SYSTEMATICS AND DIVERSITY OF SPIDERS (ARANEAE) IN NANDA DEVI BIOSPHERE RESERVE, UTTARAKHAND, INDIA

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Certificate

This is to certify that the thesis of **Ms. Shazia Quasin** entitled **"Systematics and Diversity of Spiders (Araneae) in Nanda Devi Biosphere Reserve, Uttarakhand, India"** is an original piece of work submitted to the Saurashtra University, Rajkot (Gujarat), for the award of **Doctor of Philosophy in Wildlife Science**.

Ms. Shazia has put in more than six terms of the research work embodied in this thesis under my guidance and supervision. The work presented in this thesis has not been submitted to any other University or Institution.

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Summary

Introduction:

Spiders (Order: Araneae) are one of the most diverse groups of animals in terrestrial ecosystems and functionally important predators regulating the terrestrial arthropod population. They are highly sensitive to natural conditions and disturbances (natural and anthropogenic). This makes them, effective biological control agents, popular ecological indicators and important to monitor habitation modifications. Their relatively high abundance and diversity in almost all microhabitats, coupled with the ease of sampling and collection also allow for effective monitoring in the environment. However, despite their fundamental roles in most natural ecosystem they have largely been ignored in conservational studies.

India being a mega-diverse country is rich in both flora and fauna; however there are gaps in knowledge on the diversity and distribution of spider fauna. Furthermore, the knowledge of Himalayan spider diversity and distribution is sparse as compared to other regions, because of its inaccessible terrain and harsh climatic condition that hinders extensive species inventories. The present study was carried out in Nanda Devi Biosphere Reserve (NDBR), Uttarakhand, India, which is located in the northern part of the Western Himalaya in India, one of the important sites of wilderness and biodiversity in the Himalayan region. This study was selected for its conservation value, representation of biome and little existing information.

The present study was conducted from January 2008 to July 2011.The study aimed to investigate the spider community structure along the altitudinal gradient and the influence of habitat covariates like vegetation types, ph, litter depth, humidity and temperature, on spider assemblages in the intricate landscape of the NDBR. The pattern of species diversity was explored using a set of standard methods and ecological indices. This study obtained the first comprehensive representation of the spider fauna in NDBR, which would help in assessing the status of spider diversity in the region keeping in mind its conservational value.

Systematic and Distribution of Spiders in Nanda Devi Biosphere Reserve (NDBR):

Spiders globally include about 42473 described species (Platnick, 2011) under 3849 genera and 110 families. In India, 1520 spider species belonging to 377 genera of 60 families have been reported so far (Sebastian and Peter 2009). The families represented by the highest number of genera and species in India are the Salticidae (66 genera and 192 species) followed by Thomisidae (38 genera and 164 species). This study provides the first comprehensive inventory of the spiders from the NDBR, including description of anatomical features of spider in general, their classification, and genera of spiders sampled from the NDBR during three years of fieldwork. Using contemporary systematics approaches (Platnick, 2011) and traditional morphological methods (Pocock 1900, Tikader and Malhotra 1980, Tikader 1982) new species were identified and classifications were refined. Checklist and interactive keys for collected spider species were produced and would be accessible to the public domain in the future. The study thus accelerates the rate of description, documentation and understanding of Himalayan spider biodiversity, using an integrated approach for capturing, assembling, analysing and managing taxonomic information. Furthermore, this increased understanding of larger taxonomic and ecological frameworks can facilitate the development of appropriate conservation objectives for spider fauna in NDBR.

Diversity of Spiders along the Altitudinal Gradient:

The patterns of distribution of arthropods along the elevational gradients have long been a contentious topic. The present study, intended to look at the pattern of spider species diversity along three altitudinal gradients (replicate sites) within NDBR (region). Sampling was carried out on the three years to obtain data across different seasons covering substantial altitudinal gradient (1800-4100m). Sampling methods pitfall traps, sweep netting, and other semi-quantitative were used to capture spiders from all possible niches. A total of 244 species belonging to 108 genus and 33 families were recorded during the entire sampling period. Using the abundance based estimator Chao1, the predicted richness for the three sites were 153.43±0.9 (Lata Kharak), 162.75±1.24 (Malari) and 206.43±0.9 (Bhyundar Valley). The inventory was complete at the regional scale (91%). Comparisons of the different altitudinal zones revealed that the species diversity was higher in the lower altitudinal zones.

This study revealed the relative importance of diverse habitat types on diversity and composition of spider assemblages in NDBR. I documented spider diversity by investigating the function of altitude in structuring community. Thus, I tested the species diversity patterns along the three altitudinal gradients of NDBR. Results showed that species diversity was negatively related to altitudinal gradient and also altitude was influencing the species diversity on a regional scale. It was also observed that the regional species diversity patterns were explained most robustly as an interactive effect of site and altitude. I also explored the species composition changes along altitudinal gradient in the three sampling sites using NMS ordination. The results of the ordination revealed that the species composition of the three sites formed separate clumps indicating that each site was composed of species that were specific to a particular altitudinal zone. Thus, different altitudinal ranges were bearing different species composition. The guild-wise analysis across the elevation showed that out of the three guilds (Ground wanderers-GW, Plant wanderers-PW, Web builders-WB) the ground dwelling spiders showed a hump shaped decline in all the three sampling site. In addition, analysis of the effect of local habitat factors on regional spider richness and diversity was also tested.

Assessment of Morphometric Changes in Spiders across Guilds and Altitude

The study explored body size and proportional changes in body parts such as the prosoma, the opisthosoma and the legs along the altitudinal gradient. Fourteen morphometric measurements were recorded from 357 adult spider (both sexes) specimens. All measurements were taken in millimeters (mm) using a binocular dissecting microscope (Leica DFC 290) with an eyepiece scale calibrated with a slide micrometer. Variation in morphological characters of the spider species was assessed by measuring prosoma length-width, opisthosoma length-width, measurements of the leg dimensions and absolute body length. The data was then subjected to PCA (Principal component Analysis) to generate principal components that explained 75.2% of the variation in the data in reduced dimensions. Thereafter, I investigated the relationship of these principal morphometric components with mid altitude (in Km), altitudinal range (in Kms), niche, sex and guild of spider sampled based on *a-priori* ecological hypothesis. I constructed Generalized Linear Models (GLM) to explain variation in spider's morphometry with the fixed and interaction effect of the above explanatory or predictor variables. The results showed different patterns in spider morphometry. The highest variance in the data was explained by the pattern of the differences in relative leg lengths and absolute lengths of coxa to patella and species were segregating most widely along this gradient. I observed difference in body and leg dimensions across guilds and altitude. Length of legs related to the body as well absolute length of coxa to patella was less in plant wanderers than the other two guilds. The other relevant pattern observed in absolute body and leg sizes. The general body size increased with mid altitude thus following Bergmann's rule. Legs dimensions may play an important role in determining the space spider occupies in a given altitude. Opisthosoma of the spider morphometry was not influenced with altitude. The influence altitudes on guilds were mostly related to their predatory methods. The body size differs among populations because of distinct resource accessibility or foraging strategies.

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CHAPTER 1

INTRODUCTION

1.1 Himalayan Biodiversity

The Himalaya is the highest and the youngest mountain system in the world (Devan, 1988). The Himalayan orogenesis started about 70 million years ago with the clash of the tectonic plates of the Indian sub-continent and the Eurasian continent and the subsequent closing up of the Tethy's sea (Wadia, 1966). There are broadly three zones in this region: the Outer Himalaya (upto 1500m above msl), the Middle Himalaya (upto 5000m) and the Greater Himalaya (from 5000 upto 8800m), which includes some of the highest peaks in the world such as Everest, K2, Khangchendzonga (Wadia, 1966; Jhingran, 1981). The Shiwaliks and the Indo-Gangetic plains running parallel to the southern and the northern sides respectively, of the outer Himalaya, have been formed by the silt and debris deposition, by the rivers originating from the Himalaya (Wadia, 1966). The Himalayan region covers approximately 18% of India's land surface and spreads over an area of approximately 2, 10, 626 km^2 (Maikhuri and Rao, 2005).

The formation of the Himalaya ultimately resulted in new barriers and corridors, which lead to the creation of ideal habitats for a variety of floral and faunal species. It is situated at the transition zone between the Palearctic and Indo-Malayan realms with species representing both the realms and is divided into four provinces *viz.*, North-Western, Western, Central and Eastern (Rodgers and Panwar, 2000), each province characterised by its distinctive flora and fauna. It's unique and rich biodiverse repository comprises of tropical, subtropical, temperate, sub-alpine and alpine habitats, making it one of the richest biogeographical zones in the world (Rodgers and Panwar, 1988). The high species diversity and richness is attributed to variations in climate, altitude, complex topography and habitat types (Rau, 1975; Polunin and Stainton, 1984).

The Indian Himalayan Region (IHR) spreads across Jammu and Kashmir, Himachal Pradesh, Uttarakhand, West Bengal and Arunachal Pradesh (Mani, 1974). IHR supports about 18,440 species of plants (Singh and Hajra, 1996), 1748 species of medicinal plants (Samant et al., 1998a, b), 241 mammalian species and 979 birds species (Ghosh, 1996). The representative biodiversity rich areas of the IHR have been protected through a Protected Area Network (PAN) Programme. At present there are 7 Biosphere Reserves (BRs), 31 National Parks (NPs) and 111 Wildlife Sanctuaries (WLS) covering 51,899.238 km^2 in area (Mathur et al., 2002).

The Western Himalaya, spanning across Jammu and Kashmir, Himachal Pradesh and Uttarakhand is distinctly different from the Eastern Himalaya. Its gentler and wider slope, continental climatic conditions with lower humidity and higher snowfall, lower treeline, narrow ranging *krummholtz* and alpine scrub zone, and an overall lower primary productivity lends a vast difference in the biological diversity of the two regions (Miller, 1987; Mani, 1994). Of the 137 species of endangered Himalayan plants listed so far in the Red Data book, 56 species are from the Western Himalaya (IUCN, 2011). 11 species of endemic birds including the Cheer pheasant (*Catreus wallichi*) and the Western Tragopan (*Tragopan melanocephalus*) (Statersfield et al., 1998) are found in this region. Endemic mammals like Kashmir markhor (*Capra falconeri*), Asiatic ibex (*Capra sibirica*), Kashmir red deer (*Cervus elaphus hanglu*), Tibetan antelope (*Pantholops hodgsonii*) and Eurasian lynx (*Lynx lynx*) are found exclusively in the Western Himalaya (Rodgers and Panwar, 1988; Macdonald, 2001).

The fragile Himalayan ecosystem is undergoing rapid degradation, fragmentation and loss of wildlife habitat with increase in human population, unsustainable harvesting of biological resources like firewood, food timber, large-scale developmental projects, extensive livestock grazing, illegal extraction of rare and threatened plants and poaching of endangered animals (Bawa, 1993).

Most of the information available for this region pertains to flora and to large mammals and birds (Samant, 2001; Samant, 1993; Kala and Rawat, 1998; Samant and Joshi, 2003; Kala, 1997; Kala et al., 1997, 1998; Samant et al., 1996; Hazra, 1983; Schaller, 1977; Gaston et al., 1981, 1983; Green, 1985; Chundawat, 1992; Sathyakumar, 1993; Mishra, 1993; Bhatnagar, 1997 and Bhattacharya, 2005). Smaller mammals, reptiles, amphibians and fishes have been poorly studied (ZSI, 1997), while the invertebrates have been largely ignored, with the exception of a few studies of the Himalayan Lepidoptera (Mani, 1986; Haribal, 1992).

1.2 Need for Arthropod Studies in the Himalaya

Invertebrates are the most diverse and abundant animals in most ecosystems (New, 1995) and include 97% of all animal species. Arthropods, the largest animal phylum, are included within invertebrates. The number of species varies widely; one estimate indicates that arthropods have 1,170,000 described species, while another study estimates that there are between 5 to 10 million extant arthropod species, both described and yet to be described (Wilson and Peters, 1988). More recent literature estimate the number of species to be closer to 10 million (Dobson, 1996). These wide variations in the estimates arise from the variation in the method of calculation of those estimates (Hawksworth, 1991; Solbrig et al., 1996). Samways (1993) estimated that only 7 - 10 % of all insect species have been described and of those, only a small percentage have been studied extensively enough to get a glimpse of their biology.

In the past, arthropods were largely ignored in the design of conservation management strategies. Their conservation in existing parks and reserves has been purely incidental (New, 1999; Skerl and Gillespie, 1999). The primary limitation in using arthropods in conservation studies is mainly because of: 1. time constraint, 2.lack of knowledge of the taxonomy, biology and distribution, 3. non-standardised sampling protocols, and 4. inadequate number of taxonomists. Furthermore, arthropod surveys generate extremely large samples which demand a substantial effort to process in terms of time and expertise (New, 1999). Despite the above limitations of working with arthropods, they represent a group of organisms that are potentially useful when assessing the biodiversity of an area because of their – (i) generality of distribution, (ii) trophic versatility, (iii) rapid responses to disturbances, and (iv) ease of sampling (Holloway and Stork, 1991).

Arthropods are sensitive to disruption of their environments. They are suitable biological indicators of ecosystem change and habitat modification due to their small body size, short generation time (Kremen et al., 1993), high sensitivity to temperature and moisture changes (Schowalter et al., 2003).

1.3 Ecological Role of Spiders

Arachnids are an important albeit poorly studied group of arthropods that play a significant role in the regulation of other invertebrate populations in most ecosystems (Russell-Smith, 1999). Spiders, which globally include about 42,055 described species (Platnick, 2011), are estimated to be around 60,000-170,000 species (Coddington and Levi, 1991). They include a significant portion of the terrestrial arthropod diversity, being one of the dominant macro invertebrate predator groups in terrestrial environments (35–95%) (Specht and Dondale, 1960; Tischler, 1967; Van Hook, 1971; Moulder and Reichle, 1972; Schaefer, 1974; Edwards et al., 1976; Lyoussoufi et al., 1990). Spiders are copious in both natural and cultivated environments, in which their average annual abundance ranges from 50 to 150 individuals per square meter but can periodically reach maximal densities of more than 1000 individuals per square meter (Pearse, 1946; Duffey, 1962; Weidemann, 1978; Nyffeler, 1982). They occupy a wide range of spatial and temporal niches, exhibit taxon and guild responses to environmental change, show extreme sensitivity to small changes in habitat structure, primarily vegetation complexity and microclimate characteristics (Uetz, 1991). Furthermore, strong associations exist between plant architecture and species that capture prey without webs (Duffey, 1962; Uetz, 1991). Spiders respond distinctly to altered litter depth, and structural complexity and nutrient content of litter (Uetz, 1991; Bultman and Uetz, 1982). They employ a remarkable variety of predation strategies. As they are generalist predators, they are of immense economic importance to man due to their ability to suppress pest abundance in agroecosystems. The population densities and species abundance of spider communities in agricultural fields can be as high as that in natural ecosystems (Riechert, 1981; Tanaka, 1986). Spiders regulate decomposer populations (Clarke and Grant, 1968) and by doing so, they influence ecosystem functioning (Lawrence and Wise, 2000, 2004). In spite of this, they have not been treated as an important biological control agent since very little is known of the ecological role of spiders in pest control (Riechert and Lockley, 1984). Their high biomass also makes them a critical resource for larger forest predators such as salamanders, small mammals and birds (Duchesne and McAlpine, 1993; Churchill, 1997).

Spiders can be used as successful biological indicators to assess the health of an ecosystem because they can be easily identified and are differentially responsive to natural and anthropogenic disturbances (Pearce and Venier, 2006). For a species to be identified as an effective ecological indicator, it must meet the primary criteria of being feasible and cost effective to sample, easily and reliably identified, functionally significant, and ability to respond to disturbance in a consistent manner. Spiders readily meet the first three criteria. Their high relative abundance, ease of collection, and diversity in habitat preferences and foraging strategies allow for effective monitoring of site differences (Yen, 1995). Many studies have widely recommended the potential of spiders as bioindicators (Duchesne and McAlpine, 1993; Niemelä et al., 1993; Butterfield et al., 1995; Beaudry et al., 1997; Atlegrim et al., 1997; Churchill, 1997; Duchesne et al., 1999; Bromham et al., 1999; Werner and Raffa, 2000; Heyborne et al., 2003).

1.4 Spider: Threats and Conservation

Anthropogenic impacts on spider diversity have been well documented. Factors including habitat loss and degradation (Howarth, 1983; Stanford and Shull, 1993), habitat fragmentation (Mclver et al., 1992), grazing regimes (Gibson et al., 1992; Zulka et al., 1997), pollution (Clausen, 1986; Deeleman-Reinhold, 1990) and pesticides (Martinat et al., 1993; Wisniewska and Prokopy, 1997) severely affect the spider populations. Introduced exotic species threaten spider populations directly through predation (Gillespie and Reimer, 1993; Standford and Shull, 1993) or indirectly by degrading their habitats (Fridell, 1995). Some larger species are further impacted by collection for pet trade (Leech et al., 1994; World Conservation Monitoring Centre, 1998).

