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A Study on the Species Diversity Among Selected Insect Groups

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CONTENTS

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SUMMARY

Insects are the major component of the world's biodiversity. By virtue of their vast numbers of both species and individuals, they are vital determinants of terrestrial ecological processes. Quantitatively, insects are important pointers for species-rich geographical areas. Qualitatively they are also important, whether the subjects of conservation themselves or as tools for identifying biotic areas with high endemism.

Insects are the dominant and ancient group of animals on the earth. Over one and half million living and about 12,000 species of fossil insects have been identified and described all over the world and they are representing about 90 per cent diversity documented for the animal kingdom. Nearly one tenth of the insect species are still unidentified. Several species lived in the past and became extinct without their identification.

Insects have immense capacity of adaptation to extreme environments than any other animal groups. They are always equipped with very suitable defensive and attacking devices and are adapted to feed on a variety of resources. The classification of insects is such a vast assemblage that it poses great difficulties for taxa identification and lead to other taxonomic uncertainties. In recent updated insect classification, 29 insect orders have been described.

Keeping in view the diverse and characteristic features of insects, the present study on insects in one of the globally significant protected areas i.e. Great Himalayan National Park Conservation Area (GHNPCA), Himachal Pradesh, Western Himalaya was initiated for the first time during July, 1995. The study aimed to assess patterns of diversity among selected insect's orders.

The GHNPCA due to its strategic location, and large altitudinal variations (>1,500 m to 6,000 m) provide a diversity of habitats and associated flora and fauna. Thirty two surveys of an average 10 days each during July, 1995 to December 1997 covering different watersheds, 18 intensive study sites in three different seasons were carried out. Hand picking, aerial netting and light trap methods were employed for collection of specimens. Only six insect orders *viz*. **Coleoptera, Hymenoptera, Diptera, Hemiptera, Odonata,** and **Lepidoptera** were selected for the present study. Presently, the insect collection is housed at the Research Base Camp, GHNP, Banjar, Distt. Kullu. A number of reputed scientific institutions and experts were consulted for identification purposes. A list of such institutions/individuals is appended. The selected **six orders** represented **37 families, 108 genera** and **125 species** among the specimens identified so far. The order Lepidoptera represented higher diversity in terms of **55 genera** and **61 species** among the **six (6)** orders investigated. This was followed by the order Coleoptera which had **41 genera** and **47 species**. Studied **six (6)** orders can be arranged in a descending diversity order as Lepidoptera - Coleoptera - Hymenoptera - Odonata - Hemiptera - Diptera. Out of 37 families, **seven (7)** families were found in wide altitudinal range (1,500- >3,500 m) while **seven (7)** families had a narrow distribution (1,500-2,000 m).

During the present investigations all the studied orders were broadly divided into three categories based on characteristic features i.e. **phytophagous** (feeding on plants), **pollinators** (helping in pollination), and **biodiversity indicators**. Moreover, since the insect-flower relationships have been traditionally one of the focused subject in the field of forest ecology, attempt were also made to establish ecological relationships between flowering plants of sub-alpine and alpine areas with their corresponding insect visitors.

Visualising the likely use of present report by amateurs, frontline staff of GHNPCA, students and tourists, efforts have been made to make this report as simple as possible by incorporating insect terminology and several illustrations on collection methods and a broad pictorial key. It is hoped that the anticipated user groups will found this report useful and informative. Further, the scope of present study is being enlarged and it is expected to collect additional information on distribution and abundance of insects belonging to above mentioned six orders during the next two years. Hence, comments/suggestions are solicited from users of this report.

1. INTRODUCTION

The Government of India (GOI) has accepted a major funding by the International Development Association **(IDA)** and launched a pilot conservation project in 1995. The project aims to conserve biodiversity in two globally significant Protected areas **(PAs)** by implementing the ecodevelopment strategy. Two PA sites are: (i) The Great Himalayan National Park **(GHNP)**, Himachal Pradesh, and (ii) Kalakad- Mundanthurai Tiger Reserve **(KMTR)**, Tamil Nadu. The project has been designated as "Forestry Research Education and Extension Project **(FREEP)**". Likewise, a yet another mega project, named as "India Ecodevelopment Project **(IEP)** with funding from the Global Environmental Facility **(GEF)** has been launched in seven selected PAs located in different biogeographical zones. The FREEP and IEP aim to conserve biodiversity by addressing both: (a) the impact of local people on PAs, and (b) the impact of the PAs on local people. More specifically, the two projects have following three main integral components:

(i) Improved PA management by having activities those would (a) improve PA planning processes and building capacity by strengthening PA management plans and skills; (b) protecting and managing ecosystems and habitats, and (c) upgrading PA amenities for field staff,

(ii) Village ecodevelopment to reduce negative impacts of local people on biodiversity and elicit support of local people for conservation, and

(iii) Development of more effective and extensive support for PA management and ecodevelopment by undertaking: (a) environmental education and conservation awareness campaign, and (b) monitoring and research activities.

The present study forms a part of the monitoring and research component of the FREE Project in The Great Himalayan National Park (GHNP), Himachal Pardesh. Recognising the importance of diverse insect fauna, this component was incorporated in the research proposal relevant to FREE-GHNP Project.
Task 6 of this proposal explicitly deals with study on diversity of insects and identification of monitoring indicators.

1.1 HIGH ALTITUDE ENTOMOLOGY IN INDIA : AN OVERVIEW

The oldest collection of high altitude insects of Himalaya was probably made by **Von Hugel** in the first half of the last century **(Singh 1983)**. His collections, comprising several hundred species, were identified by various eminent European specialists like **Kollar** and **Redtenbacher** around 1848. The credit for next important attempt to collect high altitude insects go to the untiring efforts of the renowned naturalist and geologist **Col. Stoliczka**, who was a member of

the Yarkand Mission in 1872, and who worked exclusively in the North-West Himalaya. Later on, many professionals as well as amateurs have made collections in different parts of the mountain chain, the important among them are being Guy Babault Yale University, North India Expedition, Italian Karakoram and German Naga Parbat Expeditions and several successive Everest Expeditions. Practically all these collections provided adequate steps in its own right. But none of these studies paid any attention to the numerous complex and inter-acting ecological factors that govern the distribution and existence of such a fantastic variety of insect life at extreme high elevations. Also no serious effort was made to uncover the biogeographical affinities and evolutionary tendencies of the high altitude insect fauna.

The credit for the coining the term “high altitude Indian entomology” go to **Mani (1954)**, who has rightly been called the “Dean of High Altitude Entomologists” by late **Prof. Gorden Alexander**, of Colorado University. He and his associates organised many entomological expeditions during the last twenty five years or so and published a series of papers on the faunistics, systematics, field ecology and biogeography of the high altitude insects. Significance of **Mani’s (1962, 1968, 1974, 1978)** monumental contributions in this field can never be over emphasized.

Himalaya which is the source of all the north Indian rivers is the most ideal region for the study of aquatic insects life. In recent years some attempts have been made to study the Ephemerida, Plecoptera and Diptera of in the upper catchment of river Beas (**Khan and Sahni, 1978**; **Kulshrestha, 1978)**. **Mani and Singh (1955**), and **Mani (1962)** have recorded the phenomenon of mass assemblage of insects, particularly Coccinellidae, on the high mountain slopes, ridges and snow fields. **Mani (1962, 1968**) and **Singh (1983)** have described various aspects of active migration by many butterflies, moths and scope of entomology over mountains in high altitude, specially in Himachal Pradesh.

1.1.1 Importance of insects in biodiversity studies

As in lowland ecosystems, even at high altitudes, insects are the dominant animals. Insects successfully dominant almost every conceivable habitat and flourish at the highest limits of existence of animal life. The high altitude insects are an ecologically highly specialized group of mountain autochthonous species. Insects have the broad range of adaptation and can survive in the extreme environmental conditions, prevailing at high altitudes, so as to counteract the unfavourable effects of the whole complex. On the basis of behavioural patterns, insects have been classified in various groups. Some of the major groups are described below:

1.1.2 Tree Insects

A forest is a highly organised system of communities in which plant diversity and structural complexity provide numerous niches. The ecological dynamics of a forest are the sum of a

complex series of interactions among animals, plants (including microorganisms), and physical factors. Those interactions that lead to loss of yield, reduction in quality, or alteration of trees aesthetic values are of concern in forest entomology. Indeed, the objective of this discipline is to understand insect tree interactions sufficiently to prevent or retard economic or socio-economic damage. The inter-relationships in the forest environment require the thorough understanding of insects other than those that damage trees and of other organisms associated with forests or forest insect. Although soil insects, soil microflora, symbiotic fungi, vertebrate predators, and so on, may not directly damage trees, yet their activities may affect the behaviour, physiology, and ecology of phytophagous species **(Barbosa and Wagner, 1989)**. A phytophagous species is considered a pest when it interferes with the intended use of a tree, forest, or forest product. The relationship between intended use and type of injury determines the significance of inflicted damage and the appropriate strategy of control.

1.1.3 Insects as pollinators

Though many flowering plants are capable of self-fertilization, the majority of them depend on pollination of their flowers from those of another plant in order to set fertile seed and maintain genetic diversity. The process of cross-pollination may be brought about by various agencies, including transfer of pollen by wind, water, birds but by far the most common method depend on the activity of insects which visit flowers, usually to collect food in the form of pollen and nectar, and in doing so transfer pollen form one flower to another. The mutual advantage of this association have led to the evolution of a great variety of pollination mechanisms, some very complicated and highly specific and involving many structural, functional and behavioural adaptations in both insects and plants.

1.1.4 Insects as biodiversity indicators

The focus on conservation of biodiversity has recently received attention. Various studies and protocols have been proposed to test the apropos patterns of biodiversity (**Wilson 1988; Noss 1990; Enrich and Wilson 1991**). **Hunter *et al*. (1988)** and **Vane Wright *et al.* (1991)** also classified a hierarchical composition of different level of organizations as well as groups of taxonomically related species to test the patterns of biodiversity conservation. A certain insects were used to identify the state or changes in a landscape (**Harrington and Stork, 1995**). The use of indicator taxa in conservation efforts from pollution control to biodiversity has been the focus of attention (**Landres *et al.* 1988**).

