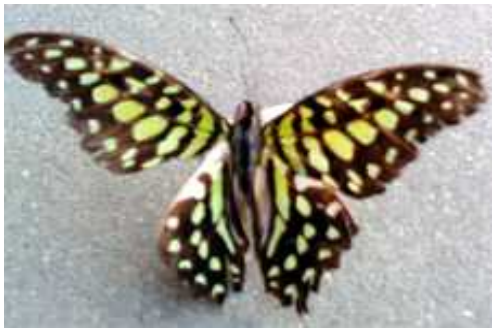
BIODIVERSITY OF BUTTERFLIES IN BADIKHEL VDC, LALITPUR



A DISSERTATION SUBMITTED TO

CENTRAL DEPARTMENT OF ZOOLOGY (ENTOMOLOGY),

TRIBHUVAN UNIVERSITY

KIRTIPUR, KATHMANDU

FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR MASTER'S DEGREE OF SCIENCE IN ZOOLOGY

BY

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FEBRUARY, 2010

CENTRAL DEPARTMENT OF ZOOLOGY

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RECOMMENDATION

It is recommended that Ms. Pragya Chalise has completed her dissertation work entitled **"Biodiversity of butterflies in Badikhel VDC, Lalitpur"** as a partial fulfillment of M.Sc. in Zoology under my supervision.

I recommend that the dissertation be accepted for the partial fulfillment of the requirements of Degree of Masters of Science in Zoology (Entomology).

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LETTER OF APPROVAL

On the recommendation of supervisor, Prof. Dr. Ananda Shova Tamrakar, Tribhuvan University, this dissertation of Ms. Pragya Chalise entitled **"Biodiversity of butterfies in Badikhel VDC, Lalitpur"** is approved for examination and submitted to Tribhuvan University for the partial fulfillment of the requirement for M.Sc. Degree in Zoology.

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APPROVAL

This is to certify that dissertation entitled "**Biodiversity of Butterflies in Badikhel VDC, Lalitpur"** by Ms. Pragya Chalise has been accepted on the recommendation of supervisor Asst. Prof. Bhaiya Khanal for the Examination and submitted to the Tribhuvan University in the partial fulfillment of the requirements for the Masters Degree of Science in Zoology (Entomology).

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DECLARATION

I hereby declare that the dissertation entitled **"Bio-diversity of Butterflies in Badikhel VDC, Lalitpur"** is submitted to Tribhuvan University, Department of Zoology, under the supervision of Assoc. Prof. Bhaiya Khanal.

The following thesis has not been submitted to any other University than Tribhuvan University, Kirtipur, Nepal. The work presented here is that of the researcher.

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ABSTRACT

The Bio-diversity of Butterfly of Badikhel VDC was observed during the period of three month - Pre-Monsoon (April-May, 2009), monsoon (June-July, 2009). Altogether 75 species of butterflies belonging to fifty-one genus and 9 families were collected.

For the collection, sweeping insect net and forceps were used and after collection, they were killed and kept in paper envelop. Their wings and body were set by keeping them in the spreading board by pinning. Later the specimens were brought to the lab and identified.

Nymphalidae was the most dominant and species rich family. On the other hand Acraeidae was the least dominant. Among the 75 species collected or observed, 167 individuals belonging 63 species of family Nymphalidae were observed during Pre-Monsoon, 70 individuals belonging to 34 species during monsoon and 197 from 55 species during post-monsoon season. The Family Acraeidae was represented by single species having 15 individuals during Pre-monsoon and 16 during Post-monsoon. Among the rest of the families, Nymphalidae was followed by Satyridae; (151, 5, and 193), Pieridae (120, 54 and 115), Papilionidae (85, 26, 88), Hesperiidae (65, 46 and 48), Danaidae (70, 18 and 28), Lycaenidae (44, 4 and 48) and Acraeidae (15, 0, and 16;) having species richness in decreasing order. The massive forest fire during May owes to the relatively low number of butterflies during Monsoon.

Among 75 species of butterflies collected sixty species were ranked as "common" seven species were ranked "rare", two "getting rare", two vary "rare" and one CITES listed species. The area was observed to be a potential site for CITES listed species Troides aceacus, rare species like Caltoris tulsii, Hebomoia glaucippe, Mycalesis heri, Ypthima avanta, Precis atlites , Symbrenthia niphanda, Neptis spp.,vry rare species like Tanaecia lepidea and Phaedyma aspasia kathmandia. Graphium agamemnon and Cyrestis thyodamus; which was recorded as common species during 1997; reported to be getting rare at present.

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ABBREVIATIONS AND ACRONYMS

% = Percentage

CDZ = Central Department of Zoology

CFUGs= Community Forest User Groups

Cu. Ft. = Cubic feet

DSF= Dry Season Form

IUCN= International Union for Conservation of Nature and Natural resources

JBNHS= Journal of Bombay Natural History Society

MAP= Medicinal and Aromatic Plants

NHM= Natural History Museum, Nepal

NTFPs= Non- Timber Forest Products

THH= Total Households

Ton.= Tonnes

VDC= Village Development Committee

WSF= Wet Season Form

CHAPTER 1
INTRODUCTION

1.1 Background

Biodiversity can be looked upon as the number and variation of living organism in any unit time at a particular area. It is also known as species diversity- the number of species present in a particular habitat.

Nepal has a complex biogeography due to its past geological history as it is present at the crossroads of two bio-geographic realms, Palaearctic and Palaeotropic and two major zoogeographic kingdoms, Palaearctic in the north and Indo-Malayan in the south (NBRB, 2007). Situated in the southern Himalayan flank, Nepal is roughly rectangular in shape with a total area of approx. 147,181 km^2. Twenty-nine percent of the total area is covered by forests, 22% by shrub-land and pastureland, 20% area is cultivated land, and the remaining 29% land is non-cultivated mountain, settlements and river areas. Stainton (1972) recognizes following six main geographical divisions in Nepal while describing the vegetation types: a. Terai Bhabar, Dun valleys and outer foothills; b) the midland areas and southern sides of the main Himalayan ranges; c) the Humla-Jumla area in the north-west; d) dry river valleys; e) inner valleys; f) the arid zones with much of the character of Tibetan Plateau. For describing Vegetation, Dobremez (1872) divided Nepal into six bio-climatic zones or belts with 11 subzones:

- Tropical belt (up to 1000 m altitude): Lower up to 500 m, and Upper 500-1000 m.
- Subtropical belt (1000-2000 m): Lower, 1000-1500 m and Upper, 1500-2000 m.
- Temperate belt (2000-3000 m): Collinean, 2000-2500 m and Montane, 2500-3000 m.
- Sub-alpine belt (3000-4000 m): Lower, 3000-3500 m and Upper, 3500-4000 m.
- Alpine belt (4000-5000 m): Lower, 4000-4500 m and Upper, 4500-5000 m.
- Nival belt (above 5000 m) (FAO/MFSC, Country Report, 2010).

Phulchoki is much popular as a historical place in the past. It has been explained as religious and sacred place for Hindus and was earlier known as *phulocha.* It is a part of lesser Himalaya and a place of natural area of idyllic ecosystem in the mid-hills of Nepal. It is the highest peak around the Kathmandu valley attaining the height of 2715 m from the sea level. It is located at south-west corner of the valley- 16 km from the central city. The central forest area (Naudhara community forest) covers an area of 147 hectares approx while the total area of forest is 1005.32 ha including the National forest. It lies between 27°22' N and 27°36' N and 85°22' to 85°26' E and covers an area of 50 km^2. The steepness of the northwest forest slope is 15-50°. It is well-known for plant species *Nepeta phulchowkians* which is present only on the area and named after this place. Over 80% of total rainfall is encountered in the form of intermittent Monsoon showers. It is more humid and cooler than the valley (DMP Bulletin, 1974, 1986).

The slope on Phulchoki is steep and cross drainage has dissected the area to form ravines and gullies. Marine fossiliferous rocks of Silurian age have been recorded from the hill. It is syncline and contains calcareous rocks in southern part an also areas near peak. However the northern part from middle of the slope to the top consists of argillaceous and siliceous rock and calcareous rock are exposed near the northern base of the hill. The calcareous group near peak has lead and traces of zinc. The middle part of hill consists of ferruginous rock and large deposits of hematite ores. Many tilted block of metamorphosed limestone which form marble deposits of considerable size abound the base (DMP Bulletin, 1974, 1986). Phulchoki continues forward as Badikhel; the adjoining hill sharing similar Geographic features, Vegetation and Fauna.

1.2 Ecology of study area

With a total population of Five thousand, six hundred and twenty two, the Godavari area embodies five hundred seventy-eight households (THHs). The Phulchoki area includes 4 Community Forest User Groups (CFUGs). Out of 1005.32 hectares of total forest area, 777.32 hectares of forest at the base is managed by CFUG while remaining 228 hectares at top is the National Forest managed by the government (DFO Lalitpur, Annual Report, 2009).

Badikhel area covers an area of 5 km^2 and is located 15 km from the central city**.** The community forest, it embraces, is run by five CFUGs in Badikhel. This area includes five hundred, seventy-nine households with a total population of three thousand, two hundred and twelve. Badikhel embraces 267 ha of agricultural land, 320 ha of shrub-land and 5 ha of rocky and river covered area. The most consumed non-timber forest product on the area is resin. The Brahmin community on the area depends mostly on the agriculture for their living while the Pahari community depends on bamboo handicrafts for their living. Thus it seems that bamboo plantation is the best option to uplift economic standard of the people (DFO Lalitpur, Annual Report, 2009).

The climate on the area is typical monsoon type with rainy summer and dry winter. Over 80% of total rainfall is encountered during early June to late September while only few specks of monsoon rain is encountered during winter (Jan-Feb). The total deviation in rainfall compared to the valley can be attributed to the favorable arrangement of folds of Phulchoki Mountain for bringing down more precipitation down to Godavari. The climate of Godavari area can be subdivided into three major types:

- **Pre-Monsoon period** starts during March and ends in May. This period has usually hazy atmosphere with dusty winds in its initial phase and the later part is characterized by more precipitation.
- **Monsoon period** falls under a period of June-July and characterized by the appearance of monsoon clouds. The major amount of precipitation is received during this period.

Post-Monsoon falls under September to November and characterized by sunny dry climate with gradual decrease in rainfall and temperature (DMP Bulletin, 1974, 1986).

The temperature and rainfall on a particular area play a major role in shaping up butterfly diversity. The temperature and rainfall at Godavari over past five years is listed below:

Latitude: 27°35' Longitude: 85°24'
Elevation: 1400 m

Table I. Rainfall in mm for Godavari from 2004-2008

YEAR	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
2004	33.5	1.5	5.5	71.8	176.7	149.5	577.2	262.1	154.4	114.7	5.2	0.0
2005	72.6	14.5	39.6	88.0	89.1	221.9	272.7	381.5	141.6	117.5	0.0	0.0
2006	0.0	0.0	24.4	88.9	163.9	272.0	285.8	321.2	249.2	23.1	1.5	24.8
2007	0.0	94.3	48.4	78.7	169.2	221.3	398.2	386.5	491.5	45.3	0.0	0.0
2008	7.1	1.0	20.7	55.4	121.5	482.4	349.6	346.4	266.7	22.3	0.0	7.9

Table II. Temperature in °C from 2004-2008

Year →	2004		2005		2006		2007		2008	
Month ↓	T_{max}	T_{min}	T_{max}	T_{min}	T_{max}	T_{min}	T_{max}	T_{min}	T_{max}	T_{min}
Jan	15.3	2.9	15.0	3.4	20.2	3.1	16.3	2.8	16.5	2.9
Feb.	18.6	4.7	19.7	5.1	21.3	8.2	16.1	4.8	17.6	3.6
Mar.	24.5	10.2	22.4	9.1	23.0	8.0	21.3	7.7	22.6	8.8
Apr.	25.0	12.4	26.5	10.9	24.5	11.2	25.7	12.8	26.3	11.6
May	26.6	15.2	26.1	13.2	26.0	15.6	27.1	15.4	25.4	13.7
June	26.6	17.3	27.9	17.7	26.8	17.4	26.8	17.7	26.0	18.1
July	25.0	18.7	25.7	18.8	26.2	19.0	25.3	18.9	25.7	18.7
Aug.	25.9	18.8	25.4	18.9	25.8	18.4	25.6	18.8	25.6	18.7
Sep.	25.0	17.4	26.7	17.5	24.6	17.0	26.0	17.5	26.1	16.8
Oct.	22.2	11.7	23.7	12.3	23.8	12.2	23.7	13.3	24.2	12.0
Nov.	19.1	7.0	20.2	7.2	20.4	7.9	20.2	7.6	21.8	8.0
Dec.	16.5	4.5	18.4	3.4	18.3	4.5	17.8	3.4	18.6	5.4

1.3 Vegetation Types

The flora of Kathmandu Valley is represented by 1500 vascular plant species, which is about 21% of the Nepal Flora. Thus the bio-diversity of Kathmandu Valley is very rich. At the same time, Kathmandu Valley is loosing some 18 orchids and 6 fern species due to fast urbanization, deforestation, environmental degradation and other human impacts. The study shows that 7.3% of the Kathmandu Valley flora is: 3% threatened, 2.2% rare, 1.4% endangered and 0.7 % vulnerable, so there has been a necessity to conserve flora of Kathmandu Valley

(FAO/MFSC, Country Report, 2010). For this, it is necessary to realize the appropriate policy, legislation, institutional building, and manpower support, for conservation activities and mobilizing NGOs and local people. Due to the high concentration of endangered, threatened and rare plant species in the Phulchoki and Godawari area, the area should be declared as a conservation area immediately in order to stop further degradation of valuable flora, for future generations and to maintain the ecological balance of Kathmandu Valley. The area harbors three distinct evergreen broadleaved forests at north facing slope: mixed forest of *Schima wallichii* and *Castonopsis indica* and *Castonopsis tribuloides* species at 1500 to 1800 m, Oak (*Quercus* spp.) – laurel and Rhododendron forest at 1800-2000 m and evergreen oak forest (*Quercus semecarpifolia*) above 2000 m while only two at south facing slope including Oak-Rhododendron forest at 2090-2500 m and pure *Quercus semecarpifolia* forest above 2501 m (Uprety and Ghimire, 1982).The vegetation prevalent on this area plays a major role in shaping up Biodiversity of certain area.

The Badikhel area harbors luxurious and diversified vegetation. The forest area covers 532 ha of the total area with 356 ha of mixed hardwood forest and 176 hectares of broad leaf-conifers. About 252.09 hectares of the total forest area is occupied by the community forest while the rest is the national forest. The major source of water for the area is monsoon rainfall and Kodku River located at the lap of the Badikhel hill. The majority of the household in the community are dependent on firewood fuel. The major vegetation encountered in 4 of the community forest includes Khote Salla (*Pinus roxburghii*) and two of them include *Castonopsis, Schima wallichii* and *Alnus nepalensis*. The area also harbors some important medicinal plants like Dhasingare, Timur, Chutro (*Berberis asiatica*), different species of lichen, Tejpat, Kukurdaino, Nundhiki, Ghodtapre (*Centella asiatica, Hydrocotyle sibthorpioides*), Thackel (*Cirsium* spp), etc (DFO Lalitpur, Annual Report,2009).

Table III. Forest Product Consumption Rate

Consumption within the Group			Sale outside the Group		
Timber (Cu. Ft.)	Firewood (ton.)	Others (MAPs/NTFPs) (kg)	Timber (Cu. Ft.)	Firewood (ton.)	Others (MAPs/NTFPs) (kg)
2227	11851	500	-	-	4990

*MAPs-Medicinal and Aromatic Plants, NTFPs-Non-Timber Forest Product

*Source: DFO Lalitpur, Annual Report, 2009.

Table IV. VDC-wise Forest Resource Income Flow

	Income Flow within the Group			Income Flow outside the Group		
	Timber (Rs.)	Firewood (Rs.)	Others (MAPs/NTFPs)(Rs.)	Govt. Share (Rs.)	VAT (Rs.)	Total(Rs.)
Badikhel	77,354	10,690	25,950	-	2495	116,489
Phulchoki	-	19,711	-	-	-	19,711

*Source: (DFO Lalitpur, Annual Report, 2009).

The physiographic data shows that Nepal embraces 4.7 million hectares (29% of total land area) of forest area. The forest covers in terai and hills is reported to have decreased at an annual rate of 1.3% and 2.3% respectively between 1978/79 and 1990/91 (NBRB, 2007). Forest land data of the past shows that forest area in Nepal has declined from 45% in 1964 to 29% in 1996. Currently, the annual deforestation rate in Nepal is estimated at 1.7%, excluding community forests, which is about one fourth of the total forest land of the country, (FAO/MFSC, Country Report, 2010). Similarly, the total growing stock of forests has declined from 522 million m^3, in the mid 1980 to 387.5 million m^3 in 1999 (FAO/MFSC, Country Report, 2010).

1.4 Fauna of Badikhel

Phulchoki as well as Badikhel area is rich in its faunal diversity. It is well known site for bird watching, butterfly tour and observation of flora and fauna on the area. The fauna recorded from the area and reported by the local residents consists of Leopard Cat (*Felis bengalensis),* Barking Deer (*Muntiacus muntjak*), Chittal (*Axis axis*), Yellow Throated Martin, Common Leopard (*Panthera parades)*, Himalayan Black Bear (*Ursus thibetanus*), Common Indian Hare (*Lepus nigricolis),* Flying Squirrel (*Pteropus giganticus*), etc (Chalise, 2000/01, NBRB, 2007). BCN has declared Phulchoki as important bird site and 300 species of birds are present on the area. The valley is known for its faunal and floral expeditions as early as 1793 (NBRB, 2007). An estimated 550 species of birds are found inside Kathmandu Valley. Phulchoki area is alone home to 265 species; Godavari has a total of 100 species. Some significant bird species found includes Barred Cuckoo Dove (*Macropygia unchall*), Oriental turtle dove (*Streptopelia chinensis*), Peregrine Falcon (*Falco peregrines*), Dark Kites (*Milvus migrans*), Nepal kalij pheasant (*Lophura leucomelanos*), different species of Drongo (*Dicrurus* spp), Red Billed Blue-Magpie (*Urocissa erythrorhyncha),* Asian Koel (*Eudynamys scolopacea),* Endemic Spiny Babbler (*Turdoides nepalensis), etc* (Inskipp *et al*,2000).

