GENERAL CONSIDERATIONS

Life on earth has existed for four billion years during which it has increased in diversity to the richness we see today. The distribution of life on earth is highly patterned both in terms of quantity (biomass) and variety (biodiversity). Biodiversity is a term commonly used to describe the number, variety and variability of living organisms (Groombridge, 1992). Heywood (1995) defines it as the total variability of life on earth. Historically, the nature and value of Earth's life support systems have largely been ignored until their disruption or loss highlighted their importance. Biodiversity is part of our lives and livelihood and constitutes resources, nations and future generation. Human activities are threatening to wipe out a large proportion of this diversity within a tiny fraction of that time. The threat to biodiversity is unique in three ways. First it is irreversible. The second unique feature of biodiversity depletion is that by attempting to solve the problem, by learning more about the world biodiversity and how to manage it and use it, we can gain enormous benefits in scientific knowledge. The third unique feature of biodiversity is that scientists do not know much about it on a global scale (Wilson, 1993).

In twentieth century, we began to realize Importance of living in harmony with the nature and to understand its importance. Forest is the biggest source of conserving biodiversity, as they harbor good biodiversity on earth. There is general consensus on the importance of reserve system to prevent the rapidly declining biodiversity due to human impact (Primack and Ros, 2002). All forests have some biodiversity value, although some forests are much richer than others community wise and species wise. The loss of any forest leads to loss of resources, including the loss of biodiversity value. Forest loss is relatively easy to see and measure but it is less easy to see biodiversity loss.

Gujarat has several habitats with floristic, faunal and climatic peculiarities. The state has not only a rich store of biodiversity but also harbors a variety of livestock. There is also an urgent need to identify factors that effect the depletion of biodiversity (Pilo, 1996).

Gir PA is one of the oldest sanctuaries of Gujarat in the country and is one of the largest biologically intact continuous tracts of land in India reserved primarily for the conservation of its native wild fauna. Gir PA supports a diverse mixture of drought resistant plants and animals and has been one of the most biologically diverse areas in Gujarat and is also source of cultural and religious evolution in Saurashtra (Singh, 2001). The present Gir PA is

the part of larger part of dry deciduous forest. This geologically complex region of 1412.12 sq. km. contains several mountain ranges. The largest part of this biome is dominated by teak forest, non-teak forest and riverine forest. The difference in vegetation from west to east is largely the result of highly variable topography and soil types (Patel, 1992). The major rock types dolomite, basalt and limestone occur in a mosaic pattern and largely determine the local soil and vegetation development. Four major reservoirs and seven perennial rivers with scattered human habitation (Maldharis) and few highways cut through the Gir PA and thus have led to a fragmented landscape. The result has been a loss of habitat for some species and a reduced quality of habitat for others. The reservoirs and parts of major rivers form permanent aquatic system. Several streams and rivulets get filled up during monsoon providing perennial water bodies in Gir P A. Season wise variation are observed in the forest, therefore, suggesting community variations in different localities during different seasons. The flora has a high degree of botanical relictualism. Teak and its associated plants dominate the western part of Gir P A and eastern part is dominated by *Acacia* spp. and *Zizyphus* spp. woodland (Chauhan, 1993).

Gir is the last adobe of the Asiatic Lion, and these felines form the last surviving gene pool in nature. Gir P A also supports thirty-six species of mammals, around 300 species of bird, thirty-three species of amphibians. Parikh (2002) made a trailblazing effort to enumerate invertebrate fauna at Gir PA. She has recorded more than five hundred species of invertebrates inhabiting Gir PA.

In the present study survey of general diversity of arthropod taxa and their habitats, with the emphasis on two main functional groups: insecta and coleoptera, was undertaken. There is need to improve the understanding and management of these taxa so as to advance entomology as an ecological research in Gir P A. The foundation of this process lies in identifying existing knowledge gaps to provide a baseline data for future studies.