The members of family Cicindelidae (tiger beetle) of order Coleoptera is identified as an appropriate indicator on the basis of its richness patterns to determine the regional patterns of biodiversity **(Pearson and Cassola 1992)**. They also highlighted some of the following logistical and biological criteria that maximize the usefulness of a taxon as an indicator:

* Taxonomy of tiger beetle is well known and stabilized
* Biology and life cycle are well understood
* Individuals are readily observed in the field
* The family occurs world-wide and in a broad range of habitat types
* Patterns of species richness are highly correlated with those of vertebrate and invertebrate taxa
* It includes species of potential economic importance

The logistical advantages provide some of the strongest point to select tiger beetles as an appropriate indicator taxon. Species diversity of tiger beetles are relatively well known for 129 countries. Eight countries alone accounts for more than half the world total of 2,028 known species. Species numbers are also indicated for eleven biogeographical zones of the world. The taxonomy of tiger beetle is well known. All are predacious on small arthropods, and they share similar larval and adult body forms around the world. Adults are generally diurnal and found primarily on soil surface. Larvae are easy to raise in the laboratory and are relatively easy to find and observe in the field (**Palmer 1978; Knisley and Pearson 1984; Shivashankar 1969**).

The ground beetles **(Carabidae)** have also been recognised as the indicators of biodiversity and land use change **(Harrington and Stork, 1995)**. The suitability of these beetles are helpful due to their taxonomic stability, ease of monitoring, seasonality and feeding habits. The relationship between ground beetle and type of land use depend on the vegetation cover type, and on species responses to environmental factors such as soil moisture and altitude. The habitat of insect must, by its definition, supply the needs of each insect species throughout its life time. These need will comprise, at the very least, food and suitable climatic conditions, and may also include shelter from disturbance and natural enemies. Land use is a major determinant of these needs for all terrestrial insects, and possibly also for many aquatic insects.

Thus 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 ecosystems. The class insecta also has several members, even within one taxon (Hymenoptera) that operate at different trophic levels, therefore providing varied, sensitive indication of changes. Various groups of macro invertebrates have been used in monitoring of water quality and disturbance, the Ephemeroptera and Placoptera groups are particularly sensitive. Mayflies are used for monitoring the water quality. Aquatic insects generally have narrow thermal requirements and vary considerably between species and life stages of the same species. River and stream species will also be affected by possible changes in the temporal distribution of rainfall because this may influence the frequency of spates and droughts **(Samways, 1994)**.

1.1.5 Insects as specialist feeders

Insect species feed on such a wide variety of tree tissues and it would be difficult to designate any single feeding type as representative of an order. However, generalization can be useful in representing the most significant damage caused by representative of an order. Overall, Lepidoptera, Hymenoptera, and Coleoptera are the most important dendrophagous groups in the forest. Bud, twig, and terminal feeders are principally in the Lepidoptera and Coleoptera. These two orders and the Hymenoptera and Diptera contains the most important seed feeders. Foliage feeding species are spread across the Lepidoptera, Hymenoptera, Coleoptera, Diptera, and Orthoptera. Species of Coleoptera, Lepidoptera, and some Diptera represent the major bark-boring species. Wood borers are found primarily among the Coleoptera, Hymenoptera, and Lepidoptera, whereas root feeding species occur mainly among the Coleoptera.

Tissue mining is a feeding activity that damage tissues of leaves, needles, stems or buds. Leaf miners generally consume the mesophyll layer of the leaf without feeding on the upper or lower leaf layer. Wood and bark borers feed on roots, seeds, stems, branches, and twigs. Their feeding results not only in scoring the wood but also in peppering the surface with emergence holes. Inner-bark feeders, such as bark beetles and some wood borers, form galleries that eat the xylem and visible when the outer bark is removed.

2. JUSTIFICATION FOR THE PRESENT STUDY

The Great Himalayan National Park Conservation Area (GHNPCA) constitutes the largest contiguous PA network in Himachal Pradesh which supports several endangered animals *viz*. Snow leopard (*Panthera uncia*), Himalayan musk deer (*Moschus chrysogaster*), Western tragopan (*Tragopan melanocephalus*) and other animals listed under Schedule-I of the **Indian Wildlife (Protection) Act 1972**. In spite of higher conservation significance of the GHNP in the region and importance of insect fauna in biodiversity studies no effort has been made to study and documented insect fauna in GHNPCA. Hence, present study was considered necessary and undertaken.

3. THE OBJECTIVES

The following objectives were set forth for the present study:

(i) To assess the diversity of insects among selected six orders (Coleoptera, Hemiptera, Hymenoptera, Diptera, Odonata and Lepidoptera) in GHNPCA

(ii) To determine the status and distribution of different insects groups in the GHNPCA, particularly,

(a) The **phytophagous group**: mainly Coleoptera and Hemiptera (many families of these orders feed and depend on plant life);

(b) The **pollinators group**: Diptera, Lepidoptera and Hymenoptera: (majority of pollinators belongs to these orders); and

(c) The **indicators of biodiversity**: Tiger beetle, ground beetle and dragonflies are recognised as indicators of biodiversity and land use change.

(iii) To generate baseline information and develop a long term monitoring system for insect fauna.

4. THE STUDY SITE - GHNPCA

4.1 LOCATION, CONSTITUTION AND AREA

The present study was undertaken in the Great Himalayan National Park Conservation Area **(GHNPCA)**. The GHNPCA represents the Biogeographic zone - 2A North-West Himalayas **(Rodgers and Panwar, 1988)**. The area is located between Lat. 31°33’00"and 31°56’56" North and Long. 77°17’15" to 77°52’51" East. Administratively, the study site lies in the Kullu district of Himachal Pradesh **(Map 1)**, covering a total area of 1,171 sq km and comprising a NP (765 sq km), Sainj WLS (90 sq km), Tirthan WLS (61 sq km) and an Ecodevelopment Project Area (250 sq km). The study area is characterised by high ridges, deep gorges and precipitous cliffs, rocky craggy glaciers and narrow valleys and makes catchment of the Tirthan, Sainj, Jiwa and Parvati rivers which together forms the upper catchment of the major river i.e. river Beas. Much of the eastern part of the GHNP is perpetually snow covered or under ice. The area exhibits an altitudinal variation from 1,300m to 6,110m.

4.1.1 Climatic conditions in GHNPCA

The micro climate of the area is the sum of the meterological and topographical conditions that determine the average state of the surroundings. The precipitation in GHNPCA is moderate throughout the year and abundant during the monsoon months (July to September). The winter months (October to March) are colder throughout the area and receive precipitation in the form of snow generally upto the elevation of 2,000 m, but during the present study twice snowfall at lower elevations was also recorded in the month of December 1997 and January 1998 upto 1,200 m altitude. The mean annual rainfall in the area is 1,300mm and temperature ranged from -5^{0}C to 30^{0}C (**Negi, 1996**).

4.1.2 Vegetation in GHNPCA

The forested area of GHNPCA is only 32.53% because of preponderance of high altitude meadows beyond tree lines and rocky and snow bound areas (**Negi, 1996**). The forest areas covered by dense Himalayan Moist Temperate forests are characterised by both conifer and broadleaves species. According to **Champion and Seth (1968)**, the forest types in GHNP can be described in to 14 categories. However, a more recent classification by **Gaston *et al*. (1981**) categorised forests into six categories *viz.* (i) Sub-tropical pine forest, characterised by chir-pine (>600-1,700 m), (ii) Himalayan moist temperate forest characterised by both coniferous and broad-leaved species (1,500-3,000 m),
(iii) Sub-alpine forest dominated by birch and fir species (3,000-3,400 m),
(iv) Moist sub-alpine scrub characterised by *Rhododendron* species (3,000-3,500 m), (v) Dry alpine scrub characterised by *Junipers* species (3,400-3,600 m), and (vi) Vast and scattered alpine pastures or alpine meadows occur over 3,600 m altitude above msl.

5. CLASSIFICATION OF INSECTS

The system of nomenclature in universal use is binomial, each kind of animal bears two names, the first generic and the second specific. The classification was adopted from 10th edition of the *Systema Naturae* of Linnaeus in 1758, when a binomial nomenclature was established for animal kingdom. During the subsequent growth of taxonomic nomenclature has become a matter of some complexity, and in order to regulate the procedure an International Code of Zoological Nomenclature **(ICZN)** has been adopted **(Davis, 1988)**.

Phylum Arthropoda is triploblastic, bilaterally symmetrical, metamerically segmented animals. Body is covered with thick chitinous cuticle forming an exoskeleton. Their body segments usually bear paired lateral and jointed appendages. Phylum Arthropoda is further divided into four classes *Viz.* Crustacea, Myripoda, Insecta and Arachnida **(Fig. 1)**.

The members of class Insecta are air breathing mostly terrestrial and rarely aquatic arthropods. Their body is divided into three distinct regions, head, thorax and abdomen. Head consists of six fused segments and bear a pair of compound eyes, a pair of antennae and mouth parts adapted for chewing, biting, piercing, sucking and sponging type. The class Insecta is further divided into three sub-classes *viz*. Apterygote : wing less insects with five orders; Exopterygota : wings are usually present, abdomen devoid of appendages with fifteen orders and, Endopterygota : wings develop internally, metamorphosis is complete and young stages are known as larvae with nine different orders and all the orders are further divided into families.

It was not possible to study all insect orders during the present investigations, only six orders were studied on the basis of their characteristic features *viz*. phytophagous, pollinators and biodiversity indicator groups.

6. METHODS ADOPTED FOR THE STUDY

6.1 COLLECTION

Collections of various insects groups were made from all the four valleys in GHNPCA *viz*. Tirthan, Sainj, Jiwa and Parvati. The areas chosen for their collection comprises various forest types and alpine pastures ranging from 1,500 to 4,300 m above mean sea level **(Map 2)**. Details of season wise surveys undertaken in different valleys are present in **Table 1**. In all 32 surveys were carried out. Inaccessibility of several difficult areas and frequent landslides during the monsoon season prohibited surveys and insect collections. Hence, surveys during the monsoon season confined to Tirthan valley. The Parvati valley could be surveyed only once during the present study. It is proposed to concentrate further surveys in Jiwa and Parvati valleys.