1.5 Butterfly of Nepal

Insect diversity is largely affected by various ecological factors. It is observed that for an increase in 100 m in altitude, there is a decline of 1° C in temperature. Each altitudinal gradient corresponds to the change in temperature which in turn affects the vegetation and habitat pattern shaping up the distributional pattern of different species of butterfly. Biodiversity Profile of Nepal (1996) has recorded 635 species of butterfly in Nepal among which 4 species and 5 subspecies are possibly endemic. 656 species of butterfly were subsequently recorded in 1998 (Thapa, 1998). The current list includes 651 species (NBRB, 2007).

The environmental events also cause minor but well marked differences in size, coloration, seasonal variation, as well as distribution of local butterfly population. Different butterflies have been found to appear in four recognized season as explained below (Smith, 1989):

- **Spring butterflies**: The season of these butterflies start in early March in Terai but in early April in Kathmandu
- **Pre-Monsoon butterflies**: The season of these butterflies start in May in Terai but in early June in Kathmandu
- **Post-Monsoon butterflies**: The seasons of these butterflies start in early July in Terai but in late August in Kathmandu
- **Summer butterflies**: The seasons of these butterflies start in early September in Kathmandu but between October and November in lower altitude (Pokhara).

Nepal houses an excellent representation of butterflies found both Oriental and Palaearctic realms. It comprises only 0.1% of the land area on a global scale; it supports disproportionately rich diversity of flora and fauna at genetic, species and ecosystem level including about 3.72% of globally known butterflies (651 spp) (NBRB, 2007). All these species are categorized under 11 families of the existing 15 families in the world. The great species richness in Nepal becomes apparent from its great bioclimatic variation from tropical and subtropical zone to the Tundra and the arctic zone (Thapa, 1998). The monsoon climate and huge altitudinal range found here create a wide array of habitats, from the lowland (as low as 67m above mean sea level), Evergreen Tropical Forests in the terai and low hills (below 1000m) through Temperate Broadleaved and Coniferous Forests to the tree line. Above this, Rhododendron Scrubland extends up to the high alpine meadows before plant life gives way to the frozen and biologically barren snow capped peaks including Mount Everest (8848m)(NBRB, 2007). Distribution patterns of Nepalese butterflies are varied with respect to physiographic zones which include 51.2% (325 spp.) in Terai and Siwalik zone, 87.7% (557 spp.) in mid hills and 12.9% (82 spp.) in the highlands of the country (NBRB, 2007). The Red Data Book of the Fauna of Nepal (BPP, 1996) listed 142 species of which 12 were endangered, 43 vulnerable and the remaining 87 species susceptible to becoming threatened in the future. About 29 species and subspecies have been found endemic to the country.

Butterflies have been found thriving at the maximum altitudinal level of 5500 meters in the Himalayas. *Parnassius acdestis* (Sikkim Banded Apollo), *Aglais ladakensis* (Ladak Tortoise Shell) and *Pontia sherpae* (Sherpa White) exist in such a high level of altitude in the West Himalayas. *Parnassius* species (Apollo) are confined above 2800 meters of elevation stretching from east to the west Himalayas. Speciation has been found high among the Himalayan species.

Mid mountain region is the meeting point both for the Palaearctic and oriental species. The notable and rare species found in this part include *Teinopalpus imperialis* (Kaiser-I –Hind), *Papilio krishna* (Krishna Peacock) and many other species (Khanal and Smith, 1997).

Table V. Distribution of Butterflies in different regions of Nepal

Group Name	**Terai and Siwaliks**		**Midhills**		**Highlands**	
	Spp.	Percentage	Spp.	Percentage	Spp.	Percentage
Butterflies	325	51.2	557	87.7	82	12.9

*Source: Nepal nature.com

The best season to watch butterflies around the Kathmandu valley is from April to September. It is also observed that wet season forms are more colorful with pronounced ocelli than the dry season forms; the latter being dull and leaf-like. Most of the butterflies are forest dwellers except for few families.

1.6 Butterfly of Phulchoki/Godavari

Within the Kathmandu Valley, the climate is quite mild with day temperatures reaching 18°C in mid-winter. There are butterflies all the year round. The best seasons for butterfly watching are late March/April, mid May/ mid June, late August/September. There are forested areas in the valley which are still remarkable places for butterflies, and they include open country near Chobar Swayambhu; the base of the hills and forest streams at Godavari, Nagarjun, Budhanilkantha and Sundarijal; the forested hilltops of Phulchoki, Jamachowk and Shivapuri, and the open scrubby bush areas of Nagarkot, Suryavinyak and Chandragiri. There is very little activity except for the very common Oriental Species, with the distribution of butterflies in Nepal being quite specific with about 10% of the butterflies being Palaearctic species above 3,000 metres, and about 90% Oriental species below the altitude (Khanal and Smith, 1997).

The valley floor of Kathmandu and its surrounding mountains are remarkable and display more than 360 species of butterflies having different status level. *Teinopalpus imperialis*, *Papilio krishna*, *Diagora nicevillei*, *Troides aeacus* etc. are the notable species found in Kathmandu. The southern part stretching from Godavari to the Phulchoki can be considered to be one of the most potential sites for the butterflies of Nepal. This area is home to 300 species of butterflies. There are about 20 Kathmandu Valley species on the endangered or vulnerable list (Khanal and Smith, 1997).

Four very attractive butterflies of Kathmandu that are under this threat level include *Teinopalpus imperialis*, *Meandrausa gyas*, *Papilio krishna* and *Euripus consimilis* that inhabits phulchoki. Similarly *Phaedyma aspasia kathmandia* is the endemic subspecies reported from Godavari. Species like *Amblopala avadiena nepalica*, is the next endemic subspecies reported from the Nagarjun forest of the northwest Kathmandu (Khanal and Smith, 1997).

1.7 Impact of Marble Factory and Deforestation

Fifty-six species of mammals (31% of the total reported species), 226 species of birds (27%), 25 species of reptiles (25%), nine species of amphibians (21%), 35 species of fishes (19%), and 142 species of butterflies (22%) are believed to be vulnerable through habitat destruction (NBS, 2002).The biological diversity is in gradual loss mainly due to unsustainable utilization and inappropriate land uses. Changes in ecosystem characteristics and species composition, loss, degradation and fragmentation of habitats, deforestation, overgrazing in rangelands, overexploitation, poaching, inappropriate farming system, invasion of alien species (e.g. *Mikania* sp., *Lantana camara*, *Parthenium hysterophorus*) and the loss and/or erosion of genetic resources for various use values are the major causes of loss and/or degradation of

biodiversity in the country (NBS, 2002). The continuous human encroachment on the area either in the form of marble extraction or illicit felling of trees have been the root cause of biodiversity loss in Phulchoki and Badikhel region as well.

It is estimated that more than 70% of all animal species on earth are insects, but less than 0.1% of these have been assessed for threatened status. The large, brightly colored Kaiser-e-hind is one of the 557 insect species included in IUCN's Red list of threatened species (IUCN, 2001). This butterfly living in one of Nepal's most diverse ecosystems is threatened by limestone mining activities of Godavari Marble Industry. The quarries that feed the marble factory have destroyed the lower slopes of Phulchoki mountain, and the factory has polluted the district`s air and water.

E-LAW partners at the Forum for Protection of Public Interest (Pro Public) in Nepal have filed suit against the marble company to protect the forests from further degradation. Pro Public`s efforts to defend Godavari began in 1989. On behalf of LEADERS, a local NGO, Pro Public lawyers presented a writ petition against Godavari Marble Industry, the Ministry of Industry, and others, calling for closure of the marble factory. In October, 1995, the Supreme Court of Nepal issued an important judgment holding that the right to life includes the right to a healthy environment, and that public interest environmental organizations, such as LEADERS, have the right to go to court.

Despite this landmark ruling, the Supreme Court of Nepal did not order closure of the Godavari marble factory. Although the Court recognized that effective mitigation and corrective measures for environmental conservation had not been taken, this was not in clear violation of any Nepalese legislation. The Supreme Court issued advisory directives to the Ministry of Industry, Cabinet Secretariat, and others to enact legislation for the conservation of air, water, and the environment. Earlier this year, the government of Nepal renewed the Godavari Marble Industry`s lease.

In April, 2002, Pro Public filed suit again, arguing that the decision to renew the lease violates Nepal`s new Environmental Protection Act as well as new Supreme Court directives to protect the ecologically-sensitive Godavari area. They have called on the E-LAW network for information about the impacts of limestone mining. E-LAW U.S. scientists provided information on the environmental impacts of limestone mining in ecologically significant regions, including several case studies from India. Advocates at Pro Public hope to convince the Court that the damage caused by the limestone quarrying exceeds the economic benefits. They hope the Godavari area will be designated a protected area so that its rich biodiversity can be enjoyed by generations to come (Khanal, Pers. Comm., 2010).

1.8 Impact of Climate Change

The human has a continuous persistent influence on the nature. A continental decline in precipitation in highly polluted and industrialized regions can be attributed to an increase in atmospheric particulate matter that inhibits raindrop nucleation (Rosenfield, 2001). Most

significantly, the global climate has been changing as a result of increasing green house gas emissions since the beginning of industrial revolution. The potential negative consequences of shifts in temperature, precipitation and seasonality are sweeping and might easily become catastrophic over the next several decades. Many reviews of climate change theory and its possible biological consequences are available (Menendez, et. al, 2006; Thomas, 2005).

Butterflies and climate are inexorably linked. Regional shift in butterfly habitat observed over the world offer strong circumstantial evidence that climate change is already affecting butterflies too. It is observed that some species of butterflies are found at upper level than their previous records. Common grass yellow, *Eurema hecabe* previously reported within an altitudinal range of 4400-7400 ft has now ascend 50 metres up as recorded at the study area. Due to increase in temperature, some species are reported till November-December and few towards the mid-January viz., *Precis almana, Argyneus hyperbius, Phalanta phalanta, Pieris brassica*, and few lycaenids (Khanal and Smith, 2007).

Increase in Temperature has profound effect on shaping up biodiversity of butterfly on a particular area. Temperature increase often increases the rate of metabolism as a result there is early appearance and completion of life cycle. Most studies have concluded that insect pests will generally become more abundant as temperature increase, through a number of inter-related processes, including range extensions and phenological changes, as well as increased rates of population development, growth, and migration and over-wintering (Palikhe, 2007). Researchers have found that insect species that adapt to warmer climates also will increase their maximum rates of population growth, meaning that global warming will likely lead to increased insect populations (Palikhe, 2007). Climate change may bring new opportunities (e.g. new crop options), but also will pose new risks and challenges for farmers specifically

- Invasive insect, disease and weed pests are likely to benefit most from climate change, leading to increased pesticide and herbicide use;
- Reductions in biodiversity are likely, because climate change will tend to favor aggressive invasive at the expense of endangered species that are poor at migrating and adapting to change (Palikhe, 2007).

1.9 Seasonal Variation

Some butterfly species have environmentally induced alternative seasonal forms known as seasonal polyphenism. Short-lived butterflies with multiple generations per year usually experience different habitat conditions in successive generations, strongly influenced by seasonal climatic trends. Seasonal changes faced by different generations may include changes in ambient temperature and day-length, differential availability of secure resting places, nectar plants for adults and larval host plants, and a different set of predators and predation risk. Typically, butterflies respond to such seasonally varying biotic and abiotic conditions in two ways:

- The first is to lower reproduction under unfavorable conditions, causing pronounced seasonal population fluctuations even in many tropical species; to diapause during unfavorable seasons, a strategy that is especially ubiquitous in temperate areas.
- The second response is seasonal polyphenism, i.e. the occurrence of environmentally induced seasonal forms that show striking dissimilarity in coloration and wing patterns to each other. Several environmental cues may produce these seasonal forms: photoperiod, ambient temperature and rainfall (Tiple *et al*, 2009).

Seasonal polyphenism is common among certain butterflies in our country affected by South-West Monsoon especially belonging to families Nymphalidae, Satyridae and Pieridae. It is also well marked due to effect of climate on pupa and larva and of the vegetation on which larva feeds. In some species, it seems likely that the characteristics have been inherited from ages past and persists though the original causes have disappeared (Talbot, 1947). These populations show distinct dry and wet season forms occurring simultaneously. The wet season form is mostly invariable, brightly colored with distinct bands and spots forming distinct wing color pattern. On the other hand, the dry season form (DSF) shows considerable individual variation in coloration and pattern, especially in the extent of light coloration and indistinct spots and band pattern on the wings (Tiple *et al*, 2009). Few satyrids like *Melanitis, Mycalesis,* etc exhibits two sharply differentiated broods in which dry season form resembles a dead leaf (e.g., *Kallima inachus)* whilst that of wet season form shows conspicuous ocelli and striated or freckled markings. In some species like *Eurema, Melanitis leda,* etc, the extreme dry and wet season form are interlinked by a series of intermediate variations (Talbot, 1947).

One remarkable feature of the seasonal polyphenism is that the wet season form shows very little wing pattern variation whereas the DSF shows substantial individual variation in the extent and form of various wing pattern elements on the underside. Several non-exclusive or sometimes complementary hypotheses have been proposed to explain seasonal polyphenism in butterflies: (1) seasonal forms optimize thermoregulation in response to changes in thermal conditions across seasons, (2) predation pressure varies across seasons and the seasonal forms are best suited to match background coloration and thus enable escape from predation in the respective seasons in which they occur, and (3) seasonal polyphenism in some butterflies may have evolved in different selective environments, but persists as a by-product of dispersal and phylogenetic relationships (Tiple *et al*, 2009).

CHAPTER 2
OBJECTIVES

The current study has been carried out for the partial fulfillment of Masters Degree in Zoology (Entomology). The status and biodiversity analysis of the area so close to the capital has not been carried out so far. The species diversity of butterflies has not been carried out till date and thus this study will put a light upon the distribution and conservation status of different species of butterfly on the area.

Conservationists estimate that 50–90 % of the existing insect species on Earth have still to be discovered, yet the named insects alone comprise more than half of all known species of organism. With such poor baseline knowledge, monitoring change in insect diversity poses a formidable challenge to scientists and most attempts to generalize involve large extrapolations from a few well-studied taxa. Butterflies are often the only group for which accurate measures of change can be obtained (Thomas, 2005). The specific objectives of the study are:

- To explore species diversity and the analysis of the habitat types.
- To collect, identify and enumerate the existing butterfly species of the area
- To assess prevailing threats and conservation status of butterflies in the Badikhel area
- To explore the seasonal variation of different species of the butterfly.

CHAPTER 3
LITERATURE REVIEW

Literature review forms the basic part of all research. It aims at reviewing the critical points of current knowledge and or methodological approaches on a particular topic. The literature pertaining to present investigation entitled "Biodiversity of Butterflies in Badikhel VDC, Lalitpur" has been reviewed under the following sub-headings.

3.1 Status outside Nepal

About seventeen thousand five hundred species of butterflies have been estimated to exist in the world (NBRB, 2007). Several authors however have produced single-volume books illustrating a fairly representative selection of the world's butterflies. These are of little value for identification purposes, but offer an interesting overall coverage of the endangered and common species, and make an excellent gift to a newcomer to butterfly-watching, acting as a stimulus for further investigation. In 1973, Lewis published "Butterflies of the World" illustrating 7000 species of Butterfly present globally. It also includes the skippers; however it covers many species not depicted in other works and contains an outdated nomenclature. In 1975, Smart published "Encyclopedia of the Butterfly World" illustrating 2000 species and covering all aspects of butterfly biology. In 2001, d' Abrera has published "Concise Atlas of Butterflies of the World" that covers several thousand species from all regions of the world, excluding Skippers. This book also deals with anatomy, taxonomy and controversial counterrevolutionary arguments. In 2006, he again publishes "World Butterflies", a paperback version of the previous book depicting a general overview of the world's butterflies. In 2000, Braby has published "Butterflies of Australia" and covers the entire biology, identification and distribution of all Australian species.

The study rewinds as early as 1939 and 1945 when Talbot gives an elaborative account of butterflies in his "Fauna of British India"; which forms an important landmark to the development of study and conservation of butterflies in SE Asia. In 1992, Isaac Kehimkar describes 735 species of butterflies occurring in Indian subcontinent. The book deals not only in the biology and identification of butterflies, but also has sections on butterfly watching and photography, and even guides the readers to plan their own butterfly garden. In 1996, he again published "Identification Manual for Indian Wildlife-Butterflies Section" which was published by Ministry of Environment & Forests / World Wide Fund for Nature- India. Otsuka also publishes "Field guide to the butterflies of Borneo & south-east Asia" in 2001.

The Journal of the Bombay Natural History Society has become an important publication of scientific papers on Indian sub-continent. In 2006, Kunte reported additions to known larval host plants of Indian butterflies. In 2007, Kalesh and Prakash reported some larval host plants of butterflies of the Western Ghats, Kerala, southern India (Rhopalocera, Lepidoptera): Part 1. In the same volume, Singh reported a new butterfly species of the genus *Ypthima hubner*

(Nymphalidae: Satyrinae) from Garhwal Himalaya, India and it was named later as *Y. kedarnathensis*. Kunte (2008) reported natural history and early stages of the western ghats endemic Golden Flitter *Quedara basiflava* (Hesperiidae, Lepidoptera) from south-western India. In the same volume, he again reported Range extension of the Wavy Maplet *Chersonesia intermedia* (Nymphalidae, Lepidoptera), from Pakke Tiger Reserve, Arunachal Pradesh, India. Shubhalaxmi (2008) reported a new record of Hawkmoth *Sataspes tagalica* f. *hauxwellii* (Lepidoptera: Sphingidae) from Sanjay Gandhi National Park, Mumbai, India. Kunte, Kunhikrishnan, Balakrishnan and Susanth (2008) publishes status and distribution of *Appias lalage* butterfly (Lepidoptera: Pieridae) in the Western Ghats, south-western India. Singh (2009) publishes a checklist of 147 species of butterflies from Kedarnath Musk Deer Reserve, Garhwal Himalaya, India.

