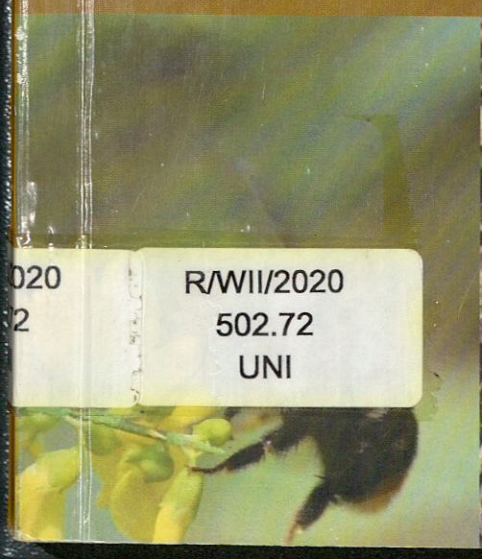
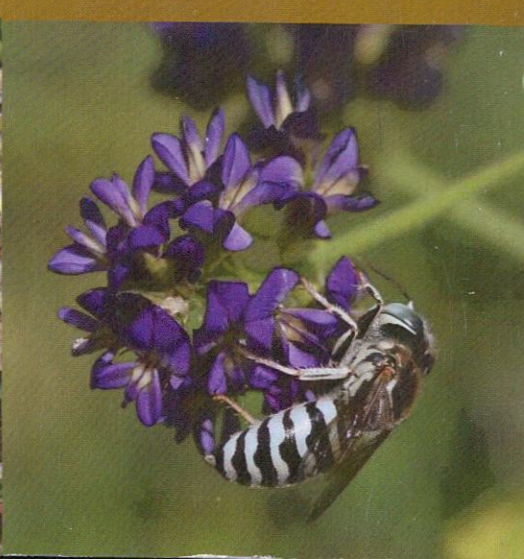
Assessment and Conservation Practices of Pollinators through Community Participation in the Indian Trans Himalayan Region: Climate Change Perspective





Annual Report 2019-2020

Assessment and Conservation Practices of Pollinators through Community Participation in the Indian Trans Himalayan Region: Climate Change Perspective

Ministry of Environment, Forest & Climate Change

Navdanya

GBPNIHESD

भारतीय वन्यजीव संस्थान
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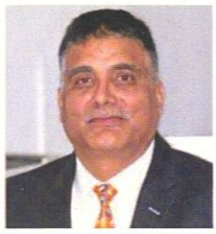

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Contents

Chapter 1

Introduction

1.1 Trans-Himalayas

The Himalaya, is an allurement territory of the nature where the stateliness of the world's highest mountain peak is mirrored in the detached gratefulness and marvellous culture of the people who are living under its shelter. The section of the Himalaya in India (IHR) underlay in the south (Shiwaliks) region and expands to Tibetan plateau in the north (Trans-Himalaya), spanning 11 Indian states and union territories of the country and renders over 5.3 lakh kilometer square of India's total geographical coverage (Sekar, 2012). According to the State Forest Report (FSI; 2015, 2011), forest surrounds~41% of geographical area in the IHR out of which approximately 16.9% area is under very dense forest cover, about 45.4% under moderate forest cover and the rest 37.7% is under open forest category.

The Indian Trans-Himalayas spread over 186,000 km^2 above tree line zone and is known for its thinly dispersed vegetation and comparatively low species diversity. In the Trans-Himalayan region of India, Ladakh contributes the highest geographic coverage (96,701 km^2) followed by Lahaul-Spiti in Himachal Pradesh, Sikkim and Uttarakhand. The Ladakh is excessively cold during winter, when temperature goes down to -30°C or -40°C. Yearly precipitation falls to the north and east, ranging from 500 to 1000 mm in the valleys just north of the Himalaya, to 100 mm in the central Trans-Himalaya such as the Upper Indus near Leh (Fox et al. 1994.)

1.2 Biogeography and biodiversity

The huge mass of the Himalayas creates a rain shadow, denying entry to the moisture laden clouds of the Indian monsoon into Ladakh. Due to high altitude, the climate of Ladakh is very cold, and air is very thin which makes the heat of sun more

intense. The percentage of oxygen is less comparative to other places at different altitude due to scarcity of vegetation, the mountains are naked and the vegetation is thinly distributed in Ladakh. The vegetation is mostly on streambeds and consist of mainly Seabuck thorn, wild roses and certain medicinal grasses. This region has a key role for regulating the climate of the country. Thus, the area is worldwide significant for the conservation of biodiversity. The flora and fauna found here is very unique as they have evolved to confront the harshness of extreme climate conditions. Its location, uncultivated landscapes and impassable slopes are the home for the rare/threatened fauna such as Wild Yak, Ibex, Tibetan Wild Ass, Black-Necked Crane, Tibetan Snow Cock and the predators such as Snow Leopard, Brown Bear, Wolf and Lynx (Indu Sharma, 2017).

The Indian Trans-Himalaya sustains more than 1000 plant species, 225 avian species and many rare and endangered mammalian fauna, including the snow leopard (Kala 2005.). Annual and perennial herbs dominate the flora of Ladakh which counts 611 plant species (Kachroo et al. 1977): 540 dicots, 65 monocots and two gymnosperms. The rich flora of mountain slopes, alpine meadows, moraines and pasture lands develops in July and August. The region is virtually treeless, except for cultivated varieties of Populus and Salix along the major water courses. *Hippophae rhamnoides* is a dominant shrub along the major river valleys. *Juniperus communis* and *Betula utilis* were common but have largely disappeared (Fox et al. 1994). Ladakh is extremely cold during winter with temperatures down to -30 to -40°C. Mean annual precipitation is 100 mm in the central Trans-Himalayan valleys and decreases to the north (Fox et al. 1994). Trans–Himalayan region is the most diverse and more appropriate for the study of high altitude, highly specialized insects, which acts as the bio-indicator for Himalaya's health due to its unique ecosystem. (Khan and Sahni, 1978; Kulshrestha, 1978).

1.3 Tourism

Ladakh officially opened for tourism in 1974 with 527 tourists visited the region (J&K Tourism Department, 2010). Since then the number of tourists has grown consistently. The total number of tourists grew from about 20,000 in 2001 to 150,000 in 2011. Existing trends indicate that tourism in Ladakh is poised to grow in the coming years. Expanding infrastructure to accommodate rapidly growing 'modern' tourism consumes more resources than can be supported by local ecosystems. This has led to over exploitation and degradation. For instance, lack of a proper sewage disposal system in Ladakh is leading to sewage overflow and pollution of local drinking water sources. Studies by ICIMOD suggest that glaciers in Ladakh region are shrinking at a rapid rate, and predicts about 35% of them will disappear within two decades. The building of hotels and restaurants, the renovation of temples, the development of arts and crafts generated by tourism have created new income sources. However, the major profits from tourism flow to airlines, foreign tour operators and Indian travel agencies. Tourism has, however, also created high inflation and increased living costs for those not directly benefiting. Some proposals are made for developing tourism in a way which would reduce these problems.

1.4 Anthropogenic stress in the region

As we know Himalayan ecosystems provide a variety of benefits to people, including provisioning, regulating, cultural and supporting services. These services are interconnected and interlinked to each other which consists conservation of biodiversity, use of natural resources and environmental protection. But the deterioration of ecosystem services due to anthropogenic activities is becoming a big issue in the world. The impact of human activities on ecosystem services includes both negative and positive effects. The negative effects have weakened the ecosystem services through changing habitat, eco-system structure and biogeochemical cycles. The main problems include industrialization, urbanization, climate change, grazing, hunting, international trade and agriculture are reported to influence risks to ecosystem

services. There are many human demands on ecosystem services and will still grow in the coming decades. Unfortunately, ecosystem services are declining around the globe. Approximately 60 % (15 out of 24) of the ecosystem services are being degraded or used unsustainably. The degradation of ecosystem services often causes significant harm to human well-being and represents risks to natural asset or wealth of a country. This combination of ever-growing demands being placed on increasingly degraded ecosystems seriously diminishes the prospects for sustainable development. Also, the degradation of ecosystem services is exacerbated by the associated lack of knowledge that could help to ensure the sustainable use of ecosystem services. Hence, it is provided that necessary management practices should be adopted to enhance and protect the ecosystem services. Also, a new concept of value addition to ecosystem services and payment for ecosystem services should be encouraged for their sustainable use (Abhay and Abha, 2019).

Mountains delineate specified areas for the observation of climatic change and assessment of climate-related impacts (Nogues-Bravo et al. 2007). The reason is because the climate changes very fast with height over comparative short horizontal distances which changes the vegetation and hydrology (Whiteman 2000), or we can say, mountains has been acknowledged as being particularly vulnerable to the harmful impacts of climate change; particularly for species having restricted ecotone or high altitude ecosystems. The global community acknowledge the significance of mountains at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992.

For instance, India's National Action Plan on Climate Change-NAPCC (GoI. 2008), considering national and global importance of the Himalayan Ecosystem, has made special provision of a National Mission for Sustaining Himalayan Ecosystem, one of eight missions and the only mission which is location specific. Furthermore, specifically focusing on forestry sector, the National Mission for a Green India has given directions for defining priorities specially in order to address climate change (CC)

vulnerabilities in the landscape by way of, enhancing carbon sinks in sustainably managed forests and other ecosystems, enhancing resilience and ability of vulnerable species/ecosystems to adapt to the changing climate and enabling forest dependent local communities for better adaptation in the face of climate variability (GoI ,2008)

1.5 Goal of the study

In this context, the carrying capacity of forests vis-à-vis agricultural intensification/diversification needs to be understood. While considering intricate linkages of forests with agriculture and horticulture in the region, among others, the role of forests in providing "pollination services" needs to be considered on priority. This need is evident, as over 90% of flowering plants are pollinated by animals and majority of crop plants are pollinated by insects; bee pollinated crops alone contributing about 30% of human food, and reduction in the population of native pollinators, due to habitat loss of insects will result into insufficient pollination and crop productivity (Mburu et al.,2006; Shivann 2011). Studies reveal that declining apple productivity in Himachal Pradesh is a result of inadequate pollination and the farmers are now compelled to rent colonies of honey bees for pollinating the apples (Ahmad et al., 2002).

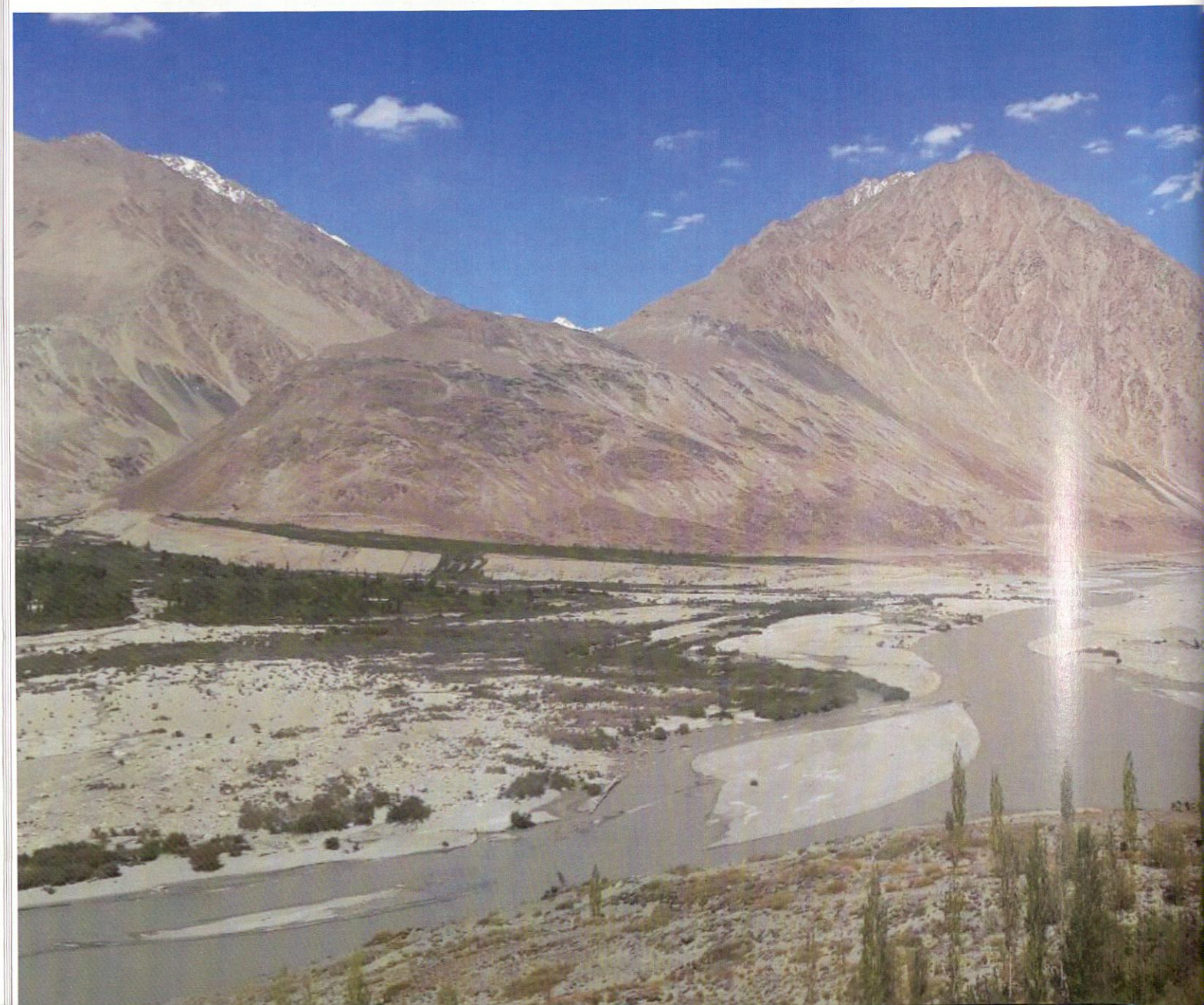
Pollination is the vital process of plant reproductive biology in which the Transfer of pollen from anthers to stigmas of plant, later enabling the production of seeds mainly by insect pollinators. For the conservation and stability of world's flora and fauna this process is critically important. The reproductive output of plants is decline by the reduced pollination services which is caused by excessive use of chemicals, pests, extreme weather, fragmentation and habitat destructions (Kevan and Viana 2003). There is a wide diversity of values linked to pollinators and pollination beyond agriculture and food production. Pollinators and their habitats provide ecological, cultural, financial, health, human, and social values. Pollinators enhance the reproduction and genetic diversity of around 80% of the plant species. More than half of plant species are self-incompatible or dioecious and completely dependent on biotic pollination. These plants are critical for the continued functioning of ecosystems as they

provide food, form habitats and provide other resources for a wide range of species (Mukherjee et al. 2014).

A very large number of insect and vertebrate species depend on flowers as a source of food (Ollerton 2017). Their dependence on food from flowers varies from obligate, as applies to almost all bees, hawkmoths, long-proboscid flies, and specialist avian nectarivores such as hummingbirds and sunbirds, to facultative, as applies to many short-tongued flies, beetles, and opportunistic avian nectarivores. Among the animals that have an obligate dependence on flowers for food, only some depend on a specific plant taxon for food. Estimates of the percentage of bees in various communities that are oligolectic (i.e. depend on a particular plant taxon, usually a genus, for food) range from 15-60% (Minckley and Roulston 2006). This form of specialization usually involves collection of pollen and univoltine reproduction that is synchronized with flowering of the host plants (Minckley and Roulston 2006). The flowers utilized by oligolectic bees are often morphologically unspecialized and abundant (and often also used and pollinated by many polylectic bees). This may reflect that specialization by bees on rare and ephemeral plant species is unlikely to persist through evolutionary time.