Spiders are marginalised when it comes to mainstream conservation research and action. Despite their documented ecological role in many ecosystems, high diversity, and threats, spiders have received little attention from the conservation community (Skerl, 1999). This lack of attention is further compounded by general negative public attitude towards spiders (Kellert, 1986), and a paucity of information on spider status and distribution. Additionally, the most critical and useful habitat association data is not found in most checklists. Such data are lacking for many spider species, particularly those with cryptic habits. However, it is important that these vulnerable species are not left out of conservation planning efforts, as they may have unique ecological requirements or require particular site selection and management activities. Preservation of spider biodiversity and better land management strategy design requires an understanding of the patterns of spider diversity on an appropriate regional scale (Skerl and Gillespie, 1999).

1.5 Present Study and Scope

Himalayan spider fauna is diverse, but effective conservation is impeded by lack of taxonomic knowledge. Few comprehensive works on spiders have been conducted in Nanda Devi Biosphere Reserve (NDBR) region of the Western Himalayas (ZS1, 1995). As such, conservation of spiders on an appropriate regional scale is necessary. Considering their role in the ecosystem, the present study has been proposed to describe the spider biodiversity in Nanda Devi Biosphere Reserve (NDBR). This study attempts to make an inventory of the spider species in different sites of the Biosphere Reserve with respect to altitudinal gradient. It also emphasizes the need for conservation of spider biodiversity by characterizing species diversity and highlighting rare and endemic species of NDBR. This systematic approach will help to pave way for better understanding of the Himalayan spider biodiversity, leading to improvised long term ecological monitoring of the environment that is able to detect the more subtle environmental changes associated with human impact, consumption and climate change.

1.6 Objectives

This study is conducted with the main objective of obtaining the first comprehensive representation of the spider fauna in NDBR.

The specific objectives:

1. To study the systematics and distribution of spiders in Nanda Devi Biosphere Reserve.
2. To explore diversity patterns for spiders along altitudinal gradient.
3. To assess morphometric changes in spiders along altitudinal gradient.

1.7 Organization of the Thesis

This thesis is organized in 7 chapters. In Chapter 1, I describe the rationale, objectives and scope of the study. In Chapter 2, I describe the study area – Nanda Devi Biosphere Reserve (NDBR) with concise notes on its location area and boundaries, physical attributes, vegetation, forest types, and faunal diversity and history of the management practices by the forest department and the local communities. Chapter 3 provides a detailed description of the field methods used to collect spider samples, recounting in details the collection techniques and preservation methods. Chapter 4 deals with my first objective. It provides a comprehensive inventory of the spider fauna of NDBR with the detailed taxonomic information and interactive keys to familles and genera for this region. Chapter 5 deals with the second objective, describing the regional species diversity and composition. Here, I examine diversity patterns along altitudinal gradient, testing whether the pattern is linearly declining or unimodal and if patterns are similar across guilds. I also explore how species composition changes across altitudinal space and the influence of abiotic factors such as humidity, temperature, pH on local diversity. Chapter 6 deals with the third objective, assessing morphometric changes in the spider body along altitudinal gradient. Here, I explore with relationships between morphometric characters of the spider body, and test if morphometric patterns are associated with altitude. In Chapter 7, I summarise my key findings and the conservation and management implication of this study.

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CHAPTER 2
STUDY AREA

2.1 Introduction

The protected area network in the Indian Himalayan region consists of 7 biosphere reserves including Nanda Devi Biosphere Reserve (NDBR), 31 National Parks and 111 Wildlife Sanctuaries (Mathur et al., 2002). NDBR (30º 08'-31º 02'N, 79º 12'- 80º 19'E) is located in the northern parts of the Western Himalaya in the biogeographically classified zone, 2B (Rodgers et al., 2000; Plate.1). The entire area of NDBR lies within the Western Himalayas Endemic Bird Area (EBA) (Islam and Rahamani, 2004). NDBR comprises parts of Chamoli district in Garhwal, Bageshwar and Pittoragarh districts in Kumaun in the state of Uttarakhand. An important site of wilderness and biodiversity, it harbours several habitats for rare and endemic flora and fauna. This region is characterized by temperate forests, sub alpine forests, alpine meadows, high altitude lakes, glaciers and snow bound mountain peaks (Sahai and Kimothi, 1996; Plate.2). NDBR is bordered by the upper catchments of river Saraswati and Malari-Lapthal area in the north; village Khati in the south, Kala glacier and catchment of river Girthi Ganga in the east; and the upper catchment of river Alaknanda, Nanda Ghunti peak, and Roop Kund in the west. It has an altitudinal range of 1800m-7816m msl and covers an area of 6,407.03 km^2 (core area: 712.12 km^2, buffer zone: 5148.57 km^2 and transition zone: 546.34 km^2) which includes both the Nanda Devi National Park (NDNP) and Valley of Flowers National Park (VOFNP) (Negi, 2002).

In 1988, the NDNP (30°16' to 30° 32'N and 79° 44' to 80° 02'E) formed the core zone with the surrounding areas as the buffer zone of NDBR (2,237 km^2) and was declared a biosphere reserve under the Man and the Biosphere (MAB) Programme of UNESCO. This was later amended in 2000 to cover a total area of 5,860 km^2 to include the VOFNP (30° 41' to 30° 48'N and 79° 33' to 79° 46'E) as part of the core zone (88 km^2). NDNP and VOFNP were designated as 'World Heritage Sites' during the years 1988 and 2004 respectively. NDNP is located in the high mountain ranges of Chamoli district in the upper catchments of the river Alakananda, the eastern tributary of the river Ganga. Nanda Devi peak lies within the core area of NDNP and is the second highest peak within Indian territory (7,816 m). It is considered the world's second toughest peak to climb (Kaur, 1982). VOFNP is located in the west of NDNP harbouring a rich and diverse floral and faunal assemblage in a small area of about 88 km^2. These two core zones have the distinction of being the only two PAs in the Western Himalaya that have not been subjected to extensive livestock grazing since 1983 (Sathyakumar, 2004). They are considered to be the least disturbed areas of the entire BR. They remain intact primarily due to their inaccessibility on account of the surrounding high mountain peaks (UAFD, 2004).

2.2 Topography, Geology and Soil

The terrain of the entire region is highly undulating. The elevation ranges from 1500m to 7,817m (Nanda Devi peak in the Rishi Ganga Valley). About 90% of the total area in the NDBR region (from 3500m and above) is covered in snow and alpine meadows and 52.7% of the reserve has slopes of 20° to 40° (Kandpal, 2010; WII-GIS lab). The rocks are highly metamorphosed crystalline type of the Vaikrita group (Marou, 1979). The core zones of the biosphere have been divided into four geological formations *i.e.* Lata, Ramani, Kharpatal and Martoli. The geological succession varies from the Shiwalik formations in the fringe areas to the lesser Himalayan formations (Negi, 2000). Most of the NDNP falls within the central crystalline, a region of young granites and metamorphic rocks. Along the northern edge, the exposed Tibetan-Tethys consists of sandstones, micaceous quartzite, limestone and shale (Kumar and Sah, 1986). The Tethys sediments form Nanda Devi peak along with many of the surrounding peaks, displaying spectacular folds and evidence of thrust movements, while other mountains like Changbang are made up of granite. The basin displays an array of periglacial and glacial forms covering a wide range of phases of their growth. The combinations of normal and perched glaciers on different rock types form interesting features in the basin (Reed, 1979). Geologically VOFNP falls in the Zanskar range (Wadia, 1966). The rocks are primarily sedimentary with mica schist and shale. The soil is acidic in nature (Ph 3.8 – 6.1).

2.3 Climate: Temperature, Rainfall and Humidity

The climatic trends change as one moves from North-west to South-east in the biosphere. There are four main seasons that are experienced by the BR: (i) winter: December to March with heavy snowfall in the months of December - February (ii) spring: April to mid June (iii) summer: mid June to September (iv) autumn: October to November. The major portion of the biosphere area remains under a thick carpet of snow during winter, and is accessible only for a limited period from late June to early October. Generally, the snow cover is thicker on the northern slopes than on the southern slopes (Lavkumar, 1979; Lamba, 1987; Plate.3 & Plate.4). About 60% of the buffer zone and 81% of the core zone remain snow bound or covered by glaciers throughout the year (Sahai and Kimothi, 1996). During rainy season, the climate as a whole is dry, with low annual precipitation. Average annual rainfall is 928.81mm. About 47.8% of annual rainfall occurs over a short period of two months (July-August). There is considerable inflow of warm air up the gorges, resulting in light mist over the high meadows. The mists in the month of June keep the soil moist, which in turn helps in supporting luxuriant vegetation (Lavkumar, 1979; Lamba, 1987). The maximum temperature ranges from 11^0C to 24^0C and minimum from 3^0C to 7.5^0C. The elevation of the Trans-Himalayan region ranges from 4400 to 5500 msl. It receives very scanty rainfall and exhibits all the characteristics of typically cold-arid conditions (Rawat, 2005)

2.4 Forest types, Flora and Fauna

Forest Types: The forests in the study area are mainly dominated by *Quercus* and *Abies* species forming the climax communities at various altitudinal zones. According to Champion and Seth (1968) forests of NDBR is divided into four major categories (Table. 2.1) -

(a) Temperate forests (2000–2800m): This type has two sub categories – (i) Deciduous forests and (ii) Coniferous forests. Deciduous forests are dominated by *Acer caesium, A. pictum, Celtis australis, Betula alnoides, Alnus nepalensis* and other associated species such as *Rhododendron arboreum, Aesculusindica,* and *Juglans regia.* Coniferous forests are dominated by *Abies pindrow, A. spectabilis, Picea smithiana, Pinus wallichiana, P. roxburghii, Cedrusdeodara* and *Taxus wallichiana.* Shrubs such as *Rubus* sp., *Desmodium elegans, Viburnum continifolium, Deutzia staminea and Sinarundinaria falcata* occupy the middle layer.

(b) Subalpine forests (2800–3500m) are dominated by *Abies spectabilis, Taxus wallichiana, Betula utilis* forms the transition zone between subalpine forest and alpine meadow near the treeline. Shrub species such as *Juniperus communis, J. indica, Rhododendron campanulatum, R. anthopogon, Cotoneaster* spp., *Rosa sericea, R. macrophylla* are present as dominant understory vegetation.

(c)Alpine scrublands (3800–4500m) are dominated by *Rhododendron anthopogon, R. lepidotum, R. campanulatum, Juniperusindica.*

(d)Alpine meadows and moraines (>3500m) are dominated by herbs and shrubs *viz*., *Juniperus indica*, *Rhododendron anthopogon, Cassiope fastigiata, Danthonia cachemyriana, Salix elegans, S. denticulata, Carex nubigena, C. stenophylla, Bistorta* spp. and *Anaphalis* spp.

Flora: The reserve supports over 1,000 species of plants including bryophytes, fungi and lichens (Samant, 2001). About 620 species of flora has been reported for NDNP and the list comprises of 531 Angiosperms, 11 Gymnosperms and 33 Pteridophytes. Smythe (1938) surveyed VOFNP and the adjacent areas and reported 262 plant species. Later, Kala (1998) made a floral inventory of vascular plants exclusively, inside the NP and recorded 521 species of vascular plants (Angiosperms, Gymnosperms and Pteridophytes) belonging to 72 families and 248 genera. The vegetation comprises mainly of temperate, sub alpine and alpine types. The alpine meadows are locally known as 'bugyals' which harbour high value medicinal plants such as

Aconitum spp. *Dactylorhiza hatagirea, Podophyllum hexandrum, Nardostachys jatamansi, Jurinea dolomiaea, Trillium govanianum, Gaultheria trichophylla* and aromatic plants *viz.*, *Nardostachys jatamansi, Angelica glauca, Saussurea gossypiphora, Skimmia anquitilia, Geranium wallichianum, Artemisia nilgirica*, *A. gmelinii* supporting over several alpine faunal communities. The reserve also supports large numbers of other native, endemic, rare, endangered and charismatic floral species *viz., Saussurea obvallata, Meconopsis aculeata, Dactylorhiza hatagirea, Angelica glauca, Podophyllum hexandrum*.

The alpine meadow of NDBR supports a wide variety of flowering plants such as *Androsace globifera, A. sarmentosa, Cyananthus spp., Gentiana* spp.*, Geranium, Morina, Potentilla* and *Primula* etc. (Samant, 1993; Kala and Rawat, 1998; Samant and Joshi, 2003). The sub alpine forest of birch (*Betula utilis*) and *Rhododendron campanulatum* forms the timberline vegetation*.* There are about fifteen rare and endangered plant species like *Aconitum violaceum, A. heterophyllum, Circeaster agrestis, Epipogium aphyllum, Listera* spp., *Meconopsis aculeata, Nardostachys jatamansi, Dactylorhiza hatagirea, Podophyllum hexandrum, Saussurea obvallata* and *Taxus wallichiana* (Kala, 1997; Kala et al., 1997, 1998; Samant et al., 1996 and Hazra, 1983).

The trans Himalayan meadows are dominated by grasses, a few sedges and stunted herbs such as *Arenaria bryophylla, Chesneya nubigena, Leontopodium alpinum, Oxytropis lapponica, Potentilla bifurca, Rheum moorcroftianum* and *Waldhemia tomentosa.* Other common species are *Cassiope fastigiata, Danthonia cachemyriana, Kobresia nepalensis, Persicaria vivipara, Selinum tenuifolium* and *Trisetum spicatum* besides several medicinal plants such as *Aconitum violaceum*, *Picrorhiza kurrooa, Pleurospermum densiflorum, R. australe, Rheum moorcroftianum* and *Saussurea obvallata* (Rawat, 2005).

Table 2.1: Forest cover of NDBR

Vegetation types	Geographical area (area in km^2)	Percent of total area (%)
Dense forest (crown density >40%)	234	10
Open forest (crown density 10-40%)	176	9
Scrub (crown density <10%)	87	4
Non-forest (including settlement, agriculture, wasteland, water bodies and glaciers)	1740	77
Total	2237	100

Source: Sahai and Kimothi, 1996

Fauna: Over 518 faunal species including mammal, birds, fishes, reptiles, amphibians, molluscs, annelids and invertebrates are found in NDBR. The vertebrate and invertebrate faunal groups comprise of 29 mammals, 228 birds, 3 reptiles, 8 amphibians, 6 annelids, 14 molluscs and 229 species of arthropods (Kumar et al., 2001). Snow leopard (*Unicia unica*), musk deer (*Moschus chryogaster)*, bharal (*Pseudois nayaur*), Himalayan tahr (*Hemitragus jemlahicus*), serow (*Captricornis sumatraensis*) Himalayan black bear (*Ursus ursus*) and Himalayan brown bear (*Ursus arctos)* are found in NDBR (Dang, 1967; Khacher, 1978; Kandari, 1982; Lamba, 1987; Uniyal, 2004; Sathyakumar, 1993, 2004; Bhattacharya et al., 2006; Bhattacharya et al., 2009 and Kandpal, 2010).

Nearly 200 species of birds are reported from the BR (Shankaran, 1993). Some of the birds like Himalayan golden eagle (*Aquila chrysactos daphancea*), eastern steppe eagle (*Aquila rapax nipalensis*), black eagle (*Ictinaetus malayensis perniger*), Himalayan bearded vulture (*Gypaetus barbatus*), and Himalayan snowcock (*Tetragullus himalayansis*) (Shankaran, 1993; Tak and Kumar, 1987; Reed, 1979 and Sathyakumar, 2004) have been reported from NDBR. Galliformes like the Himalayan monal pheasant (*Lophophorus impejanus*), koklass (*Pucrasia macrolopha*) and satyr tragopan (*Tragopan satyra*) are found in this region (Sathyakumar, 2004).

However, very little information is available on the invertebrate fauna of the BR. Kumar et al. (1997) reported 218 forms of invertebrates from NDBR: 15 species of Mollusca, 6 species Annelida, 17 species of Arachnida, 1 species of Thysanura, 2 species of Collembola, 6 species of Odonata, 14 species of Orthoptera, 7 species of Dermaptera, 13 Hemiptera, 4 species of Neuroptera, 80 species of Lepidoptera, 2 species of Trichoptera, 24 species of Diptera, 24 Hymenoptera and 3 species of Chilododa. There is a rich diversity of butterflies in the BR; some of the butterflies found in these areas are common yellow swallowtail (*Papilo machaon*), common blue apollo (*Parnassius hardwickei*), dark clouded yellow (*Colias electo*), Queen of Spain fritillary (*Issoria lathonia*), and Indian tortoiseshell (*Aglais cashmirensis*) (Baindur, 1993 and Uniyal, 2004).