In 2009, Paulo Enrique Cardoso Peixoto and Woodruff W. Benson study and report daily activity pattern of two co-occurring tropical satyrine butterflies *Hermeuptychia hermes* (Fabricius) (Leptidoptera: Nymphalidae) and *Paryphthimoides phronius* (Godart) published in Journal of Insect Science.

3.2 Current Status in Nepal

Kathmandu Valley has been studied for butterflies over the last 150 years. A lot of work has been carried out on butterflies in different parts of the world. Among Nepal's fauna, butterflies are the best studied group throughout the country (Smith 1994).

In 1995, 640 species of butterflies were recorded in different ecological zones of Nepal. The Red Data Book of the Fauna of Nepal (BPP, 1995) listed 142 species of which 12 species are endangered, 43 vulnerable and the remaining 87 species susceptible to becoming threatened in the future. Four species and twenty-five subspecies are possibly endemic. There are 325 (51.2%) species of butterflies found in Terai and Siwaliks, 557 (87.7%) species in Mid-hills and 82 (12.9%) species in the Highlands (BPP, 1995). The current list includes 651 species of butterflies and 785 species of moth (NBRB, 2007).

3.3 History of Butterfly study in Nepal

The first known Butterfly collector in Nepal was General Thompson Hardwick who died in 1833. There seems to be absence of enough record where and when he collected; however foreigners weren't allowed outside valley then. 42 species among his total collection of 44 species still flies in the valley. 10 species and 3 subspecies were new to science then. The next collector, Major General Ramsay was a British Resident in Kathmandu (1852-67). *Euploea diocletianus ramsayi*, Magpie Crow, which inhabits Chitwan was named after him. The most notable of his 34 records from the valley includes the magnificent Kaiser-i-Hind. The most important contribution was made by Lieutenant Colonel F.M. Bailey, Resident 1935-38. He adds 134 species to the "Kathmandu" list, including some very rare ones.

After 1950, Collection was done mostly by Japanese or other foreign Scientific Expeditions. Igarashi (1963), a Japanese national was able to observe and draw the picture of immature stages of 16 species of butterflies of Nepal. In particular Fujioka (1963) added another 18 records for the

valley and named three new races there *kurumi* for the Walnut Blue**,** *kathmandia* for the Great Hockeystick Sailer and *hige* for the Pale Forestor**.** He also recorded 263 species of butterflies from Nepal which is reported in the special bulletin of Lepidopterological Society of Japan (Nos. 1, 2).

Smith (1975) recorded 100 genera of common butterflies of Nepal in bulletin series published by NHM, TU. In 1977, he further recorded 8 new species of butterflies from Godavari. He further added 26 more species to the available list of butterflies from eastern Nepal. Shrestha and Smith (1977) studied variation among Nepal's butterfly. In 1978, Smith listed 565 species of butterflies including 21 additional species. In 1980, he reported Spring, Pre- and Post-Monsoon Butterflies from Western Nepal in bulletin series I and IV published by NHM. Finally in 1981, he published "Field Guide to Nepal's Butterflies" listing 200 genera and 480 species in Bulletin series II published by NHM.

Khanal and Bhandari (1982) reported food plants of larvae of eighty species of butterfly. Forty-seven percentages were found to be pests of fodder plants, 42% thriving on commercial plants while 11% on weeds. Khanal (1982) also reported butterflies from Lamjung and Manang regions. In 1983, he again reported some day flying moth of Nepal. The same year, H.S. Nepali "Kaji" and Bhaiya Khanal reported *Baltia shawi* (Bated), a new butterfly from Nepal, also reported mimic pattern among Moths and Butterflies, and 26 species of butterflies under 6 families from Trans-Himalayan region of Dolpo and Mustang districts of Nepal. Khanal (1984) reported remaining 21 species of butterflies from Lamjung and Manang regions. He again reported *Polyommatus arenefawcett,* a new species of lycaenids from Nepal in the same year. The next year Khanal again reported 52 species of butterflies in Gorkha-Trisuli trek and 39 species of butterflies in Pipar, Kaski District. Smith (1989) published a book mentioning 614 species of butterflies existing in Nepal of which 43 species were papilionids, 49 species pierids, 173 species Lycaenids, 2 species lybytheids, 107 species of Hesperids, 82 species Satyrids and 15 species of Danaids. Smith described 266 species of beautiful butterflies of Nepal in 1990, but same year he was suspecting more than 643 species of butterflies from Nepal. Smith studied distribution of butterfly diversity in Nepal in 1996 where he found disproportionately large number of butterflies species distributed in this country. Finally, Khanal (1999) published a list of 71 species of butterflies of Kailai and Kanchanpur districts of Far Western part of Nepal. These species were categorized under eight families.

Giri (1991) reported 117 species of butterflies representing 68 genera and 8 families from Sankhuwasabha district. In 1998, Thapa published "An Inventory of Nepal's insects Volume II" illustrating a checklist 656 species of butterfly from Nepal. It was published under IUCN Nepal Biodiversity Publication Series 3. He has also mentioned genus *Orionoma* (Gray*)* (1846) and one of its subspecies endemic to Nepal. Subba (2005) reported a checklist of butterflies of Gajurmukhi Village Development Committee, Illam District, eastern Nepal. Khanal and Smith (2007) published "Butterflies of Kathmandu Valley, Nepal" in Know Nepal Series 13. Bhusal and Khanal (2008) reported seasonal and altitudinal diversity of 40 species of butterflies in eastern Siwalik region of Nepal. Khanal also reported diversity and status of 85 species of butterflies in lowland districts of West-Nepal. In 2009, Thapa and Bhusal reported species diversity and seasonal variation of 43 species of butterfly fauna in Thankot and Syuchatar VDC of Kathmandu valley, Nepal.

CHAPTER 4
MATERIALS AND METHOD

4.1 Methodology

The present research on the Biodiversity of butterflies in Badikhel VDC, Lalitpur was carried out on Sep. 2008-Oct. 2009. This study was based upon primary data collected in the study area. The details of materials and techniques used for study during the course of investigation are described below:

4.2 Materials

The necessary equipments for collecting butterfly consist of following items:

1. Insect Collecting Net
2. Envelopes or Chart board Paper
3. Entomological Forceps
4. Sheet of plain white paper
5. Camel's Hair Brush
6. Altimeter
7. Box
8. Carrying Bag
9. Camera
10. At least 1 Killing Bottle
11. Setting Board
12. Plastic Bags
13. Note book

A small binocular was carried frequently for identifying certain species as well as hill topping species that perch in the canopy some distance from the ground. The behavioral details were noted in a small notebook, kept in collecting bag or shirt pocket together with information on locality of the capture, habitat and date for each captured specimen. Species observed but not collected, were also entered in the notebook so that a list of fauna recorded for that area on that particular day was easier to be documented. At a later date, the information was then transferred to personal computer (Borror *et al*, 1989; Braby, 2000).

Fig. I. Map of Lalitpur District showing Godavari Area

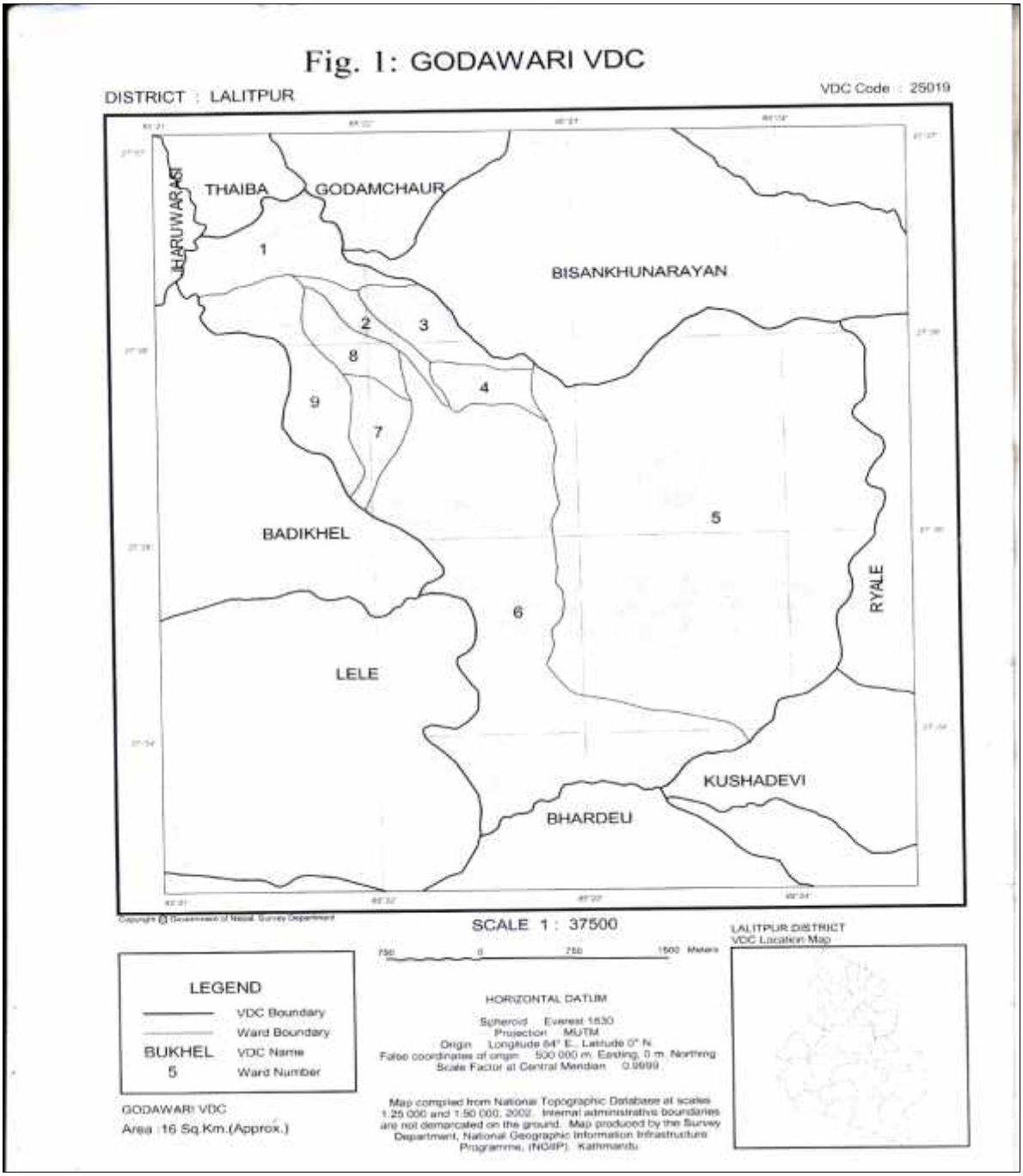
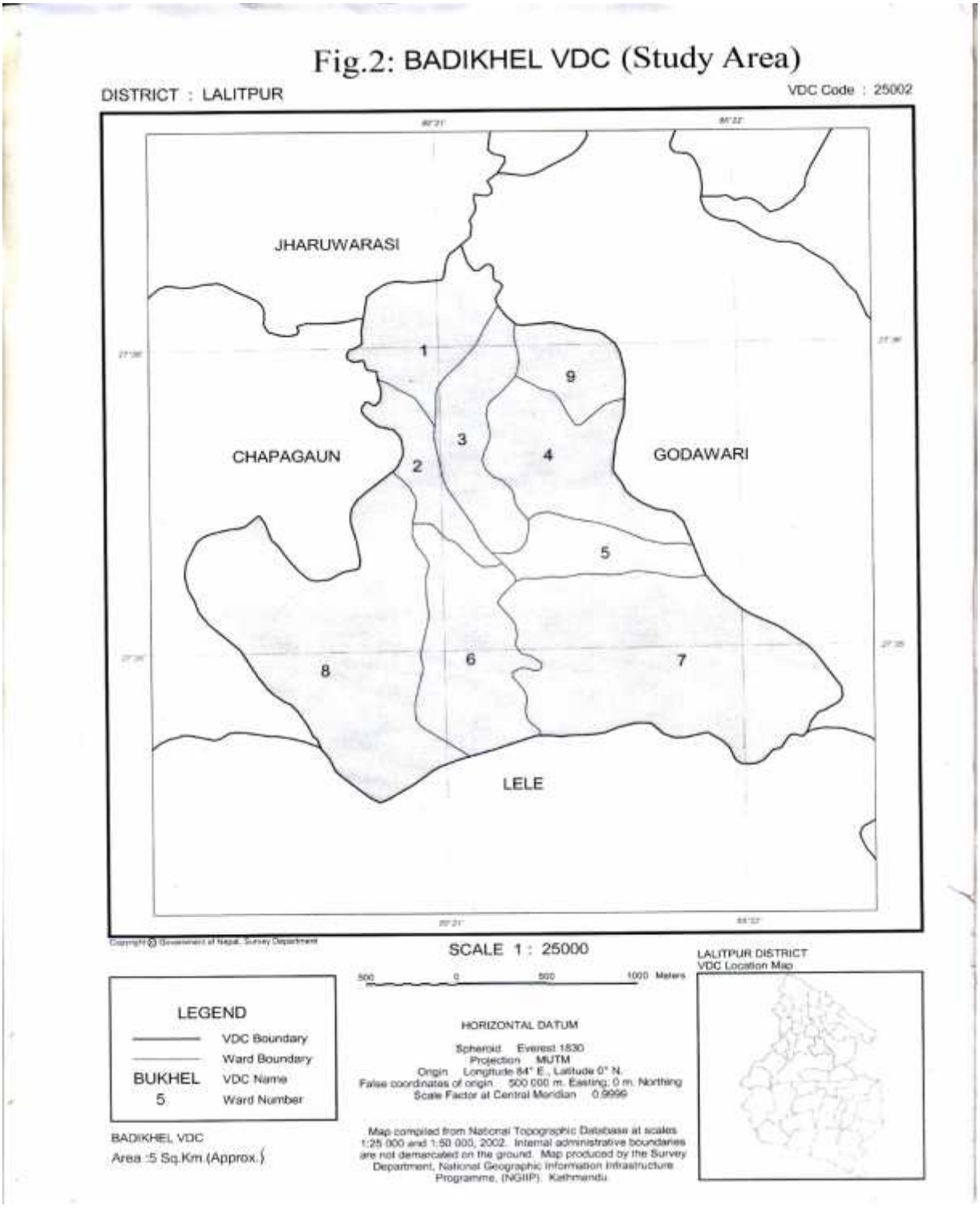


Fig. II. Map of Badikhel VDC (Study Area)



4.3 Data Collection

The observation was taken inside the Badikhel VDC, Lalitpur, ward no. 1, 3 and 4; the primary data has been collected by visiting the study site. The study area was first divided into three microhabitat- "edge" area, riverside, cultivated land and forest. Specimens were collected by taking a long transect walk along each of these regions. The specimens were collected and enumerated in the habitat in three seasons- Pre-Monsoon, Monsoon and Post-Monsoon. The species which were high flying and out of reach were identified and noted in the field. The data was collected from May 17-28 to April 12-18, 2008 in Pre-Monsoon period; second visit during monsoon i.e. June 15-28, July 18 and Aug 28 during Monsoon and third visit during Post-Monsoon i.e. Sep. 28 and Oct. 11-18, 2008/09. The primary data was collected in the field using the following data sheet:

Table VI. Entomological Field Record

S. No.	Type of butterfly	Locality	Altitude (in meter)	Time	Date	Remarks (No. of species observed and coloration)

The unidentified butterfly was provided with a field number or code (A_1, A_2, A_3, etc) and the locality where it is captured, altitude, time, date and number of species observed within the area was enumerated.

The secondary data was collected from Central Library, Kirtipur, Journal of Natural History Museum, publications of field related data and articles on websites, Biological Abstract and Master Thesis.

4.3.1 Net

Adult butterflies were collected by a net, the size and design varying considerably. The specimen can be caught by a short rapid sweep of the insect, followed by a twist of the handle to fold over the net bag, thus trapping the butterfly. When found resting on the ground, it was captured while holding the end of the bag up with one hand, then placing the net over it suddenly and then allowing the insect to fly upwards into the net before folding over the bag.

These nets are both available in the market and could be made by one. The simplest and one of the most effective nets has circular metal frame about 460 mm in diameter, attached in some way to a wooden, bamboo or aluminium handle. If the frame is detachable it is much easier

to pack when travelling and the fine net beg can be replaced more readily if should be torn. Three simple methods for attachment are often used:

- 4 mm steel wire (No. 8 fencing wire) can be bent so that it fits into grooves in the end of the wooden handle and held in place by sliding a metal sleeve or hose clamp over them (Fig. IA)
- A 12.5 mm X 3 mm aluminium strip can be used for the circular frame and bent drilled so that it can be bolted to a wooden handle (fig. IB) (Borror *et al*, 1989; Braby, 2000);

The two ends of the steel wire was each bent to form small rings which fitted over a screw thread of appropriate diameter protruding from the end of the handle, and held firmly in place by a nut. Alternately, a light strong net frame can be made from the cane. The cane should be steamed and bent around to form a large loop, with its ends firmly clamped to a cut-down copper plumbing T or glued into a welded Y-shaped metal ferrule, into which handle can also be fitted.

