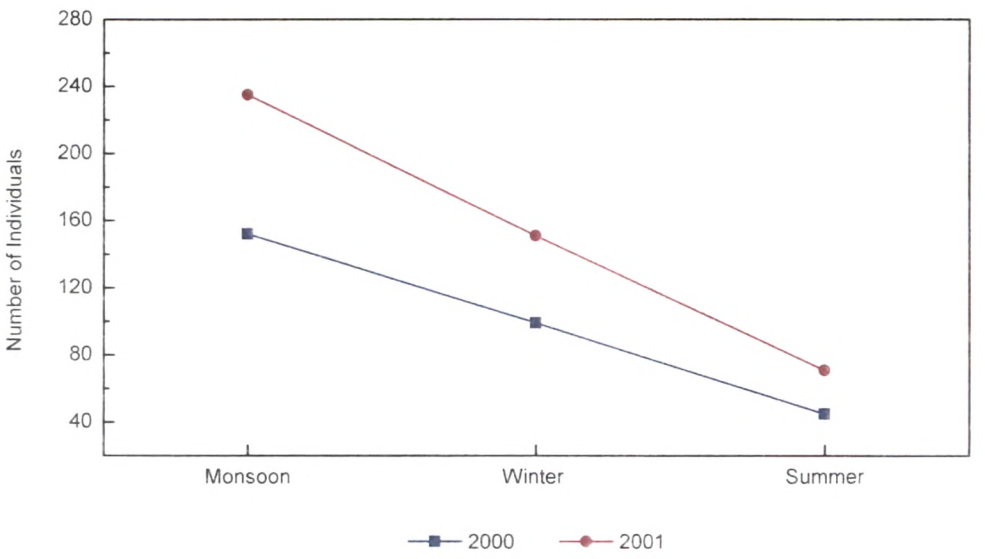

FIGURE 2.20 Dragonflies and Damsel flies

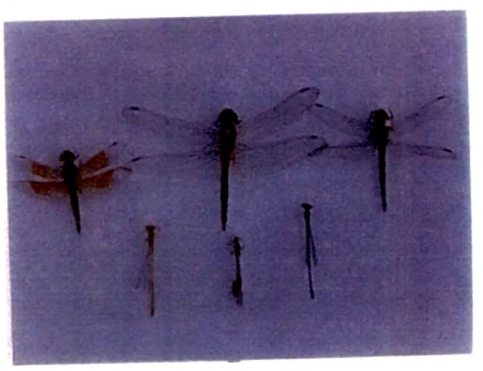

FIGURE2.21 Neuropterans

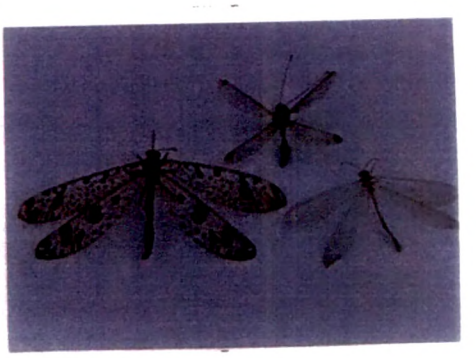

FIGURE 2. 22 Mantis which pray for prey

FIGURE 2. 23 "Stick insect " Phasmida

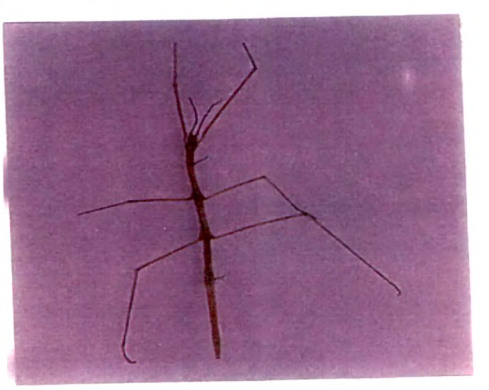

FIGURE 2. 24 Short horned grasshoppers

FIGURE2.25 Long horned grasshoppers

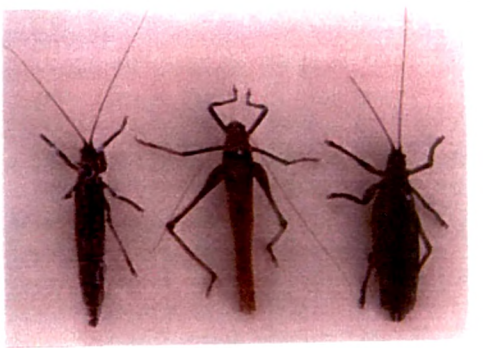

FIGURE 2.26 Swarm of "Bug" during monsoon