The insects collections were carried out in the early hours of the day because butterflies are usually active at early sun rise, therefore, it was easy to observe and collect them. Some of the plant feeder insects (phytophagous) were easy to locate on their hosts during sun rise. Broadly following methods were adopted for the collection.

(a) Hand picking: Small Coleopteran like Coccinellidae, Chrysomelidae, Curculionidae, etc. were collected by hand with the help of a fine forcep. The forcep was used carefully to avoid damage to the insect. Insects like leaf-miner (Diptera), bark inhabiting beetles, insects living under stones and leafleters (Coleoptera) were collected by hand picking.

(b) Aerial netting: Aerial net was used to collect free living flying insects like Odonata, Lepidoptera, Diptera etc. Soft bodied insects like Lepidoptera were gently removed from the bottom of the bag, after it becomes enclosed in the bag by a rapid twist of the handle; often the fold of the net enclosing the insect was removed after killing by vapour of the killing agent (**Fig. 3**).

Table 1. Showing season wise insect surveys in different valleys.

Valley	Year	Summer (Apr-Jun)	Monsoon (Jul-Sept)	Winter (Oct-Mar)	Total visits
Tirthan	1995	-	1	1	15
	1996	2	2	3	
	1997	2	2	2	
Sainj	1995	-	-	1	11
	1996	4	-	2	
	1997	3	-	1	
Jiwa	1995	-	-	1	5
	1996	1	-	1	
	1997	1	-	1	
Parvati	1995	-	-	1	1
	1996	-	-	-	
	1997	-	-	-	
Total		13	5	14	Total=32

(c) Trapping: As insects attract towards light sources, the collection was done near the lamp posts/street lights in the various sites lying in the ecodevelopment area. Apart from this a few attempts were also made to use the light trap

(Fig. 2) at specified village sites in Tirthan valley.

Locations of 18 (eighteen) intensive study sites selected in different valleys are shown in map (2) and their distribution details valley-wise and altitude wise are given in **Table 2 and 3**.

Table 2. **Intensive study sites in different valleys**

Ecodevelopment area	Tirthan valley	Sainj valley	Jiwa valley	Parvati valley	Total
5	6	5	1	1	18

Table 3. Intensive study sites in different altitudinal ranges and forests

Sub-tropical broad leaved (1,500-2,000 m)	Temperate mixed coniferous (>2,000-2,500 m)	temperate coniferous (>2,500-3,500 m)	Alpine pastures (>3,500m)	Total
4	6	5	3	18

6.1.1 Equipment

(a) Killing bottle : Killing bottle **(Fig. 4)** was used to kill and preserve insect without affecting its colour. Glass jar with a layer of Benzene was used as a killing agent. The liquid was poured over a layer of cotton and one or two filter papers or blotting papers were used to soak cotton and also to prevent the specimen from coming in direct contact with cotton. Insects were handled carefully while they were put inside the bottle or taken out to prevent any morphological damage.

(b) Collection vials: Small specimens were killed and preserved for the further study. Such specimens were kept in small plastic or glass vials
(Fig. 4).

(c) Paper packets: Paper packets **(Fig. 4)** were used to keep Lepidoptera, Odonata and many other insects. Specimens of such orders transferred to paper packets.

6.1.2 Preservation for taxonomic study

(a) Pinning of Insects : Insects with hard body were pinned directly by piercing pin through the body and care was taken to choose the correct size and number of pin (each insect pin has a specific number) to avoid damage to the internal part. Insect pins vary in diameter and length and are numbered 0, 1, 2, 3, 5, etc. the first being very slender and last most stout. Most often 0-3 size pins were used, although longer pins of 37-39 mm. in length were used for large bodied insects **(Fig. 8)**. A list of suppliers of entomological equipment is given in **Annexure III.**

(b) Location of pinning: The point at which the pin was inserted also varies. The order-wise locations for pinning of insects are as follows:

(i) *Coleoptera (Beetles)* : Pin through the right elytra, near front margin, near middle line **(Fig. 8a)**.

(ii) *Hemiptera (Bugs)* : Pin through the scutellum to the right of the middle line **(Fig. 8b)**.

(iii) *Hymenoptera (Bees)* : Pin through thorax, to the right of the middle line, between or a little behind the bases of forewings **(Fig. 8c)**.

(iv) *Lepidoptera (Butterflies & Moths)* : Pin through centre of the thorax or a little behind, between base of the forewings **(Fig. 8d)**.

(v) *Diptera (Flies)* : Pin through to right of middle line of thorax (**Fig. 8e**).

(vi) *Odonata (Dragonflies)* : Pin through centre of the thorax or a little behind, between base of the forewings **(Fig. 8f)**.

(c) Spreading : It is a process to arrange the wings for taxonomic study, with the help of spreading board which consists of two flat parallel pieces of soft wood with an inner groove lined by cork. A properly relaxed specimen with a pin thrust vertically, was inserted inside the groove so that the wing bases remain at level with the edge of top part. Two narrow paper strips were used to hold and spread the wings, and after adjustment of the wings at a desirable position the collected specimen was pinned using a fine pin **(Fig.5)**.

(d) Mounting : Small delicate specimens were pinned with a minute, fine pin on a piece of pith, through other end of which a longer pin is inserted. The collection date and other details on a paper label was attached to this long pin and specimen handled with the long pin only **(Fig. 9)**.

Insects once collected and preserved in such a manner allow examination of the specimens even after a long lapse of time. This necessitates undistored mounting, pinning and labelling with complete information of collection *viz*. date, time, location, altitude, and host plant. Insects, once mounted or pinned were arranged in drawers of a insect cabinet which act as permanent storing place **(Fig. 6 & 7)** Naphthalene balls and Paradichlorobenzene were used in cabinets for safe preservation against any pest or fungal attack.

6.1.3 Taxonomic keys for identification

The purpose of a taxonomic key is to facilitate identification of a specimen. The goal was achieved by presenting subsequent appropriate diagnostic characters in a series of alternative choices with dichotomous characters **(Mayr, 1974)**. For the identification of butterflies the reference key and illustrations as provided by **Mani (1986); Haribal (1992)** and **Carter (1992)** were used.

Broadly following two type of keys were used for identification purposes:

(a) Dichotomous Key : Dichotomous key (divided or dividing into two parts) key, which is not offering more than two alternatives at any point was used for the identification at various levels. Published fauna on different taxonomic sub-groups were consulted for the identification at genus and species levels.

(b) Pictorial Key: An attempt to develop a simple pictorial key was made for identification of specimens during field investigations. It is expected that amateurs and frontline staff of the park would be able to make use of this pictorial key for identification of specimens atleast upto the order level **(Annexure - I)**.

6.1.4 Institutions visited for identification

Insects collected during afore described surveys using various methods in GHNPCA were identified and studied taxonomically with the help of relevant literature and comparing the specimens with authentic identified collections available at different scientific institutions. Some of the important institutions those were contacted for comparisons and confirmation of the identified specimens are mentioned below. Further, a detailed list of such institutions and individuals is provided in **Annexure - III**.

* Zoological Survey of India (ZSI), DehraDun and Port Blair.
* Division of Entomology, Indian Agriculture Research Institute (IARI), New Delhi.
* Department of Zoology, Punjab University, Chandigarh.

* Department of Zoology, Punjabi University, Patiala.
* Regional Research Station, Himachal Pradesh Krishi Vishawavidyala (HPKV), Bajaura, Kullu, Himachal Pradesh.
* Department of Zoology, Kurukshetra University, Kurukshetra.

7. INSECT FAUNA OF GHNPCA

7.1 BACKGROUND

Although pioneer work on high altitude insects has been done by Mani but insect studies on the basis of individual Protected Areas (PAs) are greatly lacking. Studies on biodiversity of Silent Valley National Park, particularly butterflies and moths by **Mathew and Rahamathulla (1993, 1995)** and butterflies of Periyar Tiger Reserve by **Palot *et al***. **1997** are a few prominent ones. Few records of food preferences of butterflies of GHNP by **Uniyal 1996**, **Uniyal and Mehra (1996**) and **Uniyal and Kumar (1997)** have recently been documented. **Uniyal and Singh (1996)** provide the ecological relationships between flowering plants and honey bees and butterflies of GHNPCA and the insect survey was also conducted nearby GHNP area by **Saini and Vasu (1997)**.

7.2 DIVERSITY PATTERNS

Diversity patterns observed for studies order are being described in the following text via-a-vis their affinities with vegetation and altitudinal distribution.

7.2.1 Vegetation affinities

In present study, identified specimens belonging to six selected orders (Coleoptera, Hymenoptera, Diptera, Hemiptera, Odonata, and Lepidoptera) represented 37 families, 108 genera, and 125 species. **Table 4** provides details of genera and species represented by each family and studied insect orders. **Table 4** revealed that the order Lepidoptera represented highest diversity in terms of 54 genera and 61 species among the six orders investigated. This was followed by order Coleoptera which had 41 genera and 47 species. Studied six orders can be arranged in a descending diversity order as: **Lepidoptera, Coleoptera, Hymenoptera, Odonata, Hemiptera** and **Diptera. Table 5** describes altitudinal distribution of 37 identified families. Distribution of families has been presented in four broad altitudinal range categories corresponding to major vegetation types *viz.* Sub-tropical broad leaved forests (1,500-2,000 m); Temperate mixed coniferous forests (>2,000-2,500 m); Temperate coniferous forests (>2,500-3,500 m) and Alpine pastures (>3,500 m).