In the present study on Arthropods other than insects, a total of 81 species were observed representing 14 orders and 43 families of class Crustacea (21*%), Chilopoda (21%) Diplopoda (14%) and Arachnida (43%), depicting dominance of arachnids amongst the four classes. Monsoon season was a preferred season for the occurrence of diplopods and chilopods. Probably it is the humid environment, which provides a favourable condition for their occurrence in higher number. Moreover, the occurrence of spiders was more prominent during monsoon and during the initial part of winter that suggests the availability of the prey as well as favourable climatic regimes for the group. High abundance of spiders testifies to the biodiversity and resilience of this system.

* Values corrected to the nearest whole number

Arthropod diversity in forest ecosystems has much importance as they play role as herbivores, predators, omnivores, pollinators and detritivores and make them a key component of the ecosystem. A general lack of detailed information about distribution of many arthropod species makes it difficult to predict their occurrence in a particular habitat.

Insects are the most numerous and diverse animals of forest ecosystem both as far as number of species and individuals are concerned (Asquith *et al.*, 1990). Insects and their relatives represent 85% of biological diversity in these forests and serve key ecological functions by aiding in nutrient recycling, determining forest structure, providing pollinator services and facilitating energy transfer within food webs. The functions of insects are complex and important. Insects as pollinators, play a critical role in forest ecosystems because a vast majority of higher plants depend on insect mediated pollination (Buchmann and Nabhan, 1996; Spira, 2001).

During the present study nineteen orders, seventy-six families and two hundred and thirty eight species of insects other than coleopterans have been recorded. There occurred a marked seasonal and spatial variation species composition and abundance in insects. Their maximum occurrence was prevalent during monsoon season, followed by winter and was least in summer.

Apterygotans (thysanura, diplura, and collembola) were dominant during monsoon season. Their role in forest ecosystem cannot be overlooked or ignored due to their participation in disintegration of organic matter and thereby helping in nutrient cycling (Seastedt and Crossely, 1984).

Pterygotans are represented by sixteen orders from which order dermaptera, embioptera, neuroptera and mecoptera showed distinct monsoon occurrence. Very less is being known about their ecological role however, on a broad scale their seasonal occurrence does suggest their relationship with other organisms either as prey or predator. All these insects receive little attention as compared to their significance in terms of species diversity or regarding their ecological importance. Small size, lack of aesthetic appeal, and associated lack of knowledge, lack of support and funding and to top it all biased listing efforts within the class insecta could be the deterring factors for disregard towards them (Boeckeien, 1987; Hafernik, 1992; Murphy, 1991; Van Hook, 1994) Nonetheless, their small size, diversity, sensitivity to environmental variability make them good indicators of habitat heterogeneity, ecosystem biodiversity and environmental stress (Beown, 1991; Hafernik, 1992; Oliver, 1993;Kremen, 1993).

Ephemeropterans are known to spend their major part of life cycle in water probably serving as a food source of fresh water organisms. Odonats are indeed the dragons of the air with their magnificent power of flight, often brightly coloured wings, acute vision and large size. Members of this group are predators and thereby help in keeping the insect population under check. Since four major reservoirs remain filled and seven perennial rivers meander through Gir PA, it provides favourable habitat for their survival during larval stages. Orthopterans were represented by an appreciable good diversity. Maximum concentration of all the species was recorded during monsoon and post monsoon season when good vegetation cover was available all throughout the area. Increased richness in turn generates a good prey predator relationship and hence promotes good diversity of both. Insects, as herbivores, are a critical component of forest ecosystems (Miller, 1993). Interspecific and intraspecific competition in plants is influenced by changing levels of herbivory, resulting in changes in the floral composition and microhabitat conditions in the forest (McEvoy *et al.*, 1991). Furthermore, because herbivores are important food sources for other organisms, eliminating this group will inevitably reduce the food supply for many birds, rodents, spiders and amphibians that are dependent upon these herbivorous insects. Some taxa are considered good representatives of biological diversity and make satisfactory conservation evaluation criteria (Webb, 1989; Cousins, 1991; Dufrene and Legendre, 1997; Stork 1990; Pollard and Yates, 1993). Their presence or absence can tilt the delicate equilibrium of the ecosystem on either side and consequently can affect positively or negatively.

