Materials and Methods
The research material dealing with the present studies comprises of about 3700 adult specimens of all castes (queens, workers and males) belonging to genus *Bombus* Latrielle represented by 30 species, distributed over ten subgenera of the subfamily Apinae under family Apidae, from this region.

**Study area**

During the last four years (2007-2010), thirty five major and fifteen minor collection cum survey tours were conducted in various localities situated in the State of Jammu and Kashmir falling in an altitudinal range of 1000-5500m (Table 4). These localities were systematically explored, every year twice or thrice (May to July for queens and August to October for workers and males) for the collection of all the three castes of every species. Attention was paid to the areas above 2000m. Altitude of each site was measured with digital altimeter. Sampling was conducted at sites dominated by the most representative vegetation types of the region. However, three species which could not be found during the present study were procured on exchange/loan basis from BMNH, London.

**Methods of collection**

Bumblebees were collected with sweeping hand net made up of nylon cloth and latter killed with ethyl acetate. Some collection was also made with the help of malaise trap. Most of the collections were available from open areas rather than closed ones. The collection was based mainly on random sampling methods, covering different agro-ecosystem(s). In addition to collection their live photography was done with Olympus camera equipped with different macro lenses. During the study it was found that bumblebee collection with sweeping hand net
was found more effective than malaise trap, the latter does not work at high altitude because of very high wind velocity accompanied with intermittent rains.

**Killing and setting techniques**

The collected insect material was first sorted out in the field and latter brought to the laboratory for further identification and analysis. For the collection of these insects, special transparent killing jars were designed, so as to preserve the colour of the pubescence. At the bottom of 10 inches long transparent glass jars, paste of plaster of paris was poured and dried. The POP so added was rinsed with ethyl acetate. After putting a cotton plug at the top of the POP it was covered with a layer of thick blotting sheet, so as to prevent the direct contact between insect and ethyl acetate rinsed POP. The inner sides of the killing jar were also covered with filter paper so as to absorb the water vapours which otherwise spoil the pubescence of the insect. As the colour of the pubescence in bumblebees’ holds great importance in identification of species, so its proper care was taken during the collection period. Keeping in view the delicacy and grace of pubescence, insects killed in the killing jar were continuously shifted to other jar of same size so as to protect the pubescence. After coming to the laboratory, the specimens were pinned with the help of entomological pins of different sizes, keeping in view the size of specimen. After stretching the specimens were appended with data label containing the important information regarding its locality, altitude, date of collection and name of the collector. Later on, stretched specimens were transferred to the storage boxes, poisoned with ethyl acetate soaked cotton and naphthalene powder filled in the side grooves of boxes. All the identified specimens have been deposited in the Department of Zoology, Punjabi University, Patiala for future references. For the reference collection, FRI, Dehradun and IARI New
Delhi were visited. Some of the material was also procured on loan/exchange basis from different museums of the world.

**Microscopic permanent and temporary slide mounts**

Temporary slides of different parts *viz.*, male genitalia, labrum, pollen collecting apparatus, antenna, meso and meta basitarsal segments etc were prepared in glycerin and alcohol. In fresh specimens genitalia could easily be pulled out with fine forceps whereas in dried materials the body has to be relaxed overnight in distilled water until it becomes pliable and then genitalia was taken out with forceps and placed in 70% alcohol for further study. Some of its important features like penis valve, gonostylus, gonocoxites, gonobase, volsella and spatha holds a great taxonomic significance.

**Microscopy and field photography**

The microscopic examination of various morphological features was performed with the help of binocular microscope fitted with an ocular grid. The photography of male genitalia was done with Image processing unit and photography of collected specimens were taken with Canon 18 MP LOS 5D. During field survey live photographs of bumblebees along with their host plants were taken with “Olympus” Zoom Digital camera (7.2 MP, C A Media C-7070). Studies have also been made with respect to food preference of different bumblebees. All the food plants of these bees were collected side by side and got identified from the Centre of Plant Taxonomy, University of Kashmir and finally got confirmed from FRI Dehradun.

**Direct observation and marking method**

Colony size, foraging range and visiting timing’s of some dominant
species of *Bombus* were recorded for which direct observations and marking method (Dramstad, 1996) was followed from time to time at different altitudes of Kashmir Himalaya during 2007-2010.

**Identification**

While dealing with bumblebee taxonomy in general, the following taxonomic characters were found trustworthy, stable and unambiguous *viz.*, colour of the pubescence, ocello-ocular area, inter ocular distance, length of malar space, sculpturing of the labrum, length of antennal segments 3, 4 and 5, mandibular teeth number, 7th tergum & sternum in females, shape of mesobasitarsus and corbicular area on metabasitarsus and different parts of male genitalia. Two major keys which were helpful and repeatedly consulted in this connection were by Bingham (1897) and Williams (1991).

**Species diversity index**

Species diversity index of bumblebees was calculated after completing the identification of bumblebees. Species diversity (H) was calculated by the formula given by Margalef (1958) based on Shannon-wiener function as;

\[ H = \sum \frac{P_i \ln P_i}{P_i} \]

where \( P_i = \frac{N_i}{N} \), \( N_i = \text{Total number of individuals in a species} \), \( N = \text{Total number of individuals in all species} \).

Evenness (j) was calculated to estimate the equitability component of diversity using the formula;

\[ j = \frac{H}{\log_{10}S} \text{ (Pielou, 1975)} \]
Richness was computed by using formula;

\[ ma = \frac{S-1}{\log_{10}N} \] (Pielou, 1966)

where \( S \) = total number of species collected.

The present study provides quantitative evidence in the form of species richness, evenness, and characterization of species diversity and abundance of common bumblebee species portraying their role in pollination.

Examination of various morphological characters at different levels was carried out. All the descriptions have been written on a uniform pattern. For this purpose the most typical specimen were selected in each case and variations, if any, are mentioned separately. Synonymies (if any) have properly been traced. Distributional data including date of collection, number of specimens examined and locality with altitude has been provided using a uniform pattern to facilitate comparison. The terminology proposed by Williams (1991) for male genitalia has generally been adopted. Coloured photographs of the genitalia have been provided. Pictorial key for both males and females has been prepared. The international code of Zoological nomenclature (1999) has been consulted wherever required. An inventory of different host plants of bumblebees from Kashmir Himalaya has been prepared, indicating insect host relationship. A separate list of host plants and their bumblebee pollinators has been provided.