The dominant tree species characterising the sub-tropical broad leaved forest type were *Juglans regia*, *Aesculus indica* and *Rhododendron arboreum;* the shrub species were *Sarcococa hookeriana*, *Prinsepia utilis*, *Indigofera hetrantha*, *Desmodium elegans*, *Vibarnum cotinifolium*, and *Berberis lychium*. The prominent herbs species were *Viola odorata*, *Strobilanthus atropurpurea*, *Rumex* nepalensis, *Urtica dioca*, and *Iris melsii*. Among the studied insects groups, species belonging to seven (7) families representing three (3) orders *viz*. Coleoptera (Lampyridae, Cicindelidae, Carabidae, Cucujidae); order Hemiptera (Cicadidae, Aspidiotidae); and order Lepidoptera (Lasiocampidae) were found in this forest type. It is presumed that these insects groups were having close association with the plant communities of this type of forests. In the temperate mixed conifer forest type, dominant trees species were *Pinus wallichiana*, *Quercus leucotrichophora*, *Quercus diltata, Acer caesium, Picea smithiana* and *Lyonia ovalifolia*. The dominant herb species were *Viola odorata*, *Taraxacum officinale*, *Bergenia ciliata,* and *Veleriana jatamansii*. Only one family Cassididae of the order Coleoptera was recorded from this forest type (>2,000-2,500 m). Family Andrenidae of order Hymenoptera was recorded from the temperate coniferous forests types (> 2,500-3,500 m) where the dominant and co-dominant plants species recorded were *Cedrus deodara*, *Taxus baccata, Abies pindrow*, *Rhododendron campanulatum, Berberis chitria* and *Cotoneaster microphylla*.

Within the alpine pastures of GHNPCA, three (3) families *viz.* Papilionidae, Nymphalidae and Pieridae of order Lepidoptera; family Syrphidae of order Diptera; and members of family Chrysomilidae, Curculionidae, and Coccinellidae of order Coleoptera were recorded. The Apollo butterfly was observed above 4,500 m elevation and a few species of Coccinellidae were observed over the snow surface. The dominant flowering plants species in this area were *Primula denticulata, Primula reptans, Primula macrophylla, Meconopsis aculeata, Impatiens sulcata, Allium humile, Iris kumaonensis, Aconitum violaceum, Jurinea dolomiaea, Caltha palustris, Anemone rupicola, Rananculus hirtellus, Oxygraphis polypetala* and *Polygonum* spp.

7.2.2 Altitudinal affinities

Out of the 37 families recorded during the present study, seven (7) families were found in a wide altitudinal range (1,500 - >3,500 m). These were : order Coleoptera (Coccinellidae, Curculionidae and Chrysomelidae); order Diptera (Syrphidae); and order Lepidoptera (Papilionidae, Pieridae and Nymphalidae). Four (4) families belonging to three (3) orders were found within an altitudinal range from 1,500 to 3,500 m covering three forests types. These were : order Coleoptera (Cerambycidae); Hymenoptera (Xylocopidae and Vespidae); and order Lepidoptera (Lycaenidae). Sixteen (16) families belonging to four (4) orders were found between 1,500 to 2,500 m covering two forest types i.e. sub-tropical broad leaved forests and temperate mixed coniferous forests. These were: order Coleoptera (Buprestidae, Elateridae, Lucanidae, Scarabaeidae and Meloidae); order Hymenoptera (Halictidae); order Odonata (Aeshnidae, Libellidae); and order Lepidoptera (Hesperidae, Saturnidae, Geometridae, Arctiidae, Noctuidae,

Sphingidae, Lamantridae, Zygaenidae). On the basis of field observations and specimens collected, insects were divided into three broad categories *viz*. abundant (commonly distributed in the area), occasional (distributed in some of the pockets) and rare (few in numbers). Out of 125 species recorded in GHNPCA, 96 were abundant, 21 occasional and only eight (8) species of butterflies were rare. These species of butterflies were recorded from alpine pastures **(Annexure-II).**

7.3 FEEDING HABITS - PHYTOPHAGOUS GROUP

Further, above identified insect fauna in GHNPCA has been characterised on the basis of their feeding habits, focusing mainly on the Phytophagous group; functional roll as Pollination; and biodiversity indicators.

7.3.1 Coleoptera (Beetles)

Characteristic features : The Coleoptera are among the dominant forms of high altitude insects occurring almost on all the mountains of the world. They are minute or large, hard-bodied insects, with the fore wings modified into elytra, to support body during flight and protection the membranous hind wing when at rest. A total of 14 families were recorded in which eight were highly in phytophagy they are:

(a) Cerambycidae : (Long-horn beetle) The long horn beetles are usually large with very long antennae. The adults are nocturnal or diurnal, sluggish and live on woody plants. The eggs are laid inside the plant by cutting slits with the help of sharp mandibles and inserting with the ovipositor. Four species belonging to four genera were collected between the elevation from 1,500 to 3,500 m were: *Aeolesthes sarta, Apriona cinerea, Apomectra pertigera*, and *Lophosterus hugeli*.

(b) Buprestidae : The members of this family are metallic coloured with short, serrate antennae. Thorax and abdomen firmly united. The adults are lover of bright sunshine and inhabit wooded areas. The larvae are remarkable for the great development of the pro-thoracic segment, vestigial or obsolete legs, they bore tree stems. Only *Ancylocheira* sp. was collected and identified in this family.

(c) Elateridae : (Click-beetle) The click beetles are minute or medium-sized, hard, elongate, slightly flat, black, grey, brown, sometimes brilliant metallic. The larvae known as wireworm, are long, cylindrical and slightly flattened. The larvae of many species live in dead wood or under bark of the tree. They also feed on plantations and pastures. Five species belonging to this family recorded between 1,500 to 2,500 m elevation were: *Agrypnus sp., Melanotus sp., Cardiophorus sp*., and *Pectocera* sp.

(d) Lucanidae : (Stag-beetle) The stag beetle are usually black or brown. Mandibles of males are enormously enlarged and antler like. The larvae breed in wet, decaying wood. Three species *viz. Dorcus sp., Parallelipipedus sp.*, and *Lucanus* sp. were recorded between the elevation from 1,500 to 2,500 m.

(e) Scarabaeidae : (Dung-beetle) The members of this family mostly feed on dung of various large herbivore which they roll into convenient-sized ball, bury them in underground chambers and feed at leisure. Maximum representation of species was recorded in this family. Eleven species representing eight genera upto 2,500 m elevation in GHNPCA recorded were: *Oryctes nasicornis, Geotrupes* sp., *Xylotrupes gideon*, *Anomala dimidiata*, *Anomala rufiventris, Anomala lineatopennis, Phyllognathus dionysius, Catharsius sagax*, *Melolontha indica*, *Melolontha furcicauda*, and *Hilyotrgus holosericeus.*

(f) Coccinellidae : (Ladybird-beetle) The lady bird beetles are minute or small, circular or oval, hemispherical with black, yellow, brown, red, and often spotted. This is a large family with 3,000 species recorded all over the world, it is widely distributed and occurring nearly all the year round. The great majority of the species feed on small soft-bodied insects. Out of total known species, nearly 500 species are peculiar phytophagous. During the present investigations six species belonging to five genera were identified and *Coccinella septempunctata* L. var. *divaricata* was collected during May over the snow surface at 3,700 m altitude.

(g) Cucujidae : Minute or small, flat, often nearly as flat paper, occurring in tree bark. Some species live inside leaf petioles. A number species are important pest of seeds and other similar products. Only *Cucujus sp.* was recorded from 1,500 to 2,000 m elevation in GHNPCA.

(h) Curculionidae : (Weevil-beetle) The weevils are minute or large, with the head prolonged into a rostrum, with the mouthparts at the tip. They are also phytophagous and feed on roots, boring stems, fruits and mine leaves or also feed on stored cereals. Five species representing five genera were recorded in all the described forest types and altitudinal ranges in GHNPCA. These were: *Mecyslobus (Mecyslobus) fasciatus*, *Menectetorus raja, Aclees cribratus*, *Paramecops farinosus, and Blosyrodes* sp.

(i) Chrysomelidae : Based on comparison with known collection and discussion with subject specialist, two unidentified specimens seems to be new species from the region. Specimen await final identification. The chrysomelids are minute to small, hard, often brightly coloured insects and larvae feed exclusively on leaves of a variety of plants, mine inside leaves or sometimes stems. Some of the species are serious pest to forest plantations. Three species *viz. Hoplasoma unicolor, Merista sexmaculata,* and *Merista quadrifasciata* belonging to this family were recorded and they represented all the vegetation types of GHNPCA.

(j) Meloidae : (Blister-beetle) The blister beetles are medium-sized, soft-bodied often with the elytra loosely connected; mostly black, brown or some times bright metallic-blue or green. The adults are mostly phytophagous and feed on flowers. *Mylabris macilenta* was recorded between 1,500 to 2,500 m elevations, mainly on the flowers of *Impatiens*.

7.3.2. Hemiptera (Bugs)

Characteristic features : The bugs are minute to large, phytophagous or predacious insects, with piercing and sucking mouthparts. The following two families were recorded in the present study:

(a) Cicadidae (Cicada)*:* The loudest singers of the forest are cicadas, they lay eggs into crevices of bark and incubate for about six weeks. The newly hatched nymphs drop off to the ground, dig with the powerful fossorial fore legs to a depth of about 50 cm and spend their long life underground, sucking the sap from the plant root. The well known 'seventeen-year cicada', the nymph comes up above ground after seventeen years, after it went underground. Only *Cicada* sp. was recorded from 2,000 m elevation in GHNPCA.

7.4 POLLINATOR GROUP

7.4.1. Hymenoptera (Bees)

(a) Characteristic features : Five families representing eight species in the order Hymenoptera were studied. The bees are with two pairs of membranous wings; hind wings always smaller than fore wings, venation greatly reduced and sometimes absent. They are free-living, predatory, entomophagous parasitic or social insects, usually lovers of warmth and sunshine and are thus diurnal insects that lead a predatory life or gather pollen and suck the sweet juices of plants.

(b) Habitat preference : The bees stand in the forefront of all invertebrates, as they have been the subject of studies by some of the most famous naturalists. At least 1,00,000 species are known throughout the world **(Davis, 1988)**. The vast majority of bees are solitary in habit like other insects, individuals of some groups live together in great societies. Hymenoptera are also remarkable for the highly evolved state that parasitism has reached among their larvae, tens of species betray this habit and present special respiratory and other adaptation in accordance with their mode of life. From the economic standpoint the Hymenoptera confer many benefits upon man. Bees are important pollinators of fruit trees and other plants, while the honey-bee is well known to yield honey and wax. The important part played by the parasitoidal Hymenoptera in controlling the population density of many injurious insects in a recognised feature in pest management.