Mantids, phasmids and homopteran although, were represented by few species during the studies. Their co-dominance during monsoon and winter depicts their relative ecological role as predators and phytophagous insects in this forested ecosystem. Members of order blattaria were maximally seen during winter season. Their omnivorous feeding pattern helps them to survive and proliferate round the year.

Of the homopterans and hemipterans, the later was represented by a fairly good number of representatives. However aphids showed a noticeably low number in their occurrence. This is not surprising because of the fact that, the study area is a semi arid type of ecosystem and the population of these insects could be affected by the dry spell during summer season.

Among all the orders of insecta excluding coleopterans, lepidoterans and hymenopterans dominated both in terms of number of species and number of individuals and also showed a clear-cut seasonal variation. Climatic changes potentially affects insects through plant association (Dennis, 1993). Lepidopterans are strictly terrestrial. Virtually all of them are associated with plants and therefore their occurrence depends on the presence of plants. Dry deciduous forest is a habitat with a modest number of lepidopteran species. They show seasonal preference, becoming more active between pre-monsoon showers and late

winters. However, some of them may be active during the summer in the riparian patch, whereas others are dormant. Observations supporting this fact were made during the present study in Gir PA. Various factors might be responsible for seasonality such as availability of larval host plant, plant in its correct growth stage and suitable temperature and humidity.

Order diptera was studied to know about their diversity in the study area. Fifteen species of this order were identified and recorded. Being saprophagus and vector, knowing about their diversity in this forested area can become more useful for the management point of view. Hymenopterans have a crucial role in pollination biology, being known as pollinators their diversity and seasonal occurrence can provide valuable information to the forest department authorities for further conservation aspects. Since dipterans and hymenopterans are parasitic, they are useful as indicators of conservation value, as they interact with a broad spectrum of niches and microhabitats.

Insects in general, are particularly suited for monitoring landscape change because of their abundance, species richness, ubiquitous occurrence and importance in the functioning of natural ecosystem. Insects are susceptible to the same anthropogenic threats as vertebrates (Samways, 1990; Wolda, 1992). And hence they can be used as indicator species to assess the health of the ecosystem and can be helpful for planning or managing any habitat including forested habitat for managing other natural resources. Wilson (1988) estimates that species extinctions are occurring at the rate of at least 1000 times faster than before human induced extinction pressures. However, most insect population declines and extinctions go unnoticed or unappreciated. This is largely a result of apparency-related obstacles. Small size and inconspicuous habits, together with tremendous diversity and a mostly tropical distribution, make insects largely invisible to human attention and concern (Samways, 1990). Complex life cycles are common in insects, especially species taxa with large, readily apparent species such as Coleoptera, Lepidoptera, and Diptera. Variation in appearance and ecological specialization associated with different life stages can be extreme and influence both our concern and our ability to conserve species. Extreme differences in life stage forms can lead to conflicts of interest, taxonomic confusion and a need for increased research efforts.

Coleopterans are forming a large component of biodiversity known today; this dominance of coleopteran has been used to arrive at an estimation of thirty million insects (Erwin, 1982). They participate in virtually all aspects of ecosystem processes as predators, herbivores, folivores, detritivores, scavengers, fungivores, wood eaters and grazers. Although being more diverse group, it is strange that more importance is not given to them for use in environmental perturbations (Ashworth *et al.*, 1991). In India this group was studied by

people interested in knowing their role in forested ecosystem like Stebbing (1914) and Beeson (1941) which are considered and referred to even today as being pioneer work related to coleoptera and other insects. Present study is probably the first attempt to study coleopteran diversity of one of the worlds' famous and much important protected area of Gujarat, Gir national park and sanctuary (PA) that has become synonymous with Asiatic lion. Such studies can help in generating tremendous amount of conservation related information. Long term monitoring gives variability but as there is no such thing as a 'normal year' for insect abundance. A short timeframe usually provides a fairly true picture without having to resort to long-term sampling (Samways, 1994; Wolda, 1992).

