1. GENERAL INTRODUCTION

Butterflies are the most abundant group of insects on the earth which belong to the insect order Lepidoptera, under phylum Arthropoda and are recognizable among the general public, and science due to their beautiful colours, and graceful flight. The butterflies are found in every part of the world wherever the flowering plants are existing and even in very high-altitude, arctic, antarctic mountains, covered with perpetual snow and glaciers. Butterflies are one of the best studied groups, not only geographical subspecies, but even varieties, races, seasonal and sexual forms have been named and described from different regions of the world.

1.1. Study Areas:

The study area, Kashmir Valley, is of paramount importance, because of its central position in Asia, and also as a doorway in between Palaearctic and Oriental region in the Northern India. Kashmir Valley lies between 33°20′ and 43°54′ N Latitude and 73°55′ and 75°35′ E Longitude, covering an area of 15,948 Sq. Kms. Topographically, it is a deep elliptical bowl-shaped valley bounded by lofty mountains of the Pir Panjal Range in the south and south east and the Great Himalayan Range in the north and east, with 64% of the total area being mountainous. The valley is an asymmetrical fertile basin stretching from northeast to northwesterly direction. Its diagonal length (from southeast to northwest corner) is 187 Km, while the breadth varies considerably, being 115.6 Km along the latitude of Srinagar. The altitude of the floor of the valley at Srinagar is 1600m (above sea level). On the basis of temperature and precipitation, the Kashmir valley has four seasons as: (a) Winter Season (December to February); (b) Spring Season (March to May); (c) Summer Season (June to August) and (d) Autumn Season (September to November) in a year.

Kashmir Valley is divided into six districts- Anantnag, Baramulla, Budgam, Kupwara, Pulwama and Srinagar. However, with the creation of four new districts namely Bandipora, Ganderbal, Kulgam and Shopian, the total number of districts of valley has now increased to ten (Anonymous, 2008, 2009) (See Fig., 253; Plate- LIX). In the present study, being first of its kind from the valley, nearly 60 different places belonging to ten administrative districts of the valley and falling in different altitudinal ranges were extensively surveyed during the years of 2004-2007. The district-wise localities and areas, covered during the course of present survey are: Anantnag (Aru, Baisaren, Jawahar Tunnel, Kokernag, Pahalgam,); Bandipora (Hajan, Sonwari,); Baramulla (Baba Reshi, Boniyar, Gantmulla, Gulmarg, Model Town, Mirgund, Pattan, Salamabad, Sangri, Sopore, Tangmarg, Trikanjan, Uri,); Budgam
(Budgam, Chadoora, Dodhpathri, Khan Sahib, Magam, Narbal, Soibugh); Ganderbal (Ganderbal, Safapora); Kulgam (Kulgam, Qazigund); Kupwara (Bakpora, Handwara, Langate, Trehgam, Vedhpura); Pulwama (Awantipora, Pampore); Shopian (Aharbal, Shopian) and Srinagar (Bemina, Botanical garden, Cheshmashahi, Dachigam National Park, Harwan, Hazratbal, HMT area, Hokersar, Nishat, Pantha Chowk, Parimahal, Shankaracharya and Shalimar).

Some of the places like Aharbal, Aru, Baba Reshi, Botanical Garden, Cheshmashahi, Dachigam National Park, Harwan, Hazratbal, Hokersar, Kokernag, Nishat, Parimahal, Pahalgam, Shankaracharya, Shalimar, Srinagar, and Uri, are famous tourist spots. Places like Baisaren and Dodhpathri, are the newly identified tourist places having tremendous diversity of flora and fauna, and were extensively surveyed for the butterfly fauna during the course of present study.