2.5 Local Communities and Land Use Practices

Human habitation inside the core zones of NDBR is not permitted. There are 47 villages located in the buffer zone of the NDBR. Of these, 34 villages are in Chamoli district, 10 villages in Pithoragarh district and 3 villages in Bageshwar district (UAFD, 2004). The inhabitants belong to the Indo Mongoloid (Bhotias) and Indo Aryan groups. Traditionally, the Bhotia tribesmen migrate to the alpine pastures in the summers and come down to the lower valleys during the harsh winters (Nautiyal et al., 2005). They have unique indigenous culture, tradition, religious beliefs and tribal customs. Major sources of livelihood are agriculture, rearing livestock and sheep; however ecotourism is also fast becoming an important industry (UAFD, 2004).

The traditional communities and local people depend on the different forest types and alpine meadows for various bio-resources mostly used in agriculture, livestock, traditional health care system, cosmetic, medicines, food and other small industries (Maikhuri et al., 2000, 2001; Nautiyal et al., 2001). Inaccessibility, environmental heterogeneity, biological, socio-cultural and economic variations in the NDBR have led to the evolution of diverse and unique traditional agroecosystems, crop species, and livestock, which help the traditional mountain farming societies to sustain themselves (Maikhuri et al., 2001).

Traditional crops cultivated in these regions include legumes, cereals, pseudocereals, potato, mustard etc. (Nautiyal et al., 2003). The main herb and fodder species found are *Ficus roxburgii*, *F. nemoralis, Grewia optiva, Dabregesia hypoleuea, Carpinus viminea, Celtis* sp., *Potentilla, Geranium, Fritillaria, Lilium, Corydatis, Cyananthus, Anemone, Ranunculus, Impatiens* etc. (Kala et al.,1998; Silori and Badola., 1999) and the important medicinal plants are *Aconitum heterophyllum, Dactylorhiza hatagirea, Nardostachys grandiflora, Picrrohiza kurrooa, Angelica glauca, Allium* spp. etc. (Maikhuri et al.,1998; Nautiyal et al., 2001). Animal husbandry constitutes an important component of the rural economy of the Himalayan region. Livestock feed is derived from grazing and crop by-products. It provides a wide range of services and products including draught power, manure, wool and supplementary nutrition (Maikhuri and Ramakrishanan, 1990, 1991; Maikhuri, 1992, 1993, 1996). Increasing population of human and livestock (eg. cows, goats and mules) has had a noticeable effect on the high altitude forests of Western Himalaya. These livestock graze in the alpine meadows during summer and is brought back to lower altitudes during mid autumn (Singh and Singh, 1987; Kala et al., 1998; Kittur et al., 2010). The people of the BR are by and large poor with little hand holdings and the literacy rate amongst the tribals is also poor (UAFD, 2004). Due to the difficult, inaccessible and remote location of most villages, there have been few scopes for development.

2.6 History of Forest Management

The forests came under British control after they defeated the Gorkhas in 1815. However, after independence, initial government control began only in the last two decades of the 19th century. The reservation began in 1911 and technical management by the Conservator of Forests in 1912 (UAFD, 2004). The reserve was declared a sanctuary in 1939 and was given World Heritage status in 1992 (Rao et al., 2000). Subsequently, various activities *viz*., trekking, mountaineering, biological surveys and expeditions started in this fragile ecosystem and there was no restraint on human pressure. The entire area was declared as NDNP in 1983. Since then, the NDNP has been closed for all human activities. Further, in January 1988 the area was notified as the second BR of India and designated as the NDBR.

NDBR was the second reserve in India to be established under the Man and Biosphere Programme (MAB) launched by the UNESCO in 1970 (McGinley, 2008). In 1974, the widely acclaimed “Chipko Movement” began in Reni village, located enroute to Nanda Devi and brought to light the efforts of villagers in conservation of forest resources. Realizing the importance of its biological diversity and occurrence of several rare and endangered flora and fauna, NDBR was listed as World Heritage Site in December 1988 (McGinley, 2008). Later the area of NDBR was enlarged by Government notification in 2000. At present the buffer zone consists of reserve forests, civil forests, and village managed *panchayat* forests (forests administered by the Forest Department and Revenue Department and earmarked for a specific *panchayat*, or village wherein user rights are clearly defined and managed by an elected village council) (NDBR Management Plan, Forest Dept., Uttarakhand).

The 1983 ban covered grazing, hunting, harvesting herbs, wood-collection, mountaineering and trekking in the core area of the then projected BR, including the whole National Park (Sathyakumar, 2004). Thus, communities traditionally dependent on sheep rearing and local resources had to seek alternate pastures, change their vocations or emigrate (Silori, 2001). The 1998 ‘*Jhapto Cheeno’* protests against the restrictions on grazing and mountaineering and against official indifference, enlisted world-wide interest. State support for potential development of the basin by national and multinational interests paved the way for the creation of the Nanda Devi Development Authority, by the villagers in 2001. Following this initiative, the Protected Area management began to promote local entrepreneurship and actively involve local communities which had previously been ignored, in conservation activities (McGinley, 2008). These now receive a share in the trail management fees and help to prevent fires and poaching. Support from the MAB programme, initiatives of the Indian government and the latest ecotourism policy of the newly created state of Uttarakhand, regulated tourism was allowed and community-based tourism plans for the villages around the Park (Lata, Tolma, Peng and Reni) were prepared. Under these plans, capacity-building, the training and registration of local youths as guides, creation of home stays for visitors, establishment of local tour operator groups for eco and cultural tours, development of handicrafts and medical plant cultivation and direct involvement of Women's Welfare Groups have all been introduced. Eco-Development Committees were established in all the villages and PRA- (Participatory Rule Appraisal) based micro-plans were prepared by them which were supported with funds from various sources. This success was recognized in 2004 by an ecotourism award (McGinley, 2008). In 1993 an expedition was made to assess the biodiversity changes that might have occurred by a team of scientists supported by the Corps of Engineers of the Indian Army through the ‘Scientific and Ecological Expedition to Nanda Devi’. The status of flora and fauna showed an improvement and recommended that NDNP should remain closed (www.ndls.org). The ‘Biodiversity Monitoring Expedition to Nanda Devi’ undertaken during June–July 2003 has evaluated the status of flora, fauna, and their habitats. It assessed the changes in the status of flora and fauna over a period of two decades, also conducting base line surveys for new aspects of study in Ecology and Geology. This expedition also reported improvement in status of some species/taxa and habitats or no change in status (www.ndls.org).

VOFNP was closed for livestock grazing in 1982 and people of Bhyundar were no longer allowed inside the valley. With support from the Forest Department, the local communities formed Eco-Development Committees (EDCs). The EDCs at Bhyundhar and Govindghat provide support to the park management and look after the waste disposal and management of visitor facilities along the trail outside the NP. However, some families are still economically unstable but others earn well from tourism and the pilgrimage and are very supportive of the Park (Srivastava, 1999).

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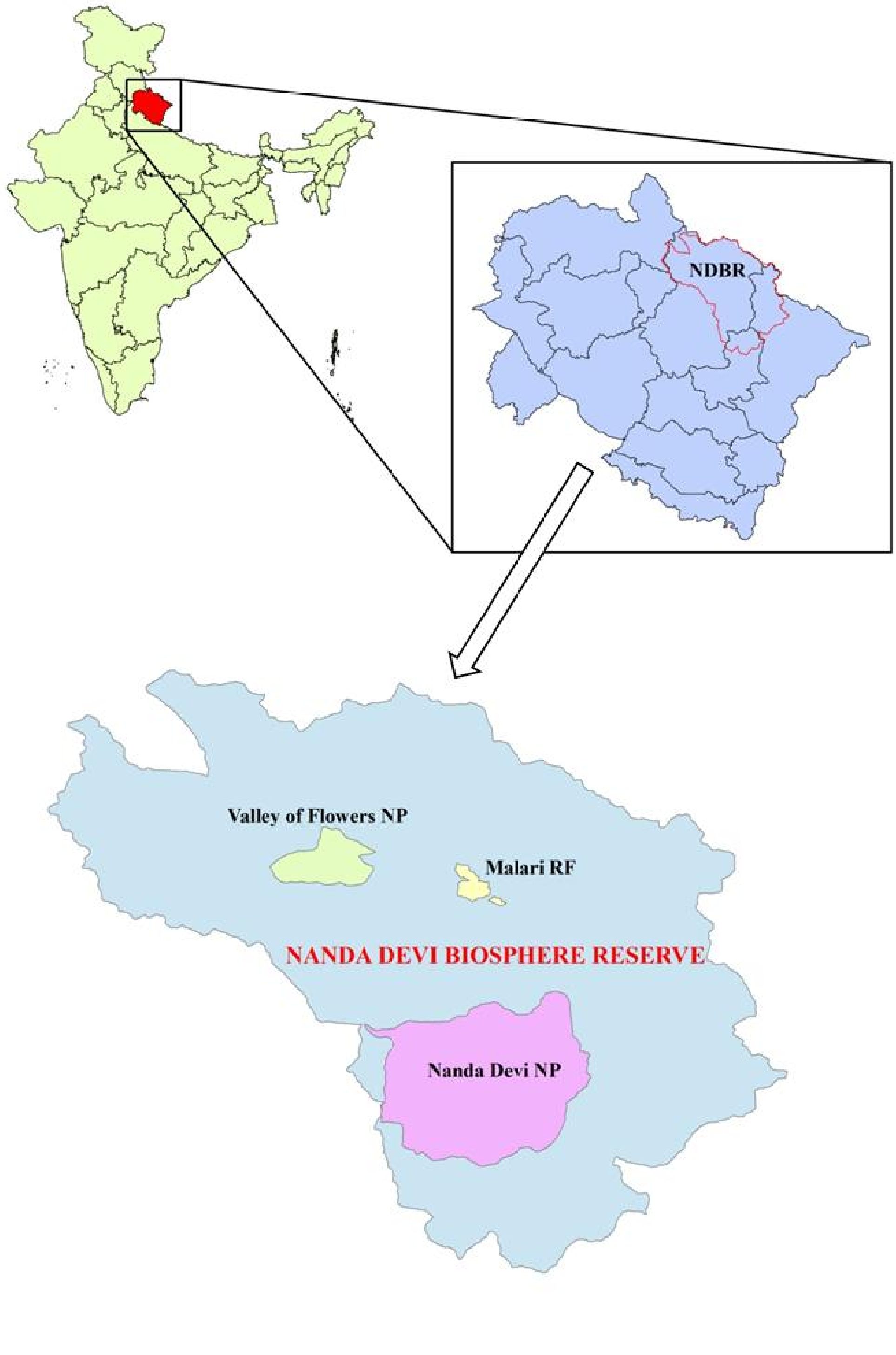
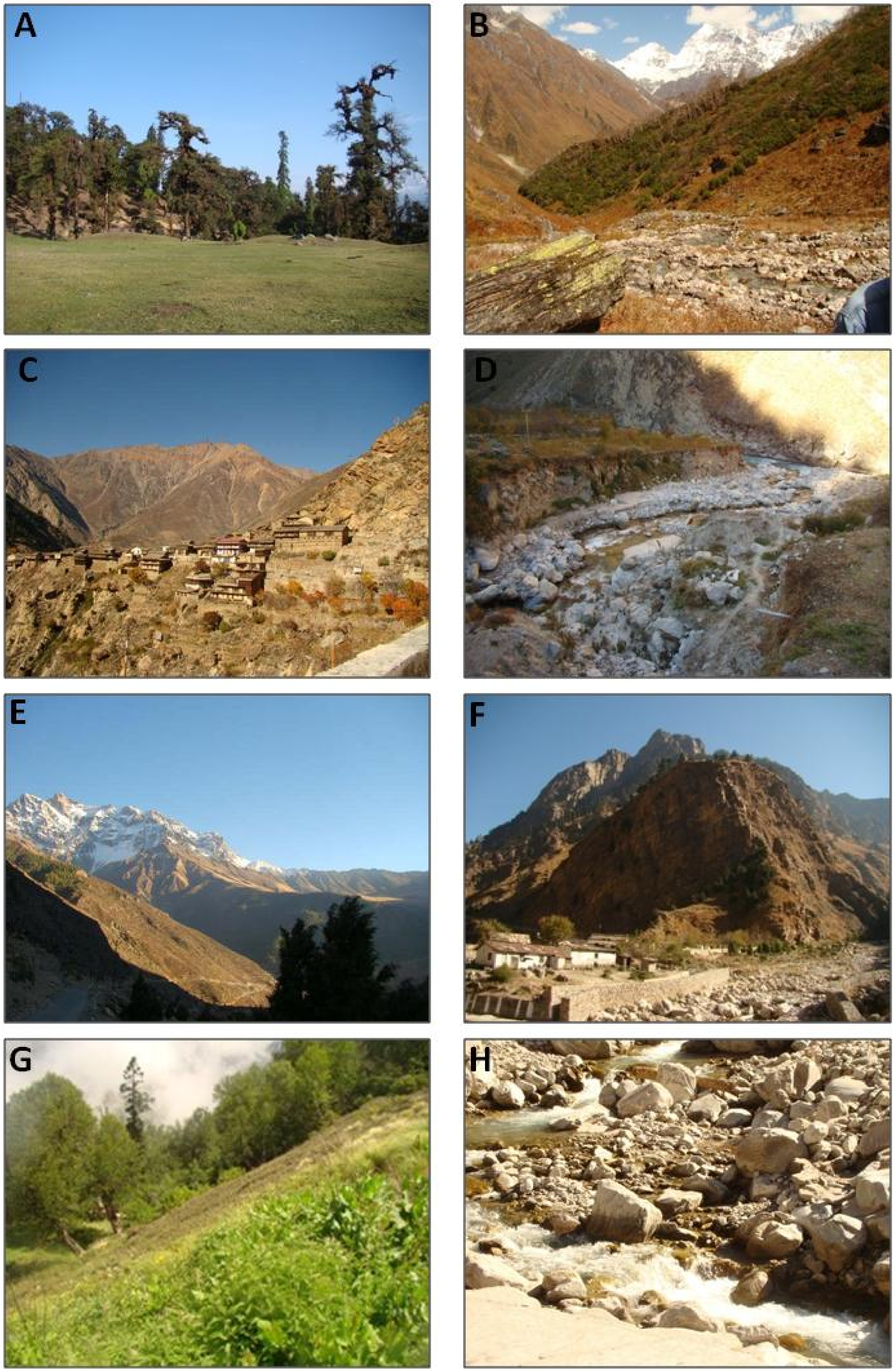


Map of Nanda Devi Biosphere Reserve (NDBR)

