CHAPTER I
INTRODUCTION

Background
Geographical complexity and lack of sufficient number of expertise has left many parts of the country unexplored for butterfly diversity. This study determined the distributional range of different species of butterflies in six potential districts of central Nepal which are linked to each other in their geographical boundaries.

Butterflies are scaly winged insects so they are placed under the order Lepidoptera (Lepidos = Scales, Aptera = Wing) and the class Insecta. Butterflies are distributed in most of the places from the lowland to the highland and from the forest to the open areas. This insect is distributed to varied climatic zones and habitat types. *Parnassius* species (Apollo) are confined above to 2800 m of elevation and never come down below this elevation. This species has hairs and black spots on its body which are the adaptive features to cold climatic condition.

My study on butterflies for several years also helped me to conduct this research effectively and systematically. This study also explored species diversity of butterflies occurring in different forest and ecosystem types which were not studied extensively before. This also helped to update the country’s list of butterflies besides categorizing their current status based on IUCN Redlist and CITES Appendices.

Tropical species occur below 1000 m of elevation. The common species of this part are *Pontia daplidice* (Pieridae), *Aropha* species (Lycaenidae), *Discophora sondaica* (Amathusiidae), *Cirrochora aoris* (Nymphalidae), *Sticopthalma camadeva* (Amathusiidae) etc. The species which are adapted to the subtropical forests are varied and include species like *Metaporia agathon* (Pieridae), *Troides helena* (Papilionidae), *Papilio demoleus* (Papilionidae), *Dodona adinora* (Nemeobiidae) etc. Very few species are confined to the Himalayan climate above 4000 m of elevation. Khanal et al (2011) published an account on butterfly of Langtang National Park of Central Nepal. They included the diversity records of this park. They reported only the distribution and altitudinal limits and forest ecosystems of each butterfly species. Their study covered the...
elevation range of 1960 m to 4300 m. *Parnassius* species are the native Himalayan species. Inomata (1998) published an account on *Parnassius* of Nepal in which he included 12 species from Nepal Himalaya. Some species like *Aglais cashmirensis*, *Issoria issaea* etc also share their habitats both in the tropical and Himalayan climatic zones. Some Nymphalids like *Precis iphita*, *Precis almana*, *Phalanta phalantha* are also found both in lower and higher regions.

Some species of the family Pieridae like *Pieris canidia* (Pieridae), *Pieris brassicae* (Pieridae), *Colias fieldii* (Pieridae), *Eurema hecabe* (Pieridae) are confined to the cultivated land of the low and midland regions up to the elevation 3000m. Butterflies which are distributed to the forested habitats of the midland zones include *Phaedyma aspasia* (Nymphalidae), *Achillides krishna* (Papilionidae), *Teinopalpus imperialis* (Papilionidae), *Euthalia sahadeva* (Nymphalidae), *Troides aeacus* (Papilionidae) etc.

The diversity and distribution of a particular species of butterfly is dependent not only on the geography of the area and the ability of the species to move around within it, but also on the ecological demands of the species (Khan et al, 2011).

The distribution range of *Zizeeria maha* (Lycaenidae) is very wide from the low to the midland areas. This species prefers open areas and flies low to the ground. Satyrid species like *Callerebia* species are found in the moist and shady forest of the midland zone. Similarly, some Satyrids like *Aulocera* species are well distributed in the forested parts of the subtropical and temperate climatic zones. *Melanitis leda* (Satyridae) which is a tropical species occurs only in the shady parts of the jungle. This species displays a continuous variations in its colouration and markings on the ventral side of the wings

Some species like *Lycaena phlaeas* (Nymphalidae) and *Coenonympha amaryllis* (Satyridae) have very narrow distributional range in the upper temperate zone. They do not occur in the lower temperate and the upper Himalayan regions. *Polyommatus* species (Lycaenidae) are absolutely the Himalayan species and are distributed above 2500 m of the temperate zone.

Habitat preference varies specieswise. Some species prefer open area of the forested zone e.g. *Teinopalpus imperialis* (Papilionidae) and *Achillides krishna* (Papilionidae) and some species prefer forest trails e.g. *Stibochiona nicea* (Nymphalidae), *Chilasa agestor*
(Papilionidae), *Euthalia franciae* (Nymphalidae) etc. *Eurema hecabe* and *Pontia daplidice* (Pieridae) are found in cultivated area.