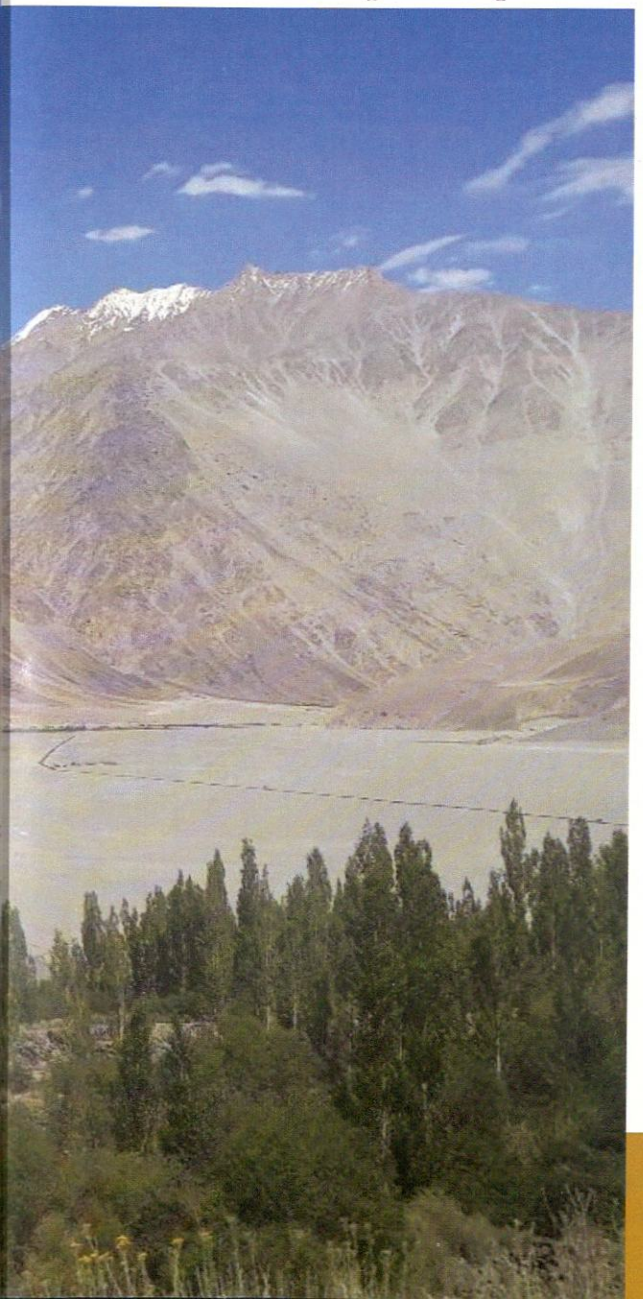
It is obvious that a landscape devoid of flowers, such as a monoculture of cereal crops, will lose many of the animal species that visit flowers for food. A positive relationship between floral abundance and diversity of flower-visiting animals at the habitat scale is now very well established (Potts et al. 2003, Hines and Hendrix 2005, Scheper et al. 2015). However, such relations may in some cases reflect local aggregation of animals and not necessarily a change in population sizes (Roulston and Goodell 2011). Declines of bee species at the countrywide scale have been shown to be correlated with declines in specific host plants (Biesmeijer et al. 2006, Scheper et al. 2014), but it is not easy to establish causality in such large scale correlative studies. In Europe, specialist long-tongued bumblebees have narrower host plant ranges than generalist short-tongued bumblebees and have also declined more rapidly, suggesting that lack of

floral resources, particularly of pollen-rich legumes, has been a causal factor in their decline (Goulson and Darvill 2004, Goulson et al. 2005). The most convincing evidence for an effect of floral resources on pollinator populations comes from demographic studies which show that colony growth and reproduction in bees can reflect the availability of floral resources (Crone and Williams 2016, Spiesman et al. 2017). Beekeeping provides jobs for hundreds of thousands of families all over the world (Hilmi et al. 2011; Johannsmeier 2001). Beekeeping can also form the basis for gaining and Transmitting knowledge about ecological processes (IPBES 2016). Furthermore, understanding of flowers and pollinators is part of the knowledge base for indigenous people and local communities, for example, in some regions, flowering phenology



provides indications for decisions regarding weather predictions. Pollinators and pollinator-dependent plants support technological and knowledge advances through inspiration and application of their biology to human innovations, such as the visually guided flight of robots (IPBES 2016a).

Beekeeping associations can enhance social bonds among beekeepers that facilitate cooperative actions and social connections, having potential to increase or exchange knowledge, improve livelihoods, and long-term resilience (Garibaldi et al. 2016). Furthermore, beekeeping can be a potentially effective intervention tool for empowering youth to link biodiversity, culture and society and take action on issues of environmental impacts on pollinators and pollination (IPBES 2016b).



Pollinators are also critical for the subsistence of many home gardens, which contribute to the creation and maintenance of social relations (Calvet-Mir et al. 2012). By keeping all in mind following objectives were framed:

- Assessment-Impact of land use changes on the pollinators and the risks associated with the loss of pollination services.
- Adaptive management-Identifying the best management practices and technologies to overcome declines in pollinators.
- Capacity Building-Build and strengthen alliances and expertise to increase the benefits from pollination.
- Mainstreaming-Supporting national plans for the conservation and sustainable use of pollinators, and increasing the awareness of governments, industry and the public.

Chapter 2
Study Site:

2.1 Leh-Ladakh

The Himalayas are considered as the highest mountain range globally and covered with huge peaks and difficult terrains (Chevuturi et al. 2018). According to Kumar et al. 1999 and Dey & Kumar 1982, these ranges show significant impact on the climatic patterns at global, regional, local, and micro scales levels however all these changes results in reversible effects on its own climate and vice versa (Dimri and Niyogi 2013). The main five ranges of the Himalayas are Pir Panjal, Great Himalayas, Zanskar, Ladakh and Karakorum (Chevuturi et al. 2018). Ladakh is newly formed Union Territory of India and comprised with Karakoram range in the north and the Great Himalayan range in the south, the Ladakh range and Zanskar ranges are two parallel ranges and extending from northwest to southeast and separated by the Indus (Chevuturi et al. 2018). Ladakh has many old names like Muryul, Last Shangrila, Broken Moon and Moon Land as the names suggest it was an isolated area due to its mountain ranges and inaccessible terrain but many nomadic tribes migrated in 2nd and mid-3rd millennium B.C. (Jina, 1996). Leh-Ladakh is the cold desert part of India and home for cold adapted organisms (Yadav et al. 2015) (Fig. 1). The Ladakh has two main cities Leh, occupied by Buddhist people while Kargil with Muslim community and one

of the least populated area of Indian Himalaya at 4500 m altitude (Otsuka et. al. 2005).

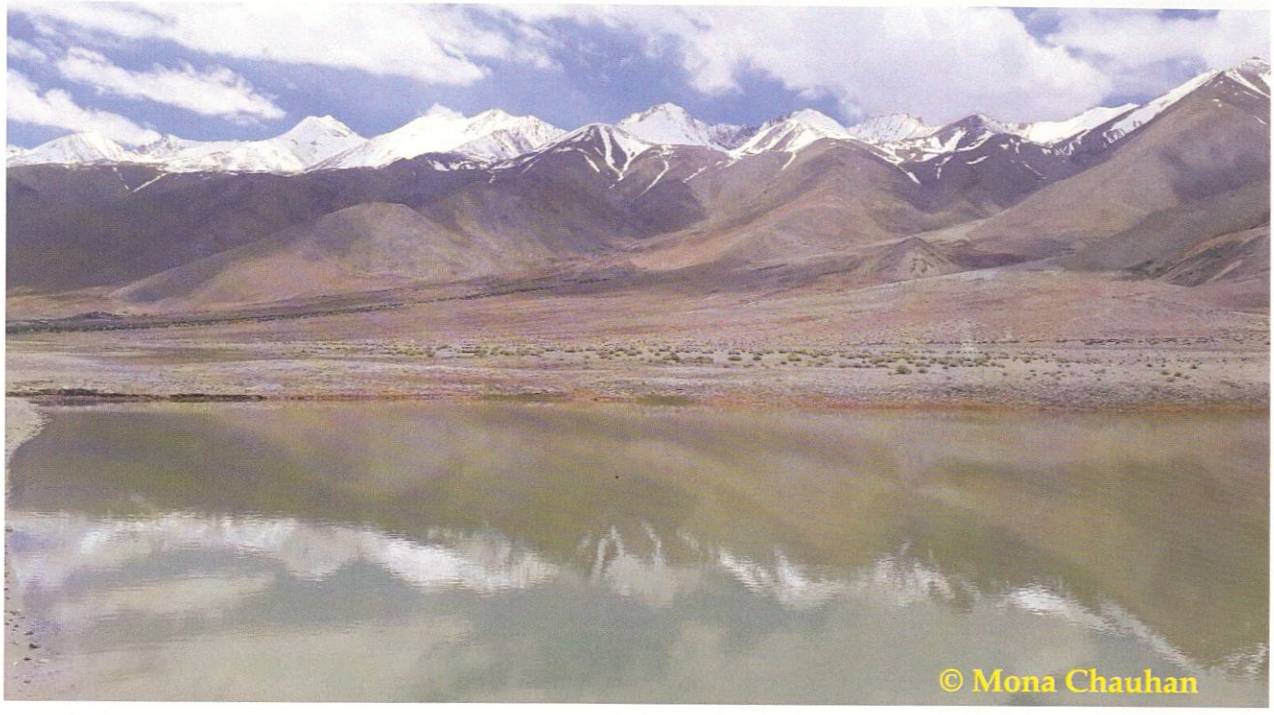


Figure 1. Changthang Wildlife Santcuary, Leh-Ladakh

The Pangong Tso or Pangong Lake is one of the largest salt water lake and situated at the height around 4,250 m with 134 Kilometer in length and ranges to China (Yadav et al. 2015) (Fig. 2). The tidal bore in rivers is the rare natural phenomena which occurs in Indus River, the Zanskar river is a main tributary of the Indus river which is flowing in north direction (Yadav et al. 2015). This region is host to a large and permanent military presence over the past 50 years because of the border dispute with Pakistan and China. This area had an important history and background and was an important market center along the trade routes connecting India to central Asia and Tibet before 1947 or independence of India (Goodall, 2004). In present situation of rapid urbanization which significantly affects Himalayan region and there is a need to assess these developing risks and vulnerabilities (Anhorn et al. 2015; Hewitt and Mehta, 2012; Seto et al. 2010; Tiwari et al. 2018). However, mountain towns are more prone to air and water pollution due to their specific topographical situation (Borsdorf et al. 2015).

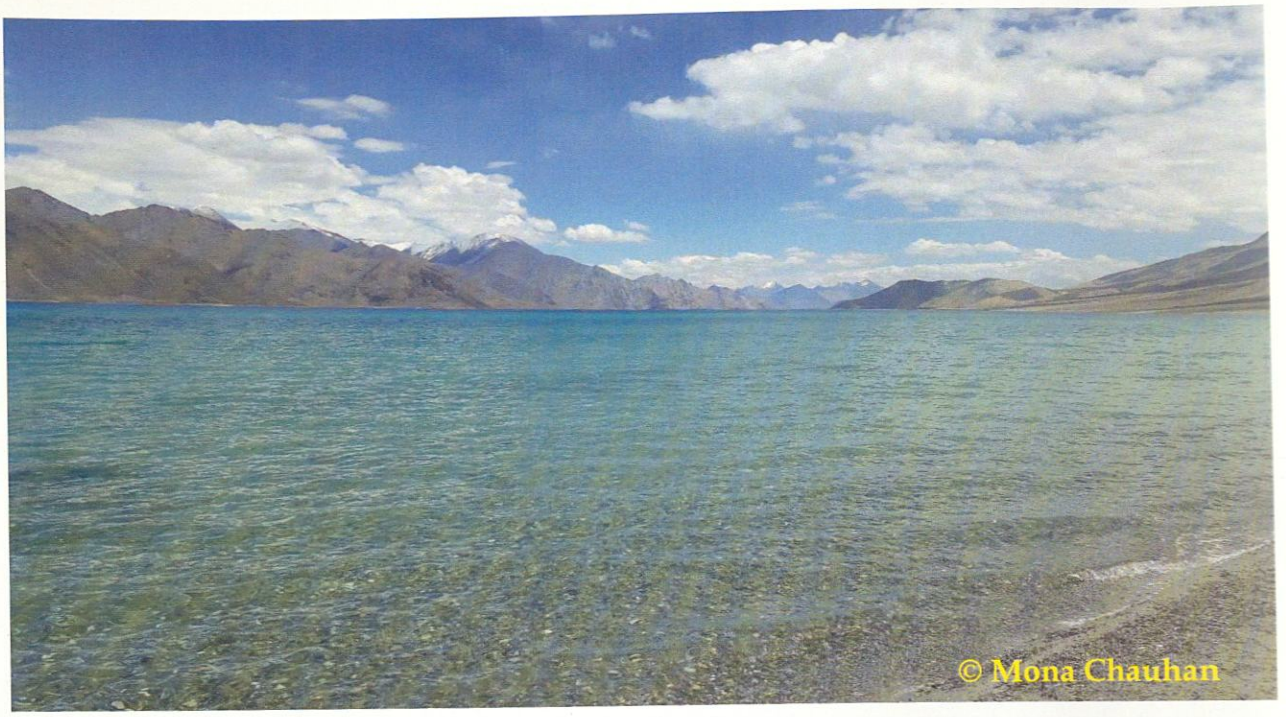


Figure 2. Pangong Tso Lake, Leh-Ladakh

In regions like Ladakh due to excessive aridity the crop cultivation completely rests on glacio-nival meltwater for irrigation (Dame & Mankelow, 2010; Nüsser et al. 2012). Over the last few decades, it is reported that excessive urbanization happen in Ladakh which leads to more migration from both, within and outside Ladakh, as well as for tourists this rapid urbanization results in scarce water resources and a high risk of natural hazards which cause many serious challenges for urban planning and governance (Dame et al. 2019). New constructions and settlements work by year 2003 in Ladakh were happened these are mainly residential and administrative quarters which results in massive increase in buildings urbanization (Dame et al. 2019).

Ladakh has a very vast Buddhist culture, the Buddhism was carried to Ladakh by Mons and Dards during 2nd century A. D. which is later strengthen by Mongolians and Tibetans in 9th century (Jina, 1996). Nubra valley is largest and most irrigated valley of Ladakh and mainly get water from Nubra and Shyok rivers with area of 9216 square miles, 128 miles in length and 72 miles in breadth and surrounded by Karakoram Mountains and on the south by the Kailash range (Jina, 1996).

Approximately 60% population of Ladakh is Buddhist while other inhabitants belong to Sunni and Shiite traditions of Islam in which Baltis and Ladakhis are prominent (Gielen, 1995). The Baltis of Ladakh share their food culture and language to neighboring Baltistan occupied by Pakistan, many cultural differences and political tensions separates the Ladakhi Muslims to Ladakhi Buddhist (Gielen, 1995). Dah, Hano situated at the northern bank of Indus river and inhabited by Dards and Brokpas which means highlanders (Drew, 1976). Brokpas have their villages at the narrow valleys along the Indus River, surrounded by snow-capped mountains. The Brokpas inhabiting these villages are Buddhists and Muslim Dard groups inhabit few villages in Drass. In the 17th century the border between Ladakh and Baltistan at Gur-Gur-Do, separated the Dards (Bhasin, 2008). The Brokpas have totally different culture and traditions from other Ladakhi's they worship Juniper tree and cow and its meat, milk and even its dung is offering to their Gods so they don't drink cow's milk, nor do they eat or make butter from it and neither do they burn cow-dung-the most common used fuel in Ladakh moreover they use bull or Dzo (a hybrid between cow and yak) for ploughing purpose so they have Dzo and Goats and alternate option and use only goat's milk in the households. Generally, a household has at least 15-30 goats and sheep, but few households have more than 100 sheep and goats (Bhasin, 2008). Apart from these Ladakh is also a home for Christians, Hindus, and Sikhs and these are characterized by specific occupation, dress code, language, mode of life while rest have more than one occupation (Bhasin, 2005). The Ladakhi's response to health problems and disease with various techniques and medicines systems, these mainly include Ladakhi medical pluralism are Lamaism, Shamanism (locally known as Lhawaism), scholarly Amchi medicine and allopathy and with their old folk medical system Ladakhi people have been able to survive and maintain the ecological balance (Bhasin, 2005).

The Greater Himalayas are the largest and youngest range, almost cover 10 % of total land space of India and provide habitat to the unique flora and fauna as well as 9000 species of Angiosperms hence considered as the hot spot of biodiversity and are

about 3470 species considered exclusively endemic to the Himalayas (Tewari & Kapoor, 2013). The flora is mainly consisting of annual herbs, perennial herbs and bushes which dominate the flora of cold deserts, these species are mostly xerophytes and mesophytes (Tewari and Kapoor, 2013). William Moorcroft was the first European who studied the wildlife of this region in 1820 and after him Ferdinand Stoliczka, an Austrian-Czech paleontologist had done the massive expedition to explore the area in 1870.