Family Apidae was represented by three species *viz*., *Bombus sp., B. haemorhoidalis,* and *B. tunicatus*. Beside these, wasps of the family Vespidae, represented by *Polister maculipennis* and *Vespa auraria*, were widely collected between the elevation of 1,500 to 3,500 m. The flowering plants visited by these bees and wasps were the dark or pale blue flowered (*Aconitum violaceum)*, greenish-purple flowered *(Aconitum heterophyllum*, *Potentilla fruticosa)* and *Potentilla atrosanguina* with pure bright yellow, or yellow mixed with orange or dark red flowers, bluish-purple flowered (*Delphinium cashmrianum)*, golden yellow flowered *(Adonis chrysocyathus)* and white flowered *(Anemone tetrasepala).* The bees also visited the Queen of Himalayan flowers, the blue poppy (*Meconopsis aculeata)* as also the small delicate perennial *Corydalis cashmeriana*, with blue tips. Among shrubs, the purple flowers of *Aquilegia pubiflora, Aster diplostephioides, Nepeta connata,* the large purple and yellow flowers of *Nepeta govaniane* and the lemon yellow flowers of *Pedicularis oederi*, also attracted many species of Apidae and Vespidae.

Family Andrenidae represented by *Andrena* spp. was collected at the altitude of 2,900 m. The important flowering plant species present at this altitude are *Clematis buchananiana* with cream or yellow, sweet scented flowers on long leafy branches, and *Clematis connata* with yellowish white flower. The yellow inflorescence of *Inula cappa* and *Inula grandiflora* attracts most of the *Andrena* spp. At the altitudes between 1,500 to 3,500 m, *Xylocopa fenestrata* of Xylocopidae were observed on flowering clusters of *Cyathula capitata* and on the minute pinkish flowers of *Pilea* spp. *Helictus* spp. of family Halictidae was observed on the red flowers of *Aster thomsonii,* small pink or purple flower of *Calamintha umbrosum* and *Salvia hians. Vespa auraria* of Vespidae was observed on pink, deep red or white flowers of *Polygonum amplexicaulis* **(Uniyal and Singh, 1996)**.

7.4.2 Lepidoptera (Butterflies and Moths)

(a) Characteristic features: The insects of this order are distinguished from other insects by their wings which are more or less densely covered with minute scales of various colours, hence the name Lepidoptera. Hence, order Lepidoptera comprises an enormous number of different species is further divided into two sub-order Heterocera or Moths, and Rhopalocera or Butterflies. The distinction between two sub-orders is primarily based on the structure of antennae as expressed in the term Rhopalocera (a club; horn), and Heterocera (Different; horn), the antennae of butterflies being more or less uniform in structure and clubbed at the tip, while those of moths exhibit great variations of structure among genera and species, and even in the different sexes of the same species.

But there are several other characteristics by which butterflies can generally be distinguished from moths. Butterflies are never nocturnal in their habits. Some species fly at twilight, but with a few exceptions they fly only in day-time, and as a rule are active on wings only during sunshine; the eyes of butterflies too are larger and more prominent than those of moths.

Again the antennae of butterflies, which are straight, filamentous and more or less clubbed at the tip, are always held erect or extended in front of the head, and are never either twisted or folded away by the insect. However, the antennae of moths are highly flexible, and during repose are invariably folded backwards along the body and concealed under the wing. Butterflies may be distinguished by the position of wings in repose, more or less erect over the back and never folded close along the body or butterflies when in repose usually exhibit the under-surface of the wing; moths in repose have only the upper surface visible. Five families of butterflies represented 37 genera and 44 species during the present investigations.

(b) Habitat preference: Butterflies are the best known insects for their diurnal and readily recognised by their bright and showy colours. They are widely distributed all over the world and occur commonly in gardens, fields, scrubland, deserts and forests and from the seashore to the mountains. They generally visit flowers for nectar and are indeed among the dominant cross pollinators. Many species of butterflies congregate on moist ground, near streams and some species are attracted towards rotting or over-ripe fruit, animal dung and bird droppings. While most species are doubtless lovers of bright sunshine and occur on open ground and among bushes and tree top. The larvae generally feed on leaves of many plants species.

(i) Laying of eggs : The eggs of butterflies are deposited either single or in group, on leaves or tree bark as a rule; sometimes on the calyx of flower, but always on or near the food-plant of the caterpillar **(Uniyal and Kumar, 1997)**. The eggs are strangely diversified in form and pattern, far more so than the birds; but for each species the eggs are uniform in shape, colour, and structure, so that the species to which any particular eggs belong can easily be identified. At the same time the eggs of closely allied species often differ widely, so that among butterflies the eggs afford little or no indication of the affinities with other insect group. The laying season varies depending upon species habits. Some kinds passing the winter or hibernating in the egg state, some as caterpillars.

The family Papilionidae comprises the swallowtail butterflies those are tropical and sub-tropical. The larvae exhibit marked preferences for certain species of food plants. Six species of family Papilionidae were recorded in the present study. They were representing all the altitude and vegetation types in the area. *Parnassius hardwicki virdicans* known as Common blue apollo resident of alpine area was recorded at about 3,700 m elevation in the Tirthan and Sainj valleys of GHNPCA. Some of the translucent white endangered butterfly of the same genera were also observed above Saketi at 4,500 m elevation in the Tirthan valley. *Papilio machaon* (Yellow swallowtail) a rare butterfly in this area was recorded at about 3,500 m in Tirth area of the Tirthan valley **(Table 7)**.

Family Pieridae represents mostly white, orange or yellow diurnal butterflies, their larvae feed on various species of Cruciferae, Capparidaceae and Leguminosae. Species variations among

the Pieridae members based on wet and dry seasons were prevalent in the area. They have a great affinity for congregating together in large numbers at pools or muddy bank of water bodies. In general, sexes are similar in morphology, but specific cases of marked sexual dimorphism were also observed. Nine species of this family were recorded covering all vegetation types in the study area. The cabbage butterfly (*Pieris* sp.) was common in lower altitude upto 2000 m. *Colias fieldii* (Dark clouded yellow), with orange-red with black border found throughout the alpine pasture just after melting of snow, and feed various species of low growing flowers of genus *Primula*. The Common brimstone (*Gonepteryx rhamni nepalensis*), a sulphur coloured or greenish yellow butterfly of family Pieridae was found between the elevation of 1,500 to 2,500 m on the edges of forest openings.

Like elsewhere, family Nymphalidae represented maximum number of species in the present study **(Table 6)**. Total 22 species were recorded from different vegetation types in the area. The Nymphalids are medium to large sized, with a great fondness of sunshine, swift powerful fliers, brightly coloured, with wide range of flight. The Indian Red Admiral (*Vanessa indica indica*) are dark brown with fore wings with central red divided in the inner side by large black spots. While hind wings having red margined band with black in the centre. Two rows of disjoint white apical spots. It belongs to open forest openings or grassy glades. It was recorded upto 2,500 m in GHNPCA. Few species *viz*. *Aulocera padma, Aulocera swaha, Neope pulaha, Letha* sp. and *Poligonia c-album* were rarely observed in alpine areas. The larvae of Yellow coster butterfly (*Pareva vesta*) was observed on the leaves of *Debregeasia salicifolia* of family Urticaceae which is a good fodder plant in the region and found only upto 2,500 m elevation. The *Parantica sita sita* (Chestnut tiger) and *Danaus (Salathura) genutia* (Common tiger) **(Fig.11 & 12)** were recorded between 1,500 to 2,000 m elevation throughout the sub-tropical broad leaved forests.

Family Lycaenidae is remarkable family of minute or small butterflies, usually metallic-blue, green copper and bronze, hind wings usually with tail lobes. Six species of this family were recorded and they were mostly found at lower elevation.

A single species i.e. the Common spotted flat (*Celaenorrhinus leucocera*) was representing the family Hesperidae was recorded during the present study.

Seventeen species of moths representing eight families *viz*. Saturniidae, Lasiocampidae, Geometridae, Arctiidae, Noctuidae, Sphingidae, Lamantriidae and Zygaenidae were recorded from the different valleys and altitudinal zones in GHNPCA.

Family Saturniidae is the world wide family of over 1,000 species including many of the world largest and most spectacular moths. Because of their size and beautiful colours many species have well developed eyespots or transparent patches on both fore and hind wings. Number of

Table 6. Diversity of butterflies in different regions

Families	Total species reported in the world *	Indian region	GHNPCA (Identified)
Papilionidae	573	19	6
Pieridae	1200	109	9
Nymphalidae	6000	521	22
Lycaenidae	6000	443	6
Hesperidae	3050	321	1
TOTAL	16823	1501	44

* As per **Gaonkar (1995).**

Table 7. Rarely observed butterflies in GHNPCA

Species	Family	Locations	Altitude(m)
Papilio machaon	Papilionidae	Tirth	2000-3500
Parnassius hardwicki virdicans	Papilionidae	Dhela and Saketi	3000 & above
Polygonia c-album	Nymphalidae	Shilt and Nada	2500-3500
Aulocera padma	Nymphalidae	Dhela and Saketi	2500-3500
Aulocera swaha	Nymphalidae	Dhela	2500-3500
Letha sp.	Nymphalidae	Tirth	2500-3500
Neope pulaha	Nymphalidae	Saketi	2500-3500

species have long tail on their hind wings. Wing patterns in male and female are generally different. Only four species *viz. Actias selene, Samia cynthia, Nadaurelia* sp., and *Saturnia pyri* of this family were recorded during the present investigations.

Actias selene (Indian moon moth) is beautiful white with pale or bluish green colour, its hind wings with long tail with yellow colour. Sexes are similar but male have more strongly feathered antennae and heavy furry body than female. Eyespots are characteristic features and pink crescent shaped marking on hind wing tail. *Samia cynthia* (Ailanthus silk moth) is ground colour moth and varies from brown to an olive green or orange brown. A brown pale band traverses in both the wings, a narrow crescent shaped patch in the centre of both wings. Antennae of male are well strongly feathered. *Nudaurelia* sp. is banded and shaded with reddish, yellowish and purple brown. The fore wing eyespots are ringed with black and orange and translucent oval centres. The *Saturnia pyri* (Great peacock moth) can be easily recognized with its red, black, and brown ringed eyespots on all wings. The wings are brown with light and dark bands, and the edge of the fore wings are suffused with silvery white.