The net bag was prepared from soft light weight, non tear material such as Terylene, or even mosquito net offering low air resistance, and capable of drying rapidly as it become weight. While many nets are made from white material, green or black nets allow the content or the butterfly being captured relatively non-visible and were thus avoided. For a frame 460mm in diameter, the net bag of about 810mm in depth was used, to allow ample room for the enclosed insect to be trapped in the lower half of the bag when it was folded over. The bag, when folded, was able to taper slightly and turned rounded at the bottom. The mouth was machined to it by a doubled over band of muslin or fine-mesh bolting cloth 40 mm in width through which wire or can frame was passed. A strong gusset was also provided to prevent tearing the mouth of the net nearest the handle (Borror *et al*, 1989; Braby, 2000).

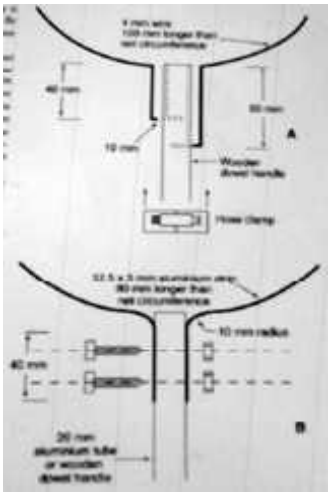


Fig. III. Method of attaching net frames to handle

A.net with wire frame B. net with aluminium frame

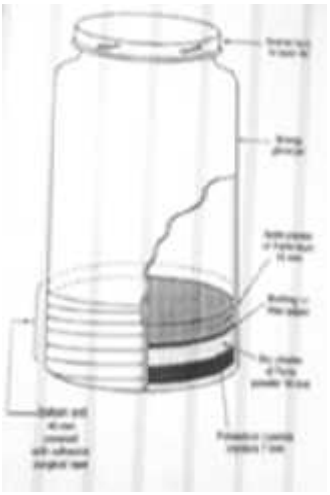


Fig. IV. Killing Bottle

Handle was light, strong and about a meter long. Grooves and holes were cut in one end of the handle. A net used with care will last a longer time. Hence it was kept away from stout thorns and barbed wire to avoid tearing, collection loss and kept dry. The collectors swept or simply swing it back and forth for butterfly collection and turned over itself to prevent escape of captured specimen. The captured specimen was then grasped with forceps and killed by pinching its thorax. These specimens tend to dry out very rapidly and the appendages particularly the antennae are subjected to extensive breakage. A separate box was used for Lepidoptera collection as this group possesses delicate wings easily damageable and scales on wings easily faded and come off (Borror *et al*, 1989; Braby, 2000).

4.3.2 Handling the catch

Each lot of insects was associated with a data slip indicating at least the date and the place of the collection. A specimen without data is perhaps better than no specimen at all. A specimen with incorrect data is even worse and creates trouble to later workers, especially taxonomists who place considerable importance on the data accompanying the specimen.

Many collectors prefer to stun immobilize larger butterflies while the specimen remained inside the net. This was done by first moving the net with the captured butterfly into a shaded area away from direct sunlight and letting the insect settle for a few minutes. Once it had stopped beating its wings the wings folded back above the body, the thorax was given a gentle pinch between the finger nail of the thumb and forefinger of the same finger from outside the net. Great care was taken not to rub scales off the wings or break off the appendages. When used quickly and deftly, this method had the advantage of preventing undue damage to the specimen by its fluttering in the net or the killing bottle, and also made its escape less likely. With practice the correct amount of pressure was applied without causing noticeable external damage to the butterfly (Borror *et al*, 1989; Braby, 2000).

After a specimen is immobilized in this way it was placed in a killing bottle. The killing bottle was prepared by very carefully placing about 7 mm of crystalline potassium cyanide in the bottom of a wide-mouthed glass jar and covering it with 7 mm of dry plaster of Paris. A circular piece of blotting paper was then placed over the dry plaster of Paris and thick mixture; about 12 mm deep, of plaster of Paris and water was poured into the bottle. The bottle having a tight-fitting lid was used. When the plaster had dried fully (preferably in the open air), a pad of tissue was cut to fit firmly at the bottom of the bottle over the plaster so as to absorb surplus moisture and the lid replaced. For the potassium cyanide to give off its poisonous gas it must react with water and it was therefore necessary to add a drop or two of water to the tissue as the bottle dry out. As cyanide is an extremely dangerous poison, the killing bottle was well taped around the base.

Specimens removed or killed at the field were placed in pill boxes or paper envelope for temporary storage. Paper envelope either ordinary paper envelopes or triangular paper was

prepared as shown in the figure. These are excellent for temporary storage of large winged insects such as butterflies, Dragonflies or Damselflies, etc. These triangular papers were made quickly from a sheet of notepad or glossy chart-board paper such that the specimens remained in good condition inside them. Data on the collection was written outside the paper. The adult of this group was not placed on alcohol. It was clearly labeled and kept out of reach of children.

When cyanide was not available, an effective killing bottle was prepared by pouring 20 mm of plaster of Paris directly into the bottom of the glass jar and, when completely hardened and thoroughly dry, adding a few drops of liquid ethyl acetate to plaster. The plaster was then properly covered with the thick pad of tissue after the chemical had thoroughly been absorbed to ensure insect never came in contact with the liquid or moistened plaster. This type of killing bottle needed to be recharged before each day's collection. Ethyl acetate is relatively harmless, but one should avoid inhaling its vapor any more than necessary. Care must be taken with lycaenids as the wings are invariably permanently stained if the liquid has not been vaporized completely. Ethyl acetate was bought from an entomological supplier or obtained from polish remover from a pharmacy (Borror *et al*, 1989; Braby, 2000).

If liquid specimens were not immobilized by first pinching them in the net, they should be introduced to the killing bottle inside the net. This was done by carefully working the bottle, with stopper or lid removed, into the net bag, and placing the mouth of the bottle over the specimen; the stopper was gently replaced on the outside of the net until the specimen stopped fluttering. The bottle was then withdrawn from the net and the stopper replaced. Many butterflies, lycaenids especially, reverse their wings in the killing bottle and if this was not corrected at the time they were very difficult to handle later without damage. As soon as they had stop fluttering in the bottle the legs or thorax was gently grasped with a pair of curve-ended forceps and the wings returned to their normal position by gently blowing them apart.

After specimens had remained in the killing bottle for 10-15 minutes, they were removed and transferred individually into paper envelopes to reduce unnecessary scale loss that might otherwise occur. Alternately, some collectors, whilst in the field, prefer to pin the specimens (especially hesperids and lycaenids) and place them into a small relaxing box to keep them fresh. If the specimens were not removed promptly after death they were prevented from sliding about inside the killing bottle and becoming damage during field transportation. By loosely filling the bottom half of the bottle with wad of tissue, the butterflies, with their wings folded over their body, were placed carefully between the tissue and the inside of the bottle by means of forceps. In order to allow the specimens to be pinned or spread within the next couple of days they were not allowed drying out. After a specimen had been killed, rigor mortis was allowed to set in quite rapidly and after a period of about 6-12 hours, it again became fully relaxed and suitable for handling (Borror *et al*, 1989; Braby, 2000).

4.3.3 Paper envelopes

Paper envelopes were made from semi transparent, rigid, grease-proof paper and might be rectangular or triangular in shape. Rectangular envelopes was either purchased from most post offices or philatelic shop; otherwise triangular envelopes were made from rectangles of light weight paper, such as high quality tracing paper (90-95gsm), one and a half times longer than wide; they were cut into various size of the specimens to be papered. A supply of these were cut and folded in preparation for the day's collection (Borror *et al*, 1989; Braby, 2000).

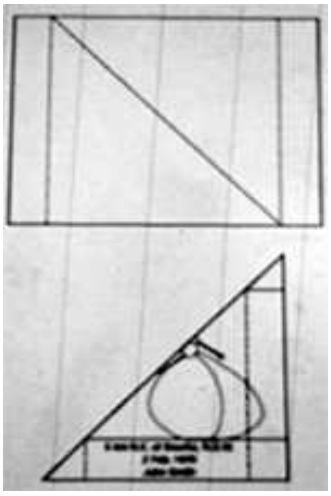


Fig. V. Butterfly paper Envelope

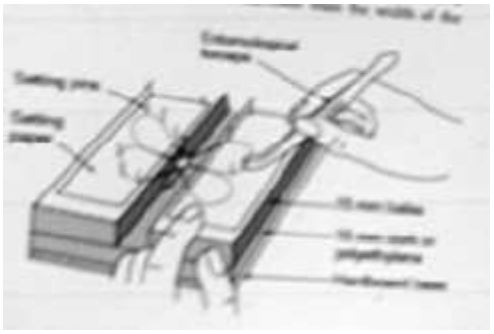


Fig. VI. Method of Spreading of wings of butterfly

Before enclosing the specimen in the envelope, the locality, date and other information were written on the opened flap. Alternately, if several specimens were being collected from the same locality the details were entered on a separate sheet of paper that was placed in the container of papered specimen. The specimen was placed in the envelope with its wings folded back-to-back with the antennae lying parallel to the costa of the forewing, preferably along the diagonal fold of the paper triangle. In this way the antennae was less likely to break when the dry specimen was later removed from the envelope. The two triangular flaps were then folded down.

In the field, paper envelopes into which the fresh specimens had been transferred were placed flat into a small container, such as a tobacco or cigar tin or plastic box which was carried in bag or directly into a relaxing box. The container was moistened slightly by placing a damp sheet of blotting or tissue paper into it to prevent drying of the soft tissues of the specimen (Borror *et al*, 1989; Braby, 2000).

4.3.4 Relaxing-boxes/ Dessicator

Freshly collected papered specimens were, at some stage during a day's collection, transferred to a relaxing box so that they remained moist and soft. In this way the specimens was pinned or spread that evening or within 48 hours.

Plastic containers (e.g. Tupperware, take-away, ice-cream) also served well for relaxing-boxes, provided they were airtight. The bottom of the container was covered with a piece of plastic absorbent sponge cut into shape and a piece of 5 mm thick balsa wood of the same dimensions placed above it, followed by several layers of tissue paper. The plastic sponge was kept thoroughly wet so that balsa wood remained moist, but not over saturated with free water. Some crystals of chloro-cresol were added to prevent mould growth.

The papered specimens were laid carefully between the layers of tissues on the top of the balsa wood. If the specimens were not to be pinned or spread on the day of the collection it was often a good idea to place the relaxing-box into an ice block or a freezer (if possible) or was kept completely dry with small amount of naphthalene ball (Borror *et al*, 1989; Braby, 2000).

4.3.5 Pinning

The best specimens are those that are pinned soon after being killed and spread while still fresh. Thus a specimen must be properly relaxed before it can be pinned. To pin the specimen, the thorax was first gently hold between the thumb and fore finger of one hand so that the wings were folded back above the body. Then with light pressure the wings was opened slightly so that the point of the pin, held in the other hand, was carefully inserted from above into the middle of thorax. The pin was then passed vertically through the thorax (not angled in any direction) so that the point emerged between the bases of the mid legs. The pin was then gently pushed through the specimen until two-thirds (approx. 24 mm) of it protruded beneath the body. Accuracy of pinning is important for successful spreading of the wings.

Butterflies were pinned only with stainless steel entomological pins. These were usually 38 mm in length and are manufactured especially for the purpose. No. 3 pins was found suitable for most of the species, but the largest species required No. 5, and some of the very small lycaenids required No. 2 pins or even micro pins (D1). Nickel or plated Brass pins were not satisfactory, because in many species the body acids will corrode the brass and the green products of corrosion, called verdigris will eventually destroy the specimen. Household pins were also unsatisfactory because they corroded and were too small, thick and blunt for the pinning of insects that were to be included in a permanent collection.

After pinning, the fresh specimens might have its wings spread immediately on a setting board or it might be pinned temporarily either into a relaxing box for spreading within the next 48 hours or into a store box to dry and be relaxed and spread at a later date (Borror *et al*, 1989; Braby, 2000).

4.3.6 Store-Boxes

Pinning specimens temporarily into store boxes was particularly useful during long field trips when there was a surplus or backlog of the material that cannot be spread. Each pinned specimen was placed in the store box, preferably with the wings held either flat or partially open above the body. All the specimens collected from a specific locality on a particular day was neatly and compactly arranged in a row or rows at the end of which there was a single label giving the relevant collecting details. It was advisable when field pinning to use only one side of the store-box; otherwise the wing tips of specimens on opposite sides of the box might damage each other. Large specimens were held in position with two cross-pins placed over the abdomen to prevent the specimen from moving and damaging adjacent specimens.

Store-boxes were constructed of wood with plywood tips and bottoms in standard sizes, and open so that specimens were easily pinned into polythene foam or cork that lines the inside of both top and bottom. Boxes were deep enough so that the heads of the pins did not touch one another when the box was closed. Convenient boxes are 450 mm x 300 mm x 100 mm or 360 mm x 250 mm x 100 mm. They should be light-proof, airtight and insect proof. The boxes were not coated with a wood finish as this prevents the moisture from escaping and the insects drying completely. Coated boxes might be used for storing fully dried and spread specimens in a permanent collection (Borror *et al*, 1989; Braby, 2000).

4.3.7 Relaxing dried specimen

Specimens that had been pinned or dried in paper envelopes were fully relaxed before they were spread. The dried specimens were placed in a relaxing box as described above: papered specimens were simply laid on the damp surface; where as pinned specimens were pinned into the balsa wood sheet. The time required for relaxing specimens varied with temperature, but 12-48 hours was adequate for most butterflies. The specimens were examined periodically during the relaxing period to make sure the wings were not becoming wet and stained. If still not relaxed thoroughly after this period the damp specimen were carefully removed and 0.1 to 0.2 ml of boiling water injected into the thorax using a small syringe. The hot water softens the flight muscles and permeates the veins of the wings, but care was taken not to inject too much water as this might lead to excessive wing damage, including staining and scale loss. The specimens were ready for spreading within a few minutes of injection (Borror *et al*, 1989; Braby, 2000).

Table VI. Chemical Composition of Relaxing Fluid

S. No.	Chemicals Used	Amount in cm^3
1	95% Ethanol	50
2	Water	50
3	Ethyl Acetate	20
4	Benzene	7

Source: An Introduction to the study of insects (Borror, Triplehorn and Johnson)

The bottom of the jar was covered with wet sand or cloth and little carbolic acid to prevent mold formation on the specimen (Borror *et al*, 1989; Braby, 2000).

4.3.8 Setting Board

Setting boards are used to spread the wings of specimens flat in the correct position, and to hold them in this position until the body is thoroughly dry.

Setting boards has a central groove, to accommodate the body of the insect, flanked by two flat surfaces on which the insect's wings are spread. They are usually 250-300 mm long, and can be made using a 4 mm sheet of water-proof plywood as a base on top of which is glued a 10 mm thick sheet of polyethylene foam or soft cork. Two pieces of soft balsa wood 15 mm thick are then glued to the polyethylene or cork, leaving a central groove. The top of the balsa wood is smoothed with very fine emery paper and preferably covered with 1 mm x 1 mm squared graph paper or white gloss or white gloss or art paper. The paper, placed over the board in one piece, should be glued with wallpaper paste so that it can be readily removed and the board reappeared as it becomes worn. When the paper dries, the groove is then cut. Polystyrene foam is not recommended for the construction of setting boards because pins create a small permanent hole, and the material is very soluble in most organic solvents such as ethyl acetate (Borror *et al*, 1989; Braby, 2000).

Setting papers, used to hold the wings in the desired position, are long rectangular pieces of cellophane, clear plastic, drafting paper or similar transparent material that will more than cover the entire spread of the wings. They should be a few millimeters narrower than the width of the balsa wood so that the wings can be curved with ease during the spreading procedure. The width and groove size of the setting-board depend on the size of the insect to be spread. A setting board should always be at least 3-5 mm wider than the wingspan of the specimen.

The specimen pinned on its mid-thorax was placed with its body lying on the groove parallel to the setting board. First, the fore wing was moved forwards so that dorsum or inner margin lies at right angle to the body, temporarily held in place by tightening the setting-paper with the fore finger, and then fixed permanently with one or more micro pins inserted through the setting paper close to the wing margin. The hind wing was then similarly positioned and fixed. The wings on the other side were positioned in the similar manner. Care was taken to arrange wings symmetrically on the setting board. The antennae was then arranged in position parallel to the costa of the forewing and secured under the setting-paper or held by cross pins. Finally, cross pins were inserted below, and if necessary, for the abdomen to hold it in a horizontal position. A temporary or permanent label was pinned inside the specimen immediately (Borror *et al*, 1989; Braby, 2000).

CHAPTER 5
RESULT

The data was collected from Badikhel area during September 2008 to October 2009. About sixty-one days long survey was carried out in Forest area, cultivated land as well as edge area of the study area. The study site was visited three times i.e. Pre-monsoon; Monsoon and Post-Monsoon periods and the population of butterfly and seasonal abundance were observed and studied. The three periods were targeted so as to gather information about seasonal abundance and variability. The specimen collected or observed during the study period has been presented below.

5.1 Identification and Characteristics of Recorded Species:

1. Family Papilionidae

- It includes some of the largest butterfly prevalent in Nepal.
- The ground color is black but the body and wings are often brightly colored.
- The fore wings are generally long pointed while the hind wings have wide tails
- Cubitus in front wing apparently 4-branched and hind wing contains single anal vein.
- Radius in front wing 3-5 branched

1.1. *Graphium cloanthus* (Westwood)

- Common Name: Glassy Bluebottle
- The upper and undersides are similar. The ground color is pale blue-green, costa and margin of forewing, and margin and dorsum of hind wing narrowly outlined in black, and with short tails
- Wing span: 55-70 mm
- Recorded at 1570 m flying in near river and resting in mud puddles
- Season: Pre and Post-Monsoon (May 28 and Oct 11)

1.2. *Graphium sarpedon* (Fruh.)