The ecological factors affecting the distribution of butterflies are the biotic and abiotic. The biotic factor includes plants and plant parts. Plants are the food of the larvae and the flowers which provide nectar to the adult butterfly. This also maintains habitat of this insect. The abiotic factor arises from the non-living environment and comprises climatic, geographical gradients and local influences. Climate depends largely upon the latitude and the altitude and is determined by the temperature, humidity, rainfall, wind pressure, light etc.

According to Mani (1968), each environmental factor provide a minimum threshold level below which the organism can not exist. The affecting factors to the optimum level results in the highest density of population and beyond a maximum again existence possibility is lost. The length between these two extreme conditions, within which lies the existence potentiality of the species is called the ecological valence.

Temperature is considered as an important abiotic factor that influences butterflies directly in a variety of ways but also influences them indirectly through climatic conditions such as rainfall, atmospheric pressure, wind, food, humidity, growth of vegetation etc. In butterflies, the loss of heat from the body and absorption of heat are influenced by the surroundings as the physiological activities depend upon the external temperature. All the metabolic activities in different stages of development of butterflies depend on ambient temperature. The sum total of the metabolic activities including life cycles are influenced with the change in the temperature regime (Mani 1986).

It also brings about seasonal variation and heathy growth of plants that are food for larvae. When optimum temperature is reached in spring, the flowers start blooming thus providing nectars to adult butterflies. So the role of temperature is very significant to distribute butterflies at various places. High mountains, where temperature remain lower than the lowland areas also display some robust species which share their habitats in the warmer climate of the lowland areas. *Pieris brassicae* (Pieirdae), *Lampides boeticus* (Lycaenidae), *Issoria issaea* (Nymphalidae), *Vanessa indica* (Nymphalidae), *Phalanta phalantha* (Nymphalidae), *Aglais cashmirensis* (Nymphalidae), etc. are the best examples of such species. *Parnassius* species which are the native of Himalayas never come down
below 2800 m of elevation. The body feature of this species is adapted to cold climatic condition with the presence of body hairs, densely coated scales on semi-transparent wings and black spots on wings which absorb heat.

The lack of preferable food vegetations for many species of larvae due to unfavorable temperature condition also has controlled to the diversity richness of butterflies in the Himalayan region. In the mid and lowland regions, except in winter, the temperature remains favorable to increase the diversity of butterflies. Likewise, the growth of vegetation under the influence of warmer temperature is more diversified in temperate and tropical regions thus providing preferable foods for diverse species than the Himalayan region.

Temperature plays a vital role in the degree of richness and diversity in butterflies. In species like *Teinopalpus imperialis* (Papilionidae), *Phaedyma aspasia* (Nymphalidae) and *Achillides krishna* (Papilionidae) become abundant in the temperature of May and June, when there is optimum range of temperature prevails that help emergence them from pupal case. When the monsoon rain starts at the end of June, the temperature fluctuates little low which enforces these butterflies to go into hibernation till next May. So temperature can be considered as an important climatic factors to control the distribution of butterflies in different seasons and elevations. According to Manzoor *et al* (2013), temperature directly affects butterflies throughout their life history which make direct or indirect effect on choice of oviposition sites, egg laying rates, larval development and survival rates.

Water is an essential component of every living creature. Water required by insects in most cases is obtained through food. Larvae of butterfly feeding on the succulent tissue of plants, secure a sufficient quantity of water. The availability of water is influenced by amount of preception in the region and rate of evaporation. Many butterflies like Nymphalids, Lycaenids and Papilionids are known to absorb water directly from the wet and moist soil. The bulk of water is lost from the body in most cases through the tracheal system, but considerable quantity is also lost through evaporation from the general body surface of butterfly. The loss of water is influenced by the rate of metabolism and by climatic factors like temperature, humidity, winds and others (Mani, 1968).
The vegetation diversity reaches to the peak in rainy season especially in July and August when the monsoon rain occurs. The diversity of butterflies also increases in this period reaching to maximum of the entire year. In higher elevation little rain and more snow fall occur causing less species diversity of flora which is valued as food for limited larvae. So rainfall has significant role in distributing butterflies at different elevation levels.