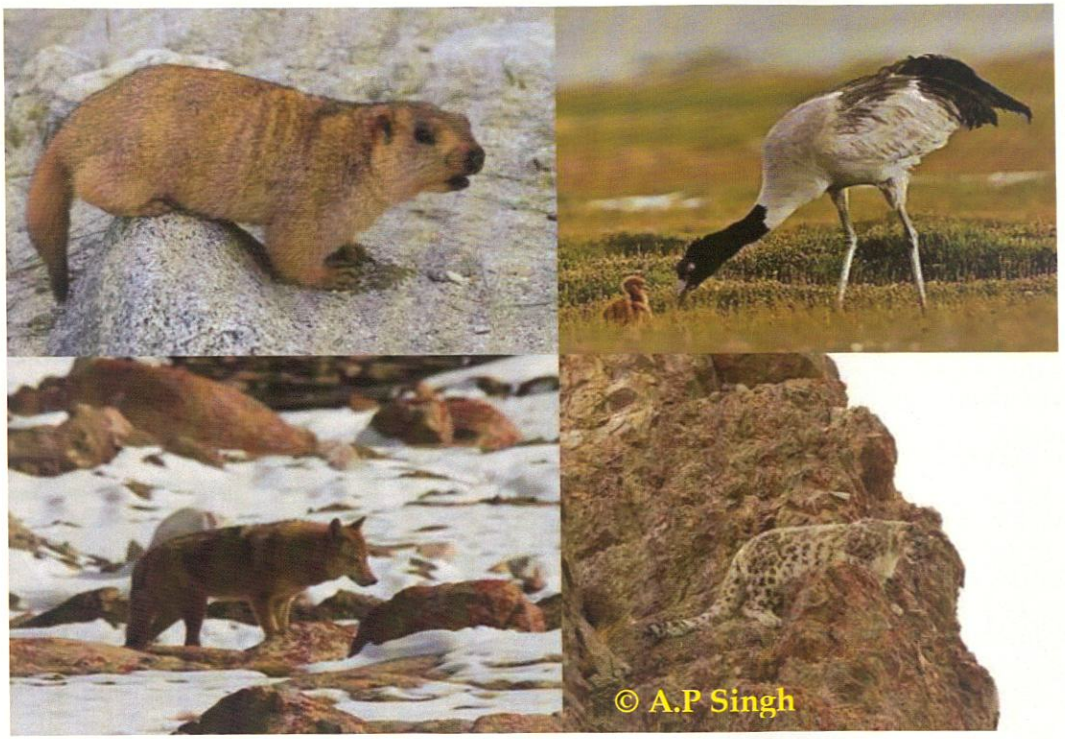


Figure 3. Mammals of the Trans-Himalayan region

In mammals, blue Sheep, Asiatic Ibex, Tibetan Antelope, Tibetan Gazelle, Kiang, Eurasian Lynx, Tibetan Wolf, Tibetan Sand Fox, Brown Bears Marmots, Hares, and pika and vole (Fig. 3) are the main inhabitant of Ladakh (Namgail, 2004; Namgail et al. 2005; Bagchi, 2006; Namgail, 2006; Bhatnagar et al. 2006; Namgail, 2007, Namgail et al. 2008). Many species of Finches, Robins, Redstarts and Hoopoe are common and the Brown-Headed Gull, Brahminy Duck, Bar-Headed Goose, Black-Necked Crane, Raven, Red-Billed Chough, Tibetan Snow cock and Chukar, Lammergeier and

the golden eagle are some rare and are present in Ladakh (Namgail, 2005). According to Pfister study from 1994 to 1997 in Ladakh, A total of 168 species was recorded in which Pallid Scops Owl (*Otus brucei*), Dunlin (*Calidris alpine*), Parasitic Jaeger (*Stercorarius parasiticus*), Greater Spotted Eagle (*Aquila clanga*), Cattle Egret (*Bubulcus ibis*), Black Drongo (*Dicrurus macrocercus*), Rusty-tailed Flycatcher (*Muscicapa ruficauda*) and Dark-sided Flycatcher (*M. sibirica*) are new for Ladakh. The flora of Ladakh is also very diverse in aromatic and medicinal plants (Chaurasia, et al. 1998). The Klimeš and Dickoré, 2005 study describe the 355 vascular plants in which 324 are indigenous species while 31 species are cultivated in the region. About 57 plants used by tribal and local people of Ladakh in medicine Most of the plants contain valuable chemical substances that may be employed in Ayurvedic, Unani, Tibetan systems of treatment (Chaurasia, et al. 1998). In 2005 study of Rawat and Adhikari, A total of 131 sites were covered during the expedition and study the 232 species of vascular plants belonging to 38 families and 101 genera which include 39 species of Poaceae, 27 species of Asteraceae, 25 species of Cyperaceae, 14 species of Brassicaceae, 12 species of Fabaceae and 12 species Ranunculaceae were recorded.

2.2 Mandakini watershed, around Kedarnath Wildlife Sanctuary, Uttarakhand

86% of the state is mountainous and 65% is covered by forest. Geographically, Uttarakhand is divided into two divisions; namely Kumaon and Garhwal that consists of 13 districts. Garhwal division comprises of seven districts in total and Rudraprayag is one of them. It is bounded by Uttarkashi in the north, Chamoli in the east, Pauri Garhwal in the south, and Tehri Garhwal in the south. It lies between the 29° 55′ 37" to 31° 27′ 3" N latitude and 78° 54′ 3" to 80° 2′ 3" E longitude. The head quarter of the district is at Rudraprayag town comprising of three tehsil/blocks *viz.* Ukhimath, Rudraprayag and Jakholi. Mandakini is the main river flowing through this district. Mandakini signifies "she who flows calmly" is a tributary of the Alaknanda River. It originates from the Chorabari glacier near Kedarnath in Uttarakhand. It is fed by Vasukiganga at Sonprayag and further joins Alaknanda at Rudraprayag. Alaknanda

then proceeds towards Devprayag where it joins Bhagirathi River to form the Ganges River. Mandakini is the major tributary of upper Ganges basin. The altitude of Mandakini River catchment extends from 670 to 6000 m.

A number of villages lie in the proximity of Mandakini River that appear at far distances from each other or sometimes seen in hamlets (Fig. 4). Village men grow variety of crops, fruits, vegetables, spices in their farms and kitchen gardens besides cattle rearing. Large number of folk men depends on the adjoining forest areas for their fuel-fodder needs.

Figure 4. Study site in the vicinity of Mandakini watershed, around Kedarnath Wildlife Sanctuary, Uttarakhand

2.3 Munsyari, Pithoragarh, Uttarakhand

Munsyari, one of the tehsil in Pithoragarh district comes under Trans-Himalayan region (Fig. 5). Munsyari refers to a 'place with snow' lies at the base of the great Himalayan mountain range. It is at an elevation of about 2,200 m (7,200 ft.). Munsyari situated on the bank of river Goriganga and is a fast growing tourist destination. It falls on entrance of Johar valley and falls on ancient silk route from Tibet. It has snowcapped peaks like Khaliya top, Ralam and Namik Glaciers. Munsyari has geographical area of 19.68 km sq. and lies between 30°4'2.69" N,80°14'.82"E. It has an elevation of 2200 m above sea level covered with dense forest on North side. It has a variation of temperature due to different attitudinal gradient. Munsyari is rich in flora and fauna. Birds like Himalayan Griffon, Raven, Serpent eagle and Magpie can also be seen. Animals like Leopard, Musk deer and Himalayan bear can be seen here. It is inhabited by Shauka and Bhotias people. Panchachuli is the beautiful snowcapped peak of Munsiyari. The upper part of Munsyari called as Malla-Johar consist of Trans-himalayan alpine villages.

Agricultural crops are mainly dominated by two types of grains in the watershed i.e. Rabi and Kharif. Wheat (*Triticum aestivum*), Barley (*Hordeum vulgare*), Maize (*Zea mays*), Chuwa (*Amaranthus paniculatus*), Uwa (*Hordeum himalayens*), Ogal (*Fagopyrum esculentum*), Chenna (*Panicum miliaceum*), Mandua (*Eleusine coracana*) are cultivated as traditional food. Rajma (*Phaseolus vulgaris*), Kalyun/Black peas (*Pisum viridis*), Bhatt (*Glygcine max*), Masoor (*Lens culinaris*) are main type of pulses grown. Potato (*Solanum tuberosum*) is the major crop of this region. It is considered as cash crop because of its better yield but a disease has been noticed since last few years, which is affecting the production. Radish (*Raphanus sativus*), Rai (*Brassica rugosa*), Palak (*Spinacia oleracea*), Methi (*Trigonella foenum-graecum*), Kakadi (*Cucumis sativus*), Kaddu (*Cucurbita maxima*), Bathua (*Chenopodium album*), bean (*Phaseolus vulgaris*), Chaulai (*Amarathus viridis*) etc. are some of the other vegetables which are cultivated in the area.

The trees of Akhrot/walnut (*Juglans regia*), apple (*Malus domestica*), plum (*Prunus salicina*) and Khubani (*Prunus armeniaca*) are present mainly on the bunds of the agricultural fields. This area is known for high medicinal value plants i.e. Chhibi (*Pleurospermum anagelicoides*), Katki (*Picrorhiza kurroa*), Satwa (*Paris polyphylla*), Dhoop (*Jurinea dolomiaea*), Dolu (*Rheum emodi*), Chook (*Hippophae salicifolia*), Hathjadi/Salampanja (*Dactylorhiza hatagirea*), Thuner (*Taxus wallichiana*) etc. The old people still practice their traditional knowledge to use the medicinal plants for various ailments.

Figure 5. Munsyari, Pithoragarh, Uttarakhand

Chapter 3

Study design

Sampling framework

Sampling was done by direct method i.e. sweep netting in case of pollinating insects. Hand picking method, visual search, vegetation beating and litter extraction, opportunistic sampling and aerial sampling methods were used. Random Sampling for pollinators has been done which majorly includes Hymenoptera, Lepidoptera and Diptera. Collected samples were photographed and documented for further Identification and higher research studies. In addition to sampling, basic agricultural techniques and farming systems, time of seed sowing-flowering-harvesting have also been discussed with the local community farmers through questionnaire sessions. A Questionnaire survey on organic and inorganic farming is also carried out to know the type of farming and use of harmful pesticides for conservation prospects of pollinators. Organizing workshops on pollinator's conservation with farmers and orchards owners and their response to that are recorded. Practices of farming and use of fertilizers and pesticides are recorded. Capacities building of local communities, youth, school children and baseline agencies have been achieved by workshop, conservation awareness program and participatory rural appraisal approach.

A total of 64 sites have been sampled, 31 from Leh (Ladakh) (Fig. 6).; seven from Mandakini watershed, around Kedarnath Wildlife Sanctuary and 26 from Munsyari block in Pithoragarh district of Uttarakhand state (Fig. 7).

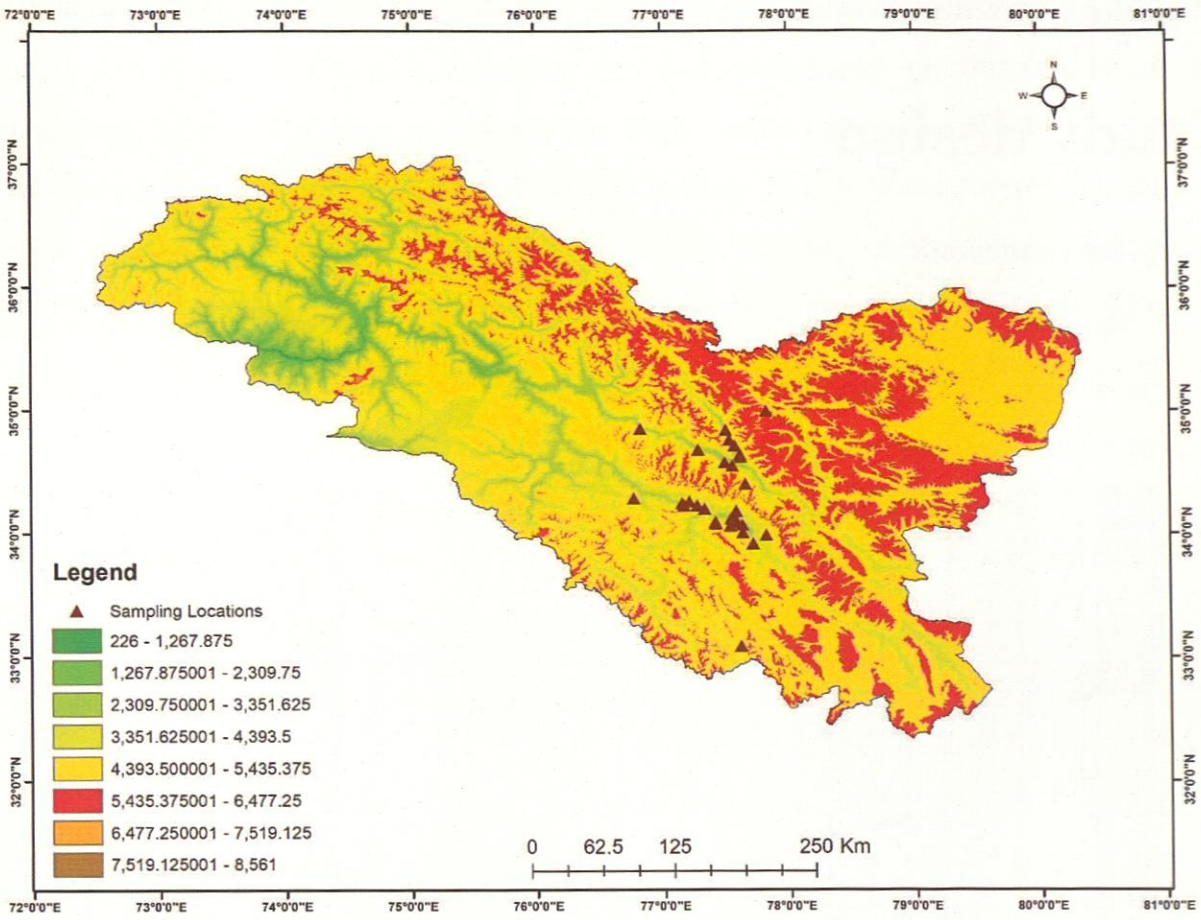


Figure 6. Sampling sites: Leh-Ladakh

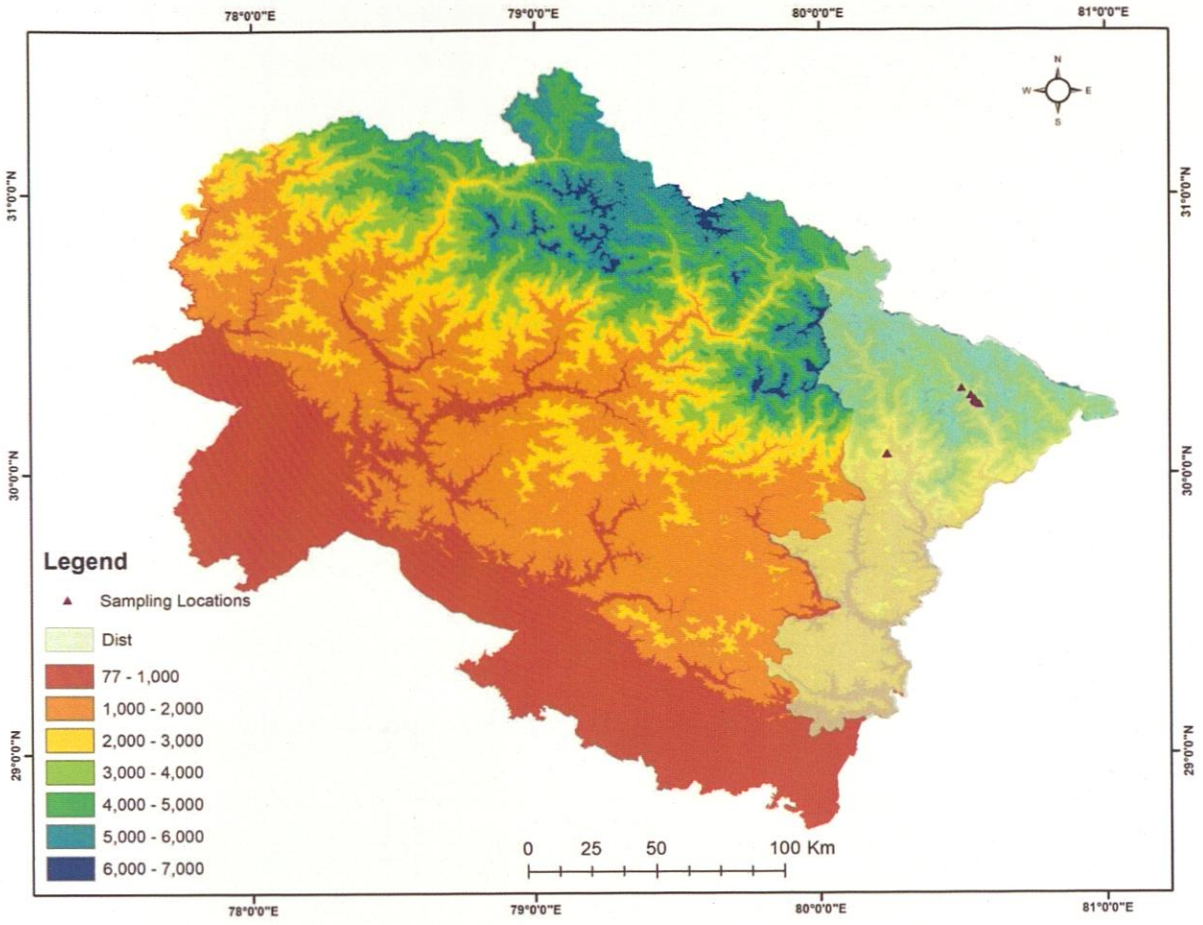


Figure 7. Sampling sites: Uttarakhand

Chapter 4:

Results

4.1 Pollinators of Leh-Ladakh

A total of 52 species of pollinators were recorded from Leh-Ladakh region (Table-1) which consists of 34 species of Hymenoptera, 9 species of Lepidoptera and 9 species of Diptera (Table-2). Among the pollinators *Bombus lucorum* and *Bombus tunicatus* were most abundant than any other pollinators and help in pollination of maximum crops of the area. The use of pesticides was very rare. The farmer and people prefer home gardening with old organic practices which could be the reason of diversification of pollinators.