Family Lasiocampidae is having about 1,000 species of medium to large sized moths occurring around the world. They are generally dull in colour with different shades with brown colour. Only one species, *Trabala viridana* (Moss green lappet), whose female moth is much larger than male and has triangular forewings with large, pale brown patches towards the base was recorded between 1,500 to 2,000 m elevation of GHNPCA.

Family Geometridae is the second largest family of moths, containing approximately 15,000 described species all over the world. They are with typically fairly large, rounded wing and slender bodies. Most species are dull in colour and but few tropical species are brightly coloured. Two species *viz. Archiearis infans* (The infant), little moth with a hairy appearance, caused by its long, coarse wing fringes. The fore wings are blackish brown, sprinkled with white scales, while the hind wings are orange, easy to recognize and *Ourapteryx sambucaria* (Swallow tailed moth) with pale yellow moth, often mistaken for a butterfly when disturbed by day. As its name suggests, a small tail-like extension on the hind wing with distinctive reddish brown spot at base of hind wing tail were abundantly recorded between 1,500 to 2,000 m elevations in the study area.

Family Arctiidae is a large family having about 10,000 species of moths all over the world. Most of them with brightly patterned with warning colours, because of mimic less palatable species. The brightly striped patterns of some species have given rise to the common name of tiger moths. Two species *viz. Syntomis* sp. and *Pericallia galactina* were recorded from this area.

Family Noctuidae is the largest and most important of all moth families, with more than 25,000 species occurring worldwide. Noctuid moths are quite robust, and range in size from extremely

small to very large. Only four species *viz. Erebus ephesperis, Trigonodes hyppasia, Othreis fullonia* and *Catocale ilia* were recorded between 1,500 to 2,500 m elevation of the study area.

Family Sphingidae known as hawk-moth is a worldwide family of about 1,000 known species with very distinctive streamlined wing shapes and robust bodies set them apart from other moths. The body structure is extremely powerful fliers, some even reaching speed of up to 50 km per hour. Two species *Marumba dyras* and *Acherontia* sp. were recorded in the area.

Family Lamantriidae having about 2,500 species are reported worldwide, but is most strongly represented in the African tropics. The moths are similar to those of the family Noctuidae, but they are generally rather hairy in appearance. The wings are usually pale or dull in colour. Only one species *Lamantria* sp. was recorded in GHNPCA.

Campylotes sp. of family Zygaenidae was recorded at the altitude range of 1,500 to 2,500 m in GHNPCA. It is a worldwide family of some 800 species of small to medium-sized moths. Most of the species in this family are day flying and many are brightly coloured indicating that they are poisonous.

7.5 INSECTS AS BIODIVERSITY INDICATOR

The insect habitat must supply the needs throughout its life time **(Samways, 1994)**. These needs will comprise, at the very least, food and suitable climatic conditions, and may also include shelter from disturbance and natural enemies. The effect of land-use changes on insects can be studied at three levels; on individual species, on the composition of species in a habitat or on simplified measures of the overall structure of the assemblage, such as species richness, diversity or biomass. In view of this, the Tiger beetles and Ground beetles of order Coleoptera and of order Odonata (dragonflies) were considered as the indicator species.

7.5.1 Coleoptera

The Tiger beetle of family Cicinidelidae, comprises about 2028 species throughout the world. Some species are yet to be identified. Five systematics revision were analyzed for naming of species and stability, a total of 406 species names (with some duplication of species between Sumatra, Sulawesi, India and between Australia and New Guinea **Pearson and Cassola, 1992)**. The tiger beetles occur in open sandy river banks and chiefly in tropical and sub-tropical forests. The larvae live in vertical or sloping underground burrows, with the dislike head just serving as a stopper for the hole. Three species of Cicinidelidae *viz. Cicindela (Cosmodela) nirgula* **(Fig. 10)**, *Cicindela (Cosmodela) flavomaculata* and *Jansonia* sp. were recorded between 1,500 to 2,000 m elevation in GHNPCA.

The Ground beetle of family Carabidae with black, brown, yellowish, reddish or metallic-blue are largely ground living forms and are found under stones, bark, in moss, rotten wood and other similar situations. Their prey consists of snails, caterpillars, grubs, maggots and other similar animals. It is a large family and widely distributed throughout the world and occur both at high north latitudes, even within the Arctic Circle, and at high elevations on mountains. The highest altitude distribution recorded for the family in the world is 5,000 m amidst ice and snow on the Mt. Everest area. Only *Zabrus* sp. was recorded in GHNPCA.

7.5.2 Odonata

All dragonflies belong to the order Odonata, they are medium-sized or large amphibiotic predacious insects with large compound eyes, biting mouthparts and short antennae; wing two pairs, similar narrow and net-veined like. The dragonflies are comparatively long-lived insects. They are mostly diurnal and powerful fliers that lead an active predatory life, capturing various small insects in flight. The adults often hibernate in winter and on occasion migrate in huge swarms over long distances. The dragonflies are indicators of water bodies because the eggs are dropped into water or on attached to submerged objects in long gelatinous string. A single female mate lay often as many as 800 eggs. The larvae are aquatic and voracious predators those subsist on various small aquatic animals, but chiefly mayfly and mosquito larvae. Two families *viz.* Aeshnidae and Libellilidae of this order representing seven species were recorded upto 2,500 m in GHNPCA.

8. SIGNIFICANT FINDINGS

Present is the first ever study on the insect fauna in the Great Himalayan National Park

* In the present investigations, total 32 shorts surveys of average 10 days each were carried out in different sub-watersheds. Out of this, 13 surveys were undertaken during summer (April-June); 5 in monsoon (July-September); and 14 in winter (October-March) season. 18 different intensive sites were selected within four sub-watersheds and different altitudinal zones including ecodevelopment area. Six insect orders (Coleoptera, Hymenoptera, Diptera, Hemiptera, Odonata, Lepidoptera) were selected for present study. The study revealed that the studied six orders represented 37 families and 108 genera with 125 species.

* The order Lepidoptera represented higher diversity in terms of 55 genera and 61 species among the six (6) orders investigated. This was followed by the order Coleoptera which had 41 genera and 47 species. Studied six order can be arranged in a descending diversity pattern as Lepidoptera - Coleoptera, Hymenoptera - Odonata - Hemiptera - Diptera.

* Out of 37 families recorded during the present study, seven (7) families were found in wide altitudinal range (1,500- >3,500 m), while seven (7) families had a narrow distribution covering the 1,500-2,000 m elevation only.

* Among 125 species recorded in GHNPCA, 96 species were abundant, 21 occasional, and 8 were rare.

* Three species of Tiger beetle *viz. Cicindela (Cosmodela) nirgula, Cicindela (Cosmodela) flavomaculata*, and *Jansonia* sp. belonging to family Cicindelidae; six (6) species of Swallowtail butterflies belonging to family Papilionidae were recorded. These species may be used as indicator of biodiversity. Hence, in the second phase of present study, it is proposed to determine the status and distribution of these indicators species which willserve as baseline information for further comparisons.

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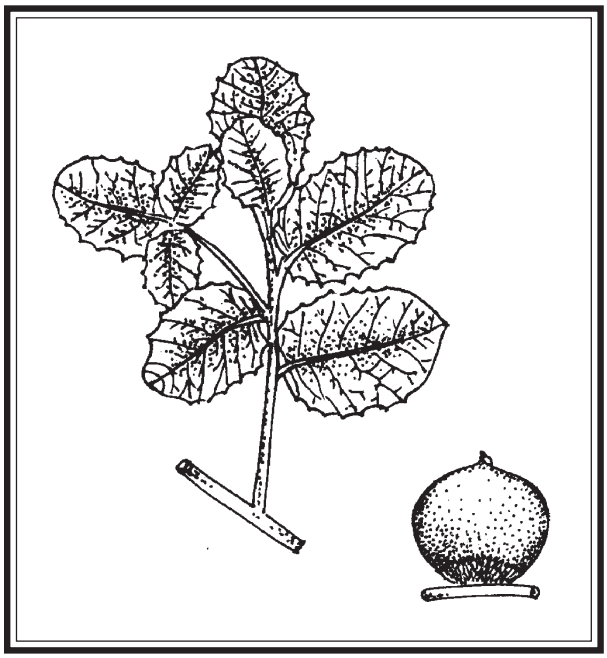
1 - *Taxus wallichiana*