In the present study 40 species of butterflies, distributed over 29 genera, belonging to eight families, viz., Danaidae, Hesperiidae, Libytheidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae and Satyridae, have been studied. Key to families, genera and species is presented in the present thesis. Biology of two species namely Cynthia cardui and Vanessa caschmirensis (Nymphalidae) is given for the first time. Eight species belonging to 3 families namely Danaus genuita, (Danaidae), Catopsilia pomona, C. pyranthe, and Eurema hecabe (Pieridae) and Issoria gemmata gemmata, Junonia orithya, J. almana, and Phalanta phalanta (Nymphalidae) are reported for the first time from Kashmir Himalayas. A systematic, updated and annotated checklist of 155 butterfly species including hitherto unknown species, being reported from Kashmir, is also given (see section 5.1.2). Besides this, many new food plants are being reported for the first time from this region and a checklist of host plants is also presented during the course of present study (see section 5.1.3).


The butterfly body is made of three parts: head, thorax and abdomen. The head has a pair of antennae or feelers which are usually long and knobbed at the ends. The antennae are sensitive to touch and smell, and have a specific number of segments, sometimes of use in identification. There is a pair of compound eyes, one on each side of the head. The eyes are beveled so that a wide angle of vision is possible. The sight of butterflies like many other insects is good for detecting movements, but not details. Each compound eye is made up of thousands of tiny eye modules called ommatidia, each of which has a small lens connected to the optic nerve. The other main feature on the head is tongue, or proboscis, used for sucking up liquids. Its structure resembles two straws fused together and zipped up, (Feltwell, 2001).
The first three segments from the head form the thorax, which bears legs and wings. There are three pairs of legs viz., Prothoracic, Mesothoracic and Metathoracic and each leg is divided into 5 segments - coxa, trochanter or hip, femur or thigh, tibia, and tarsus or foot. Coxa is the segment which is attached to the body. Trochanter is very small, between coxa and femur. Femur is the strongest part of the leg and shorter than tibia. Tibia is slender and may be long and freely movable. Sometimes tibia are armed with spurs or spines or with hair. Tarsus consists of five segments of variable length, the fifth ending in a claw, sometimes bifid, may be blunt or padded.

There are two pairs of membranous wings, called forewings and hindwings, which are supported by veins. The venation is a very important tool for classification and most of the identification of the butterflies is based on the venation and maculation of the wings. The broad area near the base from which the veins arise are known as cells. These also give important clues for identification of groups and species. The surface of the forewing is crossed by 12 veins which according to old numerical nomenclature are generally counted from 1 to 12, starting from the inner margin. However, technical names in place of numbers have been adopted in the present work, accordingly all the 12 veins are parts of five major veins namely Subcosta (Sc), Radius (R), Median (M), Cubitus (Cu) and Anal (A). The Subcosta is always undivided. There are five branches of Radius (R₁ to R₅), three branches of Median (M₁ to M₃) and two branches of Cubitus (Cu₁a and Cu₁b). The two Anal veins exist separately as 1A+2A and 3A. It is worthwhile to mention that all the 12 veins do not exist freely but instead some of the veins get fused together, others become absent and the pattern characterizes different species, genera and families. Most commonly, there is fusion or loss among the branches of Radius and the two Anal veins. The hindwing has only 8 veins because of the fusion of R₁ with Sc and the coalescence of the four other branches of Radius into a joint vein called Radial Sector (Rs). In forewing, space between anal margin-1A+2A, 1A+2A-Cu₁b, Cu₁b-Cu₁a, Cu₁a-M₁₁, M₁₁-M₂, M₂-M₁₁, M₁₁-R₁, R₁-Rₛ, Rₛ-R₃, R₃-R₂, R₂-R₁, and R₁-Sc is referred to as interspace 1a, 1b, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 respectively. Similarly, in hindwing space between anal margin-3A, 3A-1A+2A, 1A+2A-Cu₁b, Cu₁b-Cu₁a, Cu₁a-M₁₁, M₁₁-M₂, M₂-M₁₁, M₁₁-Rₛ, and Rs-Sc+R₁ is referred to as interspace 1a, 1b, 1c, 2, 3, 4, 5, 6, and 7 respectively. The numerical nomenclature and different parts of wings are shown in (Figs., 1, 2; Plate- I).