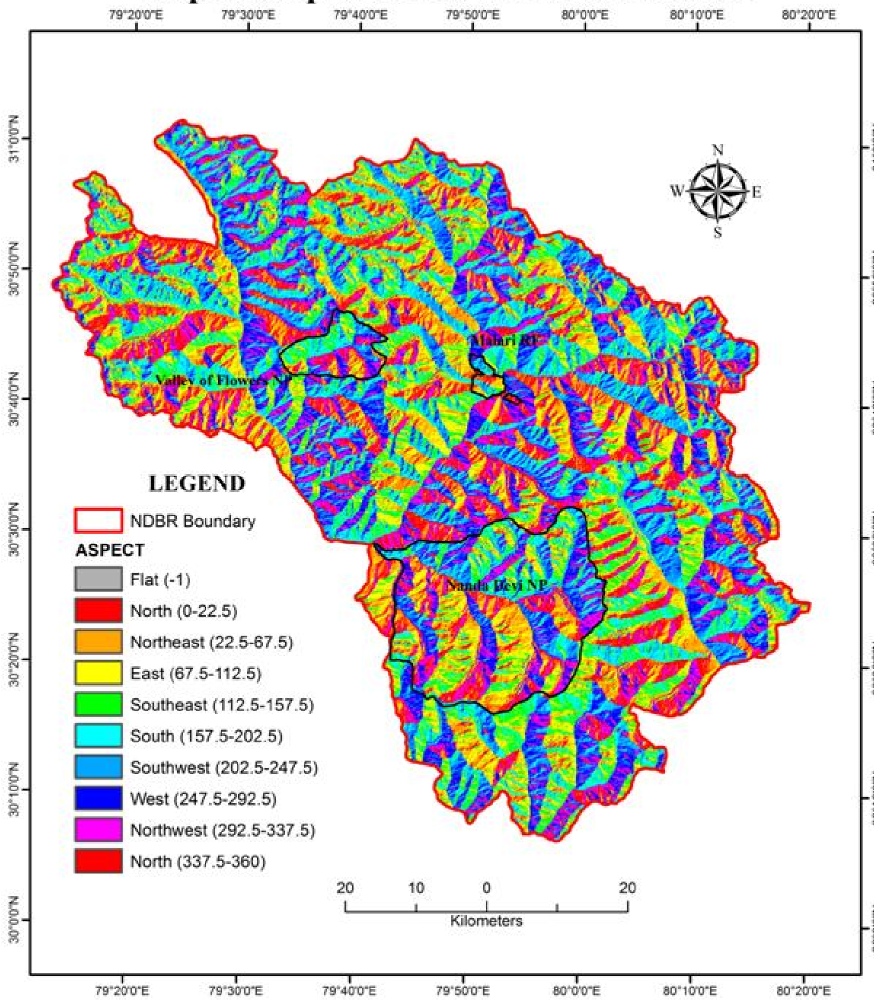
- Plate 1 -



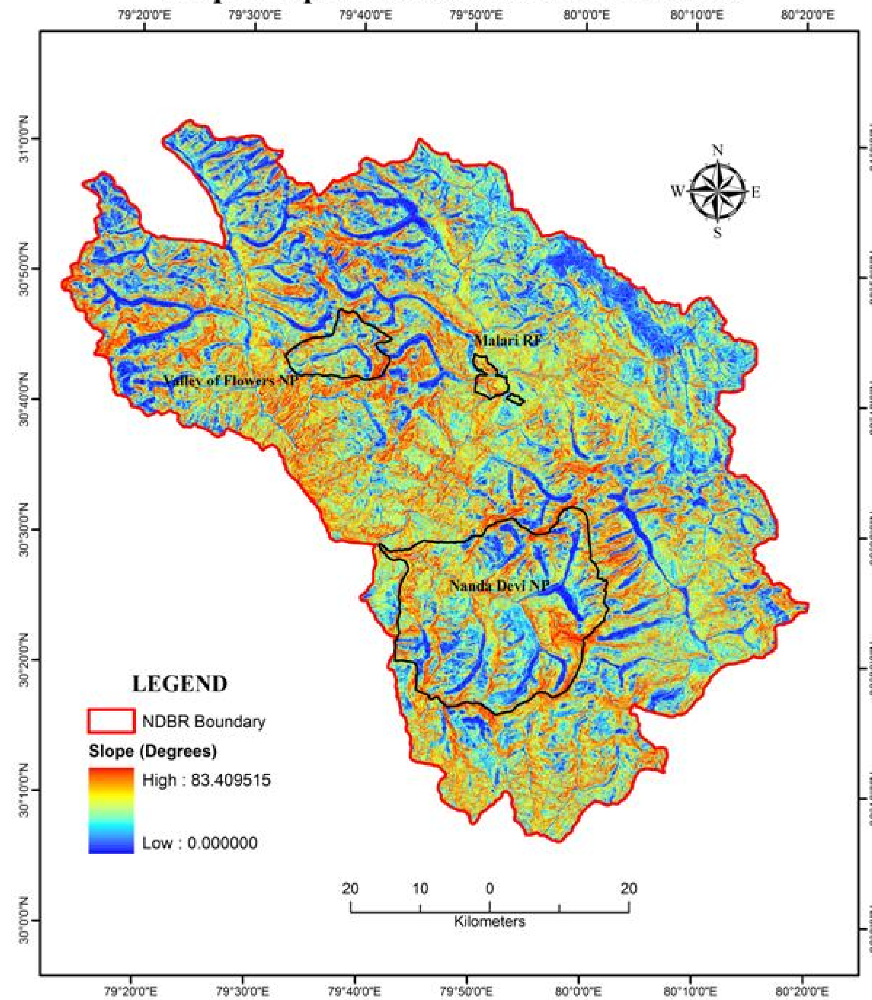
Landscape (A-H) of Nanda Devi Biosphere Reserve

- Plate 2 -

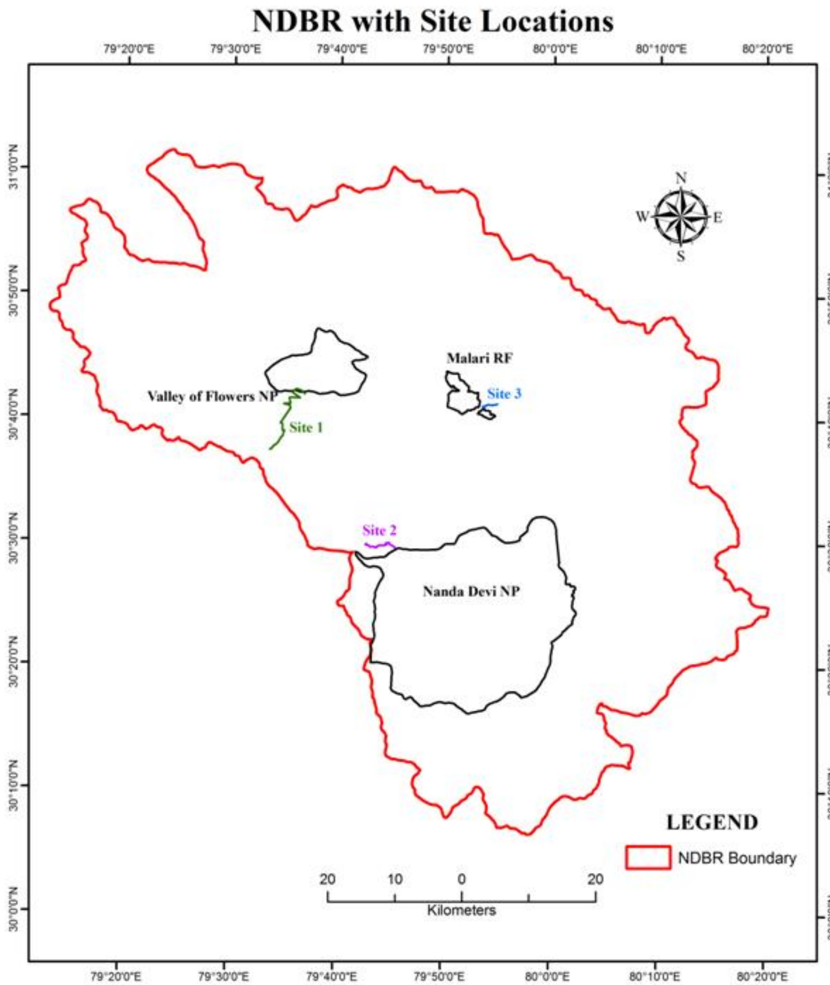
Aspect Map of NDBR with Site Locations



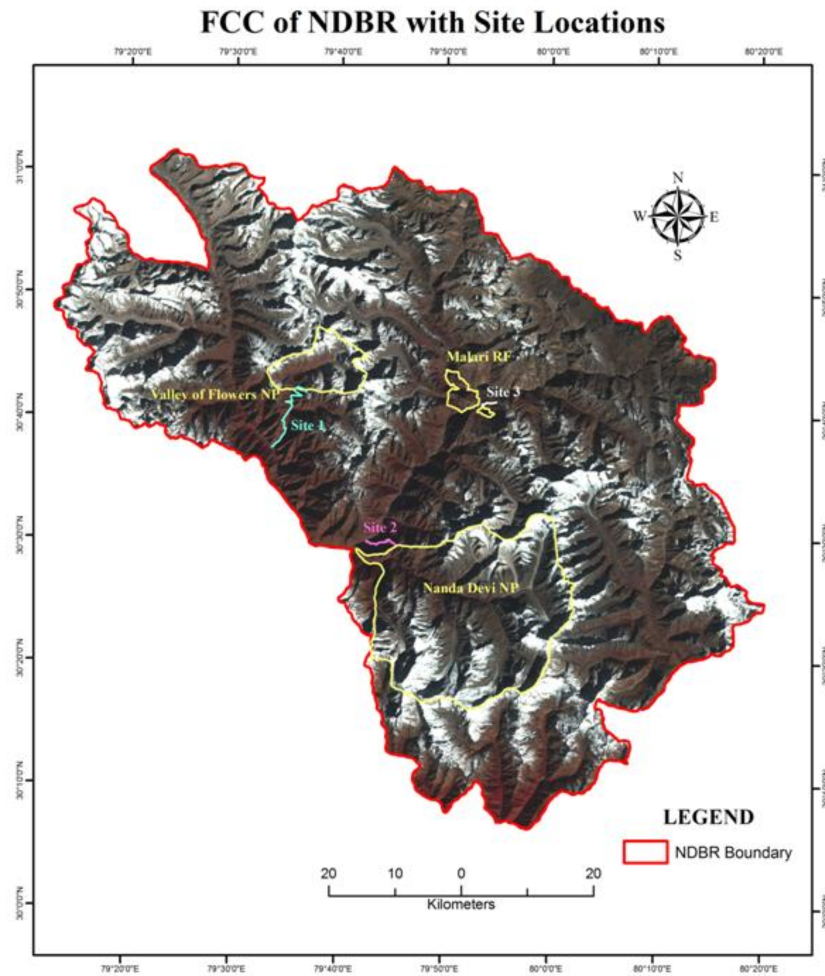
Slope Map of NDBR with Site Locations



- Plate 3 -



NDBR with Site Locations
Valley of Flowers NP
Site 1
Malari RF
Site 3
Site 2
Nanda Devi NP
LEGEND
NDBR Boundary
Kilometers



FCC of NDBR with Site Locations
Valley of Flowers NP
Site 1
Malari RF
Site 3
Site 2
Nanda Devi NP
LEGEND
NDBR Boundary
Kilometers

- Plate 4 -

CHAPTER 3
SAMPLING METHODS

3.1 Introduction

The effect of altitude on biodiversity has been a topic of great interest for many earlier and contemporary biogeographers. During the nineteenth century, latitudinal and elevational gradients in diversity were considered direct responses to climatic changes and energy interactions in the environment (Lomolino, 2001). Along altitudinal gradients changes in both climate and structure occur, leading to shifts in composition of potential prey species (Otto and Svensson, 1982). Concerning spiders, not many studies have been carried out in detail focusing on the relationship between species diversity and altitude. Spider communities existing at different locations along a gradient could be expected to show marked differences with respect to niche dimensions of the species involved. Thus, here I intent to investigate patterns of the niche dimensions in spider communities along altitudinal gradients.

Sampling was carried along the altitude gradient in NDBR for three years (2008-2010) at three sites: Site 1 Lata Kharak (2000-4000m); Site 2 Bhyundar Valley (1800-4100m) and Site 3 Malari (3000-4000m). Sampling was limited by steep and rugged terrain compounded with harsh climatic conditions, hence, instead of line transects, plots were laid along the existing trails. Randomly selected plots of 10m×10m size (106 quadrats) in the various altitudinal categories were sampled. Plots were selected systematically within a stratified altitudinal zone to ensure independent sampling protocol and to minimize spatial auto-correlation.

As spiders exploit a wide variety of niches, sampling was done in order to collect representative samples from all niches within each intensive sampling plot. Sampling required a combination of methods, so six different collection techniques *viz.,* pitfall trapping, vegetation beating, litter sampling, ground hand collection, aerial hand collection, and sweep netting (Coddington et al., 1996) were employed. Pitfall sampling was operated for 6 days (in one season) and other five semi-quantitative sampling methods were performed twice every season at the same sampling sites and plots. The principal purpose of this sampling design was to produce a relatively complete species list and associated abundance data for a representative sample of each site in the region, and of the region as a whole. The pitfall traps were kept for three days and then the samples were removed. The other five methods were employed for 30 minutes in the same sampling plot, and the time was measured with a stop watch. Aerial sampling (for upper layer spiders up to 1.5 m) involved searching leaves, branches, tree trunks, and spaces in between, from knee height up to maximum overhead arm’s reach. Ground collection (for ground layer spiders) involved searching on hands and knees, exploring the leaf litter, logs, rocks, and plants below low knee level. Beating (for middle layer spiders up to 1 m) consisted of striking vegetation with a 1m long stick and catching the falling spiders on a tray held horizontally below the vegetation. Litter sampling was done by manually sorting spiders from leaf litter collected in a litter collection tray. Sweep netting (for middle layer spiders up to 1 m) was carried out in order to access foliage dwelling spiders. Specimens were identified up to family, genus and species level when possible. All the above methods except for the pitfall traps were carried out during the morning and afternoon 8am - 3pm as night sampling was not possible in this area.

3.2 Collection Techniques

Established sampling protocols for spider collection (Sorensen et al., 2002) were adopted in different sampling plots. The detailed descriptions of the collection techniques are as follows (Plate. 5-7).

i) Pitfall Trapping - Pitfalls are the most widely used method for sampling assemblages of ground or litter-dwelling arthropods (Uetz and Unzicker, 1976; Niemelä et al., 1986; Whicker and Tracy, 1987; Halsall and Wratten, 1988; Topping and Sunderland, 1992; Davis, 1993; Krasnov and Shenbrot, 1996; Davis and Sutton, 1998; Ward et al., 2001; Jonas et al., 2002; Ranius and

Jansson, 2002; Magagula, 2003). The pitfall traps were left open for a period of three days, as this allowed maintenance of spider specimens in good conditions before they could be transported to the laboratory for their identification. However, the limitations of this method are that the number of individuals trapped is affected by environmental, weather and species-specific factors (Mitchell, 1963; Krasnov and Shenbrot, 1996; Parmenter et al., 1989; Ahearn, 1971). Despite the various limitations, pitfalls were used in this study because they are cost effective and could be operate on a full time basis (active during day and night). For this study, I used nine cylindrical plastic bottles of 9cm diameter and 11cm depth, arranged within the quadrats in three horizontal and three vertical rows, each at 5m distance from the nearest neighbour, thus forming four smaller grids of 5m×5m within the sampling plot (Fig. 2). Traps were filled with liquid preservative (69 % water, 30% ethyl acetate and 1% detergent).

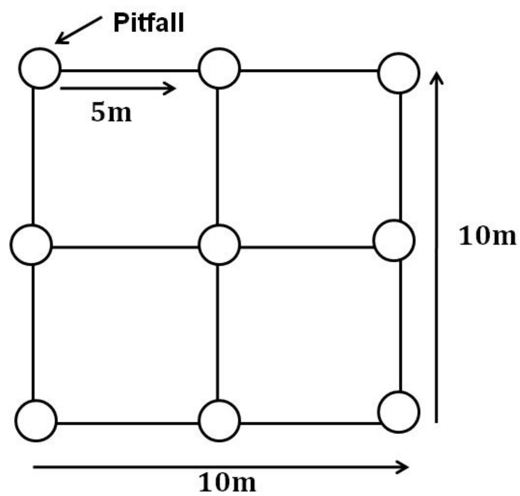


Fig 2.1: Design of the Pitfall trap

ii) Sweep Netting – Sweep-netting involves collection through the herb layer by swinging a sweep net through the under storey vegetation of shrubs for a standard number of times (Coddington et al., 1996). A number of factors such as weather, vegetation type and age, weight of net, type of mesh, and the skills of the person affect collection of samples by sweep net (Marshall et al., 2000). This sampling method was applied to collect the foliage spiders from low level vegetation of shrubs (upto 2 m in height). The sweep net consisted of a 90 cm long handle, 40 cm ring and the collection was made on white canvas. The net was emptied at regular intervals to avoid loss and destruction of the specimen. During sampling, sweep net was moved back and forth to cover all ground layer herbs and shrubs till all the vegetation in the sampling plots was swept thoroughly for 30 minutes.

iii) Ground Hand Collecting – Ground Hand collection involves the collection of spider samples from ground to knee level (Coddington et al. 1991, 1996). This method of sampling was used to collect spiders, which were found to be visible on the ground, litter, in broken logs, rocks etc. This method was employed for 30 minutes for searching the ground dwelling spiders.

iv) Aerial Hand Collecting – Aerial Hand collection involves the collection of spider samples from knee level to arm length level (Coddington et al., 1991, 1996). This method aided in the collection of web-building and free-living spiders on the foliage and stems of living or dead shrubs, tall herbs, tree trunks etc. This method was employed for 30 minutes for searching the foliage and web building spiders.

v) Vegetation Beating: The method is employed to collect spiders living in the shrub, tall herbs vegetation, bushes and small trees and branches (Coddington et al. 1991, 1996). Spiders were collected by beating the vegetation with a stick and collecting the samples on a cloth (1 m by 1.2 m). The spiders were also collected by tapping the vegetation with a heavy stick while holding a collecting tray underneath from which the spiders were sampled (Coddington et al., 1996). Vegetation beating method was employed for 30 minutes each, in all the sampling plots.

vii) Litter sampling: Litter sampling involves sorting out spiders from the litter collection tray placed on the forest floor prior to the collection where litters accumulate (Coddington et al. 1991, 1996). For the current study, a wooden frame of 1m x 1m was used for collection of the forest litter, then sorting the spider specimens by placing the litter on a white sheet. Two such litter sampling quadrats were laid in each of the 10m x 10m plot.