- Common Name: Common Bluebottle
- It is much similar to glassy bluebottle, but with a deeper ground color, with much wider black outlines and hind wing without tails
- Wing span: 55-65 mm
- Recorded at 1570 m flying in near river and resting in mud puddles
- Season: Pre and Post-Monsoon (May 28 and Oct 11)

1.3. *Graphium agamemnon* (Linnaeus)

- Common Name: Tailed Jay
- The upper surface is chequered with black and yellow-green spots. Fore wings is pointed while hind wings contain tails. Tail is short in male and long in female. The lower surface is mottled all over with purple.
- Wing span: 65-75 mm
- Recorded at 1570 m flying in grassland and resting in weeds of rice field.
- Season: Pre-Monsoon (May 28)

1.4. *Papilio paris* (Fruhstorfer)

- Common Name: Paris Peacock
- The upper is velvety black with faint red marginal lunules on the hind wing, which give away at the apex to a shiny blue green patch with a clear inner boundary. The lower surface lacks blue patch while red lunules is complete.
- Wing span: 80-100 mm
- Recorded at 1570 m flying in grassland in riverside and forest
- Season: Pre and Post-Monsoon (May 28 and Oct 11)

1.5. *Papilio polyctor* (Doubleday)

- Common Name: Common Peacock
- It is very similar to the paris peacock, but with an indistinct edge to the blue patch on the upper hind wing.
- Wing span: 90-105 mm
- Recorded at 1570 m flying in grassland in riverside and forest
- Season: Pre and Post-Monsoon (May 28 and Oct 11)

1.6. *Papilio protenor* (Fruhstorfer)

- Common Name: Spangle
- The upper is nearly all velvety black but with small red tornal spot on hindwing. The lower surface is black with red lunules on hind wing clear at apex and tornus, faint in between, no red at base.
- Wing span: 90-120 mm
- Recorded at 1570 m flying in grassland in riverside and forest
- Season: Pre and Post-Monsoon (May 28 and Oct 11)

1.7. *Papilio polytes* (Cramer)

- Common Name: Common Mormon

- The male is black with a band of white spots across the hind wing, continuing a little across the margin of the fore wing. Common female is like tailed redbreast, but with no red basal spots.
- Wing span: 65-85 mm
- Recorded at 1570 m flying in grassland in riverside and orange tree
- Season: Pre- Monsoon, Monsoon and Post-Monsoon (May 28, June 11 and Oct 11)

1.8. *Papilio helenus* (Linnaeus)

- Common Name: Red Helen
- The fore wing is nearly all black but the tailed hindwings contain upper central white patch crossed by two veins. The under hind wing has similar patch and red marginal lunules.
- Wing span: 90-115 mm
- Recorded at 1700 m flying in forest
- Season: Pre-Monsoon, Monsoon and Post-Monsoon (April 18, June 28 and Sep 25)

1.9. *Troides aeacus* (Felder)

- Common Name: Golden Birdwing
- The fore wing is nearly all black but the marginal black spots on the golden-ellow hindwings are surrounded by grayish scales at the tornus. The female has lower half of the upper hind wing all duted with grey.
- Wing span: 95-140 mm
- Recorded at 1750 m flying in forest
- Season: Pre-Monsoon (May 28)

2. Family Pieridae

- These are medium to small-sized butterfly that are basically white or yellow with markings of orange, red and black.
- First medial vein of front wing is stalked with Radial vein beyond discal cell.
- Front leg is normal and contains bifid claws.
- Wings are usually rounded, sometimes with small teeth on wing margin but lacks tail.

2.1. *Pieris brassicae* (Doubleday)

- Common Name: Large Cabbage White

- Male: The upper portion of wings is white. Fore wings with apical black reaching veins 3 or 4. Hind wings with a black apical spot
- The underside of fore wing is white with 2 discal black spots and that of hind wing is dusted with black.
- Female: The upper side of wings female resembles that of male, but black markings are more prominent at base and along costa. Fore wing contains two rounded discal black spots and a diffuse elongated spot on inner margin. The underside of forewing contains much larger black discal spots and hind wing is pale yellow.
- Wing span: 55-65 mm
- Recorded at 1570 m in flower of Mustard plant *(Brassica comprestris)*
- Season: Mar-Dec

2.2. *Pieris canida* (Evans)

- Common Name: Indian Cabbage White
- The upperside of fore wing contains inner edge of black marginal border dentate and contains prominent black spot 1 in male and 2 in female. Hindwing with marginal black vein spots and black spots.
- Underside of forewing contains large spots while lacks marginal black
- It is similar to *P. brassicae* except for its small size.
- Wing span: 40-55 mm
- Recorded at 1570 m in flower of Vicia faba
- Season: Mar-Dec

2.3. *Delias belladonna* (Gray)

- Common Name: Hill Jezebel
- The upper side of wings is black with faint white spots.
- The hind wing has many yellow spots, including one cell which is entirely yellow and is not pointed at base.
- Wing span: 65-85 mm
- Recorded at 1500 m in Riverside
- Season: Spring (April 12)

2.4. *Hebomoia glaucippe (*Linnaeus)

- Common Name: Great Orange Tip
- The upperside is plain white with orange tips. The female has dark spots on the disc and margin of hindwing.

- The underside is all mottled with light brown making it inconspicuous when settled.
- Wing span: 75-90 mm
- Recorded at 1490 m flying near Lapsi tree
- Season: Pre-monsoon (April 18)

2.5. *Colias erate* (Moore)

- Common Name: Pale Clouded Yellow
- There are two forms of each sex. The male may have solid dark borders or more usually have yellow spots on them. The females may be yellow as male or more usually white.
- Wing span: 40-45 mm
- Recorded at 1490 m flying at grassland
- Season: January-December

2.6. *Colias fieldii* (Menetries)

- Common Name: Dark Clouded Yellow
- Male bright orange with thick dark borders; female has orange spots in the borders. Underside orange-yellow with a double red-edged silver spot at end of cell.
- Wing span: 40-50mm
- Recorded at 1490m flying at grassland
- Season: Feb-June, Oct, Dec

2.7. *Eurema hecabe* (Moore)

- Common Name: Common Grass-Yellow
- The upperside is yellow with black tips and tornal markings on forewings. The under surface of fore wings contain two spots in cellapart from the end of cell squiggle. There is no spot at extreme base.
- Wing span: 35-45 mm
- Recorded at 1490 m flying at grassland.
- Season: Pre-Monsoon, Monsoon and Post monsoon (March-October)

3. Family Lycaenidae

- These are small or very small, but males are usually brightly coloured; blues and purples predominates, but green, gold, orange and silver also occurs.

- The females are often duller than males, and even when they have the same general colors as the males they have wider black margins.
- The anterior tarsi of the males are more or less shortened without one or both claws. The legs are functional and used for walking.
- The hind wings are frequently provided with delicate tail-like prolongation.

3.1. *Lampides boeticus* (Linnaeus)

- Common Name: Pea-Blue
- The upper portion of wing of male is violet-blue while female with dark borders.
- The lower portion of wing contains numerous white streaks on brownish background, including a continuous white submarginal band.
- Hind wings contain two tornal spots and tails.
- Wing span: 25-30 mm
- Recorded at 1500 m flying at grassland near riverside.
- Season: Pre-Monsoon and Post-Monsoon period

3.2. *Zizeeria maha* (Kollar)

- Common Name: Pale Grass Blue
- The male is pale blue while female is dark brown in color at upper side.
- The undersurface of wing contains regularly arranged dark discal spots. The ground color is white in male and brown in female.
- Wing span: 25-28 mm
- Recorded at 1510 m flying at grassland near crop field
- Season: Pre-Monsoon, Monsoon and Post-Monsoon period

3.3. *Zizina otis* (Fabricius)

- Common Name: Lesser Grass Blue
- Like *Zizeeria maha,* the male is pale blue while female is dark brown in color at upper side of wings.
- The second discal spot is located directly below the first one.
- Wing span: 18-22 mm
- Recorded at 1500 m flying at grassland near crop field.
- Season: Pre-Monsoon and Post-Monsoon period

3.4. *Everes argiades* (Chapman)

- Common Name: Chapman’s Cupid
- The male is dull blue and female is brown at upper side of wings.

- The lower portion is white with discal and submarginal black spots, two yellow spots at tornus of hind wing which is tailed.
- The under surface of forewing contains band of discal spots to apex.
- Wing span: 20-25 mm
- Recorded at 1510 m flying at grassland near river side
- Season: Spring

3.5. *Celastrina puspa/ Celastrina argiolus* (DeNic.)

- Common Name: Hill Hedge-Blue
- The upper portion of fore wing of male is pale blue with white discs narrow black borders dilated at apex; Female more white and black and less blue.
- The undersurface is white-grey with complete marginal spots.
- Wing span: 26-32 mm
- Recorded at 1510 m flying at grassland near river side
- Season: Pre-Monsoon and Monsoon period (April 14, June 15)

4. Family Nemeobiidae

- These are smaller butterflies with fore legs in male reduced, imperfect and brush-like, with one segmented tarsi and without claws. Females contain perfect legs.
- Some of the contains tail or lobes on their hind wings
- The oriental species are mostly brown or orange, have rapid flight and are generally located near water and rarely on flowers.

4.1. *Zemeros flegyas* (Fruhstorfer)

- Common Name: Punchinello
- This species has wings uniformly chequered with light and dark brown.
- White pre-apical costal spot is present on forewing of dry-season form.
- Margin of wing is irregular but lacks lobes or tails.
- Wing span: 32-38 mm
- Recorded at 1510 m flying at grassland near river side
- Season: Spring and Post-Monsoon period (April 15 and Oct 18)

4.2. *Dodona adonira* (Hewitson)

- Common Name: Striped Punch
- The upper surface of fore wing is brown with orange bands. The lower surface is yellow with thin black bands.
- Hind wing contains lobes but lacks tails.

- Wing span: 30-35 mm
- Recorded at 1510 m flying at grassland near river side
- Season: Spring and Post-Monsoon period (April 15 and Oct 18)

4.3. *Abisara fylla* (Doubleday)

- Common Name: Dark Judy
- The fore wing is dark brown with band across the wing from tornus to costa-yellow in male and white in female.
- Tails or lobes are lacking in hind-wings
- The underside is similar as upper side of wings
- Wing span: 42-50mm
- Recorded at 1510 m flying at grassland near river side
- Season: Spring and Post-Monsoon period (April 15 and Oct 18)

5. Family Acraeidae

- This family includes oriental forms having long narrow wings. They often discharge unpleasant fluid which helps to protect them from predators.
- These are mostly yellow or orange in color and show lazy flight.
- The female in certain species bear abdominal pouch.

5.1. *Acraea(Pareba) issoria* (Hubner)

- Common Name: Yellow Coster
- Male often has forewing yellowish in color with black only on margins. Female has the veins of fore wings heavily darkened with black color and hind wing is yellowish with black only on margins.
- The upper as well as under side of wings are similar.
- Wing span: 42-50 mm
- Recorded at 1510 m and 1750 m flying at grassland near crop field.
- Season: Spring and Post-Monsoon period (April 15 and October 18)

6. Family Nymphalidae

- The front legs are much reduced and lacks claws which lie folded on thorax; while only mid- and hind- legs are used for walking.
- The tibae are short and clothed with long hairs; thus called brush-footed.

6.1. *Cethosia biblis* (Fruhstorfer)

- Common Name: Red Lacewing
- The male has bright-red fore wings while female varies from dull-orange to grey. All borders and apex are black in color with faint white crescents. The under side contains bands of orange and black spots on yellow ground.
- Margin of wing is indented in between the margins.
- Wing span: 60-80 mm
- Recorded at 1510 m and 1750 m flying in crop field.
- Season: Spring and Post-Monsoon period (April 15 and Oct 18)

6.2. *Precis hierta* (Fabricius)

- Common Name: Yellow Pansy
- The upper surface of wings is bright yellow with dark brown borders.
- The hind wing contains a bright blue patch near the base on the costa. The lower surface of wings is almost plain yellow.
- Wing span: 40-50 mm
- Recorded at 1510 m and 1750 m flying in rice field and grass land at riverside.
- Season: Spring (April 15)

6.3. *Precis orithya* (Hubner)

- Common Name: Blue Pansy
- The upper surface of fore wing is black with pre-apical white band and tornal blue spot.
- Hind wings are blue in color with two red eye spots; base is blue in male and black in female.
- Wing span: 35-45 mm
- Recorded at 1510 m flying in rice field and grass land at riverside.
- Season: Spring and Post-Monsoon period (April 15 and Oct 18)

6.4. *Precis lemonias* (Linnaeus)

- Common Name: Lemon Pansy
- The upper surface of fore wing is brown mottled with yellow.
- An orange eye spot is present on each wing.
- The undersurface is plain in dry season, mottled in wet.
- Wing span: 38-45 mm
- Recorded at 1510 m flying in rice field near riverside.
- Season: Spring (April 15)

6.5. *Precis almana* (Linnaeus)

- Common Name: Peacock Pansy
- The upper surface of fore wing is orange with dark borders.
- The fore wing contains costal spots while each wing contains one mauvish eye spot. In the wet season form these spots are seen from underside while the dry season form is leaf-like.
- Wing span: 40-48 mm
- Recorded at 1510 m flying in rice field and grass land at riverside.
- Season: Spring, Monsoon and Post-Monsoon period (April 15, July 18 and Oct 18)

6.6. *Precis atlites* (Linnaeus)

- Common Name: Grey Pansy
- The upper surface of fore wing is grey laced with pre-apical black lines; a discal band of spots (some orange centered) across both wings.
- Two of these spots appear on the under side in wet season form; dry season form has just discal lines.
- Wing span: 48-58 mm
- Recorded at 1510 m flying in rice field and grass land at riverside.
- Season: Post-Monsoon period (Oct 18)

6.7. *Precis iphita* (Cramer)

- Common Name: Chocolate Pansy
- The upper as well as lower surface of wing is chocolate-brown; slightly banded. Fore wing toothed below apex.
- The lower surface of hind wing contains a discal line extending from tornus to apex.
- Wing span: 48-65 mm
- Recorded at 1510-1750 m flying in rice field, grass land and pine forest.
- Season: Spring, Pre- and Post-Monsoon period (April 15, July 18 and Oct 18)

6.8. *Athyma opalina* (Elwes)

- Common Name: Himalayan Sergeant
- The upper surface of wing is black with white stripes-cell streak is often broken into three. The lower surface has same pattern in brown and white, but without black dots on hind wings. Female is similar to male.
- Wing span: 48-58 mm
- Recorded at 1500-1800 m resting in *Alnus nepalensis.*

- Season: Spring and Post-Monsoon period (April 15 and Oct 18)

6.9. *Phaedyma asparia kathmandia*(Fujioka)

- Common Name: Great Hockey-Stick Sailor
- The upper surface of wing is marked with orange on dark brown ground; but with the same “hockey-stick” mark as the last two.
- The lower surface is white on orange except below hockey-stick which is grey.
- Wing span: 65-75 mm
- Recorded at 1600 m resting in *Alnus nepalensis.*
- Season: Monsoon period (June 18)

6.10. *Tanaecia lepidea* (Butler)

- Common Name: Grey Count
- The upper surface of wing in male is velvety black with grey border to hind wing; female are very dark brown with brownish grey border and paler patch on fore wing costa coming through bright yellow below.
- Wing span: 60-70 mm
- Recorded at 1490 m resting below *Alnus nepalensis* tree.
- Season: Pre-monsoon (April 18)

6.11. *Cyrestis thyodamas* (Boisduval)

- Common Name: Common Map
- The upper surface of wing in white with irregular pattern of black lines and orange on ore wing tornus, hind wing apex, across disc and dorsum. The lower surface is similar. Hind wing has tornal lobes and marginal teeth.
- Wing span: 48-53 mm
- Recorded at 1550 m resting at ground.
- Season: Monsoon and Post-Monsoon period (June 18 and Sep. 25)

6.12. *Argyneus hyperbius* (Linnaeus)

- Common Name: Indian Fritillary
- The upper surface of wing in male chequered with black spots, which show through on the under forewing. Under hindwing is greenish mottled. Female similar to male but with black apical tip and pre-apical white band.
- Wing span: 60-80 mm
- Recorded at 1700 m flying in *Alnus* forest.
- Season: Pre-monsoon, monsoon as well as post monsoon period (April 18, July 18 and October 11)

6.13. *Pseudergolis wedah* (Kollar)

- Common Name: Tabby
- Each surface of wing is plain brown in color with 3 thin black discal lines across both wings. Black spot on hind wing centered between the outer two lines.
- Wing span: 45-55 mm
- Recorded at 1650 m flying in forest near river side.
- Season: Pre-monsoon, monsoon as well as post monsoon period (April 18, July 18 and October 11)

6.14. *Symbrenthia hypselis* (Moore)

- Common Name: Spotted Jester
- The upper surface of wing is brown in color with yellow bands. The under surface is spotted all over with black; hind wing has blue-green post discal spots and is toothed. The fore wing costa contains only 6 black spots.
- Wing span: 35-42 mm
- Recorded at 1650 m flying in forest near river side.
- Season: Monsoon as well as post-monsoon period (July 18 and October 11)

6.15. *Symbrenthia niphanda* (Moore)

- Common Name: Blue-Tail Jester
- The upper surface of wing is brown in color with ragged yellow bands. The under surface is heavily spotted all over with black; hind wing has prominent blue discal spots and has blue margin from tornus to tooth. The fore wing costa contains only 7 black spots.
- Wing span: 35-45 mm
- Recorded at 1650 m flying in forest near river side.
- Season: Post-monsoon period (July 18 and October 11)

6.16. *Phalanta phalantha* (Drury)

- Common Name: Common Leopard
- The upper surface of wing is orange chequered with black spots while the lower surface is more uniform.
- The fore-wing has black tornal spot; sometimes purple washed. The fore wing also contains 4 dark lines within cell+bar end cell.
- Wing span: 48-55 mm
- Recorded at 1550 m flying in grassland near river.
- Season: Pre-monsoon, monsoon as well as post monsoon period (April 18, July 18 and October 11)

6.17. *Aglais cashmirensis* (Fruh.)