Table 1. List of sampling sites of Leh-Ladakh

S.No.	Locality	Latitude	Longitude
1.	Ganglas	34°10'42.86" N	077°35'02.67" E
2.	Kurzoo	34°10'31.60" N	077°35'03.35" E
3.	Sankar	34°10'35.66" N	077°34'54.79" E
4.	Hemis	33°54'57.17" N	077°42'46.65" E
5.	Thiksey	34°05'13.75" N	077°36'59.78" E
6.	Spituk	34°07'06.75" N	077°32'37.62" E
7.	Sakhti	33°58'59.00" N	077°49'01.10" E
8.	Karu	34°59'24.38" N	077°49'10.97" E
9.	Shey	34°03'57.41" N	077°37'50.18" E
10.	Khardung (Nubra Valley)	34°23'58.13" N	077°39'19.98" E
11.	Sumur (Nubra Valley)	34°36'59.00" N	077°37'26.17" E
12.	Panamik (Nubra Valley)	34°42'34.03" N	077°34'22.36" E
13.	Sasoma (Nubra Valley)	34°50'11.20" N	077°30'18.43" E

S.No.	Locality	Latitude	Longitude
14.	Diskit (Nubra Valley)	34°32'44.14" N	077°33'17.28" E
15.	Hunder (Nubra Valley)	34°34'21.64" N	077°29'38.99" E
16.	Turtuk (Nubra Valley)	34°50'43.71" N	076°49'31.11" E
17.	Skuru (Nubra Valley)	34°40'31.84" N	077°17'02.05" E
18.	Tigger (Nubra Valley)	34°38'11.14" N	077°37'03.79" E
19.	Murgi (Nubra Valley)	34°45'14.33" N	077°31'56.80" E
20.	Masho	34°00'12.33" N	077°38'04.75" E
21.	Alchi	34°13'27.28" N	077°10'08.99" E
22.	Lamayuru	34°16'58.93" N	076°46'08.16" E
23.	Nimmu	34°11'46.68" N	077°20'01.06" E
24.	Likir	34°15'29.50" N	077°12'39.32" E
25.	Saspol	34°14'39.54" N	077°09'16.60" E
26.	Stok (yogma)	34°03'22.88" N	077°32'15.80" E
27.	Stok (Gogma)	34°05'16.31" N	077°35'16.67" E
28.	Zinchin	34°05'29.88" N	077°25'08.04" E
29.	Basgo	34°13'26.30" N	077°16'27.60" E
30.	Rumchung	34°06'37.33" N	077°23'32.72" E
31.	Osing	34°04'37.19" N	077°25'13.49" E

Table 2. List of Pollinators of Leh-Ladakh

Order Hymenoptera			
S.No.	Family	Scientific name	Common name
1.	Apidae	*Amigella* sp.	Blue-banded bee
2.		*Amigella cingulata*	Blue-banded bee
3.		*Amigella confusa*	-
4.		*Bombus asciaticus*	-
5.		*Bombus lucorum*	White-tailed bumblebee
6.		*Bombus melanurus*	-
7.		*Bombus Pyrosoma*	-
8.		*Bombus semenovianus*	-

9.		*Bombus* sp.	-
10.		*Bombus subtypicus*	-
11.		*Bombus tunicatus*	-
12.		*Xylocopa* sp.1	Carpenter bee
13.		*Xylocopa* sp.2	Carpenter bee
14.		*Xylocopa* sp.3	Carpenter bee
15.	Andrenidae	*Andrena cineraria*	Mining bee
16.		*Andrena haemorrhoa*	Orange-tailed Mining bee
17.		*Andrena* sp. 1	Mining bee
18.		*Andrena* sp. 2	Mining bee
19.		*Andrena* sp. 3	Mining bee
20.	Megachilidae	*Megachile* sp.1	-
21.		*Megachile* sp.2	-
22.		*Megachile* sp.3	-
23.		*Megachile centuncularis*	Patchwork leafcutter bee
24.		*Megachile dorsalis*	-
25.		*Megachile simplex*	-
26.		*Megachile willughbiella*	-
27.		*Anthidium manicatum*	European wool carder bee
28.	Melittidae.	*Mellita* sp.1	-
29.		*Mellita* sp.2	-
30.	Crabronidae	*Bembix* sp.1	Sand wasp
31.		*Bembix* sp.2	Sand wasp
32.	Vespidae	*Odynerus* sp.	Potter wasp
33.		*Polistes dominula*	Paper wasp
34.		*Vespula* sp.	-

Order Lepidoptera			
S.No.	**Family**	**Scientific name**	**Common name**
1.	Lycaenidae	*Lycaena pavana*	White bordered copper
2.		*Aricia agestis*	Brown argus
3.		*Plebejus argus*	Silver studded blue
4.		*Zizina labradus*	Grass blue
5.		*Heliophorus sena*	Sorrel sapphire
6.	Pieridae	*Pieris brassica*	Cabbage white
7.	Nymphalidae	*Cercyonis pegala*	Common wood nymph
8.		*Nymphalis polychloros*	Large tortoise shell
9.		*Vanessa cardui*	Painted lady
Order Diptera			
S. No.	**Family**	**Scientific name**	**Common name**
1.	Syrphidae	*Sphaerophoria* sp.1	Hoverfly or syrphid fly
2.		*Sphaerophoria* sp.2	Hoverfly or syrphid fly
3.		*Eristalis similis*	Glass-winged dronefly
4.		*Eristalis tenax*	Drone fly
5.		*Eristalis* sp.	-
6.		*Eumerus* sp.	-
7.		*Syrphus ribesii*	-
8.		*Eristalis horticola*	-
9.	**Tachinidae**	***Nowickia* sp.**	
			-

4.2 Pollinators of Mandakini watershed, around Kedarnath Wildlife Sanctuary, Uttarakhand

Six species of Diptera (flies), 21 species of Lepidoptera (butterflies) and 11 Hymenoptera (bees and wasps) (Table-4) have been identified from Mandakini watershed, around Kedarnath Wildlife Sanctuary, Uttarakhand (Table-3).

Table 3. List of sampling sites of Mandakini watershed, around Kedarnath Wildlife Sanctuary, Uttarakhand

S.No.	Sampling sites	Latitude	Longitude
1.	Huddu	30°30′24.3″ N	79°09′01.60″ E
2.	Kanda	30°29′54.90″ N	79°08′40.00″ E
3.	Barangali	30°29′58.30″ N	79°08′21.90″ E
4.	Taala	30°30′45.60″ N	79°09′50.80″ E
5.	Ushada	30°30′25.60″ N	79°09′22.70″ E
6.	Semaar	30°29'58.0" N	79°08'34.1" E
7.	Karnadhar	30°30'26.0" N	79°08'54.2" E

Table 4. List of Pollinators of Mandakini watershed, around Kedarnath Wildlife Sanctuary

Order Lepidoptera			
S.No.	**Scientific name**	**Common name**	**Family**
1.	*Papilio polytes*	Common Mormon	Papilionidae
2.	*Mycalesis perseus*	Common Bushbrown	Nymphalidae
3.	*Heliophorus sena*	Sorrel Sapphire	Lycaenidae
4.	*Vanessa indica*	Red Admiral	Nymphalidae
5.	*Aglais cashmirensis aesis*	Indian Tortoiseshell	Nymphalidae
6.	*Cynthia cardui*	Painted Lady	Nymphalidae
7.	*Cyrestis thyodamas ganescha*	Common Map	Nymphalidae
8.	*Neptis mahendra*	Himalayan Sailor	Nymphalidae
9.	*Pieris brassicae*	Large Cabbage White	Pieridae
10.	*Pieris montana*	Mountain Green-Veined White	Pieridae
11.	*Colias fieldii*	Dark Clouded Yellow	Pieridae

12.	*Colias erate*	Pale Clouded Yellow	Pieridae
13.	*Phalantha phalantha*	Common Leopard	Nymphalidae
14.	*Issoria issaea*	Queen of Spain Fritillary	Nymphalidae
15.	*Lyceana phlaeas*	Common Copper	Lycaenidae
16.	*Parantica sita*	Chestnut Tiger	Nymphalidae
17.	*Junonia iphita*	Chocolate Pansy	Nymphalidae
18.	*Gonepteyrx rhamni*	Common Brimstone	Pieridae
19.	*Eurema hecabe*	Common Grass Yellow	Pieridae
20.	*Tagiades litigiosa*	Water Snowflat	Hesperidae
21.	*Catopsilia pomona*	Common Emigrant	Pieridae

Order Hymenoptera			
S.No.	**Scientific name**	**Common name**	**Family**
1.	*Xylocopa* sp.	Carpenter Bee	Apidae
2.	*Apis cerana indica*	Honey Bee	Apidae
3.	*Apis dorsata*	Wild Bee	Apidae
4.	*Sceliphron* sp.	Mud Dauber	Sphecidae
5.	*Vespa sp.*	Hornet	Vespidae
6.	*Ropalidia romandi*	Yellow Brown Paper Wasp	Vespidae
7.	*Polistes* sp.	Paper Wasp	Vespidae
8.	*Bombus haemorrhoidalis*	Bumble Bee	Apidae
9.	*Andrena* sp.	Mining Bee	Andrenidae
10.	*Ammophila* sp.	Thread Waisted Wasp	Sphecidae
11.	*Eumeninae* sp.	Mason Wasp	Vespidae

Order Diptera			
S.No.	**Scientific name**	**Common name**	**Family**
1.	*Bactrocera* sp.	Melon Fly	Tephritidae
2.	*Eristalis* sp.	Hover Fly	Syrphidae
3.	*Lucilia sericata*	Common Green Bottle Fly	Calliphoridae
4.	*Plecia* sp.	Love Bugs	Bibionidae
5.	*Nephrotoma* sp.	Crane Fly	Tipulidae
6.	*Episyrphus* sp.	Marmalade Hoverfly	Syrphidae

4.3 Pollinators of Munsyari, Pithoragarh, Uttarakhand:

Two species of Diptera (flies), 30 species of Lepidoptera (butterflies) and six Hymenoptera (bees and wasps) (Table-6) have been identified from Munsyari, Pithoragarh, Uttarakhand (Table-5).

Table 5. List of sampling sites of Munsyari, Pithoragarh, Uttarakhand

S.No.	Location	Latitude	Longitude
1	Dommar	30.107431° N	80.248322° E
2	Charkham	30.094522° N	80.251811° E
3	Matina	30.06175° N	80.269964° E
4	Malupati	30.065311° N	80.270406° E
5	Chaunna	29.814675° N	80.364694° E
6	Kalamuni	30.038008° N	80.199714° E
7	Josha	30.041872° N	80.299444° E
8	Imala	30.051342° N	80.285742° E
9	Bhadeli	30.075189° N	80.278017° E
10	Madkot	30.057464° N	80.294931° E
11	Timilkhet	30.081097° N	80.2683° E
12	Sheraghat	30.012336° N	80.320639° E
13	Dutibagad	29.752717° N	80.379569° E
14	Jauljibi	29.7502° N	80.378444° E
15	Payya	29.818292° N	80.3923° E
16	Toli	29.814675° N	80.364694° E
17	Baram	29.850308° N	80.357639° E
18	Lumati	29.892322° N	80.318881° E
19	Jamtari	29.814675° N	80.364694° E
20	Chhoribagad	29.814872° N	80.335528° E
21	Mawani	29.960014° N	80.304931° E
22	Bangapani	29.814675° N	80.364694° E

S.No.	Location	Latitude	Longitude
23	Basantkot	29.086964° N	80.280828° E
24	Bothi	30.083483° N	80.286808° E
25	Phalyati	30.090922° N	80.271869° E
26	Khaliya	30.061008° N	80.217775° E

Table 6. List of Pollinators of Munsyari, Uttarakhand

Order Lepidoptera			
S.No.	**Scientific name**	**Common name**	**Family**
1.	*Pieris canidia*	Indian Cabbage White	Pieridae
2.	*Gonopteryx rhami*	Common Brimstone	Pieridae
3.	*Catopsilia pamona*	Common Emigrant	Pieridae
4.	*Colias fieldii*	Dark Clouded Yellow	Pieridae
5.	*Pieris brassicae*	Large Cabbage White	Pieridae
6.	*Pieris canidia*	Indian Cabbage White	Pieridae
7.	*Delias belladona*	Hill Jezebel	Pieridae
8.	*Pieris napi*	Veined White	Pieridae
9.	*Eurema laeta*	Grass Yellow	Pieridae
10.	*Graphium cloanthus*	Glassy Blue Bottle	Papilionidae
11.	*Papilio machaon*	Yellow Swallowtail	Papilionidae
12.	*Papilio crino*	Common Peacock	Papilionidae
13.	*Papilio polytes*	Common Mormon	Papilionidae
14.	*Papilio philoxenus*	Cattle Heart Butterfly	Papilionidae
15.	*Parantica aglea*	Glassy Tiger	Nymphalidae
16.	*Neptis malba*	Himalaya Sailor	Nymphalidae
17.	*Athyma opalina*	Common Sergeant	Nymphalidae
18.	*Ypthima newara*	Three Ring	Nymphalidae

19.	*Callerebia hybrida*	Hybrid Argus	Nymphalidae
20.	*Issoria issaea*	Himalayan Queen Fritillary	Nymphalidae
21.	*Vanessa indica*	Indian Red Admiral	Nymphalidae
22.	*Vanessa cardui*	Painted Lady	Nymphalidae
23.	*Danaus chrysippus*	Plain Tiger	Nymphalidae
24.	*Danaus genutia*	Striped Tiger	Nymphalidae
25.	*Aglais cashmi*	Indian Tortoiseshell	Nymphalidae
26.	*Ypthima kasmira*	Four Ring	Nymphalidae
27.	*Heliophorus brahma*	Sapphire Butterfly	Lycaenidae
28.	*Heliophorus Moorei*	Azzure Sapphire	Lycaenidae
29.	*Liphyra brassolis*	Moth Butterfly	Lycaenidae
30.	***Allotinus drumila***	**Crenulate Mottle**	**Lycaenidae**

Order Hymenoptera			
S.No.	**Scientific name**	**Common name**	**Family**
1.	*Apis mellifera*	Europian Bee	Apidae
2.	*Apis dorsata*	Rock Bee	Apidae
3.	*Apis florea*	Dwarf Bee	Apidae
4.	*Bombus hortorum*	Bumble Bee	Apidae
5.	*Polistes* sp.	Wasp	Vespidae
6.	*Vespa* sp.	Hornet	Vespidae

Order Diptera			
S.No.	**Scientific name**	**Common name**	**Family**
1.	*Hysticia* sp.	Tachinid Fly	Tachinidae
2.	*Lucilia sericata*	Green Bottle Fly	Calliphoridae

4.4 Systematics and observations

1. Hymenoptera

Hymenoptera (sawflies, wasps, ants, and bees) are one of four mega-diverse insect orders, comprising more than 153,000 described and possibly up to one million undescribed species (Grimaldi and Engel, 2005), (Aguiar et al. 2013). As parasitoids, predators, and pollinators, Hymenoptera play a fundamental role in virtually all terrestrial ecosystem and are of substantial economic importance (Grimaldi and Engel, 2005; Chapman and Hall, 1997).

I. Family: Apidae

Characteristics features:

- Sub marginal veins particularly 2nd recurrent vein weakly developed as compared to others.
- Marginal cell opens apically or closed by weak veins (Meliponini).
- Arolia present, hind tibial spur absent (Apini).
- Wings hairless apically, tibial spur of meso leg unmodified (Melectini).
- Second submarginal cell smaller than first, female scopa with largely simple pubescence, sometimes upper part of tibia with plumose hairs (Anthophorini).