Biodiversity is unevenly distributed among taxonomic groups with a disproportionately large number of species in the class insecta. Biodiversity increase from poles to the tropics but there is no consensus as to why this is so. It has been suggested that this is because the tropics are more climatically stable or because the tropics receive more energy input from the sun (Groombridge, 2000). But in recent history due to exploitation of natural resources at rapid pace, humans have had an increasing impact on insect species extinction. Nevertheless, no precise estimate can be made on the number of insect species that have been or are being lost in major habitats. Many insect species may become extinct before even discovered or described due to inadequate knowledge about them (Ambrose, 1995). Monitoring of insects species gives fine scale measure of changes in forest processes (Franklin, 1990; Lattin, 1994). Few forest management agencies have therefore incorporated insect monitoring programs associated with fire, grazing and logging practices (Neumann, 1992; York, 1994; Vanderwoude et al., 1997). Patterns of species richness and composition of insect species reflects colonization of insect groups as well as changes in soil microbial biomass (Majer and de Chock, 1992; Andersen and Sparling, 1997).

Insects are generally unapparent, unappreciated and therefore, neglected in conservation but one should know that by using insects as tools for assessing, managing and monitoring landscape, promotes ecosystem and regional approaches that are critical to all future conservation efforts. Large-scale conservation strategies also rely on both intended and unintended biases toward large, conspicuous insects. We need to better address the 99% of species not generally considered in pest oriented research (Wilson, 1987).

Reserves and national parks, although not necessarily designed for insect protection, play a major role. But man and his needs must be built into the equation and reserves such as "biosphere reserves", which have a range of levels of disturbance decreasing to a core, may be particularly significant for insect diversity protection. Hand in hand with this is the necessary emphasis on educating the increasing human population that insects are important to man (Samways, 1994). Biodiversity of wild insects and their genetic diversity

contributes to the development of agriculture, medicine and scientific research. Keeping this in mind insect biodiversity should be conserved as a matter of principle, as a matter of survival and as a matter of economic benefit. It is known that no two species have identical habitats and therefore in case of insects, conservation implies conservation of their habitats, as well as the insect themselves (Collins and Thomas, 1991).

In one of the earlier studies in Gir PA on lions, the blood parasites were investigated and along with that there is a report of several species of insects given as a supplementary data (Mojumdar, 1975). Other than this no major attempts have been made to study systematics of arthropods in general and insect in particular. All these years lion has been the focus of all the conservation and management practices in Gir. Nevertheless, it has been realized recently that conservation of any species is possible by faithful conservation and management only if knowledge of all the components of that ecosystem is known and then the management of that ecosystem is planned as a whole (Meffe and Carrol, 1997). Therefore, the present study was undertaken as an attempt to discover the arthropod diversity in general and insect distribution pattern in particular with a special reference to the coleopteran diversity in Gir P A.

The goal is to develop management guidelines that will preserve arthropod fauna within this special forest. Current list contains a total of 81 species of arthropods other than insects, 238 species of insects excluding coleopterans, and 114 species of Coleopterans. The gathered data about some of these groups will be very useful when adequate work is carried out to further explore the area in detail. Availability of species catalogue is invaluable but they provide rather limited information about various aspects of insect life processes. The present species list should be viewed as a work in progress rather than a comprehensive list in the focal region. Although the species diversity of coleoptera has been well documented in the present work, other groups of insects require further taxonomic attention. The present work highlighting detailed ecological requirements provides an insight into the important role played by this group of animals in maintaining delicate balance of the ecosystem. Such work can provide substantial baseline information presently and future work can be planned and executed on this solid foundation.

Empirical and theoretical contributions by entomologists (insect biologists) are needed to improve existing species-focused conservation efforts, to better develop larger scale approaches and to help build conservation policies that better reflect the unique conservation needs of insects.