3.3 Preservation and Identification

Collected specimens were transferred to 70% alcohol for further measurements and identification. Accurate identification on the family, genus and species level is only feasible with an adult specimen. The identification of the spider relies heavily on the genitalia. Thus, identifying immature spiders to species level is considered impractical as sexual characters are needed for species level identification (Edwards, 1993). Identification and classification was also done on the basis of morphometric characters of various body parts along with examination of salient features like, presence of two or three claws, presence or absence of cribellum, paraxial or diaxial chelicerae, presence of one or two pairs of book lungs. A detailed taxonomic study was carried out based on the various keys and catalogues provided by Dayal (1935), Kaston (1978), Tikader (1980), Tikader and Biswas (1981), Tikader (1982), Brignoli (1983), Davies and Zabka (1989), Platnick (1989), Biswas and Biswas (1992), Barrion and Litsinger (1995), Yin et al., (1997), Song and Zhu (1997), Biswas and Biswas (2004, 2003), Nentwig et al., (2003), Platnick (2011) and other relevant literature. Voucher specimens were deposited at Wildlife Institute of India, Dehradun.

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Pitfall Trapping

Ground Hand Collection

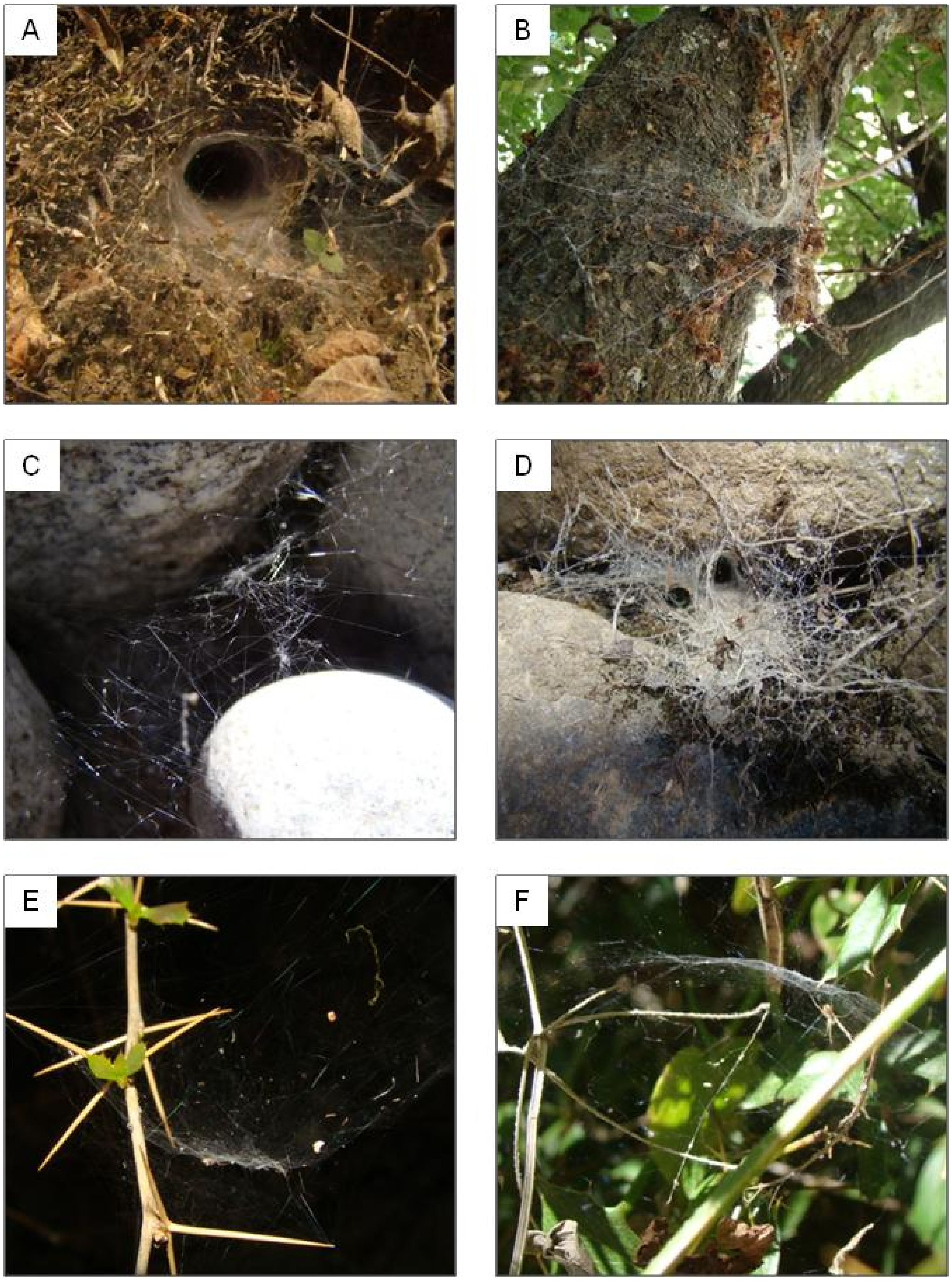
Aerial Hand Collection

Litter Sampling

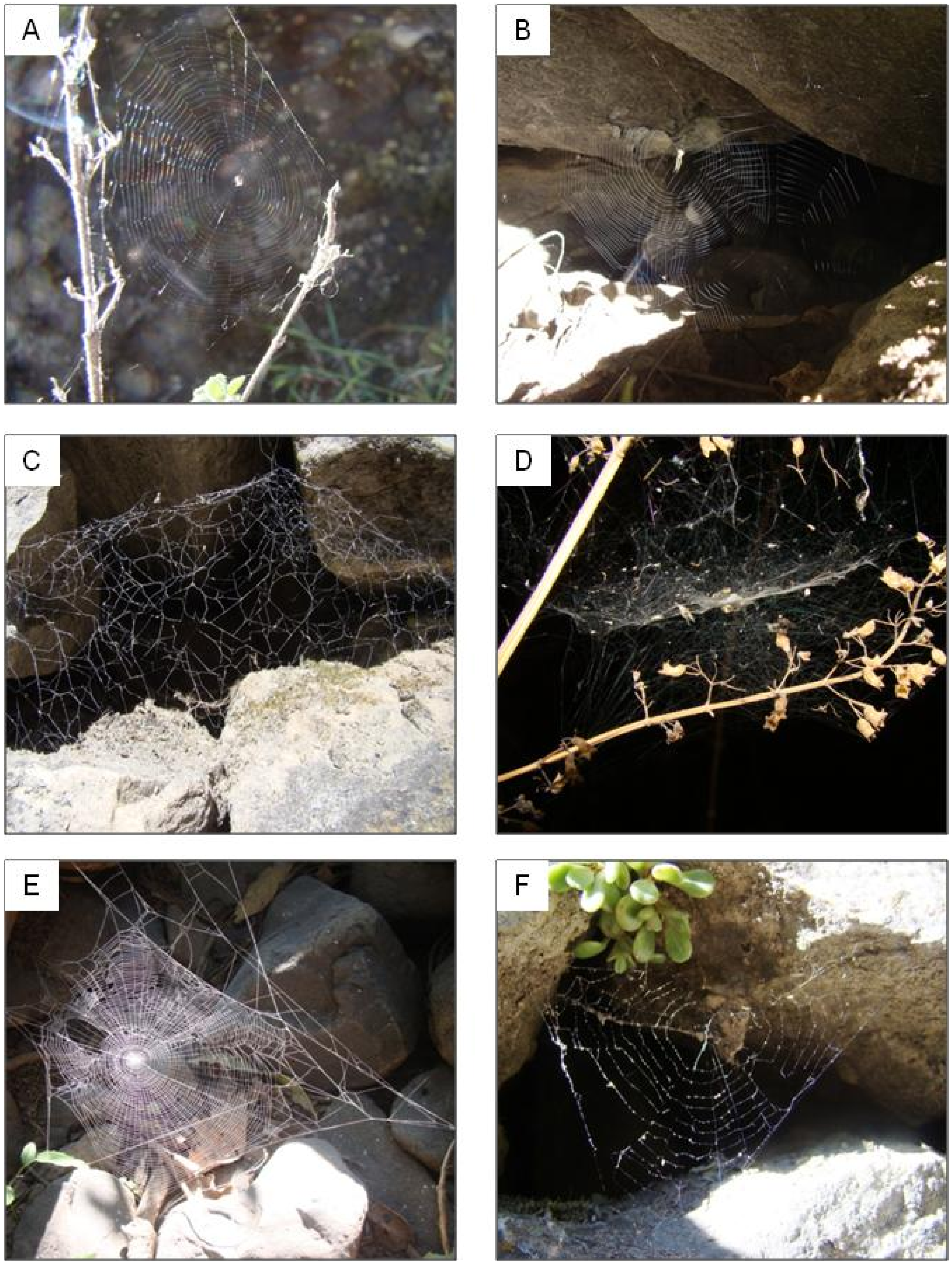
Sweep Netting

Vegetation Beating

- Plate 5 -



Various forms of Webs: A-B. Funnel web; C. Tangle web; D. Tube web; E- F. Tent or Sheet web.



Various forms of Webs: A-B. Ecribellate Orb - web; C - D. Sheet web; E- F. Cribellate Orb web.

- Plate 7 -

CHAPTER 4
SYSTEMATICS AND DISTRIBUTION OF SPIDERS IN NDBR

4.1 Introduction

Spiders are 7th largest group of animals (Nyffeler and Benz, 1980). They are abundant and ubiquitous in most terrestrial habitats, thus are valuable components of ecosystem functioning (Riechert, 1974; Wise, 1993). Platnick's 'World Spider Catalog' has provided good insights into standardized approaches for understanding spider diversity and taxonomy around the world. Spiders, which globally include about 42473 described species (Platnick, 2011) under 3849 genera and 110 families, comprise a significant portion of terrestrial arthropod diversity. Out of these, 2299 spider species belonging to 552 genera and 67 families are reported from South East Asia (Siliwal and Molur, 2007).

In India, 1520 species, 361 genus and 61 families are reported by Sebastian and Peter (2009). The Indian spider's checklist prepared by Siliwal et al., 2005 includes 1442 species of spiders belonging to 361 genera of 59 families. Twenty one of these genera are endemic to India while 13 are endemic to South Asia. Of the 1442 species, 1002 are endemic to Indian mainland, 71 species are endemic to South Asia, 65 species are endemic to Andaman and Nicobar Islands and one species is endemic to Lakshwadeep. The families represented by the highest number of genera and species in India are Salticidae (62 genera and 181 species) followed by Thomisidae (37 genera and 154 species).

The knowledge about diversity and distribution of spiders in India is sparse as compared to other regions of the world. Little information is available in the Northern part of India especially, the higher altitudinal zones of the Himalayan region. Thus, a serious need exists to explore spider diversity in the Himalayan region of the country.

4.2 General Introduction to Spider Anatomy

Spiders belong to the class Arachnida and the order Araneae. Their body consists of two main parts, an anterior portion, the cephalothorax or prosoma and a posterior part, the opisthosoma or abdomen (Fig. 4.1). These two portions are connected by a narrow stalk, the pedicel. The prosoma mainly serves for locomotion, food uptake, and for nervous integration and the opisthosoma is associated with the process of digestion, circulation, respiration, excretion, reproduction, and silk production. The prosoma is covered by plates both dorsally (carapace) and ventrally (sternum). The carapace and sternum helps in attaching the six pairs of appendages: one pair of chelicerae (first pair of appendage); one pair of leg-like pedipalps (second pair of appendage) and four pairs of walking legs. Chelicerae are used for capturing and killing the prey, courtship and mating displays and defence. The mouth part is located at the base of the chelicerae and labium. Eyes usually eight but may vary in size, number, and arrangement pattern according to families and are often diagnostic of them. They are usually arranged in two rows: anterior lateral eyes (ALE), anterior median eyes (AME) in anterior eye row and posterior lateral eyes (PLE), and posterior median eyes (PME) in posterior eye row (Fig. 4.2). Pedipalps are leg like first pair of appendages with six segments: coxa, trochanter, femur, patella, tibia and tarsus. In male the pedipalp serves as the copulatory organ. The four legs: I, II, III and IV have seven segments each: short coxa, trochanter, femur, patella, tibia, tarsus and metatarsus (Fig. 4.3). The tip of the tarsus bears 2-3 claws usually depending on the family *viz*., web building spiders have 3 claws while ground dwelling spiders usually have 2 claws.

The opisthosoma is generally soft and expansible and unsegmented except, the Mesothelae (Platnick, 1995). On the dorsal side it has numerous patterns, chevrons, stripes, humps, etc. On the ventral side lie the reproductive system, respiratory systems and the silk producing glands (spinnerets). Towards the anterior end of the ventral side, is a pair of book lungs and a single epigastric furrow. Both the male and female's reproductive organs are found beneath this furrow. Three pairs of spinnerets are situated usually at the posterior end of the opisthosoma: the anterior lateral (ALS), posterior median (PMS) and posterior lateral (PLS) (Fig. 4.4). However, there are only two functional spinnerets in Mygalomorphs: posterior median (PMS) and posterior lateral (PLS). The anterior median pair is often extremely reduced or absent. In many spiders such as Linyphiidae, Theridiidae, and Thomisidae, they are present as only a vestigial lump, which is referred to as the colulus. Spider silk is used to make webs, traps, homes, and funnels, to wrap prey, and in dispersal. Several spiders possess an additional spinning organ, the cribellum which is a small plate located in front of the three pairs of spinnerets. The region of the cribellum is often densely covered with many tiny spigots through which it extrudes thin silk threads. These thin silks are combed out of the cribellum by rhythmic movements of the calamistrum, a row of comb shaped hairs situated on the metatarsi of the fourth legs.

Although spider classification is based on the morphometric characters and it depends on the structure of the spinnerets, eye arrangements, chelicerae, tarsal claws, and the labium. However, genital structures are used mainly for the separation of species and are the only features that provide reliable identification. Subsequently, only adult specimens may be accurately identified to species level. In males the pedipalp is the copulatory organ, which is the modified form of the tibia, metatarsus and tarsus and consists of a dorsal shield-like cymbium and a rounded genital bulb. The pedipalps of male spiders vary greatly in form and complexity. The more complex pedipalp organs are formed of sclerites (hard parts) and hematodochae (soft part). The sclerites bear processes called apophysis. The genital bulb in the spiders with complex pedipalps consists of a well sclerotized tegulum, within which are found an intromittent organ called the embolus, the seminal duct and the seminal reservoir. A terminal apophysis is associated with the embolus and a median apophysis is associated with the tegulum. The variously shaped apophysis in adult males is heavily used for species identification. Female spiders possess a pair of ovaries in the opisthosoma. The lumen of each ovary leads into an oviduct, and the two oviducts unite to form a uterus or vagina. The uterus opens to the outside in the epigastric furrow. In females, however, this furrow is normally sclerotised forming an epigynal plate with a pair of pores, one on either side of the midline. The male inserts the palp containing the semen into these opening of the female during mating (Fig. 4.5). Many spiders possess a complex structured sclerotized plate just in front of the epigastric furrow. This plate, called the epigynum, extends over the genital pore and bears the copulatory openings. The epigynal structures are profoundly used to classify adult females to species level.

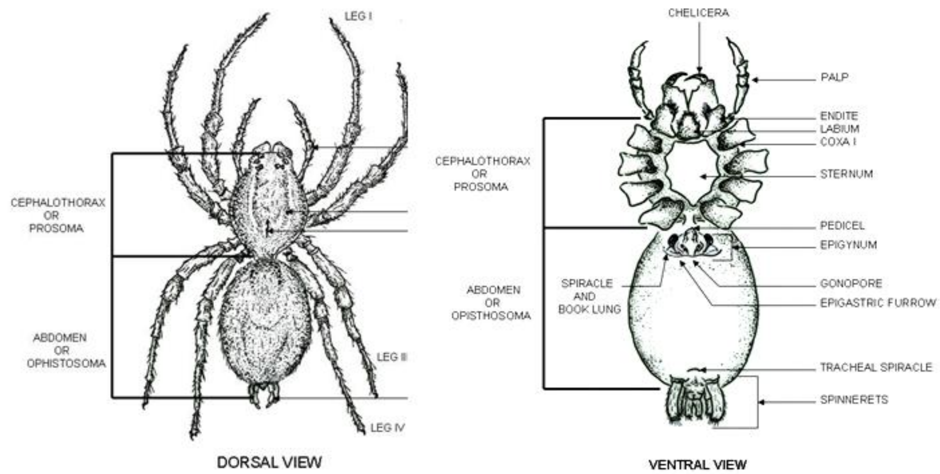


Fig. 4.1 External morphology of spiders showing the dorsal and ventral views.