1. *Amigella* (Friese, 1897)

Identifying features:

- *Amegilla* is a large genus of bees in the tribe Anthophorini.
- These are the bees with blue and metallic green coloration, separated from the genus Anthophora on the basis of arolia.
- The widely distributed genus *Amegilla* does not possess arolia as that of Anthophora which are characterized by well-developed arolia.

- ❖ Both male and female have yellowish and white markings on their face.
- ❖ In males pygidial plate is absent.
- ❖ The hind tibial scopa is characterized by a band of plumose hairs on its upper margin.

1.1. *Amegilla cingulata* (Fabricius, 1775) (Plate 1)

Common name: Blue-banded bee

Identifying features:

- ❖ Male with 13 antennal segments and female 12 antennal segments.
- ❖ Both male and female have dense pubescence on head and thorax, while it is thinner on clypeus, basal portion of metasomal segments and face below the antennae.
- ❖ Moreover, head and thorax beneath pubescence are finely punctured. Clypeus, labrum and base of mandibles are yellowish.
- ❖ Clypeus is characterized by a sub-apical line and a small triangular area above its base.
- ❖ Pale grayish pubescence on head and thorax with mixture of black hairs,
- ❖ Legs with bluish- white hairs dorsally while black ventrally, hind tibiae covered with long white hairs on upper side and black beneath,
- ❖ Metasoma covered with thin black hairs and Transverse bands of metallic blue pubescence.
- ❖ Wings fusco-hyaline and tegulae dark brown.

Distribution: Burma, India, Sri Lanka, the Malayan region to Australia, Africa (including Madagascar) and the Mediterranean basin and from the Canary Islands east across southern Europe to Japan, Korea and northeast China, south to Yemen, Indonesia, New Guinea, and the whole of Australia (including Tasmania), and east to the Solomon Islands.

1.2. *Amegilla confusa* **(Smith, 1854) (Plate 1)**

Identifying features:

- The entire body closely and finely punctured, thorax and upper part of head thickly pubescent.
- The basal part of the mandibles and the labrum pale yellowish except the spots on the base.
- Clypeus with black color characterized by a spot-on side and an upper triangular spot.
- Vertex and thorax with ash grey color sometime intermixed with black pubescence.
- Hind femora and cheeks with white pubescence, metasoma covered with thin black hairs. Additionally, the abdominal segments with Transverse white faciae dorsally (usually basal four segments or five like in males).
- Wings fusco-hyaline

Distribution: India, Burma, abundant in the holarctic and African regions, scarce in the neotropics and Southeast Asia.

2. *Bombus* **(Latreille, 1802)**

Identifying features:

- Bumblebees are plump and densely furry usually with black, yellow, and/or red coloration.
- The body is broader and stouter-bodied than honeybees,
- Abdomen tip is more rounded with broad bands of colour, the patterns helping to distinguish different species.

- ❖ Bumblebees have long tongues and collect nectar from flowers that are closed into a tube.
- ❖ Bumblebees have fewer stripes and usually have part of the body covered in black fur.

2.1. *Bombus asciaticus* (Morawitz, 1875) (Plate 1)

Identifying features:

- ❖ Body length 14-29 mm; black head prominent eyes.
- ❖ Antennae are elongated ocello-ocular region sparsely or thoroughly punctured thorax.
- ❖ Pale white or grayish pubescence with a dark band between wing bases.
- ❖ Dark fuscous wings coloration pubescence prominently blackish, while slightly rufescent on torsi, bright white pubescence on the basal two abdominal segments.
- ❖ Bright rufi-fulvous on the apical four paler fulvous red pubescence on abdominal segments of males.

Distribution: Tibet, Mongolia, India Afghanistan, Pakistan, Nepal, Kazakhstan, Kyrgyzstan, Tajikistan and China

2.2. *Bombus lucorum* (Linnaeus, 1761) (Plate 1)

Identifying features:

- ❖ *Bombus lucorum* is a large bumblebee, with the queen having a length of 18–22 mm and wingspan of around 36 mm
- ❖ The workers are smaller than the queens, with a length of 12–18 mm and weight of 0.04-0.32 g.

- ❖ The males are 16-18mm in size and differ more in their appearance from the queens with their yellow noses and larger amounts of yellow hairs.
- ❖ The species has a short proboscis.
- ❖ The predominant color is black, with a pale-yellow collar, a yellow band on the second tergite and a white tail.

Distribution: Palearctic, Oriental, Arctic, western Nearctic regions, India and Japan. Iceland, Britain.

2.3. *Bombus melanurus* (Lepeletier, 1835) (Plate 1)

Identifying features:

- ❖ Body with dense pale yellow-white hair with black stripes between the wing bases.
- ❖ In queen pubescence on head, 3-5th abdominal tergites black, pronotum, metanotum and first 2 abdominal tergites are dirty yellow; mesonotum is dirty yellow.
- ❖ In workers head and 4th and 5th abdominal tergites black; thorax and 1-3rd abdominal tergites are dirty yellow; Except malar space head covered with thick pubescence; clypeus, labrum an area lateral to and in front of ocelli and narrow stripes on inner and post orbits.
- ❖ In males head and 3-5th abdominal tergites black, thorax and 1st abdominal tergum dirty yellow; 2nd abdominal tergum with anterior dirty yellow and posterior black bands.
- ❖ On females the bright coat can reach the top of the legs, but the male's coats often end sooner.

Distribution: India, Mongolia, Afghanistan, Pakistan, Nepal, Tibet, Europe, Iran, Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, Kazakhstan, Russia, Turkey, Armenia, Lebanon, Syria, Northwestern and Northern China

2.4. *Bombus Pyrosoma* (Morawitz, 1890) (Plate 1)

Identifying features:

- Females are medium sized with pubescence on head, mesonotum, metasomal terga 2nd and 3rd black; pro and metanotum, metasomal tergite 1st golden yellow, sometimes with white hair; metasomal terga 4th and 5th white. Boss on metasomal tergum 6th nearly triangular, for some queens with a weak median groove, for workers it may be weakly ridged.
- The mid basitarsus having distal posterior corner forming nearly a right angle and not sharply pointed, hind basitarsus with the posterior margin nearly straight,
- Mandibles distally broadly rounded with three teeth;
- Dorsum of the head with large and small punctures scattered throughout, except in the ocellar depressions; wings strongly infuscated.
- Males with entirely lemon-yellow pubescence
- In males' anterior margin of labrum rounded while rest of the labrum with a mixture of micro and macro punctures; lateral tubercles slanting inward and meeting each other without any furrow.
- Compound eyes unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with one additional tooth.

Distribution: Europe, the Mediterranean Islands, Northern Africa and Asia.

2.5. *Bombus semenovianus* (Skorikov, 1914) (Plate 1)

Identifying features:

- ❖ Queen's Head black; thorax and 1st abdominal tergum yellow, 2nd and 3rd abdominal tergites black in queens.
- ❖ Worker's First 3rd abdominal tergites are black; 4th and 5th abdominal tergites brick red. Except malar space head covered with thick pubescence; clypeus, an area lateral to and in front of ocelli and narrow stripes on inner and post orbits.
- ❖ Male's head black with yellow malar space, thorax and 1st abdominal tergum yellow; 2nd and 3rd abdominal tergites black; 4th and 5th tergites brick red.
- ❖ Eyes a little enlarged relative to those females, anterior margin of labrum shallowly notched in the middle, lateral tubercles interrupted in center by a median longitudinal groove.

Distribution: Central Asia, Pakistan India and Afghanistan.

2.6. *Bombus subtypicus* (Skorikov, 1914) (Plate 1)

Identifying features:

- ❖ In queen pubescence on head, mesonotum, metanotum 1st, 3rd and 4th abdominal tergites black; pronotum and 2nd -5th abdominal tergites is yellow; around clypeus long orange hair, little grey feathered hairs on around the face and the antennal base; wings light brown.
- ❖ In worker head, mesonotum, metanotum and 3rd and 4th abdominal tergites are black; pronotum, 1st and 2nd abdominal tergites yellow; 5th abdominal tergum is white.
- ❖ In male head and mesonotum black, pronotum, metanotum and 1st and 2nd abdominal tergites are yellow; 3rd abdominal tergum black anteriorly and posteriorly yellow; 4th abdominal tergum anteriorly black and posteriorly white; 5th abdominal tergum is white.

Distribution: India, Afghanistan, Bhutan, Myanmar, Nepal, Tibet, Alaska, Canada, Northern and central China, Europe, Iran, Japan, Kazakhstan, Korea, Kyrgyzstan,

Mongolia, Russia, Tajikistan, Turkey, Yunnan, Sichuan, Gansu, Heilongjiang, North Korea, and Kamchatka Gilgit Baltistan, Pakistan.

2.7. *Bombus tunicatus* (Smith, 1852)

Identifying features:

- In queen has black pubescence on head, mesonotum and 3rd abdominal tergum. 1st abdominal tergum, pronotum and metanotum are white; 4th and 5th abdominal tergites are red brick, black band between wings.
- Population variations in queens show different shades of white and brown color on pronotum; white, brown and black on metanotum; 1st and 2nd abdominal tergum are white and black.
- In workers pronotum and metanotum are white. Head, 3rd abdominal tergum and mesonotum are black; 4th and 5th abdominal tergites are red brick.
- In male head mesonotum, and 2nd abdominal tergum are black, pronotum, metanotum and 1st abdominal tergum white; 3rd -5th abdominal tergum is brick red.

Distribution: Afghanistan, India, Nepal and Pakistan.

3. *Xylocopa* (Latreille, 1802) (Plate 1)

Identifying features:

- These are all black, or primarily black with some yellow or white pubescence.
- Carpenter Bees have a shiny abdomen without any fur like bumblebees.
- Males of some species of carpenter bees have a white or yellow face.
- In females' hind leg is entirely hairy.
- The wing venation is characteristic; the marginal cell in the front wing is narrow and elongated, and its apex bends away from the costa. The front wing has small stigma.
- Short mandibles conceal the labrum when closed and the clypeus is flat.

- ❖ Males of many species have much larger eyes than the females, which relates to their mating behavior.

II. Family: Andrenidae

Characteristics features:

- ❖ The Andrenidae are typically small to moderate-sized bees,
- ❖ These often have scopae on the basal segments of the leg in addition to the tibia,
- ❖ Presence of two subantennal sutures on the face
- ❖ The subfamily Oxaeinae bees with large eyes, resembling some of the larger Colletidae.
- ❖ Cosmopolitan family of solitary and ground-nesting bees.

4. *Andrena* (Fabricius, 1775)

Identifying features:

- ❖ Body length commonly ranges between 8 and 17 mm with males smaller and slenderer than females.
- ❖ Hairy bees that are black or dull metallic blue or green
- ❖ Male with black triangle (the "pygidial plate") at the abdominal apex and have two subantennal sutures and a straight basal vein in the fore wing.
- ❖ Compound eyes and the antennal bases, are with called "facial foveae"
- ❖ Presence long scopal hairs on the hind leg.
- ❖ Most Andrena have 3 submarginal cells in the fore wing.

4.1. *Andrena cineraria* (Linnaeus, 1758) (Plate 1)

Identifying features:

- ❖ A black species with two broad white hair bands across the front and hind of the thorax. The abdomen is very dark and glossy with a slight blue-black hue.

- The female has twelve antennal segments and the male has thirteen
- The male is much less distinctive, but still has the dark blue-black look with abundant grey hairing.
- The females are black, and have two broad ashy grey hair bands across the thorax.
- The males are similar, but the thorax is entirely clothed with less dense grey hairs, and has a very pronounced tuft of white hairs on the lower face.

Distribution: Nepal, India Europe, European Russia, Asia Minor, Iran, Turkmenistan, Pakistan, China and Mongolia.

4.2. *Andrena arima* (Cameron, 1909) (Plate 1)

Identifying features:

- Flagellum brownish beneath and mandible with apical 1/3 reddened.
- Wing membranes subhyaline, pale brownish, veins and pterostigma pale brown.
- Hairs on head moderately dense, long, pale yellowish, without brownish on vertex.
- Hairs on metasomal terga 1-2 scanty with long, erect white hairs; those on terga 2-4 short, dense, pale brown; terga 2-4 with white hair bands.
- Tibial spurs pale posterior depressions of metasomal terga yellowish brown.
- Distribution: India

III. Family: Megachilidae

Characteristics features:

- Megachilidae is the second largest bee family, containing more than 4000 described species
- These are moderate sized ranging from 5 mm to 24 mm and stout-bodied, black bees.

- The females, carry pollen on hairs on the underside of the abdomen rather than on the hind legs like other bees except the parasitic Coelioxys.
- The underside of the abdomen appears light yellow to deep gold in color with pollen

5. *Anthidium* **(Fabricius, 1805)**

Identifying features:

- These are mainly solitary bees with pollen-carrying scopa located on the ventral surface of the abdomen
- This genus belongs to leaf-cutting bees who use conifer resin, plant hairs, earth, or a combination of these as material for the nest walls
- Their abdominal bands are usually interrupted in the middle.
- Subantennal sutures are very straight.
- No arolium between front claws

5.1. *Anthidium manicatum* **(Linnaeus, 1758) (Plate 1)**

Identifying features:

- It has a wingspan of approximately 20 millimetres, with a body length of about 11–13 mm for females, and 14–17 mm for males.
- The males are substantially larger than females.
- These are black and covered with yellow-grey hairs.
- Faces and abdomen are covered in yellow spots.
- Male have a black head and thorax coated with short yellowish-brown hairs.
- Female legs are almost completely black, with very small yellow spots.
- The anterior sides of the tarsal segments of each leg of female A. manicatum have fine, soft and small white-colored hairs.

Distribution: Europe, Asia, North Africa, and North America Canary Islands, and Argentina, Brazil, Paraguay, and Uruguay. New Zealand, England

6. *Megachile* sp. (Latreille, 1802) (Plate 2)

Identifying features:

- These have a greyish appearance due to the presence of pale hairs over a black cuticle.
- Pale bands of hairs also present on the abdomen
- These ranges from 9 – 22 mm in length.
- Females of most species have large mondibles for cutting leaves and flowers.
- Megachile bees have no sticky pads (arolia) between their claws and therefore cannot climb smooth walls and glass.

6.1. *Megachile centuncularis* (Linnaeus, 1758) (Plate 2)

Identifying features:

- It is long-tongued, solitary bees, characterized by a rectangular labrum, the flap-like structure at the front of the mouth.
- This species is about 2 cm long and is largely black,
- The abdominal segments being fringed with golden hairs and the underside of the abdomen being clad with orange hairs.

Distribution: North America, Europe, Norway, Sweden, Finland, Spain, India, Ireland, and Britain.

6.2. *Megachile dorsalis* (Pérez, 1879) (Plate 2)

Identifying features:

- Elevated, finer and more closely punctured areas are present and overgrown with hairs at the sides of the second tergum.
- The scopa is white, except for the last sternum with black hairs.
- In some specimens dark hairs are present also on the apical edge of the fifth sternum.
- The sixth tergum has two well separated white spots of scale-like hairs, as in M. leachella.
- The terga are shiny because the rugosity is shallower.

Distribution: Widely distributed in the western Palaearctic, from southern Fennoscandia south to North Africa, and east to the Middle East

6.3. *Megachile simplex* (Smith, 1853) (Plate 2)

Identifying features:

- Small black color bees.
- Body is covered with grey white hairs
- Enlarged eyes with large mandibles
- Legs are also clothed with white grey hairs.

Distribution: Native to Australia

6.4. *Megachile willughbiella* (Kirby, 1802) (Plate 2)

Identifying features:

- Females have black scopal hairs on the fifth and sixth sterna, those occurring in Ireland have the sternum with the entire scopa reddish-golden.
- The female cuts semi-circular sections from leaves and uses them to build a sausage shaped nest in woody plant stems, especially willows.

Distribution: British Isles. Isles of Scilly, Scotland, Ireland and the Channel Islands, Mid and north Wales and the north Midlands Western Europe from Spain to Lithuania and Finland.

IV. Family: Melittidae

Characteristics features:

- These are small to moderate-sized bees and have oligolectic foraging habits.
- They generally mate on host-plants and nest in burrows in soil or sand and bring pollen after mating
- Many melittids such as Macropis possess specialized morphology that allow them to collect floral oil
- The scopa is restricted to the tibia.

7. *Mellita* sp. (Spencer, 1977) (Plate 2)

Identifying features:

- They are medium-sized (8 – 15 mm in length) hairy bees.
- Paraglossa is densely hairy.
- Forewing with 2 or 3 submarginal cells, second (if only 2) or second plus third as long as or longer than first; first submarginal crossvein is slanting, usually well separated from first recurrent vein
- Larvae spin cocoons.
- They have a mild sting

V. Family: Vespidae

Characteristics features:

- The members are eusocial wasps and solitary wasp

- These are predators and commonly known as paper wasps, potter wasps, yellow jackets, or hornets.
- The long slender antennae, curved but not curled (as in Pompilidae).
- The pronotum extends laterally to the tegulae; wings with usually long discoidal (M-4) cell.
- They are medium sized (9-25 mm), dark, but marked with yellow, white or red.
- Wings are usually folded longitudinally when the insect is at rest.
- The males of some species show a secondary sexual characteristic including "tusks" and abdominal spines.