- Common Name: Indian Tortoise Shell
- The upper surface of wing is black above bases, margins and fore-wing costal spots, yellow black between costal spots and the rest orange. The lower surface is black.
- The fore-wing and hind-wing has prominent teeth at margins.
- Wing span: 42-50 mm
- Recorded at 1750 m flying in grassland inside forest.
- Season: Pre-monsoon, monsoon as well as post monsoon period (April 18, July 18 and October 11)

6.18. *Vanessa indica* (Herbst)

- Common Name: Indian Red Admiral
- The upper surface of wing is red with red spots. The apex of Fore-wing is blackwithwhiye spots. The red is mostly confined to an irregular discal band on the fore wing, and a black dotted margin of the hindwing. the lower surface is dark.
- Wing span: 50-60 mm
- Recorded at 1550 m flying in ricefield.
- Season: Post-monsoon period (October 11)

7. Family Satyridae

- This family agrees with Nymphalidae, Acraeidae and Danaidae in having the fore legs imperfect in both sexes.
- This family is dominated by dull-colored butterfly having eye spot or ocelli on wings. This feature is less prominent in dry season forms.
- They are often weak fliers and mostly prefer shady condition.

7.1. *Mycalesis lepcha* (Moore)

- Common Name: Lepcha Bushbrown
- The upper surface of wing is dark brown, margins and fore-wing costal spots, yellow black between costal spots and the rest orange. The lower surface is black.
- The fore-wing and hind-wing has prominent teeth at margins.
- Wing span: 42-45 mm
- Recorded at 1750 m flying in grassland inside pine-forest.
- Season: Spring and Post-monsoon (April 14, September 10 and October 11).

7.2. *Mycalesis mineus* (Linnaeus)

- Common Name: Dark-Brand Bushbrown
- The upper surface of wing is Light-dark brown with clear forewing ocellus. The lower surface is paler brown with faint white discal lines and complete row of ocelli on hind wing, the 4 tornal ones being in a straight line.
- Wing span: 40-48 mm
- Recorded at 1750 m flying in grassland inside pine-forest.
- Season: Spring and Post-Monsoon (April 14, September 10 and October 11).

7.3. *Mycalesis heri* (Moore)

- Common Name: Moore's Bushbrown
- The upper surface of wing is pale brown with enormous ocelli on fore wing and small one below apex. Hind wing contains 2 or even 3 ocelli .
- The underside of wing contains faint discal lines with their outer and basal area mottled.
- Wing span: 46-52 mm
- Recorded at 1750 m flying in grassland inside pine forest.
- Season: Pre-Monsoon and Post-Monsoon (April 18 and Aug 28).

7.4. *Melanitis leda* (Cramer)

- Common Name: Common Evening Brown
- The upper surface of wing contains double-eyed preapical eyespot- obscure in wet season form which has a row of large ocelli on the under hind wing clear in dry season, but orange patch above but doesn't reach costa.
- Wing span: 58-75 mm
- Recorded at 1750 m flying in grassland inside community forest.
- Season: Post-Monsoon (Aug. 28, Sep 10 and Oct. 11).

7.5. *Lethe baladeva* (Moore)

- Common Name: Treble Silverstripe
- The upper surface of wing is plain brown with hind wing marginal spots. The lower surface contains 3 silver stripes across both wings.
- The hind wing contains complete set of ocelli-costal one more prominent and orange at tornus.
- Wing span: 42-48 mm
- Recorded at 1750 m flying in grassland inside pine forest.
- Season: Spring and Post-Monsoon (April 14 and Sept 10).

7.6. *Lethe rohria* (Fabricius)

- Common Name: Common TreeBrown
- The upper surface of wing in male is plain brown while female contains white band from just above tornus to mid-costa.
- The lower surface contains pattern of irregular ocelli and bands in black, brown and white.
- Wing span: 48-58 mm
- Recorded at 1750 m flying in grassland inside pine forest.
- Season: Spring and Post-Monsoon (May 17, Sep 10 and Oct 11).

7.7. *Lethe confusa* (Aurivillius)

- Common Name: Banded Treebrown
- The upper surface of wing is black. Forewing contains discal band from tornus to mid-costa.
- Under hind wing is patterned with unequal marginal ocelli – the apical one being much larger, also straight yellow discal line.
- Wing span: 48-58 mm
- Recorded at 1750 m flying in grassland inside pine forest.
- Season: Pre-Monsoon and Post-Monsoon (April 18, Aug 28 and Oct 11).

7.8. *Lethe verma* (Fruhstorfer)

- Common Name: Straight Banded Treebrown
- The upper surface of wing is black. Forewing contains white discal band from just tornus to mid-costa.
- Under hind wing is plain with very even band of marginal ocelli, and only very obscure discal line.
- Wing span: 48-58 mm
- Recorded at 1750 m flying in grassland inside pine forest.
- Season: Pre-Monsoon and Post-Monsoon (April 18, Aug 28 and Oct 11).

7.9. *Orsitrioena medus* (Fabricius)

- Common Name: Jungle Brown
- The upper surface of wing is dark brown. It lacks ocelli but the discal line is visible from below.
- The wet season form contains creamy discal line and two ocelli on both wings while the wet season form lacks it.
- Wing span: 40-48 mm
- Recorded at 1750 m flying in grassland inside pine forest.

- Season: Pre-Monsoon and Post-Monsoon (April 18, Aug 28 and Oct 11).

7.10. *Ypthima sakra* (Moore)

- Common Name: Himalayan Five Ring
- The fore wing has a double apical ocellus both above and below.
- Under hind wing is yellowish brown in color with two apical ocelli much larger than the others and usually enclosed by single yellow ring.
- Tornal double ocellus with a single ring, bands either faint or absent and a submarginal line or border present. It lacks dry season form.
- Wing span: 40-45 mm
- Recorded at 1750 m flying in grassland inside pine forest.
- Season: Pre- and Post-Monsoon (April 18, Aug 28 and Oct 11).

7.11. *Ypthima baldus* (Fabricius)

- Common Name: Common Five Ring
- The under surface wing spots are similar to Himalayan Fivering but in addition to that, it contains a male brand on the upper fore wing. The spots are reduced in dry season form.
- Wing span: 30-35 mm
- Recorded at 1750 m flying in grassland inside pine forest.
- Season: Pre- and Post-Monsoon (April 18, Aug 28 and Oct 11).

7.12. *Ypthima avanta* (Moore)

- Common Name: Jewel Four Ring
- The wings contain five rings with the 3 tornal ones in a line. There is no ocelli on upper fore wing.
- The spots are reduced in dry season form.
- Wing span: 30-35 mm
- Recorded at 1750 m flying in grassland inside pine forest.
- Season: Monsoon (June 25).

7.13. *Ypthima nareda* (Koller)

- Common Name: Large Three Ring
- The upper surface of fore wing is without brand. The under surface contains a submarginal band; no discal band. Hind wing contains a submarginal band.
- The under surface of wing contains large ocelli but not enormous.
- Wing span: 30-35 mm
- Recorded at 1750 m flying in grassland inside pine forest.

- Season: Pre-Monsoon (April 18)

7.14. *Ypthima confusa* (Shirozou and Shima)

- Common Name: Confusing Three Ring
- The under surface wing spots are similar to other threeings but it contains a much smaller under hindwing apical ocellus.
- Wing span: 32-36 mm
- Recorded at 1600 m flying in grassland inside pine forest.
- Season: Monsoon (June 25).

7.15. *Dallacha hyagriva* (Moore)

- Common Name: Brown Argus
- The upper surface of wing is brown in color and contains apical forewing and tornal hind wing ocelli.
- The underside is pale brown; the fore wing ocellus corresponding but hind wing has two pairs of apical and tornal ocelli.
- Wing span: 32-36 mm
- Recorded at 1600 m flying in grassland inside pine forest.
- Season: Post Monsoon (October 28).

7.16. *Aulocera saraswatii* (Kollar)

- Common Name: Striated satyr
- This is a common local species. The upper surface is black with white bands reaching dorsum on hind wing. There is an inner extra white spot inside the hind wing. The under surface wing spots are similar to other Three Rings but it contains a much smaller under hind wing apical ocellus.
- Wing span: 32-36 mm
- Recorded at 1600 m flying in grassland inside pine forest.
- Season: Post-Monsoon (Sep 10 and Oct 11).

8. Family Danaidae

- This family includes two groups of very tough butterflies; 1. The **Tigers** with their stripy patterns of darkened veins and 2. The velvety black **Crows** with sometimes the most beautiful iridescent purple sheen.
- All the species retain unpleasant or toxic body fluids from their larval food plants (mostly *Ascelepindaceae*) which gives them such a degree of protection from would be predators that many unrelated species mimic them.

8.1. *Danaus chrysippus* (Linnaeus)

- Common Name: Plain Tiger
- Above plain tawny brown; black edges and apex, white pre-apical bar, black spots on hind wing disc. Below as above, but hind wing has single row of white centered marginal spots. No forewing costal spot.
- Wing span: 58-68 mm
- Recorded at 1550 m flying in grassland near crop field.
- Season: Feb - Oct

8.2. *Tirumala septentrionis* (Butker)

- Common Name: Dark Blue Tiger
- Ground color darker blue, but now down to about a quarter, compared with three-quarters black, particularly with very narrow streaks beyond cells.
- Wing span: 65-95 mm
- Recorded at 1550 m flying in grassland near crop field.
- Season: March, Apr, June- Aug, Oct.

8.3. *Parantica aglea melanoides* (Moore 1883)

- Common Name: Glassy Tiger
- Ground color white, with all veins darkened also cells of wings divided longwise by black lines. Males of this genus have under hind wing tornal brands.
- Wing span: 60-75 mm
- Recorded at 1750 m flying in grassland.
- Season: Feb - Oct

8.4. *Euploea mulciber* (Cramer)

- Common Name: Striped Blue Crow
- Above male forewings black spot with purple, few pale discal spots, hind wing brown. Female brown with white striped all over hind wing white spots on forewing (purple sheen still on disc.)
- Wing span: 80-90 mm
- Recorded at 1550 m flying in citrus plant.
- Season: March - Oct

8.5. *Euploea core* (Cramer)

- Common Name: Common Indian Crow

- Above dark brown with double row of white marginal spots. Inner ones incomplete on forewing. Male has obscure brand on lower forewing disc. Forewing dorsum is straight.
- Wing span: 75-85 mm
- Recorded at 1550 m flying in grassland near crop field and in citrus plant
- Season: Apr-Sept, Dec

9. Family Hesperiidae

- As their name suggests these small butterflies have rapid darting flight.
- They are the most primitive of the butterfly families, closest to certain groups of Moths.
- They differ from the butterflies in having none of the radial branches in fore wing stalked and all arising from discal cell.
- Antennal tips are usually recurved or hooked at tips.

9.1. *Tagiades litigiosa* (Moschler)

- Common Name: Water Snow Flat
- Above forewing black with small white dots. Hind wing-base black, lower disc white (unspotted) margin with black spots that may be joined in wet season.
- Wing span: 30-35 mm
- Recorded at 2000 m flying in grassland near crop field.
- Season: March-May

9.2. *Spialia galba* (Fabricius)

- Common Name: Indian Skipper
- Above black chequered with white spots- discal and marginal, discal spot on hindwing prominent. Below forewing as above, hindwing greenish with white bands instead of spots.
- Wing span: 20-25 mm
- Recorded at 2000 m flying in grassland near crop field.
- Season: Feb, June, July, Oct, Dec.

9.3. *Notocrypta curvifascia* (Felder)

- Common Name: Restricted Demon
- Above black white discal band clearly elbowed so as to reach dorsum not tornus- also stops just short of mis-costa. Below lighter brown somewhat mottled.
- Wing span: 33-38 mm

- Recorded at 2200 m flying near forest streams.
- Season: Apr – Sept.

9.4. *Udaspes folus* (Cramer)

- Common Name: Grass Demon
- Above brown, forewing band broken into spots, hindwing discal white patch. Below hindwing very different lower three quarters white with lower discal brown cresent shaped mark, costa dark brown.
- Wing span: 33-38 mm
- Recorded at 2200 m flying in grassland near crop field.
- Season: Apr – Sept.

9.5. *Teliocota bambusae* (Moore)

- Common Name: Dark Palm Dart
- Above orange and black rather like the Darts, but with spots joined on forewing to make a complete orange patch surrounding a black diaGoNal streak, on which the male has a brand.
- Wing span: 25-28 mm
- Recorded at 2200 m flying in grassland near crop field.
- Season: July, Sept, Nov.

9.6. *Parnara guttata mangala* (Moore)

- Common Name: Straight Swift
- Above dark brown with row of white discal spots on forewing and hindwing. Hindwing row straight, forewing with two tiny dots in cell. Below brown with similar spots.
- Wing span: 28-35 mm
- Recorded at 2200 m flying in grassland near crop field.
- Season: Mar-May, July-Oct.

9.7. *Pelopidas sinensis* (Mabille)

- Common Name: Large Branded Swift
- Above dark, below pale brown spots creamy white above but silvery white on underhindwing which form a discal curve and one near base. Two cell spots on forewing under which male has brand.
- Wing span: 33-38 mm
- Recorded at 2500 m flying in grassland near crop field.
- Season: Mar-Apr, June-Sept.

9.8. *Polytremis eltola* (Hewitson)

- Common Name: Yellow-Spot Swift
- Above and below mid-brown; spots yellow on male, white on female comprising forewing with two cell spots above a large square one and hind wing containing two discal spots with a dot in between.
- Wing span: 35-40 mm
- Recorded at 2400 m flying in shady forest.
- Season: Apr, Sept, Oct.

9.9. *Caltoris tulsi* (DeNiceville)

- Common Name: Purple Swift
- Above dark brown, below purple washed. No forewing cell spots but decreasing discal row as in Colon Swift. No hind wing spots.
- Wing span: 35-40 mm
- Recorded at 2400 m flying in shady forest.
- Season: Apr, Sept, Oct.

5.2 Species Richness

Species richness, a measure of species diversity, is the total number of species within a particular sample area or study area. *Precis* is the most species rich genus of the study area which contains the entire six species present in Nepal followed by *Ypthima* containing five and *Lethe* and *Papilio* containing four species. *Mycalesis* and *Graphium* are represented by three and *Euploea, Symbrenthia, Pieris and Colias* are represented by two species. The remaining genuses are represented by single species only.

Nymphalidae was the most abundant and richest family in the study area represented by 19 species, being followed by Satyridae containing 16 species. The Hesperidae and Papilionidae family are represented by nine species while the Pieridae by 7 species. Similarly the Lycaenidae and Danaidae contain five species. The lowest record of species is held by Nemeobiidae containing three and Acraeidae containing single species only. The number of species present in Nepal and the study area, Time and Date of their collection and their status is on the table.

Table VIII. Butterfly collected/observed, Time/Date of collection, and their status in Badikhel

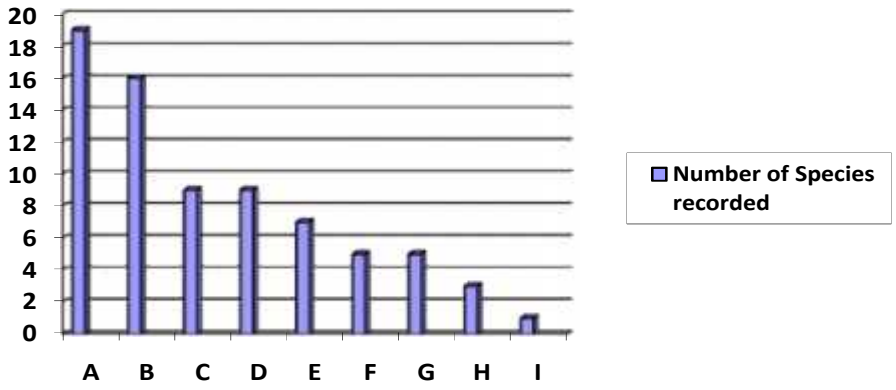
S. N.	Family	Genus	Species Diversity in Nepal	Species Diversity in the study area	Species Belonging to the Genus	Status	Date of Collection
1	Papilionidae	*Graphium (Idaides)*	4	3	*agamemnon*	Getting rare	May 28
					cloanthus	Common	May 28 and Oct 11
					sarpedon	Common	May 28 and Oct 11
		Papilio (Achillides)	4	3	*polyctor*	Common	May 26 and Oct 11
					alcinous	Rare	June 28
					paris	Common	May 26 and Oct 11
		Papilio (Menelaides)	3	1	*polytes*	Common	May 28 and Oct 11
					helenus	Common	June 28
		Papilio (Sainia)	2	1	*protenor*	Common	May 26 and Oct 11
		Troides	2	1	*aeacus*	CITES listed	June 28
2	Pieridae	*Delias*	6	1	*belladona*	Common	April 12
		Eurema	5	1	*hecabe*	Common	Apr.14, June 28 and Oct.11
		Colias	8	2	*erate*	Common	Apr.14, June 28 and Oct.11
					fieldii	Common	Apr.14, June 28 and Oct.11
		Pieris	3	2	*brassicae*	Common	Apr.14, June 28 and Oct.11
					canida	common	Apr.14, June 28 and Oct.11
		Hebomoia	1	1	*glaucippe*	Rare	May 29
3	Lycaenidae	*Zizeeria*	3	1	*maha*	Common	April 14, June 15
		Lampides	1	1	*boeticus*	Common	April 14, June 15
		Celastrina	5	1	*puspa*	Common	April 14, June 15
		Zizina	1	1	*otis*	Not rare	April 14, June 15