The Lepidopteran wings generally do not have cross veins and, therefore, the surface of the wings is not divided into cells. However, the bases of the veins Radius, Median and Cubitus usually get fused to form a basal cell which is closed by three veins between bases of
R and M termed as upper, middle and lower discocellulars. This cell is referred to as discal cell or discoidal cell. Some of the species show the presence of a short and usually curved precostal vein or precostal spur arising from near the base of Subcosta and directed towards costal margin.

The wings of butterflies are roughly quadrangular as shown in the figure…. In this figure, the margin between A and B is the anterior or costal margin, the margin between B and C is the apical margin or termen and the margin between C and D is the inner or posterior margin. The angle at A is the basal angle, the angle at B is the apex or apical angle and the angle at C is the tornus.

Wings are covered with scales and these are arranged like overlapping roof tiles. Each scale is attached by a thin shaft that is inserted into a socket in the wing membrane similar, to feathers in birds. The surface of each scale has five longitudinal ridges criss-crossed with finer ridges, giving the appearance of a honeycomb. There are three types of scales - pigmentary scales, structural scales and scent scales. The pigmentary scales are flat and coloured chiefly by melanins. Melanins are responsible for the colours black and brown, which are synthesized internally by the butterfly. The yellows, oranges and reds are taken from the food plant and are directly incorporated into integuments. Most of the blue, purple, green or metallic hues are caused by the interference of the light. Structural scales are present generally only in males and these generate the blue-green colours. Scent or androconial scales are only present in males, and are connected to secretory glands at their bases; they store chemicals known as pheromones, which are generally required in courtship displays for attracting a mate. The wings bear diverse patterns and are very useful in the identification of any butterfly. The wing colour patterns serve as a visual aid during courtship display and mating. The brightly coloured patterns of the male serve as long-range communicators. The average wing beat of a butterfly is 25 beats per minute or less, (Haribal, 1992).

The abdomen having ten segments consists of digestive and reproductive systems. The abdomen having ten segments consists of digestive and reproductive systems. The last two to three segments at the tip form the reproductive organs known as genitalia which are male genitalia and female genitalia respectively. The genitalia show various variations within different families, genera and species and are important in the identification.

Butterflies have a complete four-stage development or metamorphosis and are therefore classified as holometabolous. The four stages are; egg or ovum (Plural: ova), the embryonic stage (Fig., 60-62, 201, 233- 235; Plates- XVI, LVI, LXIV), the caterpillar or larva (plural: larvae), the principal feeding and growing stage (Fig., 181-185, 201, 203, 235-239, 242, 243, 245, 247; Plates- LI, LII, LVI, LXIV, LXVI, LXVII),; the chrysalis or pupa
(plural; chrysalides, pupae), a transition stage (Fig., 188-194, 205-207, 228, 241, 242, 246; Plates- LII- LIV, LVII, LXII, LXVI, LXVII); finally the adult or imago (plural: imagos, imagines), the principal dispersive stage and sole reproductive one. Duration of life-cycle and stages vary with the species and the season. *Cynthia cardui* and *Vanessa cashmiriensis* complete their life cycles between 31-45 and 26-38 days respectively.

1.3. Economic Importance:

The larval stages of butterflies have been found in Kashmir Valley to be destructive to diverse plant species, including agricultural and horticultural crops, forest range plantations, medicinal plants and other economically important plants. The larvae are the primary herbivores in the ecosystem; the adults generally feed on nectar and also act as pollinators of flowering plants. The caterpillars feed on leaves, bore inside buds, eat flowers and others consume fleshy fruits (Fig., 181, 183, 247, 248; Plates- LI, LXVII).