8. ***Odynerus*** **sp. (Latreille, 1802) (Plate 2)**

Identifying features:

- These are smaal black wasps and darkened wing margins.
- The bands on the abdomen are narrow and yellow.
- Males are similar but smaller and slimmer, with yellow faces and a series of lobe-like projections on the mid femora (a character shared with O. melanocephalus, which is smaller with whitish abdominal bands).

9. ***Vespula*** **sp. (Thomson, 1869) (Plate 2)**

Identifying features:

- Adult workers of Vespula measure about 12–17 mm
- Queen is about 20 mm long and black and yellow;
- Yellow pronotal bands which are almost parallel to each other and black dots and rings on its abdomen.
- Vespula species have a shorter oculomalar space andmore pronounced tendency to nest underground than Dolichovespula.

10. ***Polistes*** **sp. (Latreille, 1802) (Plate 2)**

Identifying features:

- It is a largest genus within the family Vespidae, with over 300 recognized species and subspecies.
- They prefere human habitation for nest-building which is single-layered nests like an umbrella.
- These are yellow reddish brown and black in colour
- Many Polistes species aggregate and undergo hibernation in winters.

10.1. *Polistes dominula* (Christ, 1791) (Plate 2)

Identifying features:

- These are black wasps with yellow markings including rings along the abdomen and spots located in various locations on the clupeus (face) and abdomen.
- Some individuals have one spot on their clypeus, and a greater quantity of black on the clypeus
- The flagella (antennae) are bright reddish-orange.
- Their bodies are made up of tagmata including a head, thorax, and abdomen, with a thin constriction between the thorax and abdomen.
- Ventral surface is black in females and yellow in males.
- Females are larger than males.
- Female forewing length ranges from 9.5 to 13.0 mm, whereas males' forewings range from 8.5 to 12.0 mm.

Distribution: Southern Europe and North Africa, Asia as far east as China, New Zealand, Australia, South Africa, and North and South America.

VI. Family: Crabronidae

Characteristics features:

- ❖ Commonly known as Mud-Daubers and Sand wasps, Apoid wasps and Sphecid wasp.
- ❖ Medium to large in size,
- ❖ The body is long and usually black, yellow and orange.
- ❖ They have spiny-legged and frequently with deformed ocelli.

11. *Bembix* sp. (Fabricius 1775) (Plate 2)

Identifying features:

- ❖ Large cosmopolitan genus and brightly colored predatory wasps,
- ❖ Have very synchronised movements of forelegs while digging
- ❖ Striking yellow and black-striped abdomen.
- ❖ The labrum, extended into a narrow beak in some species

2. Diptera

Order Diptera is one of the most important group and play important part in ecosystem from ecological point of view. These are the major pollinators after bees. These are cosmopolitan and found everywhere except Antarctica. Order Diptera includes more than 150,000 described species but number is increasing at a very fast rate (Pape et al. 2005 and Yeates and Wiegmann, 1999). The group is easily distinguishable from others flying insects by the presence of one pair of functional wing, mouth parts and antennae (Hutson, 1984).

VII. Family: Syrphidae

Characteristics features:

- ❖ Can be seen easily hovering or nectaring at flowers.
- ❖ Many are bee mimics.
- ❖ The spurious vein in the wing that bisects the radio-medial cross.

- ❖ Larvae are either predaceous on aphids or live in decaying vegetation.
- ❖ Their abdomens and thoraces often have glossy cuticular body surfaces

12. *Eristalis* sp. (Latreille, 1804) (Plate 2)

Identifying features:

- ❖ It is known as the dronefly, because of the resemblance to honeybee drones.
- ❖ Short brownish- yellow hairs on the thorax and the beginning segment of the abdomen
- ❖ The pupa has two pairs of cornua (horn-like bumps) on their thorax
- ❖ Larvae have a siphon on their posterior end that acts as a respiratory mechanism and also looks like a tail.
- ❖ Males tend to have lighter patterns than females.

12.1. *Eristalis similis* (Fallén, 1817) (Plate 2)

Identifying features:

- ❖ The Eristalis resembls to a robust E. pertinax but the fore and mid tarsi almost entirely dark.
- ❖ The females also have 'bigger-headed' than pertinax.
- ❖ Males are entirely dark hind tibiae
- ❖ Bands of dark hairs down the eyes and also have a broader
- ❖ Less pointed abdomen than pertinax.

Distribution: Europe, southern Scandinavia.

12.2. *Eristalis horticola* (De Geer, 1776) (Plate 2)

Identifying features:

- ❖ Wing length 8·25-11·5 mm.

- Face pale dusted,
- Antennomere 3 brown-black.
- Tergite 2 dull, even on the yellow spots.
- All Abdominal spots yellowish.
- Wing with dark clouding, more developed in the female.
- Femur 3 pale at the base in male and for basal half in female.

Distribution: Palearctic Fennoscandia South to the Mediterranean basin and North Africa, India Ireland East through Europe into Russia through Siberia to the Pacific coast.

12.3. *Eristalis tenax* (Linnaeus, 1758) (Plate 3)

Identifying features:

- Their average wing length is 9.75–13 mm and average wingspan is 15 mm.
- Their eyes are marbled in black.
- They have a stout appearance, like bees.
- The abdomen can vary from dark brown to orange.
- Have dark front tarsi and broad dark facial stripe.

Distribution: North America, Europe, Australia and Asia

13. *Sphaerophoria* sp. (Le Peletier & Serville, 1828) (Plate 3)

Identifying features:

- Body is long and narrow, with yellow and black bands.
- The wings are Transparent.
- Antennae are short and yellow.
- The face is yellow.
- Thorax is a bit dull, copper colored with broad yellow side stripes.
- Scutellum is yellow.

- ❖ The lateral scutum stripe ends at the Transverse suture and faint or strong stripe extending past the suture.

14. *Syrphus* sp. (Fabricius, 1775) (Plate 3)

Identifying features:

- ❖ The only genus that has long hairs on the upper surface of the lower lobe of the calypter.
- ❖ Its larvae feed on aphids.
- ❖ Mesonotum is dull unlike other tribes.
- ❖ Males have the eyes meeting on the top of the head, whilst females have their eyes widely separated.

14.1. *Syrphus ribesii* (Linnaeus, 1758) (Plate 3)

Identifying features:

- ❖ Frons is posterior to the lunulae, shiny black.
- ❖ Sternites have lateral and median black marks.
- ❖ Male femora 3 is black for basal 2/3. Femora 3 is yellow.
- ❖ Lateral margins of tergites are black except at the ends of the yellow bands.

Distribution: Fennoscandia south to Iberia and the Mediterranean basin, Ireland, Europe into Turkey, European Russia and Afghanistan, Siberia and Russian Far East to the Pacific coast (Kuril Isles) and Japan, Alaska, Central USA.

VIII. Family: Tachinidae

Characteristics features:

- ❖ Brilliantly colored to dull coloured and resemble blow-flies (family Calliphoridae).
- ❖ Tachinid flies commonly are more bristler and more robust.
- ❖ They have three-segmented antennae, a diagnostically prominent postscutellum bulging beneath the scutellum (a segment of the mesonotum).
- ❖ The arista usually is bare or plumose.
- ❖ The calypters are large.
- ❖ Their fourth long vein bends away sharply.

15. *Eumerus* sp. (Meigen, 1822) (Plate 3)

Identifying features:

- ❖ Body sixe ranges from 5–12 mm.
- ❖ Black hoverflies with a smooth wide, almost cylindrical body.
- ❖ The hind legs are remarkably powerful.
- ❖ They have compound eyes with fine hairs that in the male cover most of the head, but in the female are parted over the forehead.
- ❖ The face is flat with downwardly directed hairs.
- ❖ The thorax has a few light longitudinal stripes on its back which are more visible in the front half. The legs are yellowish, or white and black,
- ❖ The abdomen is roughly cylindrical, and clearly constricted at the boundaries between the various parts.

16. *Nowickia* sp. (Wachtl, 1894) (Plate 3)

Identifying features:

- ❖ These flies have a black hairy thorax and a yellow-red abdomen, with a black longitudinal marking in the middle

- Numerous long straight bristlespresent at the end.
- Wings are hyaline (glass like), yellowish at the base.
- Basal half of the palps are brown or blackish.
- Males are a little concave in theirs dorsal Centre.
- In the abdomen only segments 7 and 8 are hairy.

3. Lepidoptera

Order Lepidoptera belongs to butterflies and moths and there is about 180,000 described species and divided into 126 families (Capinera, 2008) and 46 superfamilies which collectively make 10 per cent of the total described species of living organisms (Mallet, 2007) These butterflies are further divided into two main super families Hesperiodea with skippers and Papillionoidea with true butterflies in it. (Vishakha et.al. 2019) Lepidopterans are mainly good pollinators but many of these are also act as pests for agriculture crops.

IX. Family: Lycaenidae

Characteristic features

- Antennae usually banded
- Eyes of adults indented near antennae and face is narrow between eyes
- Forelegs of males reduced, with fused tips without claws
- Forelegs of females of almost normal size" and do bear claws
- Radial (R) veins of forewing simple, not forked
- Hindwing often with thread-like extensions that resemble antennae (typical of "hairstreaks")
- Coloration often bright, iridescent.

17. *Lycaena pavana* (Kollar 1848) (Plate 3)

Common Name: White bordered copper

Identifying features:

- Wingspan: 37-40 mm.
- Forewings costa slightly arched, termun convex and dorsum straight.
- Under forewings are dull orange; under hindwings are pale fawn-grey with prominent black spots.
- A white band on under hindwings between discal row of spots and sub marginal double row of border.
- Male reddish copper in cell and basal area, and purplish sheen along margin.
- Female has upper hindwings brown and on upper forewings only discal area and cell orange –copper.

Distribution: Uttarakhand, Himachal Pradesh and Indian Himalaya

18. ***Aricia agestis*** **(Denis & Schiffermüller, 1775) (Plate 3)**

Common Name: Brown argues

Identifying features:

- Dark brown, with strongly marked discocellular spot, especially in the male.
- The spot is black and bear red spots at the outer margin.
- Underside with numerous ocelli.
- The hindwing with a pale smear from the apex of the cell to the centre of the outer margin.
- Without blue scales at the base of the wings like other female blues.

Distribution: Throughout the Palearctic ecozone north to northern Jutland (Denmark) and east to Siberia and Tian Shan.

19. ***Plebejus argus*** **(Linnaeus, 1758) (Plate 3)**

Common Name: Silver studded blue

Identifying features

- Wingspan: 26 - 32 mm
- Male have royal blue wings with a black border, white, wispy fringe.
- Metallic silver spots on the hindwings as well as spurs on their front legs.
- Females are generally brown and more subdued in color, but also have the metallic spots on the hindwings.
- The undersides are taupe in color, with rings of black spots along the edge of the wing.
- The caterpillars are green with a dark stripe along the body and can reach 1.3 centimeters in length.

Distribution: Native to United Kingdom

20. *Heliophorus sena* (Kollar 1844) (Plate 3)

Common Name: Sorrel sapphire

Identifying features:

- The Wing span is 28-33 mm.
- Upperside of wings is brown with bluish metallic colour.
- Hindwings with red reddish orange spots along the margin.
- Under hindwings having one black spot on costa.
- Wings clothed with white cilia.

Distribution: Asia

21. *Zizina labradus* (Godart, [1824]) (Plate 3)

Common Name: Grass blue

Identifying features:

- Wingspan: 23 (♀) and (20) mm ♂

- ❖ Wings are purplish blue on the upper surface with a black body and black or brown wing margins.
- ❖ The margins are larger on the female than the male.
- ❖ The underside is brown to pale brownish grey with a pattern of fawn bands and spots with the body covered in white or grey hairs.
- ❖ The wingspans of females are slightly larger than males,
- ❖ Weak, fluttering flight and so usually fly near ground level close to a food source.

Distribution: Asia and Australia

X. **Family: Pieridae**

Characteristic features

- ❖ Underside forewing white.
- ❖ Cell and costa lightly forced with black scales.
- ❖ Apex somewhat broadly tinged with ochraceous yellow.
- ❖ Hind wing, from pale, almost white, to dark ochraceous.
- ❖ Antennae black with minute white specks.
- ❖ The long hairs on head and thorax greenish grey, abdomen black, beneath, head, thorax and abdomen white.

22. *Pieris brassica* **(Linnaeus, 1758) (Plate 3)**

Common Name: Cabbage white

Identifying features:

- ❖ The upperside of the male is creamy white.
- ❖ The forewing is irrorated (sprinkled) with black scales.

- Hindwings are uniform, irrorated with black scales at base, a large black subcostal spot before the apex, and in a few specimens indications of black scaling on the termen anteriorly.
- The underside of the forewing is white, slightly irrorated with black scales at the base of cell and along costa.
- The head, thorax, and abdomen are black, with some white hairs, where underneath is whitish.
- The antennae are black and white at apex.

Distribution: Europe, North Africa, Asia, South Africa Australia, New Zealand, North America and New Zealand.

XI. Family: Nymphalidae

Characteristic features

- The first pair of legs is small or reduced.
- The forewings have the submedial vein (vein 1) unbranched and in one subfamily forked near the base.
- The medial vein has three branches, veins 2, 3, and 4; veins 5 and 6 arise from the points of junction of the discocellulars.
- The subcostal vein and its continuation beyond the apex of cell, vein 7, has never more than four branches, veins 8–11; 8 and 9 always arise from vein 7, 10, and 11 sometimes from vein 7 but more often free, i.e., given off by the subcostal vein before apex of the cell.
- The hindwings have internal and precostal veins.
- The cell in both wings is closed or open, often closed in the fore, open in the hindwing.
- The dorsal margin of the hindwing is channelled to receive the abdomen in many of the forms.

23. *Cercyonis pegala* **(Fabricius, 1775) (Plate 3)**

Common Name: Common wood nymph

Identifying features:

- Wingspan: 5.3 to 7.3 cm.
- These are brown with two eyespots on each forewing – the lower one often being larger than the upper one.
- Some may have many, few, or no eyespots on the ventral surface of the hindwing.
- In the southeastern part of its range, it has a large yellow patch on both surfaces of the forewing.
- In the western part of its range, it may have a pale-yellow patch or may be lacking one.

Distribution: Nova Scotia and Quebec west to northern British Columbia south to northern California southeast to Texas and east to northern Florida.

24. *Nymphalis polychloros* **(Linnaeus, 1758) (Plate 3)**

Common Name: Large tortoise shell

Identifying features:

- Wingspan: 68–72 mm.
- Medium to large butterflies have orange to red wings with black and yellow patches.
- Both wings with yellowish submarginal lunules, upon which follows a black band which is likewise composed of lunules and bears on the hindwing small blue spots.
- The underside of the wings is smoky brown with darker shades and black Transverse pencilling.

Distribution: North Africa, southern and central Europe, Turkey, southern Russia, the central and southern Urals, England, Kazakhstan and India.

25. *Vanessa cardui* (Linnaeus, 1758)

Common Name: Painted lady

Identifying features:

- Upperside. Ground-colour reddish-ochreous, basal areas olivescent-ochreous-brown.
- Cilia black, alternated with white.
- Forewing with an outwardly-oblique black irregular-shaped broken band crossing from middle of the cell to the disc above the submedian vein.
- Hind-wing with a blackish patch from the costal vein across end of cell, a partly confluent recurved discal band, a submarginal row of lunules.
- Between the discal band and submarginal lunules is a row of five round black spots, which in some specimens show a pale and dark outer ring.
- Underside. Forewing brighter reddish-ochreous, t.he apical area and outer margin much paler, the apex being olivescent ochreous-brown.

Distributon: Cosmopolitan except Antarctica and South America.