		Everes	3	1	*argiades*	Common	April 14
4	Nemeobiidae	*Zemeros*	1	1	*flegyas*	Common	April 15 and Oct 18
		Dodona	6	1	*adonira*	Common	April 15 and Oct 18
		Abisara	3	1	*fylla*	Common	April 15 and Oct 18
5	Acraeidae	*Acraea\ Pareba*	2	1	*issoria*	Common	April 15 and July 18
6	Nymphalidae	*Cethosia*	2	1	*biblis*	Common	April 15 and Oct 18
		Precis	6	6	*hierta*	Only P. atlites is rare; rest are common	April 15 and Oct 18
					orithya		April 15 and Oct 18
					lemonias		April 15 and Oct 18
					almana		April 15 and Oct 18
					atlites		April 18 and Oct 11
					iphita		April 15, July 18 and Oct 18
		Athyma	9	1	*opalina*	Common	April 18 and Oct 11
		Neptis	21	1	*sps*	rare	May 29
		Phaedyma	2	1	*asparia kathmandia*	Very rare	June 18
		Tanaecia	2	1	*lepidea*	Very rare	April 18
		Cyrestis	2	1	*thyodamus*	Getting rare	April 18 and June 18
		Argyreus	1	1	*hyperbius*	Common	April 18, July 18 and Oct 18
		Pseudergolis	1	1	*wedah*	Common	April 18, July 18 and Oct 18
		Symbrenthia	4	2	*hypselis*	Common	July 18 and October 11
					niphanda	rare	July 18 and October 11
		Phalanta	1	1	*phalantha*	common	Apr. 14
		Aglais	2	1	*cashmirensis*	Common	Apr. 14
		Vanessa	2	1	*indica*	Common	June 28 and Oct. 11
7	Satyridae	*Ypthima*	14	5	*sakra*	Y. avanta is rare	Aug.28 and Oct.11

					baldus	while rest are common	Aug.28 and Oct.11
					avanta		June 25
					nareda		June 25 Aug.28
					confusa		June 25
		Dallacha	1	1	*hyagriva*	Common	Oct.28
		Lethe	12	4	*baladeva*	All are common	Apr.14 and Sep.10
					rohria		May 17, July 18, Sep.10 and Oct.11
					confusa		Aug.28 and Oct.11
					verma		Aug.28 and Oct.11
		Orsotrioena	1	1	*medus*	Common	Aug.28 and Oct.11
		Mycalesis	11	3	*lepcha*	Common	Apr.14, July18, Sep.10 and Oct. 11
					mineus	Common	Apr.14, July18, Sep.10 and Oct. 11
					heri	Rare	Apr.14 and Aug.28
		Melanitis	3	1	*leda*	Common	August 28 and October 11
		Aulocera	6	1	*saraswatti*	Common	June 25
8	Danaidae	*Danaus*	4	1	*chrysippus*	Common	August 28 and October 11
		Euploea	9	2	*core, mulciber*	Both common	Apr.14, July18, Sep.10 and Oct. 11
							Apr.14, July18, Sep.10 and Oct. 11
		Parantica	3	1	*aglea*	Common	Apr.14, July18, Sep.10 and Oct. 11
		Tirumala	2	1	*septentrionis*	Common	Apr.14, July18, Sep.10 and Oct. 11
9	Hesperiidae	*Tagiades*	5	1	*litigiosa*	Common	Apr. 15
		Spialia	1	1	*galba*	Common	Apr.14, July18, Sep.10 and Oct. 11

		Notocrypta	2	1	*curvifascia*	Common	Apr.14, July18 and Sep.10
		Udaspes	1	1	*folus*	Common	Apr.14, July18 and Sep.10
		Parnara	2	1	*guttata*	Common	Apr.14, Oct. 11
		Telicota	2	1	*bambusae*	Common	July18 and Sep.10
		Pelopidas	5	1	*sinensis*	Common	July 18 and Sep.10
		Polytremis	3	1	*eltola*	Common	July 18 and Sep.10
		Caltoris	4	1	*tulsi*	Rare	Apr. 15

Fig. VII Species Richness of nine families of Butterfly



Where A=Nymphalidae B=Satyridae C= Papilionidae D= Hesperidae E=Pieridae F= Lycaenidae G= Danaidae H=Nemeobidae I=Acraeidae

The number of butterflies collected in each season is shown below (Table VIII). The potential number of species captured per season ranges from a high of 26 individuals of *Vanessa indica* during Post-Monsoon to a low of single specimen of *Graphium agamemnon* observed during Pre-Monsoon. Seventy-five species of butterfly belonging to fifty genus and nine families were collected/ observed. The seasonal distribution of number of individuals of certain species in the field is given in the following table.

Table IX. Seasonal Distribution of Butterfly species

Species	Number of Species		
	Pre-Monsoon	Monsoon	Post-Monsoon
Graphium agamemnon	1 specimen	-	-
Graphium cloanthus	12	2	18
Graphium sarpedon	9	2	12
Papilio polyctor	12	-	14
Papilio alcinous	-	+	-
Papilio paris	14	8	12
Papilio polytes	13	4	14
Papilio protenor	8	2	6
Papilio helenus	14	6	12
Troides aeacus	2	-	-
Total No. of individual counted	**85**	**26**	**88**
Delias belladona	4	-	-
Eurema hecabe	20	10	22
Colias erate	26	12	22
Colias fieldii	22	10	24
Pieris brassica	24	12	23
Pieris canida	22	10	24
Hebomoia glaucippe	2	-	-
Total No. of individual counted	**120**	**54**	**115**
Zizeeria maha	+	+	+
Lampides boeticus	+	-	+
Celastrina puspa	+	+	-
Zizina otis	+	-	+
Everes argiades	+	-	-
Zemeros flegyas	14	-	12
Dodona adonira	22	-	20
Abisara fylla	18	4	16
Total No. of individual counted	**44**	**4**	**48**
Acraea issoria	15	-	16
Total No. of individual counted	**15**	**-**	**16**
Cethosia bibilis	16	-	14
Precis hierta	2	-	-
Précis orithya	8	-	6
Precis lemonias	4	-	-
Precis almana	16	8	18
Precies atlites	-	-	2
Précis iphita	22	14	20
Athyma opalina	24	-	14
Neptis spp	6	-	4
Phaedyma asparia kathmandia	-	+	-

Taneacia lepidea	3	-	-
Cyrestis thyodamus	-	4	4
Argyreus hyperbius	18	10	22
Pseudergolis wedah	14	10	18
Vanessa indica	-	10	26
Symbrenthia hypselis	-	2	8
Symbrenthia niphanda	-	-	3
Phalanta phalantha	22	10	24
Aglias cashmirensis	12	2	14
Total No. of individual counted	**167**	**70**	**197**
Ypthima sakra	16	-	20
Ypthima baldus	12	-	22
Ypthima avanta	-	1	-
Ypthima nareda	14	-	-
Ypthima confusa	-	4	-
Dallacha hyagriva	-	-	+
Lethe baladeva	8	-	10
Lethe rohria	10	-	12
Lethe confusa	12	-	10
Lethe verma	14	-	16
Orsotrioena medus	14	-	18
Mycalesis lepcha	24	-	25
M. mineus	22	-	20
M. heri	5	-	4
Melanitis leda	-	-	16
Aulocera saraswatii	-	-	20
Total No. of individual counted	**151**	**5**	**193**
Danaus chrysippus	14	-	-
Euploea core	18	8	16
Euploea mulciber	18	10	12
Parantica aglea	12	-	-
Tirumala septentrionis	8	-	-
Total No. of individual counted	**70**	**18**	**28**
Tagiades litigiosa	15	-	-
Spialia galba	8	10	12
Notocrypta curvifascia	14	10	8
Udaspes folus	16	8	14
Parnara guttata	12	10	-
Telicota bambusae	-	8	14
Pelopidas sinensis	+	-	+
Polytremis eltola	+	+	+
Caltoris tulsi	+	-	-

Total No. of individual counted	**65**	**46**	**48**

+ indicates the species only observed or seen flying in the field. - indicates the species not seen in the field during the field study

Distribution of Different Families of Butterfly in Pre-monsoon, monsoon and Post-Monsoon

Fig VIII Distribution of Family Papilionidae in three seasons

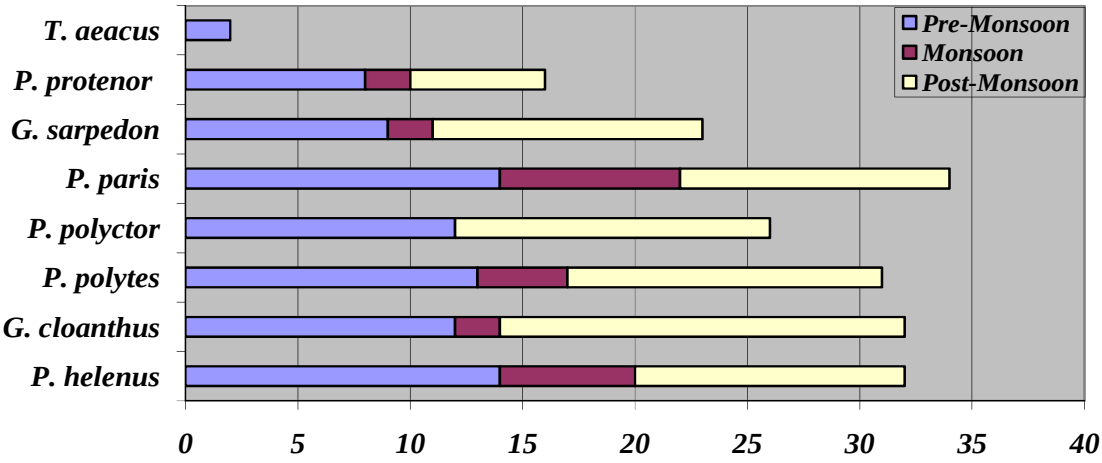


Fig IX Distribution of Family Pieridae in three seasons

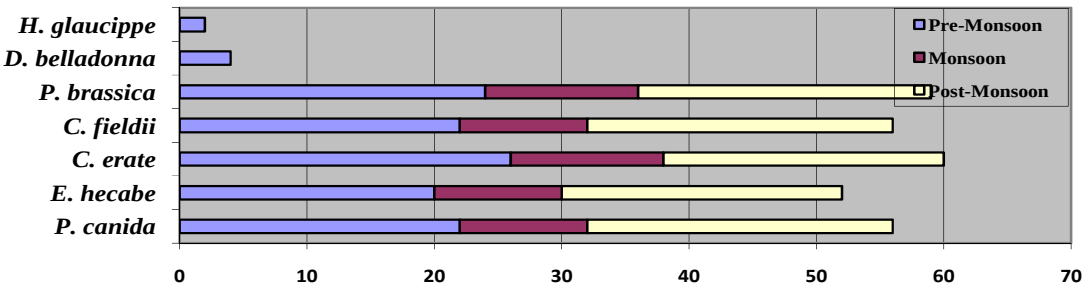


Fig X Distribution of Family Nemeobiidae and Acraeidae in three seasons

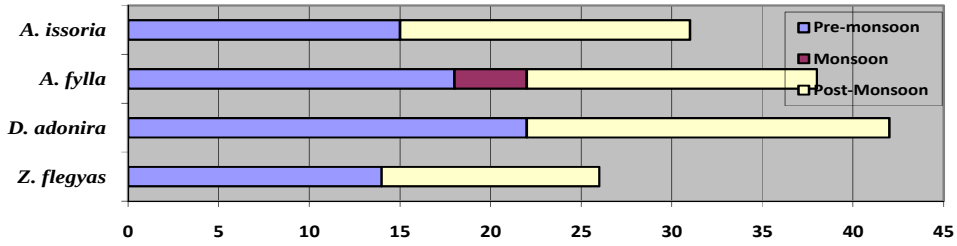


Fig XI Distribution of Family Nymphalidae in three seasons

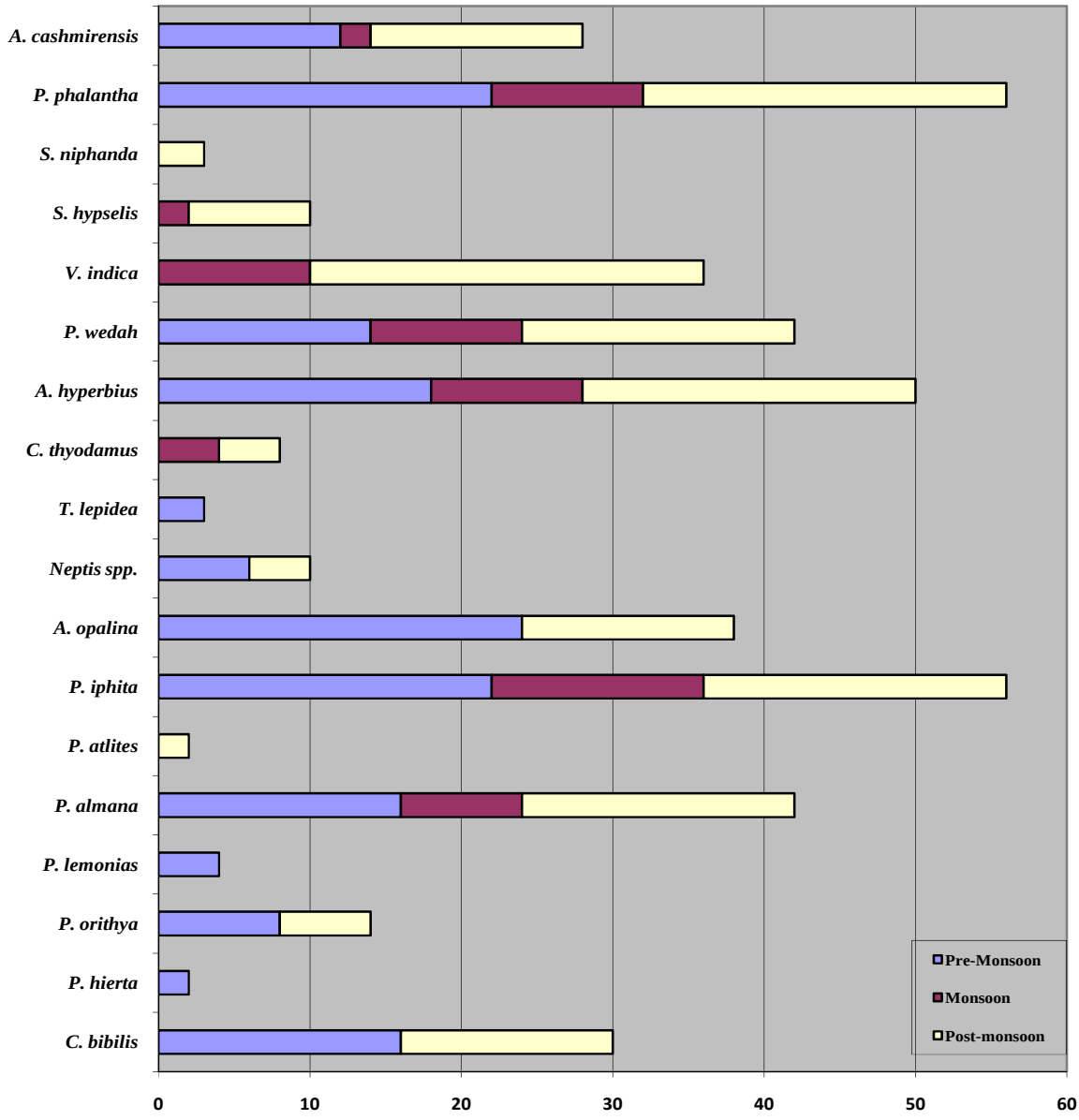

A. cashmirensis
P. phalantha
S. niphanda
S. hypselis
V. indica
P. wedah
A. hyperbius
C. thyodamus
T. lepidea
Neptis spp.
A. opalina
P. iphita
P. atlites
P. almana
P. lemonias
P. orithya
P. hierta
C. bibilis
0
10
20
30
40
50
60
Pre-Monsoon
Monsoon
Post-monsoon

Fig XII Distribution of Family Satyridae in three seasons

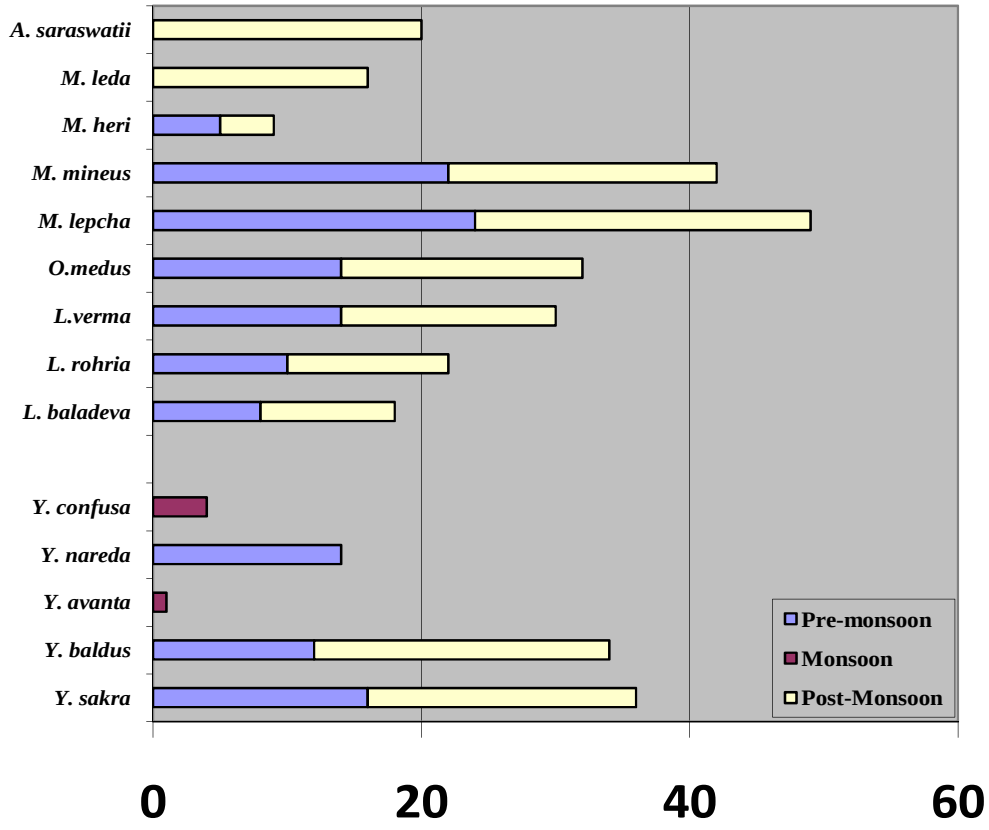
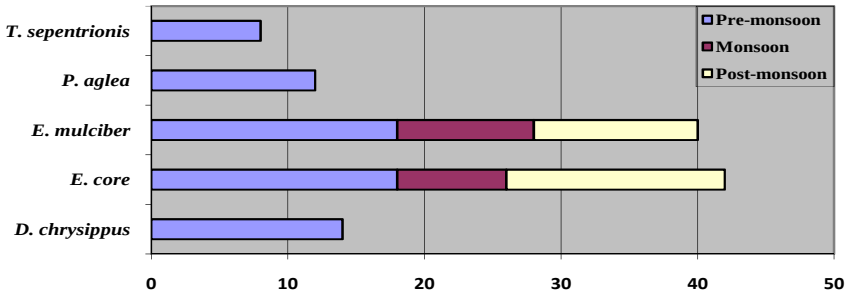


Fig XIII Distribution of Family Danaidae in three seasons



CHAPTER 6

DISCUSSION

Being located at the cross roads of Palearctic and Oriental region, the Phulchoki and Badikhel area serves as ideal place for butterflies due to its diversified vegetation, warm climate and favorable climatic factors. During the entire study period on present investigation entitled "Biodiversity of Butterflies in Badikhel VDC, Lalitpur", different species of butterflies belonging to different families were observed and collected. A total of seventy-five species of butterflies represent by fifty-one genera and nine families were either collected or observed. Among the 75 species reported, sixty species were ranked as "Common", seven species were ranked as "Rare", two getting "Rare", two very "Rare" and one CITES listed species.