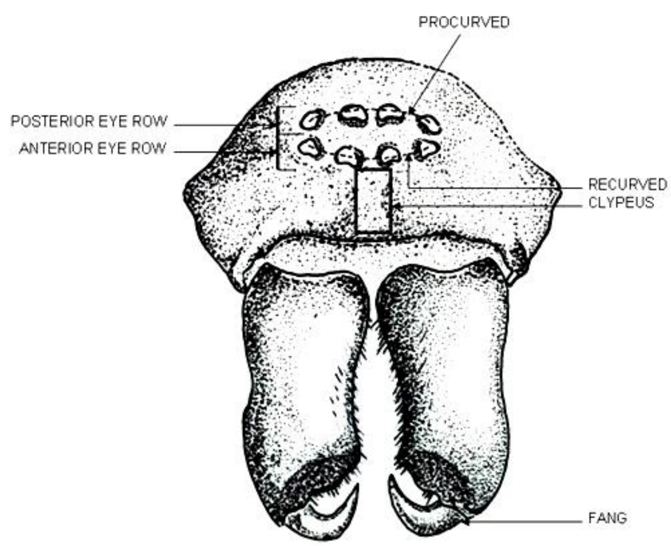


Fig. 4.2 Eye morphology and eye patterns of various eye parts.

(Source: Hore and Uniyal, 2009)

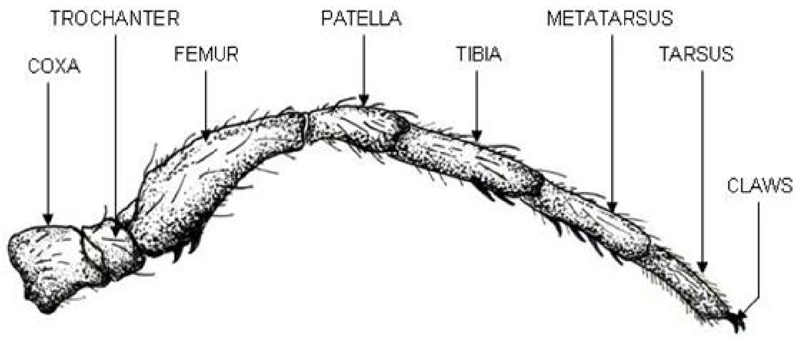


Fig. 4.3 Segments of typical spider leg.

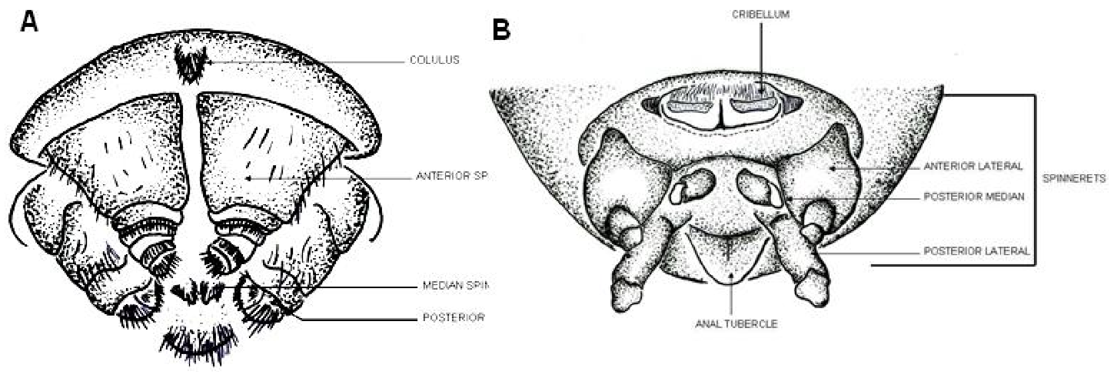


Fig. 4.4 A. Ventral view of spider showing various parts of spinnerets. B. Ventral view of cribellum of typical cribellate spider.

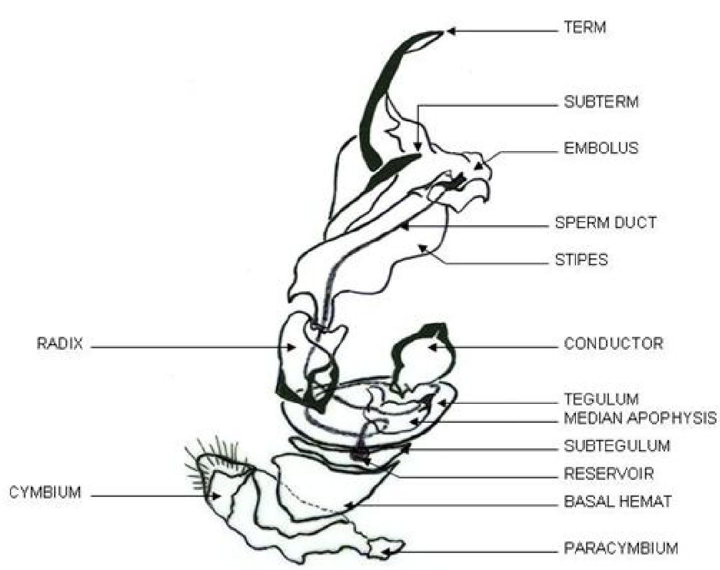


Fig. 4.5 Ventro-lateral view of an expanded palpal organ of a male spider.

(Source: Hore and Uniyal, 2009)

4.3 Spider and Their Relatives

Spiders (Order: Araneae) belongs to one of the eleven orders of the class Arachnida. The other orders of the class Arachnida are Acari (mites and ticks), Opiliones (harvestman or daddy-long-legs), Scorpiones (scorpions), Pseudoscorpiones (Pseudoscorpions, or false scorpions), Uropygi (uropygids or whip scorpions), Schizomida (schzomids), Amblypygi (amblypygids or tailless whip scorpions), Palpigradi (palpigrades or micro-whip-scorpions) and Ricinulei (ricinuleids).

4.4 Studies on Spiders in India

Spiders are abundant throughout the India, but our knowledge of the Indian spiders is extremely fragmented. Studies on Indian spiders have been done earlier by several European workers and later by Indian Arachnologists. Two of the earliest contributions on Indian spiders were made by Stoliczka (1869) and Karsch (1873). Simon (1887-1906) recorded many species from the Himalayas and Andaman and Nicobar Islands. Blackwell (1867), Karsch (1873), Simon (1887), Thorell (1895) and Pocock (1900) were the pioneer workers on Indian spiders. They described many species from India, Burma and Sri Lanka. Cambridge (1869a-b) and Karsch (1873) worked in the Indian, Sri Lankan and Minicoy Islands. Simon's works on Asian region (1885, 1889 and 1897a, b), Indochina (1904b) and the Indian region (1906) provide early information on spiders of the oriental and Indian region. Tikader (1980, 1982), Tikader and Malhotra (1980) described spiders from India. Tikader (1980) compiled a book on Thomisid spiders of India, comprising of 2 subfamilies, 25 genera and 115 species. Of these, 23 species were new to science. Descriptions, illustrations and distributions of all species were given. Keys to the subfamilies, genera, and species were provided. He reviewed the general taxonomic characteristics with reference to Thomisidae. Tikader and Biswas (1981) studied 15 families, 47 genera and 99 species from Calcutta and surrounding areas with illustrations and descriptions. In the twentieth century, Patel (1989), Narayan (1915), Gravely (1921), Reimoser (1934) and Dayal (1935) documented several studies on Indian spiders.

Pocock (1895-1901) recorded two hundred species from India, Burma, and Ceylon in his work 'Fauna of British India, Araneae' (1900a). His book provided the first list of spiders, along with enumeration and new descriptions in British India based on spider specimens at the British Museum, London. He also reported on Oriental Mygalomorphs (1895a, 1899a, and 1900b), new species of Indian arachnids (1899b and 1901) and spiders of Lakshwadeep (1904) provides with the one of earliest information from these regions. Sheriff (1919-1929) described numerous interesting species from southern India. Gravely worked on mimicry in spiders (1912), mygalomorph spiders (1915 and 1935a-b) and added information to Indian spiders.

Tikader (1987) also published the first comprehensive list of Indian spiders, which included 1067 species belonging to 249 genera in 43 families. Contributions made by Sinha (1951-52) on Lycosidae and Araneidae are also important. Tikader and Malhotra (1980), Tikader and Biswas (1981) and Biswas and Biswas (1992) have described spiders from Bengal. Spider fauna of Gujarat has been studied mainly by Patel (1973, 75), Patel and Vyas (2001), Patel and Reddy (1988-1993). Reddy and Patel (1991-93) have described spiders from Andhra Pradesh. Tikader (1980, 82) described many species from the families Thomisidae, Philodromidae, Lycosidae, Araneidae and Gnaphosidae from all over India. Gajbe (1983-99) has prepared a checklist of 186 species of spiders in 69 genera under 24 families and described many new species of spiders from Madhya Pradesh and Chattisgarh region. A brief account on spiders is also provided by Vijayalakshmi and Ahimaz (1993) in the book titled 'Spiders: An Introduction'.

Spiders of protected areas in India have received very little attention. The main work has been conducted by Gajbe (1995a) in Indravati Tiger Reserve and recorded 13 species. Rane and Singh (1977) recorded five species and Gajbe (1995b) 14 species from Kanha Tiger Reserve, Madhya Pradesh. Patel and Vyas (2001) conducted biodiversity studies in Hingolgarh Nature Education Sanctuary, Gujarat and described 56 species of spiders belonging to 34 genera distributed in 18 families. Patel (2003) described 91 species belonging to 53 genera from Parambikulum Wildlife Sanctuary, Kerala. Uniyal

(2006) recorded a total of 19 species of spiders belonging to 10 families from Ladakh. Centre for Indian Knowledge System, Chennai has also conducted ecological studies of spiders in a cotton agro ecosystem of Guindy National Park. De (2001) listed 19 species of spider from Dudhwa Tiger Reserve in his management plan. Uniyal (2004) studied spiders as conservation monitoring tools for protected areas. Studies on spiders are also conducted in agro ecosystems mainly in rice fields and coffee plantations (Sebastian et al., 2005; Kapoor, 2008). Hore and Uniyal (2008a, b) worked on the spider assemblages and their diversity and composition in different vegetation types in Terai Consevation Area (TCA). Hore and Uniyal (2008a) worked on spiders as indicator species for monitoring of habitat condition in TCA. Hore and Uniyal (2008b) also studied the effect of fire on spider assemblages in TCA. Biswas and Biswas (2004) contributed significantly to spider diversity by rendering comprehensive lists of newly recorded spider species from Manipur and West Bengal. Siliwal, et al., (2005) prepared an updated checklist of Indian spider and provided taxonomic re-evaluation of described species, referred 1442 species belonging to 361 genera of 59 families from the Indian Region. Dhali et al., 2011 reported 34 species of spiders belonging to 27 genera and 12 families from Corbett National Park. Biswas and Biswas (2010) reported 127 species of spiders belonging to 49 genera under 17 families from Uttarakhand state. Siliwal et al. (2005) prepared an updated Checklist of Indian spider and provided taxonomic re-evaluation of described species, referred 1442 species belonging to 361 genera of 59 families from the Indian Region. Of the 1442 species, 1002 were endemic to the Indian mainland.

Recently, 1520 species belonging to 361 genus and 61 familles were reported by Sebastian and Peter (2009) in the book ‘Spiders of India’. However, the information available from the Northern part of India especially, the Himalayan and sub Himalayan foothills region, is far from complete. Thus, keeping in mind, the taxonomic urgency, the current study provides a preliminary checklist of the spiders of NDBR. The current inventory will add to the existing knowledge of Indian spiders and serve to provide a base for future research on the poorly studied Himalayan spider fauna.

4.5 Spider Systematics

Systematics and Taxonomy clarify organization among organisms by analysis of relationships, classification, and naming. Prior to 1800, spiders were classified on broad categories based on paraphyletic arrangements. However, recently monophyletic arrangement for spiders has been widely adopted. They are based on the presence of abdominal appendages modified as spinnerets, silk glands and associated spigots, cheliceral venom glands, loss of abdominal segmentation, and modification of the pedipalp tarsi of males (Coddington and Levi, 1991; Coddington 2005). In the order Araneae three major monophyletic groups: Mesothelae, Mygalomorphae and Araneomorphae have been recognized by Coddington (2005). The suborder Mesothelae is characterized by the presence of segmented series of plates on the upper surface of the abdomen and four pairs of anteriorly situated spinnerets. It is represented by a single family (Liphistidae) and are found only in China, Japan, and Southeast Asia (Platnick, 2005), with five known genera and 89 species (Platnick, 2010). The infraorders Mygalomorphs are characterized by the presence of two pairs of book lungs instead of one or no book lungs and chelicerae that move parallel to one another in the vertical plane. They include the Theraphosidae (tarantulas), Ctenizidae, Nemesiidae, Actinopodidae, and Migidae (trapdoor spiders), Atypidae (purse-web spiders), Hexathelidae (funnel web spiders) amongst others. Araneomorphae spiders have the chelicerae move in opposition to each other in a horizontal plane and usually possess one pair or no book lungs. They are also referred as 'true' or 'advanced' spiders (Gertsch, 1979; Platnick 2006) and contain over 90% of described spider species (Coddington and Levi, 1991; Ubick et al., 2005). The fusion and reduction of the anterior median spinnerets to form the Cribellum (a flat sclerotized plate that bears hundreds to thousands of spigots that produce thin, adhesive silk threads) is an important synapomorphy shown by araneomorphs (Coddington, 2005). They are then categorised into two groups: cribellate and ecribellate, based on the presence or absence of a cribellum (Lehtinen, 1967; Coddington and Levi, 1991). Araneomorphe are further divided into two groups based on the complexity of their genetalia: the haplogyne and entelegynes. Shultz (1900) recognized the order Araneae to be most closely related to the group Pedipalpi (Amblypygi, Schizomida, and Uropygi) of Arachnida based on many morphological characters.

4.6 Inventory of Spiders from NDBR

A total of 244 species belonging to 108 genus and 33 families were collected during entire sampling period (Table 4.1). General description, distribution, habitat, keys to families and genera of spider families sampled in NDBR are described below. These follow the description and details provided by Murphy and Murphy, 2000; Jäger 1998, 2000; Kaston, 1978; Preston-Mafham and Preston-Mafham, 1984; Dippenaar-Schoeman and Jocqué, 1997; Cushing, 2001; Deeleman-Reinhold, 2001; Sebastian and Peter, 2009; Platnick, 2011; Siliwal et al., 2005; Hore and Uniyal, 2009; Jose, 2005; Song, 1999; Ubick et al., 2005; and the observations in field.