4. 5 Species Plates

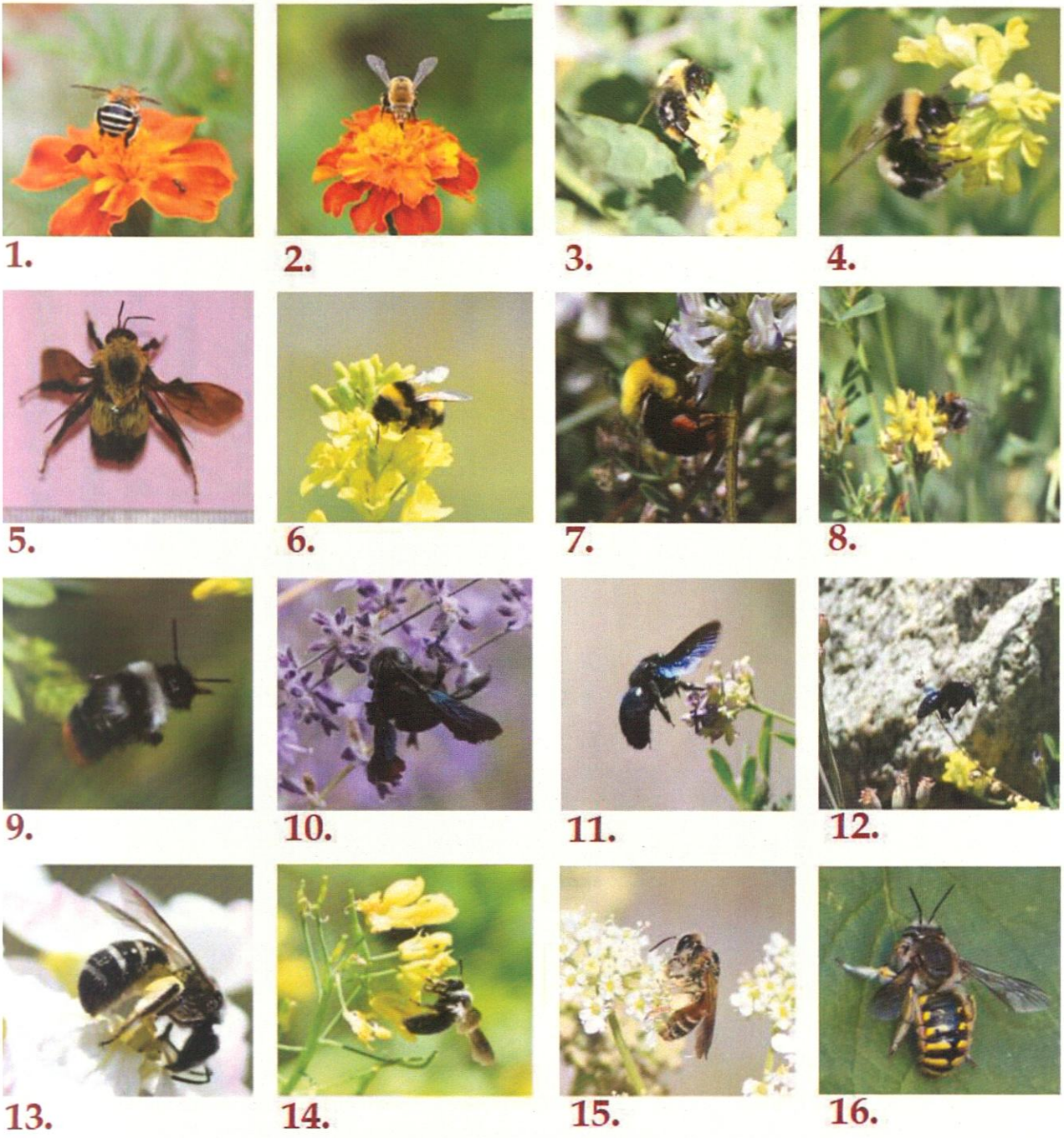


Plate 1: **1.** *Amegilla cingulata* **2.** *Amegilla confusa* **3.** *Bombus asciaticus* **4.** *Bombus lucorum* **5.** *Bombus melanurus* **6.** *Bombus pyrosoma* **7.** *Bombus semenovianus* **8.** *Bombus subtypicus* **9.** *Bombus tunicatus* **10.** *Xylocopa* sp.1 **11.** *Xylocopa* sp. 2 **12.** *Xylocopa* sp.3 **13.** *Andrena* sp.**14.** *Andrena cineraria* **15.** *Andrena arima* **16.** *Anthidium manicatum*

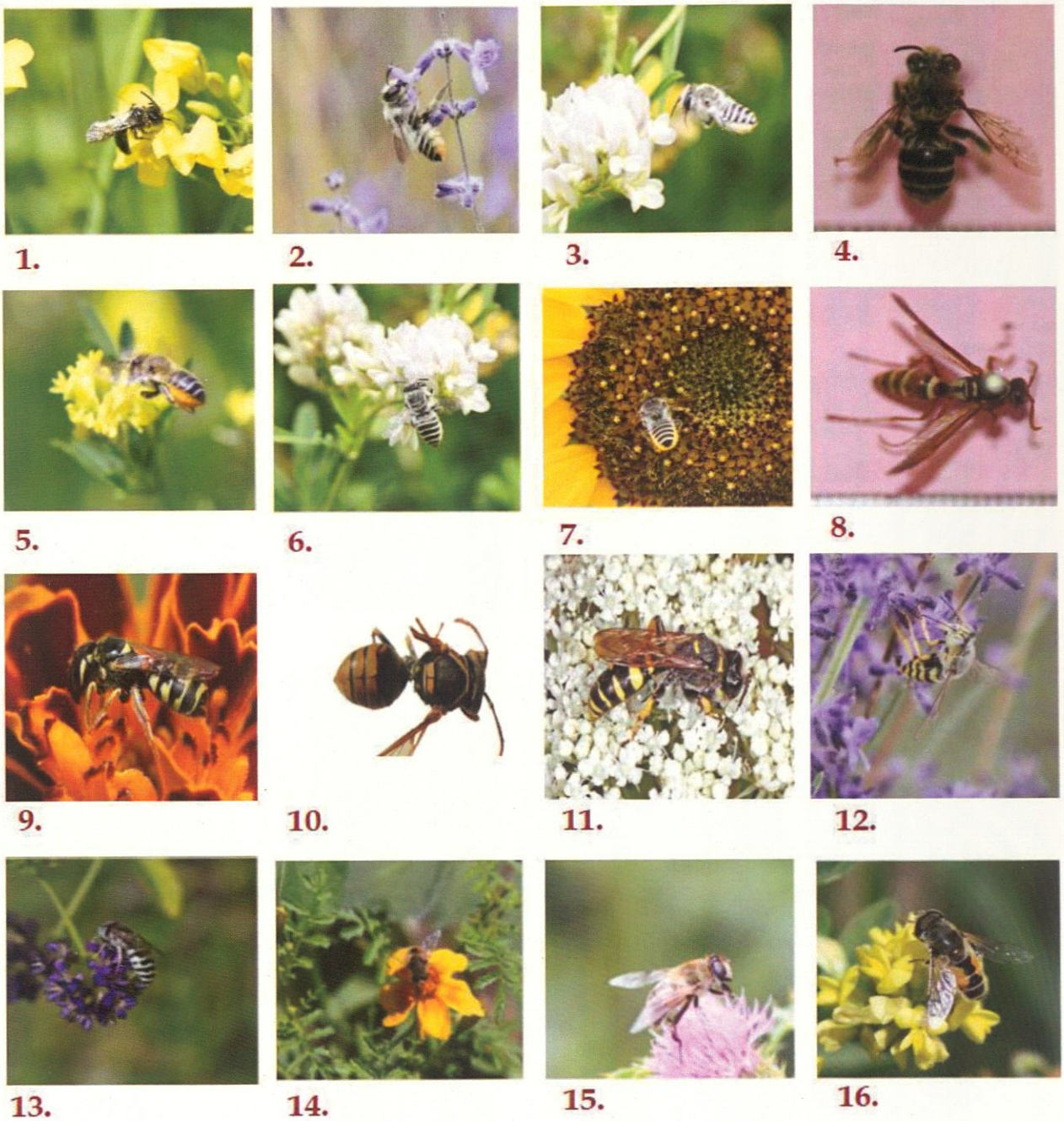


Plate 2: **1.** *Megachile* sp. **2.** *Megachile centuncularis* **3.** *Megachile dorsalis* **4.** *Megachile simplex* **5.** *Megachile willughbiella* **6.** *Mellita* sp. 1 **7.** *Mellita* sp. 2 **8.** *Odynerus* sp. **9.** *Vespula* sp. **10.** *Polistes* sp. **11.** *Polistes dominula* **12.** *Bembix* sp. 1 **13.** *Bembix* sp. 2 **14.** *Eristalis* sp. **15.** *Eristalis similis* **16.** *Eristalis horticola*

1.

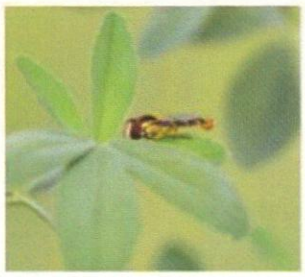


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Plate 3: **1.** *Eristalis tenax* **2.** *Sphaerophoria* sp.1 **3.** *Sphaerophoria* sp.2 **4.** *Syrphus ribesii* **5.** *Eumerus* sp. **6.** *Nowickia* sp. **7.** *Lycaena pavana* **8.** *Aricia agestis* **9.** *Plebejus argus* **10.** *Heliophorus sena* **11.** *Zizina labradus* **12.** *Pieris brassica* **13.** *Cercyonis pegala* **14.** *Nymphalis polychloros* **15.** *Vanessa cardui*

Comparison of Lahaul & Spiti and Leh-Ladakh survey

In the present study, three types of ecosystem services were focused to know the people's perception over biodiversity and natural resources with the help of proper questionnaire. Last year study of Lahaul and spiti and the present study in Leh Ladakh was compared (Fig. 8). Last year survey in Lahaul and Spiti results in: Cultural services comprises of following sub services with the percentage of awareness holding Spiritual and historical values (22 %), Aesthetic values (45%), Ecotourism (28%), Cultural practices (62%) and Education and Science (85%), second is regulating & supporting services with awareness percentage of Purification of air and water (52%), Nutrient cycling (28%), Pollination (88%), Regulation of disease & pests (64%), Erosion regulation (78%), Mitigation of droughts and floods (31%) and Climate regulation (39%) and third is Provisioning services with awareness percentage of Food (Crops) (100%), Wild foods (plants, fish, animal) (89%), Cultural animals (42%), Livestock feed (91%), Animal derived fuel (11%), Plant derived fuel (99%), Ornamental resources (10%), Plant derived medicine (97%), Animal derived medicine (32%). However, in the present study conducted in Leh-Ladakh the percentage of awareness was distinct as Spiritual and historical values(65%), Aesthetic values (97%), Ecotourism (72%), Cultural practices (89%), Education and Science (98%), Purification of air and water (65%), Nutrient cycling (49%), Pollination (95%), Regulation of disease & pests (50%), Erosion regulation (82%), Mitigation of droughts and floods (39%), Climate regulation (49%), Food (Crops) (100%), Wild foods (plants, fish, animal) (99%), Cultural animals (72%), Livestock feed (98%), Animal derived fuel (40%), Plant derived fuel (100%), Ornamental resources (52%), Plant derived medicine (99%) and Animal derived medicine (41%) (Fig. 9).

Comparatively, we have also found that instead of being aware about the role of pollinators and practices that can harm them, inorganic fertilizers and pesticides were intensively used by the farmers to increase the production of cash crops because farming system proved to be a major or sometimes only income source for them, which is why 71% of inorganic farming was reported from the region. However, 97% of

organic farming was being practiced by the farmers of Leh-Ladakh as they had attached some spiritual values towards the whole biodiversity and that is the reason why these people were found reverent towards biodiversity conservation (Fig. 10).

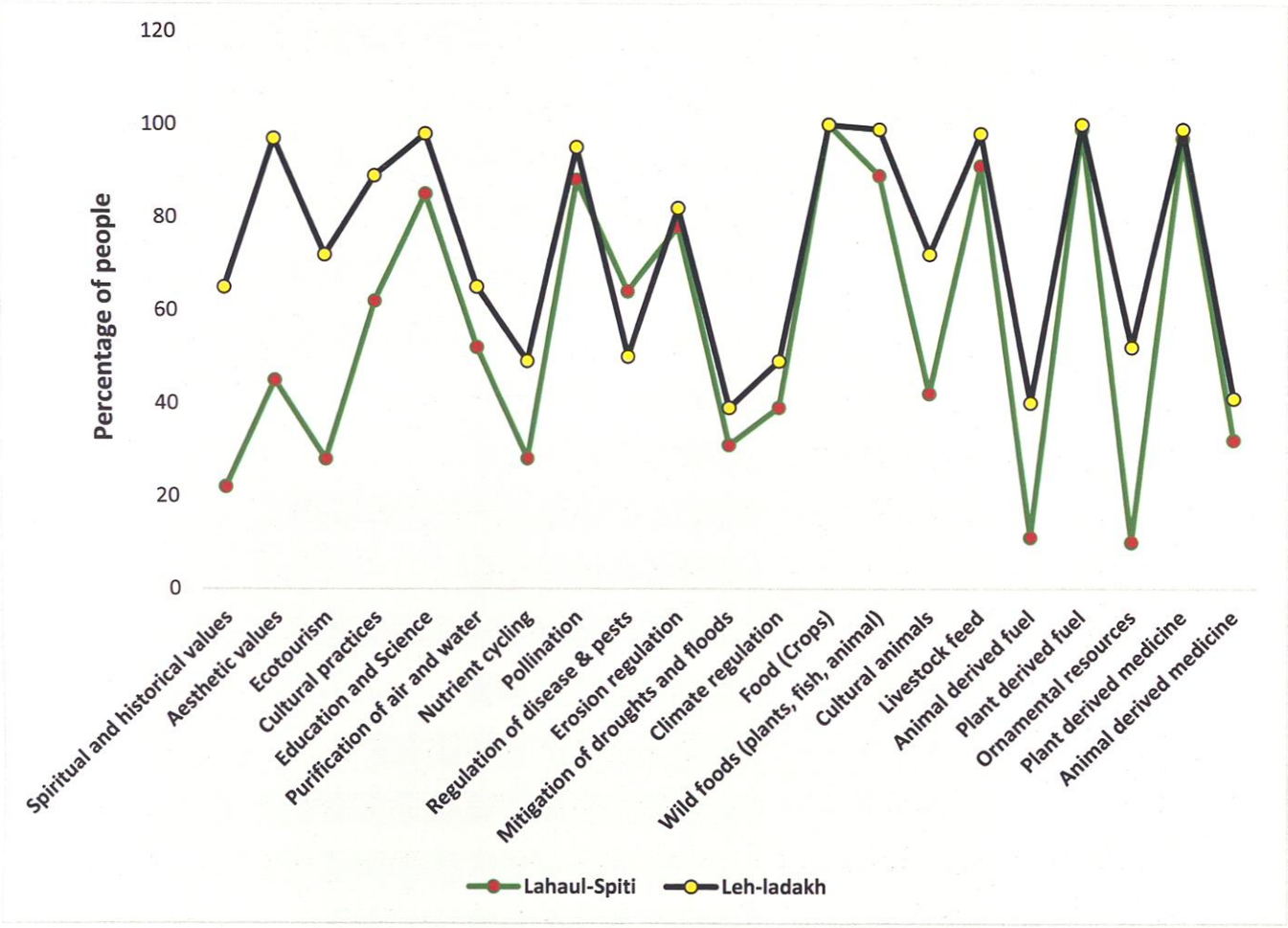


Figure 8. Comparative percentage of ecosystem services awareness people of Lahaul-Spiti and Leh-Ladakh