Butterflies are day fliers. The morning sun till noon is the best time to watch many butterflies. The species of Satyrids are distributed in shady jungle areas which can be exemplified with *Melanitis leda* and some *Ypthima* species. Similarly *Callerebia* species of the same family prefer moist and shady parts of jungle while *Teinopalpus imperialis* and *Achillides krishna* (Papilionidae) prefer open areas of the dense forest. There are many species which prefer open areas where they receive full intensity of light and therefore species diversity in such areas is more than the forested zone where light penetration is not sufficient. So light has also significant role in the distribution of many butterfly species.

In windy environment less diversity of butterflies can be noticed. Species which are tender and can not tolerate high pressure of wind are absent in windy areas. Some of the Nymphalids like *Vanessa cardui*, and *Issoria issaea* can tolerate high wind pressure while many species of Lycaenids and some Papilionids are totally absent in windy regions.

Butterfly diversity and distribution is correlated to vegetation diversity. Some butterflies are monophagous which feed only a single plant species. The absence of that plant species is lead to the extinction of that dependent butterfly species in the region. Polyphagous species feed upon two or more plant species so they have wider distribution than monophagous species. In low and midland areas, luxurious growth of vegetation provides food choices for many butterfly species. This causes high species diversity in these regions. In highland areas, the impact of temperature, altitude, humidity and rainfall act together for the growth of less floral diversity where larval food choices are less or scare. This has caused less species diversity of butterflies in high land regions as compared to mid and lowland regions.

*Parnassius* are the native Himalayan butterflies which are monophagous and feed upon the plant called *Saxifraga*. This is a small herb which grows above 2800 m of elevation in the Himalayas. So this herb has restricted the distribution of *Parnassius* in that region.
*Pieris brassicae, Pieris canidia* (Pieridae) and *Aglais cashmirensis* are all polyphagous species. Their food choices at higher elevation (3000 m) are different from the lowland plants. So they have wider distribution across tropical to alpine regions.

*Teinopalpus imperialis* (Papilionidae) has its specific food vegetation called *Daphne*. This shrub is distributed mostly at the mid to upper temperate range where this butterfly also has its distribution range (2100-2800 m). So the distribution of vegetation determines the species distribution of butterflies at different elevation levels.

Most butterflies are specifically adapted to definite climatic conditions and vegetation types, therefore they are unable to cross any large unfavorable climatic barriers or absence of suitable vegetations. Most species are unable to overcome the climatic barriers from Tarai to Himalayan zones. Most phytophagous insects are bound to associate with specific groups of plants, so their distribution is severely limited by the distribution of the habitat type and food plants.

Nepal is a country where its geography has displayed a complex physiographic feature from the lowest elevation of 62 m in tropical belt of Jhapa east Nepal to the world’s highest peak, along the Himalayas. Between these gaps a stepwise change in altitude can be noticed. This altitudinal change has created different habitat types for various flora and fauna characteristics of the tropical to the alpine zones. The differing altitudinal pattern has distinctly influenced species distribution of butterflies at the vertical ecosystem ranges. The biophysical gradients follow its changing pattern with increased elevation.