Four species were represented by only single individual in the collection-*Graphium agamemnon, Neptis spp., Troides aeacus and Cyrestis thyodamus*. *Graphium agamemnon* was once a common species prevalent in the valley (Khanal and Smith, 1997); at Badikhel a single specimen was seen flying around ricefield and was collected. However, the species was not again seen in the area during the entire study period. The Common Map *Cyrestis thyodamus* was also observed flying near riverside. It was the single species observed and was not observed again at the study site. *Neptis* sp. was collected during May with a single specimen flying near forest stream. Species identification could not be done because of its damaged wings. Thirteen species of *Neptis* is reported from Nepal among which the collected specimen is probably *N. narayana. Troides aeacus* is the CITES listed species. Its single specimen was observed flying at 1500 m at the study site during June. After this like *G. agamemnon;* the specimen was not observed during the field work period.

Hebomoia glaucippe is the largest "White" present in Nepal. Two individuals of this species were observed flying at the top of *Alnus nepalensis* tree at 1700 m during May. However the species was not seen again at the study site. This species was first recorded by Gough during 1935. The Great Hockey-Stick Sailor *Phaedyma aspasia kathmandia* (Fujioka) was observed resting in the Uttis tree *Alnus nepalensis.* This is a rare species reported from the Badikhel community forest and is an endemic sub-species present in Nepal. At the same habitat, Grey Count *Tanaecia lepidea* was also allocated. The individual was a male having upper surface of wing black with grey border on hind-wing.

The rest includes some common butterflies of Nepal. The species most commonly seen during the entire season includes *Euploea core, E. mulciber, Phalanta phalantha, Colias erate, C. fieldii, Pieris spp., Papilio protenor,* etc.

Numerous species of satyrids were present flying in ground vegetation of shady Pine forest during Pre- and Post-monsoon. The list includes aome of the most common species of forest shades including *Ypthima sacra, Y. baldus, Y. avanta, Y. nareda, Y. confusa, Dallacha hyagriva,*

Lethe baladeva, L. rohria, L. confusa, L. verma, *Orsotrioena medus, Mycalesis lepcha, M. mineus, M. heri, Melanitis leda and Aulocera saraswatii.* The majority of satyrids thus collected in the study area were very common while *Y. avanta* and *M. heri* were very few. However due to the massive forest fire immediately preceding the month of June, the monsoon season harbors the least number of butterflies species specially the satyrids living in the forest shades. The Indian Red Admiral *Vanessa indica* was observed in relatively large number during Post-Monsoon flying randomly in the ready to harvest rice field.

Three WSFs of *Melanitis leda* were collected from the field. The wet season forms thus collected are observed to exhibit seasonal variation ranging from the form having ocelli on lower surface of wings to the dry leaf-like form.

This is a potential area for butterflies where, many rare species occur. No conservation scheme has been implemented in this part. Birds and other faunal components are equally rich here. So the government should think to declare this area as the conservation area in time.

This study also made an observation on the worst situation of forest fire at Phulchoki area. This has made direct impact on many species of butterflies burning them of their different stages of life-cycle; likewise an extensive area of their habitat has also been destroyed. So it has also been suggested to become alert with such worst situation of forest fire.

CHAPTER 7

CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The Badikhel forest has a large number of diverse species of representative butterflies. The overall richness and diversity of this area shows the total of 75 species of butterflies have been either collected or observed once in the field. This species represents 11.2 % of the total species present in the world. Furthermore, these butterflies collected are similar to that from Phulchoki area.

Nymphalidae was the most abundant and rich family of butterfly according to the number of individuals and species collected in the area. The population of family Nymphalidae reaches its peak during post-monsoon containing 197 individuals and 167 individuals during pre-monsoon. The population of family Satyridae also reaches its peak during post-mosoon recording 193 specimens. However its population was most severely affected by forest fire being the species harboring forest shade. The most common and most regularly observed species occurring in the area includes *Pieris brassica, Euploea core, E. mulciber, Precis iphita, P. almana, Colias fieldii, etc.* Few species collected or observed were very rare. It includes *Tanaecia lepidea, Phaedyma asparia kathmandia, Troides aeacus, Hebomoia glaucippe, Precis atlites, Neptis, Ypthima avanta*.

The butterfly activity studied on the basis of collection shows that the butterfly species are much abundant during Pre-Monsoon (April-May). The collection of more species of butterfly on the area was favored by different factors like temperature, fluctuation of minimum and maximum temperature, river and also the flowering period of plants. However, a clean outline of butterfly population could not be determined as the study and collection of butterfly was confined to 6 months only. Further, the population of monsoon species was largely effected by the massive forest fire observed during late May. As a result, a clear outline of the monsoon species couldn't be carried out. No significant effort to record woodland species of butterfly has taken place.

The late monsoon was characterized by the presence of abundant number of *Vanessa indica* just on the onset of rice harvest. The migratory pattern of this species also couldn't be carried out due to time limitations.

The effect of temperature and rainfall on population of butterflies could not be reported as the population was severely affected by the presence of Massive forest fire during May. During field observation, the forest fire was found to affect the faunal composition of forest severely. Thus effective preventive measures have to be taken in future to preserve the faunal biodiversity in the future.

7.2 **Recommendation**

1. The study area is a potential habitat for Golden Bird wing *Troides aeacus*, which is listed by CITES as protected species. The conservation of this species can be the conservation of its habitat.

2. This area provides a highly potential habitat for numerous species of butterfly, birds and other fauna as well. On the contrary, it is still unaware of the total diversity of fauna inside the forest areas and any works regarding this has not been initiated and promoted. Due to the varying degree of altitude gradient, the study area offers rich diversity of butterfly species. But, the gradient of species diversity has not been studied so far on the area. This area so close to the capital, despite of its rich Biodiversity, is still not harbored; thus a complete biodiversity assessment of this area is urgently needed.

3. Use of regular amount of inorganic pesticides and chemical fertilizers especially on food crops has largely affected the immature stages of butterflies. It is thus, highly recommended to discourage the use of those pesticides and fertilizers in food crops.

4. The lack of modern preservation techniques has resulted in the degradation of specimens deposited in the museum and universities. The Natural History Museum and universities should implement the modern techniques in butterfly conservation.

5. The survey work carried out so far covers only limited area of the forest. The collection does not provide a complete representation of the diversity and migration pattern of these fauna. Therefore, a further study on the area is highly recommended.

6. The recorded species in the research also includes *P.aspasia kathmandia* which is an endemic species so far. This species is rare and should be conserved along with preservation of habitat.

7. This year massive forest fire during the month of May resulted in severe population depletion in population of species recorded during monsoon. Effective control and preventive measures must be taken so as to save the valuable species of the area.

8. Ignorance and lack of awareness in the local human habitants/human community about the usefulness of butterflies in our eco-system is also reason behind the severe depletion in population of butterflies. Therefore, awareness program on the usefulness and conservation of butterflies among local community is highly recommended.

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ANNEXES

Threat Factors and Conservation Status of Butterfly

1. Threat Factors

The butterfly community of a certain area is largely affected by the mentioned factors.

a. Human Impact

The human manipulation of the natural habitat in the form of intensification of farming and forestry practices has profound effect on the management of semi-natural habitats. It is one of the main causes of the decline of butterflies and moths, particularly for the more specialized species. In grasslands, many species need precise grazing regimes to maintain a suitable sward structure where the larval stages can develop properly. One of the biggest causes of decline amongst woodland butterflies has been the cessation of active broad-leaved woodland management, especially the decline of Krishna Peacock (*Papilio Krishna),* Kaiser-i-Hind (*Teinopalpus imperialis),* Common Birdwing (*Troides Helena) etc.* The restoration and maintenance of sustainable management regimes is vital for the conservation of butterflies and moths.

b. Deforestation

The rate of forest depletion was significantly high up to nineties due to the political, socio-economic and administrative reason. The last National Forest Inventory (NFI) was carried out in early nineties in Nepal. According to that inventory, forest and shrub together cover about 5.83 million ha, which is 39.6% of the total land area of the country. The rate of forest area decreasing was 1.7% per annum during 1978/79 to 1994, whereas rate of forest and shrub depleting rate was 0.5% per annum during the same period. Since then, NFI has not been done to update data on forest cover change. Community Forestry (CF) policy has been implemented from the early eighties and started to handover the entire accessible national forests to the local people for their management and use. The 90's was the decade of community forestry in Nepal and the policy and program also extended to the whole part of the country. This policy has brought significant positive change to restore denuded mountain landscape. Recent studies from 20 Terai districts (southern most districts) revealed that the rate of forest cover changed was at an annual rate of 0.06% during the period of 1990/91 to 2000/2001 (FAO/MFSC, 2009). As mentioned above, the deforestation at certain area plays a major role in wiping out the habitat of butterflies as some of them are specialist feeders.

c. Insecticide use

Pesticide is imported from six different countries in Nepal with local production in scant quantity. Fifty-five certified importers are certified in marketing of seventy-three registered common pesticides in three hundred and forty two trade names. The total number of pesticides registered in the country is seventy-three. Among the total registered pesticides, insecticides are major that amounts to a total of thirty-nine; followed by fungicides which is eighteen. Fourteen types of pesticides are banned for normal use by Government of Nepal (Koirala, 2009). The study carried out in Department of Food Technology and Quality Control during 1995-2007 for the analysis of 1034 food products reveals 12.1% samples contaminated with pesticides (Koirala, 2007). Malathion and BHC were two major pesticides that contaminated in food products. As the larvae of butterfly mostly feed on the plants, the pesticides applied for removal of pests affects them as well.

d. Illegal Collection

With growing encroachment on the forests, the animals have been ousted from their habitats due to lack of space and food. Unfortunately, those who manage to survive are often hunted or killed for various purposes. The exorbitant price one can charge for any trophy or derivative of wildlife or even insects in the international market poses as a major attraction for poachers. Phulchoki and even Badikhel area is frequently visited by these poachers for the collection of animals as well as butterflies.

According to the *Naya Patrika,* a newspaper of Kathmandu published on 31st July, 2009, few foreigners were reported to have collected numerous specimens of butterfly from Phulchoki. They were later caught Red-Handed at Lubhu; along with their collection containing 2200 specimens by the CFUGs of Lubhu and handed over to the DFO office, Lalitpur. However, there is no record of the fate of those specimens. These types of specimens should be presented to the NHM, Swayambhu for Taxonomic work (Khanal, Pers. Comm.).

e. Forest fire

The long drought in winter followed by late monsoon during this last year played a major role in shaping up biodiversity of Nepal. The major forest fire observed the preceding year during January, February and May in Phulchoki and study site at Badikhel plays a major role in decreasing the number of Monsoon species of butterfly. The larvae of numerous butterfly and numerous mollusks observed just prior to the incident forest fire during field study were found burnt down and molluscan shell damaged by it.

2. Conservation Status\ Mitigation

a. Reforestation program

Reforestation program launched at national level could be the first and foremost option in order to save the habitat of numerous woodland species including Kaiser-i-Hind, Krishna Peacock, Common Birdwing, etc.

b. Conservation Education for sustainable use

According to Central Bureau of Statistics (2002-07), the literacy rate of Nepal is fifty-seven percentages. In our country, where still 43 % of people are illiterate; conservation education can be the best option in order to educate people on different issues of conservation, sustainable use and Ecosystem. However, there seems to be no movement taken in order to educate people on this matter.

c. Ban on illegal collection

Everything from human skulls to otter skins and Rhino horns has made their way in and out of Nepal, and apart from a few arrests many of these traders remain below the radar screen and continue their trade. Even after being arrested and prosecuted, many of them manage to escape jail time by paying minimal fine/bail money. Among insects, numerous species of butterflies, Staghorn Beetles, etc is of major attraction among these traders. The district forest office also reported few cases where the Phulchoki and Badikhel area is reported to have been visited by these traders. A ban on illegal collection of these creatures can be an important mitigation in order to save them from being extinct.

d. Promotion of Organic pesticides

The chemical pesticides often impart persistent ill effect to the environment. An important mitigation measure to save the biotic community including the butterflies from pesticide poisoning can be the ban on chemical pesticides having residual effect and promoting the use of organic pesticides.

PLATES

Plate 1 and 2. A glimpse of the Tree canopy at the top of Badikhel Hill

Plate 3 and 4. Badikhel Village as seen from the Top

Plate 5. Valley as seen from the Top

Plate 6.The Variation in Ecosystem

Plate 7 and 8. Herpetofauna of the Badikhel area

Plate 9. Crab

Plate 10. Red Billed Blue Magpie

Plate 11. Asian Koel

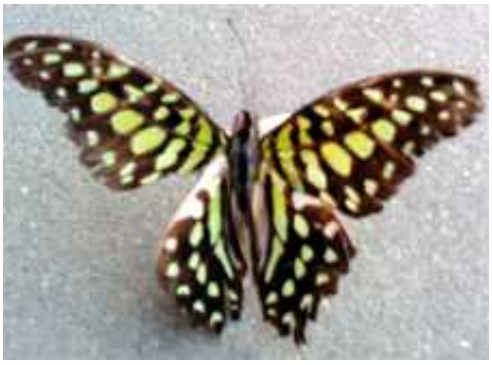

Plate 12 *Graphium agamemnon*

Plate 13 Vegetation re-growth after forest fire

Plate 14 and 15 Ground Vegetation and Trees Destroyed by the Fire

Plate 16 and 17. Larval stages of Lepidoptera

Plate 18. Noctuid Moth

Plate 19. Zygaenid Moth

Plate 20 and 21. Wet- and Dry- Season forms of Dark Judy *Abisara fylla*

Plate 22. *Graphium cloanthus*

Plate 23. Bluebottles on Mud puddles of Godavari

Plate 24. Blue Pansy *Precis orithya*

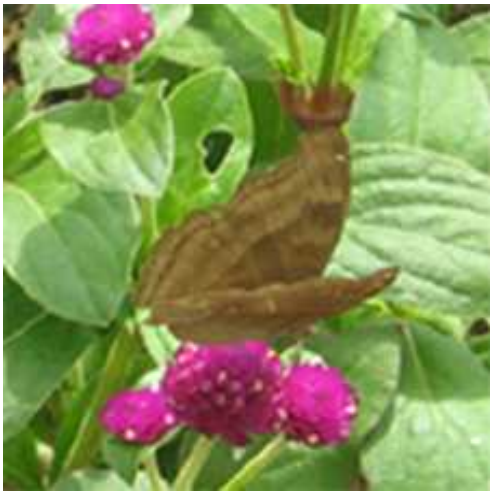

Plate 25. Chocolate Pansy *Precis iphita*

Plate 26. *Vanessa indica*

Plate 27. *Phalanta phalantha*

Plate 28 and 29 Common Map (*Cyrestis thyodanus)*

Plate 30 Cabbage white

Plate 31 Papilio protenor

Plate 32 *Argyreus hyperbius*

Plate 33 *Papilio paris*

Plate 34, 35 and 36 Continuous Seasonal Polyphenism in Three WSFs of *Melanitis leda*

Plate 34 i) Upper Side and ii) Under Side of wings

Plate 35 i) Upper Side and ii) Under Side of wings

Plate 36 i) Upper Side and ii) Under Side of wings

Plate 37 and 38 Male and Female of *Euploea mulciber*

Plate 39 *Euploea* l*core*

Plate 40 Cabbage White

Plate 41 *Cethosia bibilis*

Plate 42 *Delias belladonna*

Plate 43 Precis almana

Plate 44 *Precis lemonias*

Plate 45 and 46 Male and Female of *Pareba issoria*

Plate 47 *Aulocera saraswatti*

Plate 48 Pseudergolis wedah

Plate 49 *Terias hecabe*

Plate 50 *Colias fieldii*

Plate 51 *Athyma opalina*

Plate 52 Study Area at riverside

Plate 53 Satellite image of Nepal during Forest Fire (Downloaded from NASA)