4.6.1 Key to Spider Families Documented from NDBR

1a. With cribellum and calamistrum……………………………….……………..**2**
1b. Without cribellum and calamistrum……………….………………………. **7**

2a. Anal tubercle large, anterior margin of Prosoma with nose-like extension……………………….……………………………………...**Oecobiidae**
2b. Anal tubercle narrow, anterior margin of Prosoma without such extension………………………………………………….……………...**3**

3a. Tarsi furnished with ungual tufts and inferior claw……………..….**Psechridae**
3b. Tarsi without ungual tufts and inferior claw……………………..……….**4**

4a. Labium long and fused to sternum. Chelicerae fused together at base. Spinnerets at ventral side of opisthosoma……………………...**Filistatidae**
4b. Labium wide and free. Chelicerae not fused at base. Spinnerets at the end of opisthosoma…………………………......…………………………...**5**

5a. Tarsi with dorsal row of trichobothria. ……………………..….**Amaurobiidae**
5b. Tarsi without trichobothria……..……………………….….……..…………**6**

6a. Metatarsus IV compressed and concave dorsally………………**Uloboridae**

6b. Metatarsus IV not modified……………………………….……….**Dictynidae**

7a. Tibia and metatarsus I and II with a prolateral row of long spines………………………….……………………….……….….…**Mimetidae**

7b. Tibia and metatarsus I and II without prolateral row of spines……………..**8**

8a. Sternum much wider than long, coxae IV widely separated……………………………………………….…….…..**Trochanteriidae**

8b. Sternum not much wider than long, coxae IV not widely separated………**9**

9a. Posterior spinnerets absent or much shorter than anterior ones………..**10**

9b. Posterior spinnerets present, not shorter than anterior ones…….……….**12**

10a. Legs short and equal in length, without scopulae. ……….…...**Zodariidae**

10b. Legs I and II enlarged and with scopulae on tarsi and metatarsi……….**11**

11a. Leg I strongly enlarged and modified; patella distinctly elongated, metatarsus shorter than tarsus ……………………………..**Palpimanidae**

11b. Leg I not modified; Patella and metatarsus different………………….….**12**

12a. Posterior spinnerets strongly elongated……………………….…………...**13**

12b. Posterior spinnerets not strongly elongated…………………….……….**15**

13a. Spinnerets usually in a single transversal row………………....**Hahniidae**

13b. Spinnerets arrangement different………………..……….…………….**14**

14a. Tibia I with 2-3 pairs of ventral spines ……………...…………**Agelenidae**

14b. Tibia I without ventral spines……………………….…..…………**Hersiliidae**

15a. With less than eight eyes…………………………..…..……………….…**16**

15b. With eight eyes………………………………………………...…………..**17**

16a. Eyes in two well separated triads…………………………..….**Pholcidae**

16b. Six small eyes arranged in three well separated contiguous diads……………………………………………………….….………**Scytodidae**

17a. Eyes usually in three rows (4, 2, 2); anterior median eyes very large, second row of eyes very small, often minute; third row of two eyes of medium size………………………………………..…………..**Salticidae**

17b. Eyes arranged differently……………………………………………...**18**

18a. Legs laterigrade, directed towards side or forwards……………………..**19**

18b. Legs prograde, directed forwards and backwards……………………….**21**

19a. Tarsi and metatarsi without scopulae, legs I and II usually much longer than legs III and IV …………………………………………......**Thomisidae**

19b.Tarsi and sometimes metatarsi with scopulae, legs different……………………………………………………………………….**20**

20a. Distal metatarsus dorsally with unilobate rigid structure…**Philodromidae**

20b. Distal metatarsus dorsally with trilobate soft membrane……**Sparassidae**

21a. Tracheal spiracle situated at the middle of the opisthosoma ……………………………………………………………..….**Anyphaenidae**

21b. Tracheal spinnerets situated directly in front of spinnerets……..………**22**

22a. Posterior median eyes flat and round, without dome shaped lens, maxillae obliquely depressed, anterior spinnerets conical, not widely separated, without setae on spigots, anterior lateral spinnerets one segment with enlarged pyriform gland spigots, sometimes spinnerets long and cylindrical, far apart……………………………..….**Gnaphosidae**

22b. Posterior median eyes with dome-shaped lens, maxillae usually not obliquely depressed, tarsi without auxiliary claws, sternum mostly longer than wide, eyes in two rows……………………………………..………**23**

23a. Opisthosoma with scutum; posterior spinnerets with two large cylindrical gland spigots…………….…………………………………………..**Corinnidae**

23b. Opisthosoma without scutum; posterior spinnerets of female without such spigot ………………….……………………………..……….**Clubionidae**

24a. Eyes either in three or four rows or in three groups……………………..**25**

24b. Eyes in two rows, posterior spinnerets not particularly long or with one segment only, trochanters often notched…………………………..……...**28**

25a.Eyes in three groups 4:2:2; Carapace broad, raised towards the back………………………….…..…………….……………….…….**Pisauridae**

25b. Eyes in three rows or four rows 2:2:2:2, 4:2:2 or 2:4:2; posterior eyes not much larger than anterior ones, trochanters notched………..………..….**26**

26a. Clypeus high, posterior eyes and anterior lateral eyes forming a hexagonal group in front of small anterior median eyes, numerous long spines on tibiae and metatarsi…………………..……..…..…..**Oxyopidae**

26b. Clypeus not as high as in Oxyopidae, eye position and setae on legs different……………………………………..……………………………..….**27**

27a. Eyes sessile, not on tubercles, opisthosoma oval, smoothly rounded posteriorly, male palpal tibiae without retrolateral apophysis, cocoon attached to spinnerets, anal tubercle with one segment………**Lycosidae**

27b. At least one pair of eyes on shallow tubercles, opisthosoma almost always elongated, tapered to back, male palpal tibia with retro lateral apophysis, anal tubercle biarticulate, labium hardly longer than wide anterior lateral eyes normal…………………...………………..**Pisauridae**

28a. Paracymbium being a separate sclerite, tarsi usually cylindrical or sometimes fusiform; chelicerae often with stridulating files; spiders without dentate process on male palpal cymbium…………………….... **29**

28b. Paracymbium fused to cymbium or rudimentary, chelicerae without stridulating files, tarsi variable………..…………………………..…..……..**30**

29a. Small spiders without dentate process on male palpal cymbium………………………………………………………….……..**Linyphiidae**

29b. Larger spiders with dentate process on male palpal cymbium………………………………………………………………..…**Pimoidae**

30a. Tarsi IV with ventral comb of serrated hairs………………...…**Theridiidae**

30b. Tarsi without ventral comb of serrated hairs.........................……….….**31**

31a. Chelicerae divergent from base, usually long and strong……………………………………………………...**Tetragnathidae**

31b. Chelicerae not divergent from base……………………...……………....**32**

32a. Tarsus and metatarsus together longer than patella and tibia; small to large orb web building spiders………………………..………..**Araneidae**

32b. Tarsus and metatarsus together not longer than patella and tibia; large to very large spiders building huge webs……………..**Nephilidae (Nephila)**

4.6.2 Systematic Account of Spiders from NDBR

Family Agelenidae C.L. Koch 1837 (Funnel- web Weavers)

Diagnostic Characters:

Small to medium sized, ecribellate, entelegyne spiders. Carapace oval attenuated in front, long and narrow in the eye region. Fovea longitudinal, plumose hairs present, sternum slightly long or longer than wide. Eight eyes in two rows equal in size. Cheliceral furrow is provided with 3 pro-marginal teeth and 2 to 8 retro marginal teeth. Labium as long as wide; gnathocoxae slightly convergent. Legs long, fairly slender and armed with numerous spines; tarsi with trichobothria increasing in length towards tip; trochanters I and II lacking notches; macrosetae conspicuous; plumose hairs present; tarsi without scopulae and three clawed. Opisthosoma narrowly oval and tapering posteriorly. Posterior spinnerets two-segmented, long and slender with apical segment narrowing towards tip; colulus paired; anterior spinnerets widely separated. Epigynum is variable in structure; male palp with tibial apophysis; embolus usually long and patella and femur sometimes with apophysis. They build typical non adhesive funnel webs, consisting of a flat, slightly concave silk sheet with a funnel shape retreat at one end. Webs are usually built on grass or shrub or under logs.

Agelenidae have a worldwide distribution, mainly in Holarctic, Neotropical and Australian biogeographic realms (Ubick et al., 2005). They are represented by 42 genera, 512 species occurring worldwide (Platnick, 2011). In India it is represented by 2 genera and 10 species so far (Sebastian and Peter, 2009).

Genus Agelena Walckenaer 1805

The species of the genus Agelena often have several clearly marked chevrons on the dorsal opisthosoma. The posterior spinnerets are distinctly long. The members of this genus builds large, sheet-like web with a funnel retreat made close to the substrate. They usually make their webs in low vegetation such as grass or shrubs and are widely distributed in Europe, Africa and Asia.

Species recorded from NDBR:

Agelena sp.1

Family Amaurobiidae, Bertkau 1873 (Hackled mesh web weavers)

Diagnostic Characters:

Small to medium sized, cribellate, entelegyne, drab brown or grey ground dwelling spiders. Carapace longer than wide; usually pyriform; fovea longitudinal; cephalic region slightly elevated. Eyes eight, usually in two transverse rows; AME may be reduced, or absent. Chelicerae with boss and margins toothed; usually longer and slender in males. Labium is subquadrate in shape; gnathocoxae rectangular, almost parallel and linear serrula is present. Legs moderately long especially in males; ventral spines usually weak or absent; tarsi three clawed and claw tufts usually absent or indistinct. Opisthosoma is oval and with dense layer of setae; usually with chevron markings on opisthosoma. Six spinnerets; anterior and posterior spinnerets two segmented; PLS moderately elongated; calamistrum present; colulus absent. Epigyne usually with posterior median lobe separated from lateral lobe by sutures; male palpal tibia with simple, sclerotised retrolateral and dorsal tibial apophyses.

Commonly found in dark and damp places, under leaf litter, decomposing logs and under rocks. They are represented by 50 genera, 276 species occurring worldwide (Platnick 2011). In India this family is up till now represented by 2 genera and 4 species (Sebastian and Peter, 2009).

Key to genera

1a. Conductor with dorsal apophysis....………………………..…..**Draconarius**
1b. Conductor lacking dorsal apophysis……………………..………………..**2**

2a. Cheliceral promargin and retromargin each with 5–8 teeth………………………………………………………..**Himalmartensus**
2b. Chelicerae with less teeth usually stout, bearing short tooth-like branches; epigynum lacking stabilizing pit………………………………..**Amaurobius**

Genus Amaurobius C.L. Koch 1837

Spiders of the genus Amaurobius are mostly Holarctic in distribution; building irregular sticky webs, at low vegetation and plant foliage usually extended to crevices of the soil. They are dark in colour and covered with hairs. Legs are heavily spined and calamistrum is present on metatarsus IV. Tibial tarsus is with dorsal prong usually stout, bearing short tooth like branches. Female rests in webs with the spherical cocoon.

Species recorded from NDBR:

Amaurobius sp.1

Amaurobius sp.2

Genus Draconarius Ovtchinnikov 1999

Spiders of the genus Draconarius is mainly Holarctic in distribution. It is a large genus of Coelotinae. It is distinguished by the presence of two retrolateral cheliceral teeth. Male with posteriorly originating copulatory ducts along with the presence of a dorsal apophysis on the conductor, and the cymbial furrow more than half the cymbial length. Females exhibit large copulatory ducts and long spermathecae (Wang, 2003).

Species recorded from NDBR:

Draconarius sp. 1

Genus Himalmartensus Wang & Zhu 2008

Spiders of the genus Himalmartensus, are described from Nepal, and include three species: the type species *H. martensi* new species, *H. ausobskyi* new species, and *H. nepalensis* new species. They are distinguished by the other genera of Amaurobiidae by the presence of colulus, a single chillum, smooth trichobothria bases, and simple tracheal tubes. Both promargin and retromargin of chelicerae have 5–8 teeth. The female epigynum is modified with long and looping copulatory ducts.

Species recorded from NDBR:

Himalmartensus sp. 1

Family Anyphaenidae Bertkau 1878 (Tube spiders)

Diagnostic Characters:

Small sized to medium, ecribellate, entelegyne spiders. Carapace is ovoid or pyriform, longer than wide; fovea longitudinal; sparsely covered with setae. Eight eyes close together in two recurved rows; small, round and equal in size. Chelicerae long and slender; furrow with two rows of teeth; fangs strong. Labium oval; gnathocoxae well developed; both labium and gnathocoxae longer than wide; serrula with one row of teeth. Leg long and prograde; Leg I longest, leg formula 1423 or 4123; anterior tarsi and metatarsi scopulate; tarsi with two claws and lamelliform claw tufts; trochanters of legs are notched. Opisthosoma is usually oval or elongated; dorsum with distinct patterns of chevrons; venter without pigmentation. Six spinnerets close together; cylindrical gland spigots absent; ALS two segmented, conical and nearly contiguous at base; median spinnerets well developed posterior pair tubular as long as anterior pair. Colulus are a group of conspicuous setae. Epigyne is variable and complex with a large angular plate or a membranous area; male palp often with large tegular extensions. Embolus is slender and spiniform.

Anyphaenids are nocturnal, wandering spiders, usually found in forest litter, foliage of trees, dead leaves, logs and under stones. They hide in tubular silken sac-like retreats. They are represented by 56 genera, 514 species occurring worldwide (Platnick, 2011) especially in the Neotropical regions. In India it is represented by 1 genera and 1 species so far (Sebastian and Peter, 2009).

Genus Anyphaena Sundevall 1833

Spiders of the genus Anyphaena are wandering spiders, found in leaf litter and plant foliages; the tropical species belonging to this genus are usually small occurring at ground level, in litter and under logs and stones, on foliage. They are distinguished by the more posterior position of the tracheal spiracle, the lack of concavities on the lateral margins of the palp-coxal lobes. Also possessing one or more macrosetae on prolateral and retrolateral surfaces of tarsus I. Carapace usually with two dark paramedian bands; leg segments nearly concolours. Eyes are in two rows, small, circular and uniform in size; PE row slightly larger than the AE row.

Species recorded from NDBR:

Anyphaena sp.1

Family Araneidae Simon 1895 (Orb- Weavers)

Diagnostic Characters:

Small to large sized, ecribellate, entelegyne spiders. Carapace often flat sometimes swollen; cephalic region separated from the thoracic region by oblique depression; fovea distinct to absent; clypeus low. Eight eyes in two rows; lateral eyes widely separated from median eyes. Chelicerae is powerful, with proximal boss, freely movable with lateral condyle; cheliceral furrow with two rows of teeth; fang relatively short and stout. Labium is long and wide; distal margin swollen. Leg strongly spined, short and relatively stout; three claws, trichobothria present in all leg segments except tarsi; tarsi furnished apically with thickened serrate bristles. Opisthosoma is large but variable in form, usually globose, overhanging carapace; often with spines; dorsum frequently with distinct pattern and humps, covered with serrated setae. Six spinnerets sub-equal, simple, short, forming a compact cluster are present. Colulus present. Spinnerets have aggregate glands spigots which produces viscid silk. Epigyne partially or completely sclerotised, epigynal plate with transverse furrow; male palpal complex; paracymbium usually has a sclerotised hook, it is attached to the proximal end of cymbium; median apophysis present, bulbus rotated within cymbium. Sexual dimorphism is prominent in this group.

They are known as true orb weaving spiders, also very a diverse group occupying a wide range of habitats. It is one of the largest families of spiders and is distributed worldwide. They are represented by 168 genera, 3006 species occurring worldwide (Platnick, 2011). In India it is represented by 29 genera and 154 species so far (Sebastian and Peter, 2009).

Key to genera

1a. Posterior row of eyes strongly procurved; anterior lateral eyes smaller than posterior lateral eyes ……………………………………..……..……**2**

1b. Posterior row of eyes nearly straight or recurved, lateral eyes subequal in size...**3**

2a. Dorsum with transverse bands; shoulder humps absent; Distance between PME less than distance from PLE………………..…..**Argiope**

2b. Dorsum without transverse bands; usually one shoulder hump present; Lateral eyes separated …..…………………..……………..……**Cyrtophora**

3a. Opisthosoma wider than long; integument of opisthosoma leathery; dorsum strongly convex ……...……………………………….……**Cyrtarachne**

3b. Opisthosoma longer than wide………….………………………..…………**4**

4a. Carapace strongly convex, anterior roundish; cephalic region strongly elevated than thoracic region; opisthosoma provided with a few tubercles………………………………………………………...…**Chorizopes**

4b. Carapace may or may not be convex, anteriorly narrowing; cephalic region not elevated than thoracic region ……………………………….…**5**

5a. Posterior median eyes very close, nearly touching; carapace with a U shaped junction between cephalic and thoracic region………...**Cyclosa**

5b. Posterior median eyes not very close; Prosoma not having a U shaped junction between cephalic and thoracic region……………………..……**6**

6a. Prosoma with cephalic region bulging behind the ocular area, also provided with granules; anterior row of eyes procurved; epigyne with short beak like scape ……………………………………………..….**Parawixia**

6b. Prosoma with cephalic region not building and without granules; anterior row of eyes recurved; epigyne may or may not be procurved with scape, when present not beak like……………..…………..………………………..….**7**

7a. Opisthosoma flattish, with a tail like extension to the rear………..**Eriovixia**
7b. Opisthosoma without a tail like extension at the rear……………………....**8**

8a. Cephalic region provided with a median bulge; abdominal spines very short………..…………………………………………………..... **Thelecantha**
8b. Cephalic region without a median bulge; abdominal spines absent…………………………………………………………………..…...**9**

9a. Opisthosoma round light yellowish, pink or green with two or three pairs of discrete round black spots on rear………..……..……………….**Araniella**
9b. Opisthosoma usually not round; black spots on opisthosoma absent…..…………………………………………………………………….**10**

10a. Scape of epigynum with tip reaching more than halfway to spinnerets; palpus with two patellar setae and paramedian apophysis; opisthosoma sub-spherical……..…………………………..……….................**Eriophora**
10b. Scape of Epigyne and opisthosoma otherwise………………….……….**11**

11a. Thoracic groove transverse; epigyne with distinct scape, often wrinkled and or with lateral lobes……………………………………..……...**Araneus**
11b. Thoracic groove longitudinal; epigyne with unwrinkled scape and with one or more pairs of lateral lobes……………....……………….**Neoscona**

Genus Argiope Audouin 1826

Spiders of the genus Argiope are diurnal hunters, easily distinguished by the large females building huge orb web, often in open fields and grasslands, meadows, and forest. Sexual dimorphism is prominent in this genus with the male's size strikingly smaller as compared to the female. Posterior row of eyes strongly procurved; the posterior median eyes are closer to each other than to the posterior lateral eyes. Anterior lateral eyes are smaller than posterior lateral eyes. Lateral eyes borne on a conspicuous tubercle and close together. Median ocular quadrangle is longer than wide, wider behind than in front, forming a trapezium. Carapace is flat and clothed with thick layer of short white hairs. Chelicerae is small, weak, and with a small boss. Legs long and strong, combined length of patella and tibia shorter than metatarsus and tarsus. Opisthosoma usually flat with variable shape; dark bands present on the dorsum. Epigynum bears a thin or thick median septum. Webs provided with a zigzag stabilimentum or two crossing stabilimenta and closely spaced radial threads.