The temperature is warmer in the lowest elevation with sufficient precipitation and favorable humidity which provide luxurious growth of vegetations. Comparatively in the Himalayan region above 4000 m of elevation these gradients show reduced or unfavorable effects with low temperature and less precipitation, arid and dry condition and scarce vegetation growths. Only those species of butterflies which tolerate harsh weather condition survive at this elevation. Different species of *Parnassius* butterflies have adaptive features to cope with this type of climate. The elevation range between 3000 and 4000 m where temperature is lower than the temperate climate display less favorable gradient’s effects on the distribution of butterflies. Mostly coniferous forest with tree species like *Tsuga dumosa*, and Himalayan Laryx are found where butterfly species like *Parnassius* species, *Aglais cashmirensis, Vanessa indica, Issoria issaea, Phalanta*
phalantha, Argyneus hyperbius, etc can be seen frequently. Elevation at 3000 m is more warmer where better forest condition exists. Rhododendron sps, Alnus nepalensis, Quercus sps, Abies spectabilis etc are the popular forest trees of this part. Increase in species diversity of butterflies can also be noticed in this part. Vanessa cardui, Phalanta phalantha, Childrena childreni, Aulocera sps, Kukenthaleilla gemmata, Polyommatus species etc are common butterfly species at this elevation. At 2000 – 3000 m of elevation the influencing gradients are favorable with warmer temperature, good precipitation and favorable humid condition from the spring to the autumn seasons. Alnus nepalensis, Quercus semicarpifolia and Rhododendron forests are dominating in this zone. Good diversity of butterflies can be noticed here. Common butterflies at this elevation are Neptis sps, Dodona ouida, Callaerebia sps, Aulocera sps, Rapala nissa, Delias belladona, Papilio machaon, etc. The subtropical climate occurs at 1000 – 2000m where forests of Quercus semicarpifolia, Castanopsis indica, Schima wallichii and Alnus nepalensis can be noticed. Temperature is favourable at this elevation with humidity and heavy precipitation. This zone represents high diversity of butterflies under prevailing influence of the optimum biophysical gradients. Common species of butterflies at this elevation are Precis almana, Neptis sps, Athyma sps, Sephisa chandra, Danaus limniace, Danaus aglea, Metaporia agathon, Colias fieldii, Colias erate and many species of Lycaenids and Hesperiids.

Lower elevation below 1000m is influenced with tropical climate where high temperature, less humidity and high rain fall occurs. Luxurious growth of vegetations can be found here which provide preferrable host plants for diverse species of butterflies. Popular species at this elevation are Zizeeria maha, Celastrina sps, Freyeria sps, Ramelana jangala, Ancema blanka, Loxura atymnas, Spindasis vulcanus, Leptosia nina, Ixais pyrene, Graphium euros, Graphium nomius, Papilio memnon, and diverse Hesperiid species. Smetacek and Smetacek (2011) made a comparative study of the altitudinal distribution of those Papilioninae species that occured both in the eastern and the western Himalayan ranges. He found ten species which ascended with the latitude, one descended as latitude increased and fourteen species were almost unaffected by latitude. The presence of a suitable larval host plant appeared to be one of the decisive factors governing altitudinal distribution of these species. In four Papilioninae species, the same
subspecies was exclusively colonized entirely in different habitats in different parts of the Himalaya.

So, rise in altitude causes decline in temperature, humidity and rainfall and sum of which affects the good growth of vegetation. The vegetation components are declining at increasing elevations with the display of very few species above 4000 m. These gradients also act on species distribution of butterflies with accommodation of only few species at higher elevation. At this elevation altitude specific species which are not found below 3000 m of elevations can be noticed. These are *Parnassius* sps, *Lycaena phlaeas*, *Kukenthalliell*a sps, *Albulina* sps, *Polyommatus* sps etc.

Rodriguez and Baz (1995) in a study on the effect of elevation on butterfly community in Mediterranean mountain found that the changes in butterfly communities along the altitudinal gradients in Sierra de Javalambre were caused by harshness and environmental conditions, changes in vegetations, and presumably resource impoverishment. According to them high altitude do not seemed to select endemic butterfly fauna. The communities in the lowest elevation were composed of local and localized species while high elevation communities were less original in faunistic composition since they were composed of euryecious and wide spread species in this area.

**Status of Butterflies In Nepal**

Butterflies of Nepal keep special significance due to complexity of physiographical condition where species of different status categories are accommodated. Though the study of butterflies commenced some 150 years before in this country still many parts specially the mountains remain unexplored till date. Lack of sufficient number of expertise is the main challenge to carry out an extensive investigation of butterflies of entire country.

The southern lowland to the higher belt to the north represents several preferable habitats where 650 species (Smith 1989) have been reported so far.

This country has both the Palearctic and Oriental realms. The majority of area is occupied by the Oriental while the Palearctic ecoregion lies above the elevation of 3000m to its
northern boundary. Palearctic species are fewer in number and includes species like *Parnassius epaphus*, *Parnassius acdestis*, *Colias coccandica*, *Colis ladakensis*, *Gonepteryx rhamni*, *Kukenthaleilla mackinnoni*, *Melitea arcasia*, *Vanessa cardui*, *Polygonia agnicola*, *Polyommatus nepalensis* etc. Himalaya specific species recorded inside the country are *Parnassius hardwickei*, *Teinopalpus imperialis*, *Meandrusa gyas*, *Graphium euros*, *Graphium glycerion*, etc. Rest of the species recorded in this country bear the features of the Oriental region.