Some of the major/serious butterfly pest species, belonging to different families of agricultural, horticultural and forestry importance occurring in Kashmir are: Lycaenids- *Chaetoprocta odata* on *Juglans regia* (Juglandaceae), *Deudorix epijarbas* on *Aesculus indica*, (Hippocastanaceae) and *Punica granatum* (Punicaceae)), *Virachola isocrates* on *Punica granatum* (Punicaceae), Nymphalids- *Cynthia cardui* on *Urtica dioca* (Urticaceae), Papilionids- *Papilio demoleus* on Anar () and Pierids- *Pieris brassicae* on *Brassica* spp. (Brassicaceae), *Pieris rapae* on *Brassica* spp. (Brassicaceae) and *Raphanus sativus* (Apiaceae) and *Pontia daplidice* on *Brassica* spp. (Brassicaceae);

The butterflies are also one of the important food chain components of the birds, reptiles, spiders and predatory insects. They also have great importance for the study of genetics, insect plant interaction and co-evolution etc. (Sathe et al. 2004). Butterflies show distinct pattern of habitat utilization. The nature of vegetation is the important factor which determines the dependence and survival of a species on a particular habitat. Being highly sensitive to change in the environment, they are easily affected by even relatively minor perturbation in the habitat and are considered as indicators of environmental quality (Uniyal and Mathur, 1998). The presence of butterflies emphasizes availability of the larval food plants in great abundance. There is an intimate association between butterflies and plants (Nishida, 2002., Uniyal and Mathur, 1998) and butterflies and ants (DeVries and Poinar, 1997, Pierce et al., 2002, Thomas et al. 1989) and their lives are exceptionally interlinked. Among butterflies the ability to form intimate associations with ants has evolved in families Lycaenidae and Riodinidae. The fundamental nature of these symbiotic associations is that caterpillars provide ants with food secretions in exchange for protection against predators.
Some of the butterfly species showing symbiotic relationships with ants include *Euliphyra leucyana*, *E. mirifica*, *M. arion*, *Maculinea rebeli*, *M. telius*, etc. Many butterfly species like *Aulocera padma*, *Cynthia cardui*, *Lycaena phlaeas*, *Pelopidas mathais*, *Pieris brassicae*, and *Pontia daplidice* help in the pollination process (Fig., 177, 179, 213- 216; Plates- L, LIX).

The butterflies have also commercial values such as butterfly-farming, butterfly-Parks, etc., are gaining more importance, both in national and international economy in many countries like Canada, China, Kenya, Malaysia, Papua New Guinea, Singapore, UK, and USA. These activities form an important aspects of ecotourism and tourism-linked wildlife. In India, butterfly farming is also gaining importance and recently a butterfly Park has been established in Bangalore (Karnataka) which shows country’s interest and commitment in the conservation of butterfly biodiversity. In addition to this, the concept of butterfly gardens/parks, undoubtedly helps to boost tourism in different parts of the world, including Kashmir Valley, for attracting more tourists and to check the dwindling of natural populations of butterflies of this region thereby will offer protection to endangered species. Keeping in view the values of butterflies, Wildlife Protection Acts: Indian Protection Act 1972, 1989, as well as separate Jammu and Kashmir Act (1978), give legal protection to the butterfly-fauna. Besides, Red Data Book of IUCN (1983), has included endangered butterfly species of the World.

The butterfly-fauna occurring in diverse localities and areas of Kashmir Himalayan regions, is not fully explored. The earlier lepidopterologists who have given fragmentary taxonomic surveys and biodiversity accounts of butterfly species and their surveys were also stretched to the regions now as Pakistan Occupied Kashmir (POK) and Ladakh are; Lang (1868), Moore (1874), Bingham (1905, 1907), Leslie and Evans (1903), Evans (1932), Thomas-Glover(1936), Home (1938), Talbot (1939, 47), Wynter-Blyth (1957), Eisner (1978), Vis and Coene (1987), Eisner and Weiss (1990), and Jamdar (1991, 92). During the course of present investigations, extensive surveys have been carried out for the purpose of detailed assessment of various taxon groups of butterflies, monitoring of abundance and distribution of various species, and to ascertain the preferred host-food plants, with other bioecological observations made in vast agro-ecosystem of Kashmir Himalayan region, during different months/seasons of the year. The present detailed survey of biodiversity of butterflies has revealed that number of species, previously reported from this region were not traceable, and hence needs both *in-situ* and *ex-situ* conservation programmes for their revival.