2 - *Quercus leucotrichophora*

3 - *Quercus semecarpifolia*



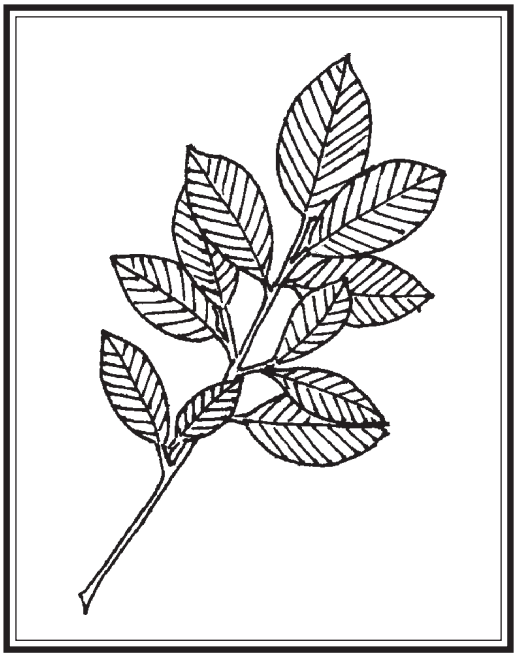
4 - *Quercus floribunda*

Plate 1

5 - *Prunus cornuta*

6 - *Aesculus indica*

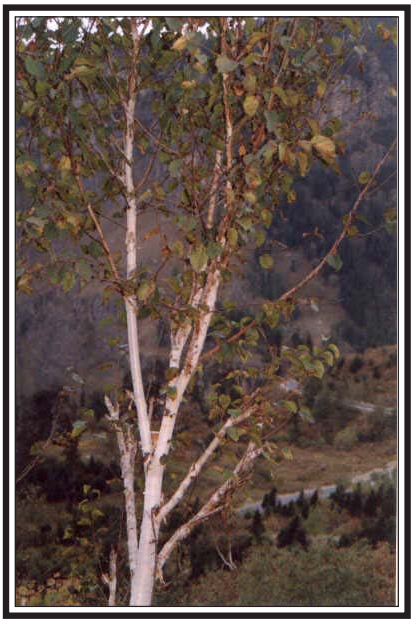
7 - *Alnus nitida*



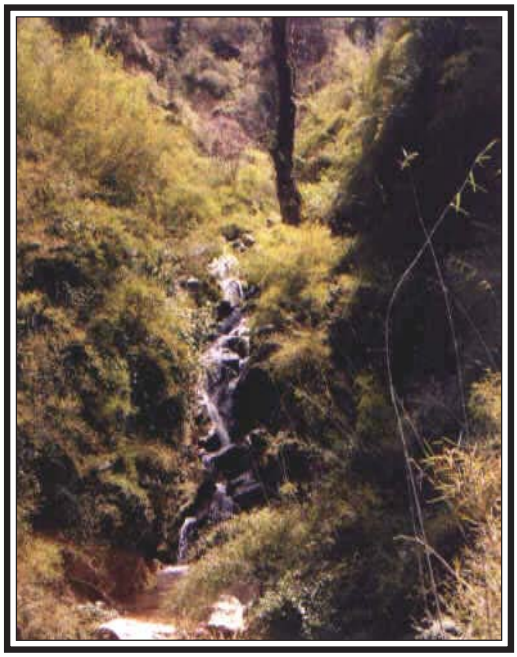
8 - *Cedrus deodara*

Plate 2

10 - *Betula utilis*



11 - *Arundinaria falcata*



12 - *Thamnocalamus spathiflora*

Plate 3

13 - *Rhododendron campanulatum*

14 - *Juniperus communis*

15 - *Berberis* spp.

16 - *Desmodium multiflorum*

Plate 4

17 - *Indigofera heterantha*

18 - *Aconitum heterophyllum*

19 - *Aconitum violaceum*

20 - *Dactyloriza hatagiera*

Plate 5

22 - *Picrorhiza kurrooa*

21 - *Jurinea dolomiaea*

23 - *Saussurea obvallata*

24 - *Nardostachys grandiflora*

Plate 6

25 - *Hypericum patulum*

26 -*Valeriana jatamansi*

27 - *Viola* spp.

28 - *Rumex nepalensis*

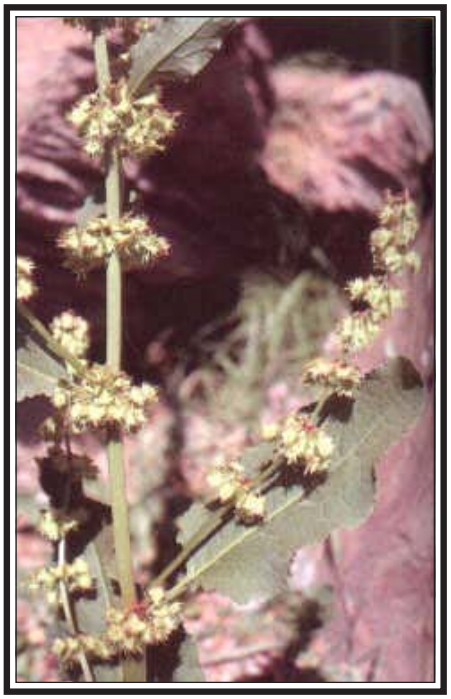


Plate 7

30 - *Polygonum* spp.

31 - *Angelica glauca*

32 - *Dioscorea deltoidea*

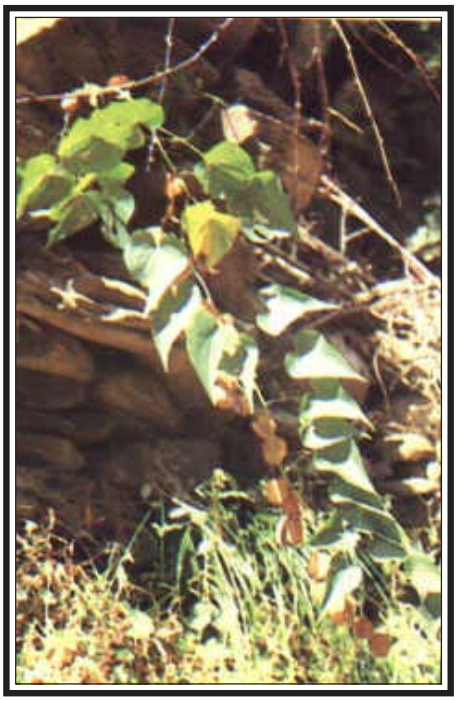


Plate 8

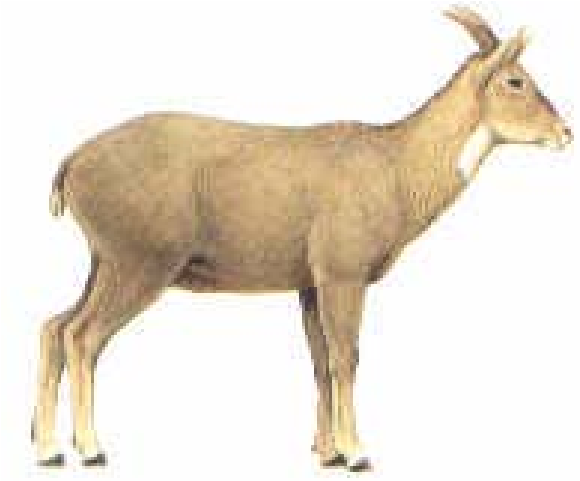
33 - *Morchella esculenta*

34 - Himalayan monal
(Lophophorus impejanus)

35 - Western tragopan
(Tragopan melanocephalus)

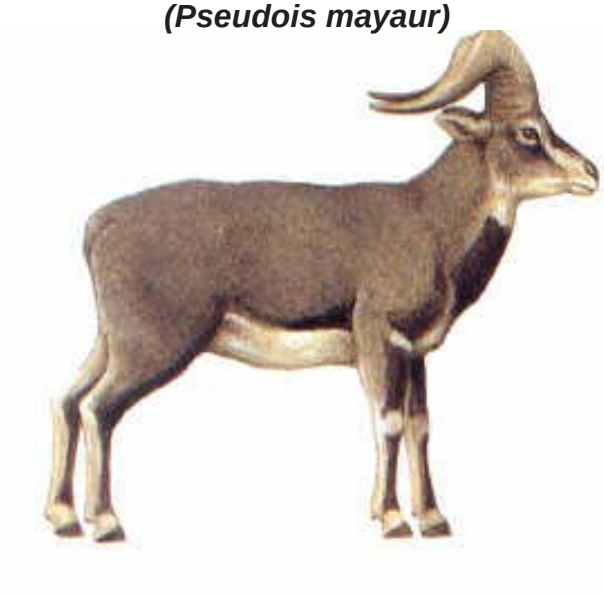
36 - Koklass
(Pucrasia macrolopha)

37 - Goral
(Nemorhae goral)



38 - Musk deer
(Maschus chrysogaster)

39 - Blue sheep
(Pseudois mayaur)



39

40 - Himalayan tahr
(Hemitragus jemlahicus)

40

Plate 10

41 - *Plutellus* sp. nov.1

44 - *Aporrectodea caliginosa*

46 - *Octolasion tyrtaeum*

47 - *Dendrodrilus rubidus*

48 - Yellow swallowtail
(Papilio machaon)

49 - Commonblue apollo
(Parnassius hardwicki virdicans)

50 - Pieridae

51 - Nymphalidae

Plate 12

52 - Lady bird beetle
Coccinellidae

53 - Tiger
beetleCicindelidae

54 - Dung beetle
Scarabaeddae

55 - Ground beetle
Carabidae

Plate 13

56 - Long horn beetle
Cerambycidae

57 - Chrysomelidae

57

Plate 14

Annexure - II

Species diversity of Insects in Great Himalayan National Park Conservation Area

Order/family/species	Altitude(m)	Status in GHNPCA
ORDER 1. COLEOPTERA		
FAMILY 1. CERAMBYCIDAE		
i. *Aeolesthes sarta* Solsky	1500-3500	O
ii. *Apriona cinerea* Cheurolat	1500-3500	O
iii. *Apomecyra pertigera* Thomson	1500-3500	O
iv. *Lophosterus hugeli* Redtb.	1500-3500	O
FAMILY 2. LAMPYRIDAE		
i. *Lampyris* spp.	1500-2000	A
FAMILY 3. BUPRESTIDAE		
i. *Ancylocheira* sp.	1500-2000	A
FAMILY 4. ELATERIDAE		
i. *Agrypnus* sp.	1500-2000	A
ii. *Melanotus* sp.	1500-2000	A
iii. *Cardiophorus* sp.	1500-2500	A
iv. *Heteroderus* sp.	1500-2000	A
v. *Pectocera* sp.	1500-2500	A
FAMILY 5. CASSIDIDAE		
i. *Cassida circumdata*	1500-2500	A
ii. *Lecoptera quadrioculeata*	1500-2500	A
FAMILY 6. CICINDELIDAE		
i. *Cicindela (Cosmodela) nirgula* Fleutiaux	1500-2000	O
ii. *C. (Cosmedela) flavomaculata* H.	500-2000	O
iii. *Jansonia* sp.	1500-2000	O