The lower belt of the country is warm and humid and provides favourable habitats for many butterfly species. Many interesting species distributed within the elevation of 62 m to 1000 m of elevation are *Flos areste*, *Surendra todara*, *Loxura atymnas*, *Spindasis elima*, *Tarucus sps.*, *Cirrochroa tyche*, *Vindula erota*, *Sumalia zayla*, *Lebadea martha*, *Nemetis mekara*, *Mycalesis sps.*, etc.

The subtropical climate within 1000 to 2000m which also touches many mountainous parts display interesting species like *Troides aeacus*, *Troides helena*, *Leptosia nina*, *Delias pasithoe*, *Delias acallis*, *Anaemorpha agostina*, *Charaxes marmax*, *Sephisa chandra*, *Precis sps*, *Mycalesis malsara*, *Orsotrioena medus*, etc.

The temperate bioclimatic zone above 2000m to4000 m of elevation accommodate species like *Colias fieldii*, *Colias erate*, *Lethe insana*, *Dilipa morgiana*, *Hestina nama*, *Euthalia aconthea*, *Neptis nysteus*, *Neptis armandia*, *Neptis ananta*, *Zemeros flegyas*, *Dodona ouida*, *Dodona durga*, *Jamides bochus*, *Heliophorous tamu*, *Heliophorous androcles*, etc.

Elevation above 4000 m is influenced with Himalayan climate where the diversity declines and represents by popular species like *Parnassius* species, *Heliophorous androcles*, *Heliophorous oda*, *Lycaena phlaeas*, *Albulina species*, *Aglais ladakensis*, *Vanessa indica*, *Vanessa cardui*, *Aulocera species*, *Gonepteryx aspasia*, *Colias erate*, *Delias sanaca*, *Esakiozephyrus* species etc.

According to Uniyal and Mathur (1998), the nature of vegetation is the important factor that determines the dependence and survival of butterfly species in a particular area. Being highly sensitive to slight change in environment, they are highly affected by even relatively minor pertuberans in the habitat so much so they have been considered as
indicators of environment quality and also treated as indicators of the health of ecosystem. The presence of butterfly in a certain locality indicates the availability of larval food plant which can be specific with specieswise. The distribution of butterflies thus largely determines by the distribution of their food plants.

The butterfly season in Nepal varies with geographical regions. Generally the butterfly watching season starts after the end of winter. At lower elevations, it starts at the end of March just before the spring commences. Butterflies start appearing at the mid of April in mountain regions. In higher elevation butterflies starts appearing when the snow is melted after the mid of May. July- August is the peak period for species diversity in this country (Khanal and Smith 1997).

Nepal has representations of 11 families of butterflies out of 14 families in the world. The species richness in every family varies from 2 to more than 175 species. This includes, Papilionidae (17 species), Pieridae (49 species), Lycaenidae (176 species), Libytheidae (2 species), Nemeobiidae (10 species), Acreidae (2 species), Nymphalidae (118 species), Amathusiidae (5 species), Satyridae (82 species), Danaidae (15 species) and Hesperiidae (107 species) (Smith 1989).

One hundred and forty two species of butterflies are included into the Red Data Book of IUCN Nepal (BPP 1995). Similarly, three species like Teinopalpus imperialis, Troides aeacus and Troides helena are placed under Appendix II of the CITES Category.

Diagora nicevillei, a Nymphalid, appears in May to June at 1575 m to 2121 m in Lalitpur district of Central Nepal, the only habitat so far known, has not been reported for the last 10 years. This has been said to be the rarest butterfly in the world (Smith 1989). This species besides Nepal, has also been reported in Mussoorie and Dalhousie of India

Though study on butterflies of Nepal was initiated in1826 (Smith 1989) and was based only on the taxonomical and distributional works and no study was made specially on the biophysical gradients and their role on distributing this insect. Being an indicator of the forest ecosystems, a butterfly exclusively depends upon its food plants (Uniyal and Mathur, 1998). So this study has made its linkage to the biotic and abiotic factors and their controlling effects for species diversity at the altitudinal habitats of the six interconnected districts of central Nepal.