FIGURE 2. 27 "True Bugs " Hemiptera

FIGURE 2.28 Homoptera

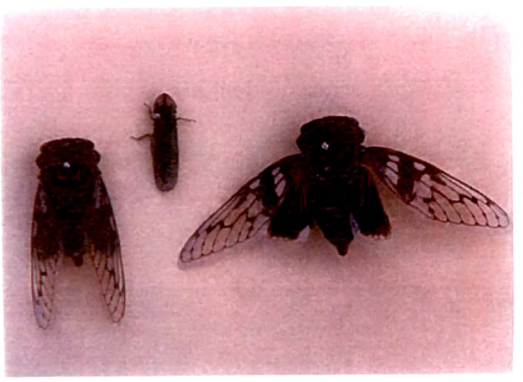

FIGURE2.29 Butterflies-Swallow Tail and Pancy

FIGURE 2.30 Pieridae With Common Crow

FIGURE 2.31 Some Common Pieridae

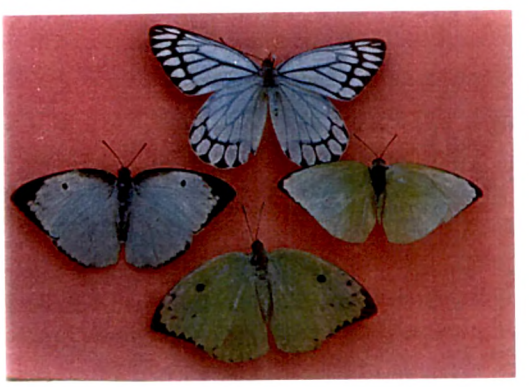

FIGURE 2.32 Danidae

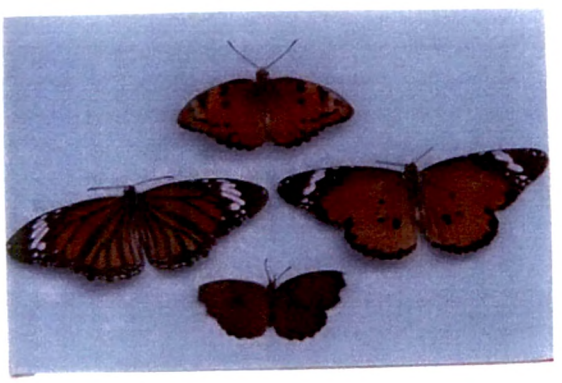

FIGURE 2.33 Moths Of Gir PA

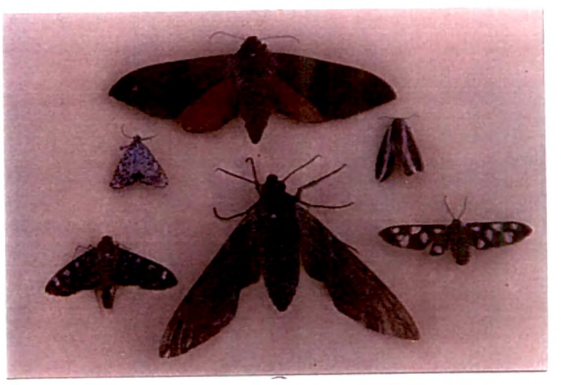

FIGURE 2.34 Tussar Moth- *Antheraea paphia*