A: abundant; O: occasional; R: rare

Order/family/species	Altitude(m)	Status in GHNPCA
FAMILY 7. LUCANIDAE		
i. *Dorcus* sp.	1500-2500	A
ii. *Parallelipipedus* sp.	1500-2500	A
iii. *Lucanus* sp.	1500-2500	A
FAMILY 8. SCARABAEIDAE		
i. *Oryctes nasicornis.*(L.)	1500-2000	A
ii. *Geotrupes* sp.	1500-2500	A
iii. *Xylotrupes gideon* L.	1500-20O0	A
iv. *Anomala dimidiata* (Hope)	2000-2500	A
v. *Anomala rufiventris* Redt.	1500-2500	A
vi *Anomala lineatopennis*	1500-2500	A
vii. *Phyllognathus dionysius* (F)	1500-2500	A
viii. *Catharsius sagax* (Quens)	1500-2000	A
ix. *Melolontha indica* Hope	1500-2000	A
x. *Melolontha furcicauda* Ancey	1500-2500	A
xi *Hilyotrgus holosericeus* Redt.	1500-2500	A
FAMILY 9. CARABIDAE		
i. *Zabrus* sp.	1500-2000	A
FAMILY 10. COCCINELLIDAE		
i. *Coccinella septempunctata* L.	1500-3000	A
ii. *C.septempunctata* L.var.*divaricata*	1500-3500 & above	A
iii. *Ballia eucharis* Muls	1500-3500	A
iv. *Hippodamia septemmaculata* De	1500-2500	A
v. *Oenopia (Coelophora) sauzeti* M.	1500-3000	A
vi *Halyzia sauserita* Mnls	1500-2500	A
FAMILY 11. CUCUJIDAE		
i. *Cucujus* sp.	1500-2000	A
FAMILY 12. CURCULIONIDAE		
i. *Mecyslobus (Mecyslobus) fasciatus* (Retd.)	1500-2000	A

Order/family/species	Altitude(m)	Status in GHNPCA
ii. *Menectetorus raja* (Steb.)	1500-2500	A
ii. *Aclees cribratus* Gyll	1500-2500	A
iv. *Paramecops farinosus* (Wied)	1500-3000	A
v. *Blosyrodes* sp.	2000-3500 & above	A
FAMILY 13. CHRYSOMELIDAE		
i. *Hoplasoma unicolor* Illiger	1500-2000	A
ii *Merista sexmaculata* K&R	1500-2500	A
iii. *M.quadrifasciata* H.	1500-3500 & above	A
FAMILY 14. MELOIDAE		
i. *Mylabris macilenta* Marsenl	1500-2500	A
ORDER 2. HYMENOPTERA		
FAMILY 1. APIDAE		
i. *Bombus haemorhoidalis* Smith	2000-3500 & above	A
ii. *B.tunicatus* Smith	2000-3500	A
iii. *Bombus* spp.	2000-3500 & above	A
FAMILY 2. ANDRENIDAE		
i. *Andrena* spp.	2000-3500	A
FAMILY 3. XYLOCOPIDAE		
i. *Xylocopa fenestrata*	1500-2500	A
FAMILY 4. VESPIDAE		
i. *Polistes maculipennis* Sauss	2000-3500	A
ii *Vespa auraria*	1500-2500	A
FAMILY 5. HALICTIDAE		
i. *Halictus* spp.	1500-2500	A

Order/family/species	Altitude(m)	Status in GHNPCA
ORDER 3. DIPTERA		
FAMILY 1. SYRPHIDAE		
i. *Sphaerophoria indiana* (Bigot)	1500-3500	A
ORDER 4. HEMIPTERA		
FAMILY 1. CICADIDAE		
i. *Cicada* sp.	1500-2000	A
FAMILY 2. ASPIDIOTIDAE		
i. *Aspidiotus* sp.	1500-2000	A
ORDER 5 ODONATA		
FAMILY 1. AESHNIDAE		
i. *Anax guttatus* (Burmeister)	1500-2500	A
ii. *Anax* sp.	1500-2500	A
FAMILY 2. LIBELLILIDAE		
i. *Pantala flavescens* (Fabr.)	1500-2500	A
ii. *Orthetrum tringulare tringulare* (Selys)	1500-2500	A
iii. *Sympetrum commixtum* (Selys)	1500-2500	A
iv. *Orthetrum* sp.	1500-2500	A
ORDER 6. LEPIDOPTERA (BUTTERFLIES)		
FAMILY 1. PAPILIONIDAE		
i. *Papilio machaon* (Moore) **(Yellow swallowtail)**	2000-3500 & above	R
ii. *P.polytes romulus* (Cramer) (**Common mormon**)	1500-2000	O

Order/family/species	Altitude(m)	Status in GHNPCA
iii. *Princeps arcturus arcturus* (Westwood) **(Blue peacock)**	1500-2500	O
iv. *Princeps sp.*	1500-2000	O
v. *Graphium cloanthus* (Westwood) **(Glassy blue bottle)**	1500-2000	R
vi. *Parnassius hardwicki virdicans* Fabricius **(Common blue apollo)**	3000-3500 & above	R
FAMILY 2. PIERIDAE		
i. *Pieris canidia indica* Evans **(Indian cabbage white)**	1500-2500	A
ii. *P. dubernardi chumbiensis* (De Niceville) **(Chumbi white)**	1500-2500	A
iii. *Anapheis aurota aurota* Fabricius **(Pioneer)**	1500-2500	A
iv. *Pareronia valeria hippia* Fabricius **(Common wanderer)**	1500-2500	A
v. *Prioneris thestylis thestylis* (Doubleday) **(Spotted sawtooth)**	1500-2500	A
vi. *Delias* sp.	1500-2500	A
vii. *Catopsilia pomona* Fabricius **(Common emigrant)**	1500-2500	A
viii. *Gonepteryx rhamni nepalensis* (Doubleday) **(Common brimstone)**	1500-2500	A
ix. *Colias fieldii* Menetries **(Dark clouded yellow)**	2000-3500 & above	O

Order/family/species	Altitude(m)	Status in GHNPCA
FAMILY 3. NYMPHALIDAE		
i. *Vanessa indica indica* (Herbst) **(Indian red admiral)**	2000-3500 & above	O
ii. *Issoria lathonia issaea*(Doubleday) **(Queen of Spain fritillary)**	2000-3500 & above	O
iii. *Aglais cachmirensis aesis* (Kollar) **(Indian tortoiseshell)**	1500-3500 & above	A
iv. *Argyreus hyperbius hyperbius*(Johanssen) **(Indian fritillary)**	1500-2500	A
v. *Neptis hylas varmona* Moore **(Common sailer)**	1500-2500	A
vi. *Parathyma perius* (L.) **(Common sergeant)**	1500-2500	A
vii. *Precis iphita iphita* (Cramer) **(Chocolate soldier)**	1500-2500	A
viii. *Cynthia* sp.	1500-2500	A
ix. *Precis hitera magna* Evans **(Yellow pansy)**	1500-2500	A
x. *Childrena childreni childreni* Gray **(Large silver strip)**	2000-3500	O
xi. *Polygonia c-album* Linnaeus (**Comma**)	2000-3500	R
xii. *Sephisa* sp.	2000-2500	A
xiii. *Aulocera padma*	500-3500 & above	R
xiv. *Aulocera swaha*	2500-3500 & above	R
xv. *Letha* sp.	2500-3500 & above	R
xvi. *Neope pulaha*	2500-3500 & above	R
xvii. *Ypthima* sp.	1500-2500	A
xviii. *Mycalesis* sp.	1500-2000	A
xix. *Parantica sita sita* (Kollar) **(Chestnut tiger)**	1500-2000	O

Order/family/species	Altitude(m)	Status in GHNPCA
xx. *Danaus (Salathura) genutia* C. **(Common tiger)**	1500-2000	A
xxi. *Danaus (Anosia) chrysippus* (L.) **(Plain tiger)**	1500-2000	A
xxii. *Pareba vesta* (Fabricius) **(Yellow coaster)**	1500-2000	A
FAMILY 4. LYCAENIDAE		
i. *Abisara fylla* (Doubleday) **(Dark judy)**	1500-2000	A
ii. *A. echerius suffusa* Moore **(Plum judy)**	1500-2000	A
iii. *Heliophrus androeles moorei* (Hewitson) **(Azure sapphire)**	1500-3000	A
iv. *Lycaena phlaeas* L. **(Small copper)**	1500-3000	A
v. *Zizeeria knyasna* Trimen **(African grass blue)**	1500-3000	A
vi. *Aricia agestis* Denis & Sch. **(Brown Argus)**	1500-2500	A
FAMILY 5. HESPERIDAE		
i. *Celaenorrhinus leucocera* (Kollar) **(Common spotted flat)**	1500-2500	O

Order/family/species	Altitude(m)	Status in GHNPCA
FAMILY 6. SATURNIIDAE (MOTHS)		
i. *Actias selene* Hubner (**Indian moon moth)**	1500-2000	O
ii. *Samia cynthia* Drury (**Ailanthus silkmoth)**	1500-2500	O
iii. *Nadaurelia* sp. (**Pine emperor)**	1500-2000	O
iv. *Saturnia pyri* Denis (**Great peacock moth)**	1500-2000	O
FAMILY 7. LASIOCAMPIDAE		
i. *Trabala viridana* Joicey (**Moss green lappet)**	1500-2000	O
FAMILY 8. GEOMETRIDAE		
i. *Archiearis infans* Moschler **(The Infant)**	1500-2500	A
ii. *Ourapteryx sambucaria* L. (**Swallow tailed moth)**	1500-2000	A
FAMILY 9. ARCTIIDAE		
i. *Syntomis* sp (**Nine-spotted moth**)	1500-2000	A
ii. *Pericallia galactina* Vander Hove	1500-2000	A

Order/family/species	Altitude(m)	Status in GHNPCA
FAMILY 10. NOCTUIDAE		
i. *Erebus ephesperis* Hubner	1500-2000	A
ii. *Trigonodes hyppasia* Cramer	1500-2500	A
iii. *Othreis fullonia* Clerck	1500-2500	A
iv. *Catocala ilia* Cramer	1500-2500	A
FAMILY 11. SPHINGIDAE		
i. *Marumba dyras* Walker	1500-2000	A
ii. *Acherontia* sp.	1500-2500	A
FAMILY 12. LAMANTRIDAE		
i. *Lamantria* sp.	1500-2500	A
FAMILY 13. ZYGAENIDAE		
i. *Campylotes* sp.	1500-2500	A

Annexure - III

10. Suggested contact persons for identification of insects

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