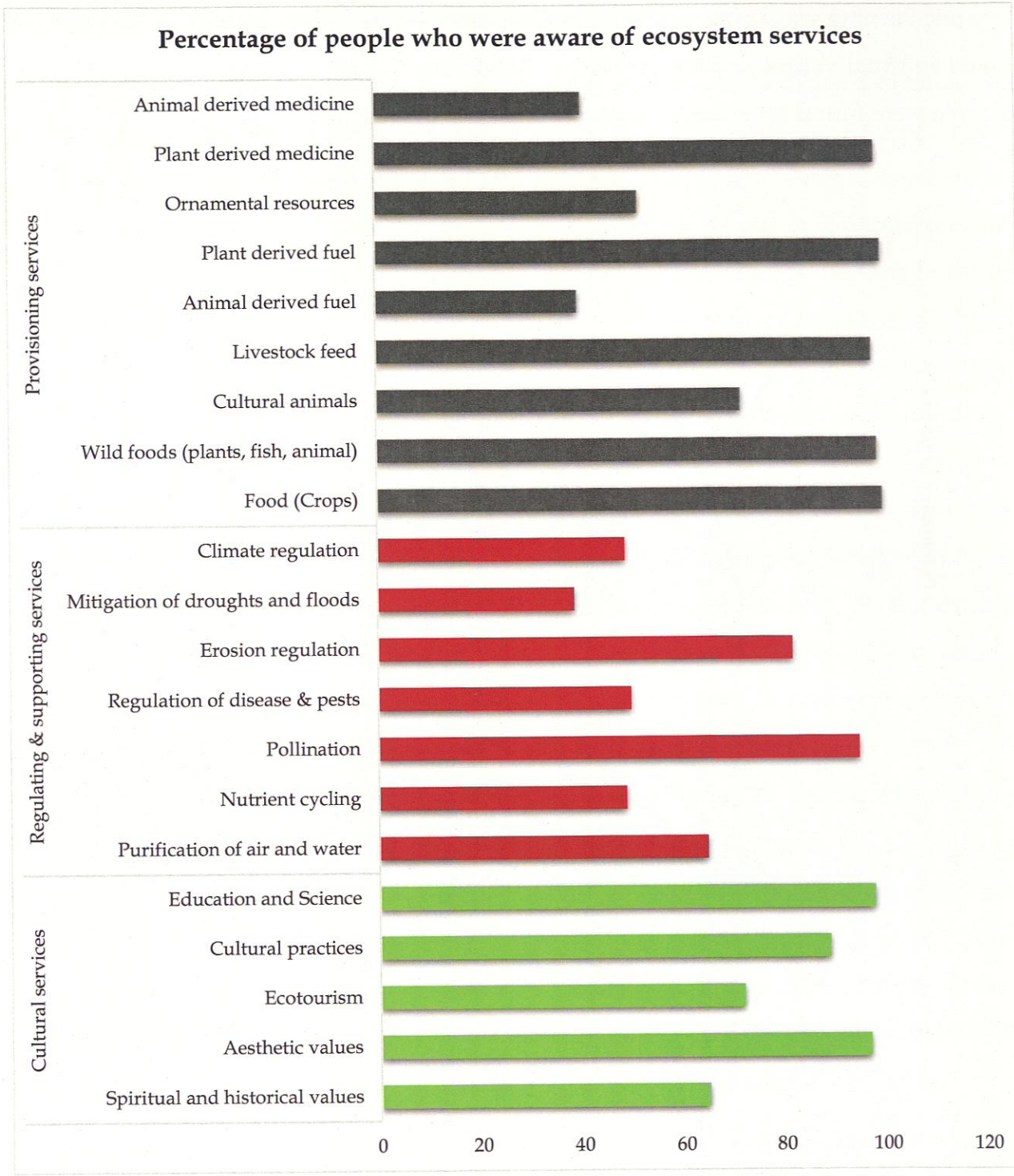


Figure 9. Awareness of Ecosystem services by people of Leh-Ladakh for each ecosystem service (N = 511)

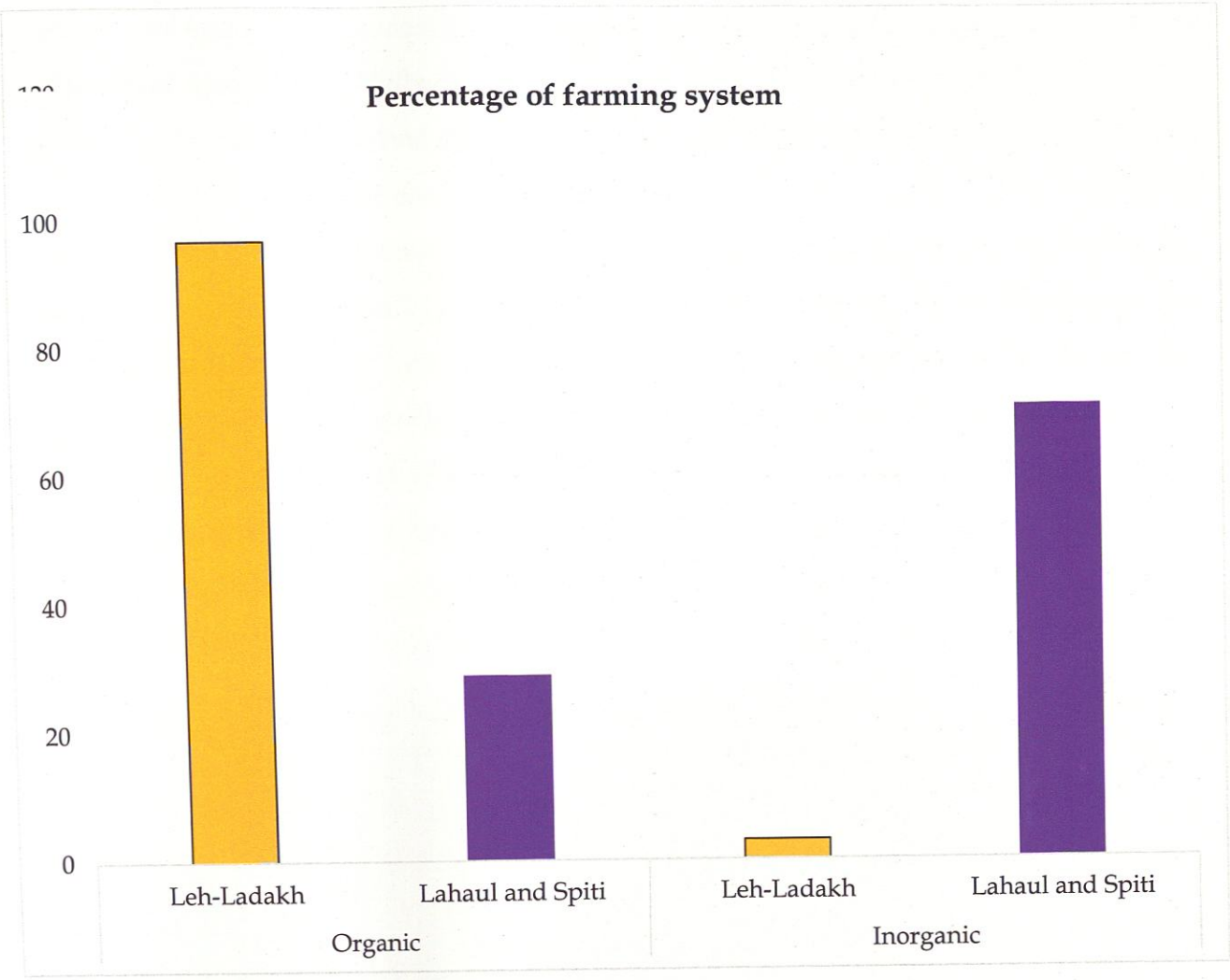


Figure 10. Farming practices in Leh-Ladakh and Lahaul and Spiti

4.5 Impact of modern architecture on traditional beekeeping practices

Beekeeping is one of the most ancient practices. The ancient Egyptian, Greek, and Roman civilizations, and parts of the Middle East and Asia have a long history of beekeeping for the purpose of harvesting honey and other bee products (Chanthayod, Zhang and Chen 2017). From products like honey to bee wax, beekeeping gives a significant benefit to the local beekeeping community. Yet, over the years there has been a gradual decline in this practice. Focusing on India, specifically the Trans-Himalayan region, beekeeping has now shifted to commercial farms rather than village households (Fig. 12).

Seen in some of the villages in Garwhal Himalayas, wall cavities are used by the bees to construct their hives. At the time of construction, the hill inhabitants leave several rectangular spaces in the walls of houses for the *Apis cerana* to build nests in these dark cavities. These spaces are located about 150 cm from the floor with their entrance of about 2 cm diameters towards the outside. The wall hives are opened only to harvest the honey and never otherwise (Verma and Attri 2006). The walls being thicker due to the traditional architectural style in the hills, provide enough insulation for the beehives. Along with its width, the plastering of the wall with cow dung and mud also provides suitable conditions for the bees to nest. Similar wall cavities are left in the cow sheds too. The number of hives in the walls varies from 1 to 4 in each of the cavities (Fig. 11). Similarly, the traditional Jaunsari housing architecture of the Mohana village (Chakrata district, Dehradun) also has a unique feature for incorporating the beehives. A typical jaunsari house is two-storied with the lower half built in stone with thick walls. This lower half is generally used to keep cattle and farm produce. Here, a window frame like cavity of 3 ft by 3ft is left of the beehives. Inside the house, the open portion of this frame is kept covered with a fine white muslin cloth. Honey is harvested twice a year and it is extracted by uncovering the cloth and cutting some of the portions from the combs, making sure that enough honey is kept for the bee colony to sustain itself (Gupchup 2017).

With the influence of the modern form of architecture as well as materials in the hills, these practices have been severely affected. The modern construct of houses creates a 25 cm thick exterior wall rather than a 45 cm wall. This change in the thickness of the wall gives no space for the bees to create a hive. Same goes for the change of material from mud to concrete which does not provide enough insulation suitable for the bees. This shift not only disrupts the bees but also create a significant impact on the communities as well as the forests around. The bee produce is found to create a steady source of food as well as income for the communities while the bees act as pollinators for the surrounding vegetation. It is not only the bees that have a positive impact on the forest

but the beekeepers too. The indigenous knowledge system of beekeeping leads people to develop a positive attitude towards forests. Most beekeepers hold the view that sustainable forest management practices are good for beekeeping, and they are willing to convince other people not to disturb the forests (Chanthayod, Zhang and Chen 2017). Thus, it is imperative to create a holistic approach to reintegrate these beekeeping practices in traditional housing systems. This could be done through creating a fixture inside the walls for beehives during the construction phase of the house as well as a concept of retrofitting bee-box post-construction. This rethinking of the traditional form of architecture with contemporary needs and ideas would help keep alive the indigenous knowledge system of beekeeping in the Trans-Himalayan regions.

Figure 11. Traditional bee keeping in the study area

Figure 12. Commercial bee farming in the study area

Chapter 5:
Capacity building programs and field activities

Participatory Rural Appraisal (PRA) exercise has been conducted with the community. The exercise developed linkages between community and natural resources of poor rural households. A total of 10 workshops were organised in 12 workshops in Leh-Ladakh at Leh (Women alliance) Saboo, Spituk, Phey, Shey, Zinchan, Stok, Sakti, Sumur, Panamik, Skuru, Turtuk (Table-7) (Fig. 13). A simple questionnaire was prepared to know the awareness of the people about the ecosystem services and to know that what type of farming system they are approaching. Workshops were also organized in the local schools for the awareness of the pollinator's importance. A total of 236 students from five government schools had participated in the workshop in Leh-Ladakh (Table-8) (Fig. 14). Awareness program has been conducted in schools of Pithoragarh district of Uttrakhand. Around 400 students have been sensitized on the conservation of insect pollinators (Table-9) (Fig. 15).

5.1 Group discussion

Table 7: Number of participants participated in workshops organised in Leh-Ladakh

S. No.	Name of Villages/Panchayat Visited	Number of Participants
1.	Women Alliance Group, Leh	76
2.	Saboo, Leh	43
3.	Phey, Leh	27
4.	Spituk, Leh	17
5.	Shey, Leh	20
6.	Zinchan, Leh	31
7.	Stok , Leh	16
8.	Sakti, Leh	17
9.	Sumur, Leh	11
10.	Turtuk, Leh	24
11.	Panamik, Leh	21
12.	Skuru, Leh	36

Figure 13. Capacity building programs for local community

5.2 Workshop

Table 8: Number of students participated in workshops organised in Leh-Ladakh

S. No.	Schools Name	Number of Students
1.	Government Senior Secondary school Leh	68
2.	Government Senior Secondary school Sumur	84
3.	Government Middle School Sakti	32
4.	Government Middle School Ganglas	26
5.	Government Middle School Skara	26

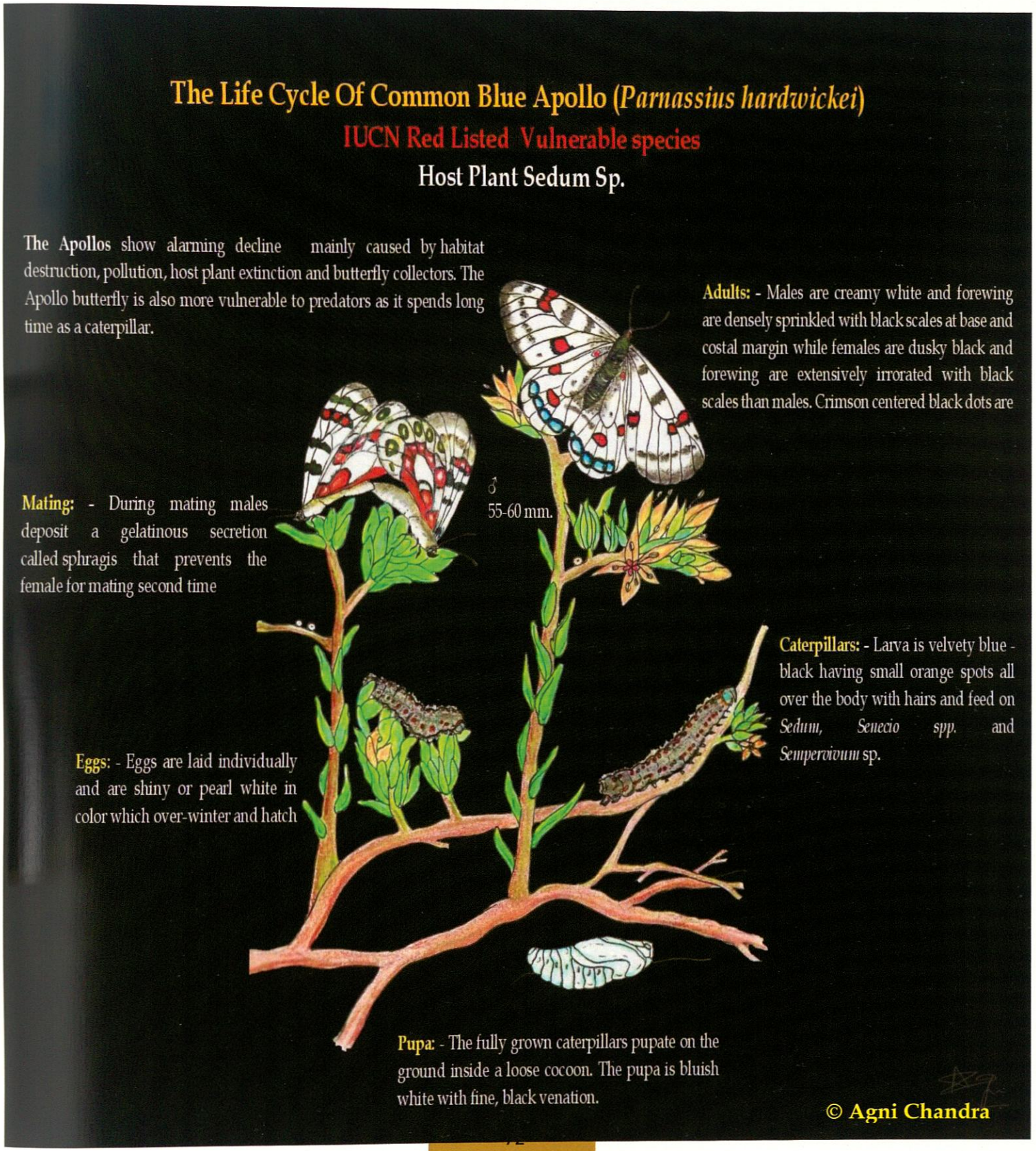
Figure 14. Workshops for school children in Leh-Ladakh

Table 9: Number of students participated in workshops organised in Pithoragarh

S. No.	School Name	District
1.	Govt Primary School Tiksen	Pithoragarh
2.	Government Inter College Madkot	Pithoragarh
3.	Government Inter College Munsyari	Pithoragarh
4.	Government Girls Inter College Munsyari	Pithoragarh

Figure 15. Workshops for school children in Munsyari, Pithoragarh, Uttarakhand

5.3 Scientific knowledge sharing through demonstration Models



LIFE CYCLE OF COMMON YELLOW SWALLOW TAIL (*Papilio machaon*)
Host plant : *Angelica glauca* (smooth angelica)

Mating pair:- Yellow spot are typically large and bright and blue not very prominent in male, while female have smaller and light colored yellow spots but a prominent blue area. The breeding season is from june to july.

Layig egg:- Female stores the sperm in an abdominal pouch called a spermatheca when the female has a full pouch of sperm, she select a host plant and lay egg singly on the upper surface of leave. She has life span of 6- 14 days.

Adult Butterfly / Imigo :- After 10 days, Adult emerge from pupa. It has yellow wing with black vein markings and a wing span of 65-86 mm..The hind wing of both sexes have a pair of protruding tails which give the butterfly its common name.

Egg:- Egg is spherical in shape and pale yellow With a diameter of about 0.8 mm. takes 3-4 Days To hatch

Catterpillar:- *P. machaon* has a length of 45 mm. when young, the catterpillar resemble a bird dropping, giving it camouflage. The catterpillar also protects itself using a large orange fork Which protrudes behind its head.

Pupa :- The catterpillar comes to rest on the lower surface of a stem, having by a thread in U- shaped. Pupation takes place a day later. pupa is initially green but changes to brown with time and complete metamorphosis to become adult.

Pre- pupatory larva :- The catterpillar moults to become yellow with black strips and false eyes. This stage lasts for 4-6 days, the body length reaches upto 3 to 26mm

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