Species recorded from NDBR:

Argiope anasuja Thorell 1887; *Argiope* sp.1; *Argiope* sp.2

Genus Cyclosa Menge 1866

Spiders of the genus Cyclosa possess prominent angular abdominal tubercle, which is often accompanied by additional humps anterolaterally or beside the posterior tubercle; paramedian apophysis stout is hooked, and ventrally directed. Body is drably colored with patterns of, yellow, grey, black on white or silvery backgrounds. Carapace strongly narrowed in front and opisthosoma bulging extending posteriorly beyond the level of the spinnerets in an angular tubercle; an anterior narrow cephalic area markedly separated from the thoracic area by an oblique groove forming a U-shape. Median ocular quadrangle is trapezium-like, distinctly narrower behind than in front. Anterior median eyes are usually larger than posterior median eyes. Posterior median eyes very close and almost touching each other. LE situated in a prominent tubercle and very close to each other. AE and PE recurved. Patella of male's pedipalp with one large strong and curved spine. Opisthosoma elongate to subglobular with humps usually paired except in the median. Epigynum small, scape weak and variable in shape *viz.*, straight, bent, wrinkle, pointed, or circular. The web, which is occupied during the day and left vacant at night, has relatively few frame threads. A stabilimentum composed of the bodies of dead prey and other debris, also sometimes with the female's egg sacs, passes vertically through the hub and the spider often sits camouflaging in it.

Species recorded from NDBR:

Cyclosa insulana Costa 1834; *Cyclosa confraga* Thorell 1892;
Cyclosa hexatuberculata Tikader 1982; *Cyclosa* sp.1;
Cyclosa sp.2; *Cyclosa* sp.3

Genus Neoscona Simon 1864

Spiders of the genus Neoscona are distinguished by the small compact cluster formed by the embolus, median apophysis, conductor, and terminal apophysis, and the broad spoon shaped epigynal scape. Carapace is with longitudinal thoracic groove. Median ocular quadrangle is slightly longer than wide, forming a trapezium. Anterior median eyes the largest or subequal in diameter to the posterior median eyes. Lateral eyes close to each other and not borne on prominent tubercles. Posterior lateral eyes smallest. Both rows recurved. Coxa I of male is provided with a ventral hook in the distal end. Tibia II has strong prolateral spines. Opisthosoma is variable in shape *viz*., ovoid, sub ovoid, triangular, or sub triangular with different abdominal patterns. Epigynum simple and spoon like; scape completely fused to the base and bears one or two pairs of lateral lobes; Epigynal openings underneath the scape. Patella of male's pedipalp with two strong, curved, and long spines. Cymbium of male's pedipalp broad. Web is usually vertical, with an open hub except for a few cross threads. There may be 18-20 radii and 30 or more sticky spirals. They are nocturnal, and remain in a retreat, usually within a curled leaf, near the web during daylight hours.

Species recorded from NDBR:

Neoscona achine Simon 1906*; Neoscona mukerjei* Tikader 1980*;*

Neoscona nautica L. Koch 1875*; Neoscona* theisi Walckenaer 1841

Neoscona vigilans Blackwall 1865; *Neoscona shillongensis* Tikader & Bal 1981; *Neoscona* sp.1*; Neoscona* sp.2

Genus Araniella Chamberlin & Ivie 1942

Spiders of the genus Araniella are small diurnal, colourful orb weavers of trees, shrubs, or tall grass. Carapace is wide and high at anterior end. Eyes small; posterior row of eyes straight or somewhat recurved. Legs yellow to brown, sometimes with distal segments darker toward tips; the opisthosoma broadly elliptical or ovoid, having 3 or more pairs of small black spots posterolaterally; 3 sometimes 2 dorsal macrosetae present on the male palpal patella, median apophysis slender hooklike; tegulum large, forming much of prolateral and ventral surfaces of genital bulb; spermathecae second part small dark. embolus long, slender, tapered to fine tip; conductor broad, often with 1 or more points; terminal apophysis long, broad, arched over distal end of bulb, overlying conductor and embolus; paracymbium lobe like. Epigynum with short broad scape; scape appearing distinctly wrinkled, often broadly attached at base; spermathecae in two parts, a large, round or ovoid ventral part and a smaller darker dumbbell-shaped dorsal part. The web is often built across the depression formed by a single leaf on a deciduous tree or shrub, and may be horizontal. The spider remains at the hub of its web throughout the day and does not build any retreat.

Species recorded from NDBR:

Araniella sp.1*; Araniella* sp.2

Genus Araneus Clerck 1757

Spiders of the genus Araneus are widely distributed throughout the world. Carapace and opisthosoma usually covered with hairs; carapace moderately convex with no horny out growths; fovea transverse in the female and longitudinal in the male, often with lateral prolongations. Median ocular quadrangle is not much longer than wide and forming a trapezium. Median eyes unequal in size. Lateral eyes close and situated on tubercles, anterior and posterior median eyes slightly unequal in size, and both rows of eyes recurved. Males with hook on coxa I and a groove on femur II, tibia II armed with spines on prolateral side and often bent. Metatarsus and tarsus of the first leg together not longer than the patella and tibia. Shape of the opisthosoma variable, in some species, provided with prominent humps, generally longer than wide. Epigynum with a prominent scape of variable form *viz.*, long, wrinkled and winding, short and straight. Male palp with a large terminal apophysis, patella of the palp provided with two strong, long, curved spines and cymbium narrow, strip-like. These spiders are orb web builders usually rest in the silken retreat constructed with leaves in the side of the web during the day; at rest, the tips of their front legs are in contact with a signal thread, which runs directly to the centre of the web.

Species recorded from NDBR:

Araneus bilunifer Pocock 1900*; Araneus ellipticus* Tikader & Bal 1981

Araneus mitificus Simon 1886; *Araneus nympha* Simon 1889

Araneus sp.1*; Araneus* sp.2

Genus Chorizopes O. Pickard-Cambridge 1870

Spiders of the genus Chorizopes are found in leaf litter usually they do not build their web. Carapace is often broadest anteriorly with highly convex and roundish cephalic region, thoracic region descending sharply behind and low. Ocular quadrangle forms a trapezium slightly wider than in front, labium transversely triangular, maxilla short, broad, converging towards inside, sternum angular, posteriorly tapering but tip is blunt, coxae IV subcontiugous, leg short, and slender. Opisthosoma is overlapping anteriorly on the carapace and provided with a few paired or unpaired conical or blunt tubercles. Epigyne is with or without a short blunt scape. Most are found in India and China, with several others found in locations ranging from Madagascar to Japan.

Species recorded from NDBR:

Chorizopes sp.1

Genus Cyrtophora Simon 1864

Spiders of the genus Cyrtophora, often builds more or less horizontal tent like orb webs in shrubs. Carapace nearly flat dorsally with long cephalic region; Median ocular quadrangle slightly longer than wide, lateral eyes sub equal and slightly separated from each other. Legs are moderately long and stout. Opisthosoma very high anteriorly and provided with distinct paired tubercles. Opisthosoma of females usually have pointed or rounded shoulders. Sometimes there are pairs of additional tubercles along the dorsal side of the opisthosoma. They do not build true orb webs, instead construct specialized tent-like, highly complex non-sticky web. These webs are aligned horizontally, with a network of supporting threads above them, remain hanging downwards from the apex.

Species recorded from NDBR:

Crytophora moluccensis Doleschall 1857*;*

Crytophora sp.1; *Cyrtophora* sp.2

Genus Eriophora Simon 1864

Spiders of this genus Eriophora are true orb-weaver. Carapace is convex with horny outgrowths. Thoracic groove is transverse in both male and female. Ocular quadrangle is longer than wide, anterior median eyes smaller than posterior medians, lateral close and situated on prominent tubercles; both row of eyes recurved, anterior row strongly recurved. Chelicerae are strong with boss. Epigyne is with a long scape. These spiders are orb web builders and usually rest under the leaves attached to the web during daytime.

Species recorded from NDBR:

Eriophora himalayensis Tikader 1975*; Eriophora* sp.1

Eriophora sp.2; *Eriophora* sp.3

Genus Parawixia O. Pickard-Cambridge 1904

Spiders of the genus Parawixia are widely distributed genus characterized primarily by the carapace with granulate and swollen cephalic region posterior to the ocular area. Carapace longer than wide; clothed with pubescence, hairs and spines. Anterior eye row procurved when viewed frontally. Opisthosoma is triangular, with paired and unpaired humps; often with a single prominent posterior hump. Epigynum is simple with a prominent beak-like scape borne on a swollen base. They construct vertical orb webs with an open hub.

Species recorded from NDBR:

Parawixia dehaani Doleschall 1859*; Parawixia* sp.1*; Parawixia* sp.2

Parawixia sp.3; *Parawixia* sp.4

Genus Eriovixia Archer 1951

Spiders of the genus Eriovixia, have flat opisthosoma with a pronounced tail like extension to the rear; usually light coloured, often seen resting in characteristic pose on the upper side of a green leaf. Ocular quadrangle is slightly longer than wide and situated on an elevation. They construct vertical orb webs usually among plants and shrubs.

Species collected from NDBR:

Eriovixia sp.1

Genus Cyrtarachne Thorell, 1868

Spiders of the genus Cyrtarachnae, build specialized webs in grass or on shrubs. Carapace is convex and unarmed without hairs. Ocular quadrangle usually wider than long; lateral eyes contiguous and subequal in size, not situated on prominent tubercles. Opisthosoma is large, strongly convex dorsally and wider than long, integument leathery and provided with large sigilla on the dorsal surface of the opisthosoma. Webs are built with sticky silk and with a few radii.

Species collected from NDBR:

Cyrtarachne sp.1; *Cyrtarachne* sp.2

Genus Thelecantha Hasselti 1882

Spider of the genus Thelecantha are closely related to the genus *Gasteracantha.* Cephalic region provided with median bulge like conical elevation; opisthosoma with very short spines. Mainly tropical in distribution ranging from Madagascar, India, Philipines to Australia.

Species recorded from NDBR:

Thelecantha brevispina Doleschall 1857

Family Clubionidae Wagner 1888 (Sac Spiders)

Diagnostic Characters:

Medium sized, ecribellate, entelegyne spiders. Carapace is ovoid, distinctly longer than wide; cephalic region slightly narrower than thoracic region; fovea shallow to absent. Eight eyes arranged in two rows, small sub-equal in size; posterior row slightly longer than anterior row. Chelicerae are rather long, slender or stout; margins toothed, promargin with 2-7 teeth, retromargin with 2-4 small teeth. Labium and gnathocoxae is longer than wide. Legs moderately long, prograde; anterior tibiae with fewer than 4 pairs of ventral spines and metatarsi with one, two or more pairs of macrosetae ventrally; trochanters with or without notches; legs formula 4132 or 1423; two claws with dense claw tufts and scopulae. Opisthosoma is oval; males sometimes with small dorsal scutum. Anterior spinnerets is longest, conical or cylindrical and contiguous; median spinnerets cylindrical in both sexes; PLS with short, rounded apical segment; PMS cylindrical in male. Epigynal plate convex and weakly sclerotised; median apophysis absent and embolus short in males.

Clubionids are free living, nocturnal wandering hunting spiders. Commonly found on vegetation, foliage, beneath loose barks, in leaf litter and under rocks. They are aggressive and use their front legs to detect and grab prey.

Sac like retreats are constructed in rolled up leaves, folded blades of grass or under loose bark. They are represented by 15 genera, 570 species occurring worldwide (Platnick, 2011). In India, this family is represented by 3 genera and 23 species so far (Sebastian and Peter, 2009).

Key to the genus

1a. Legs long; leg I considerably longer than leg II; posterior eye row not longer than anterior eye row; prosoma dorsally without furrow………………………………………….…………….... **Cheiracanthium**

1b. Legs short and stout; leg II longer than leg I; posterior eye row clearly longer than anterior eye row; prosoma dorsally with median furrow…………………………………………………...…………**Clubiona**

Genus Clubiona Latreille 1804

Spiders of the genus Clubiona are small, nocturnal moving about the stems and foliage of plants, leaf litter or under bark, often hide themselves in silken sacs during the day. Small to medium sized; usually white, cream, pale grey or yellow in colour. They are distinguished by the presence of the conspicuous dorsal groove, more than two teeth on the promargin of the cheliceral fang furrow. Carapace rather long, somewhat narrowed in front and slightly convex; covered with fine, sometimes silky hair, with a few large hairs on anterior part; thoracic groove present. Fovea usually short; faint radiating striae sometimes originate from it and occasionally form a pattern of darker veining. Eyes are in two parallel rows, nearly straight or very slightly procurved; posterior row markedly the longest. Anterior medians are closer together than posteriors medians. Chelicerae are robust and convex and usually nearly vertical; more cylindrical sometimes in males and narrower, occasionally projecting. Legs are unicolourous and bearing scopulae; absence of an unpaired ventral macrosetae near the tip of tarsus I; lack of modified macrosetae on femur and tibia II of the male. Cluster of long curved erect setae present at the anterior end of the opisthosoma. Shorter stouter embolus in the male palpus; lack cymbial spur, and large, anteriorly located spermathecae present in females.

Species recorded from NDBR:

Clubiona drassodes O. Pickard-Cambridge 1874; *Clubiona* sp.1
Clubiona sp.2

Genus Cheiracanthium C.L. Koch 1839

Spiders of the genus Cheiracanthium are swift nocturnal hunters moving on plant foliage or on buildings. Eyes are usually smaller, relative to distance between them. Posterior row of eyes are scarcely longer than anterior row of eyes. Eyes of lateral pairs very close. Legs relatively longer, and more slender; first leg longer than fourth. Only two teeth on the promargin of the Cheliceral fang furrow, the presence of an unpaired ventral macrosetae near the tip of tarsus I. Dorsal spines on femur I and II are absent; ventral spines on tibia III absent. Posterior spinnerets are prominently longer than anterior pair. Palpal tibial apophysis well developed long, slender and basal retrolateral spur on the cymbium in males; epigynum in females with central or posterior depression and funnel shaped openings leading into dark copulatory ducts which often wind around the spermathecae before entering them. They commonly make silken retreats in plant foliage. The females deposit and take care of her egg sac in a breeding nest constructed by rolling leaves or grasses.

Species recorded from NDBR:

Cheiracanthium gyirongense Hu & Li 1987; *Cheiracanthium* sp.1
Cheiracanthium sp.2

Family Corinnidae Karsch 1880 (Ant-mimicking sac spiders)

Diagnostic Characters:

Small to medium sized, ecribellate, ant like appearance in some species, entelegyne spiders. Carapace is pyriform to ovoid; elongated in ant mimics, sometimes heavily sclerotised. Eight eyes are in two rows widely spaced or closed; grouped or bulging anteriorly; posterior eye row procurved, recurved or straight. Chelicerae margins toothed, sturdy, convex; upper edge with strong curved setae. Labium is slightly convex, usually depressed transversely. Legs long and slender in ant mimics, strong with variable setae on front legs; ventral spines may be present or absent; tarsi with two claws, claw tufts may or may not be present; tarsal trichobothria present. Opisthosoma is ovoid in shape. Six spinnerets are clustered together; anterior spinnerets sturdy, conical and contiguous; PMS enlarged in females; posterior ones slightly further apart than anterior pair; median spinnerets with three and posterior spinnerets with two large cylindrical gland spigots; spigots absent in males; Colulus triangular in shape, sclerotised.

Corinnids are free living ground spiders, usually found in woody debris, litter or humus, under rocks some also occur on foliage. They are represented by 84 genera, 962 species occurring worldwide (Platnick, 2011). In India it is represented by 9 genera and 36 species so far (Sebastian and Peter, 2009).

Key to the genus

1a. With conical hump on clypeus in front of AME........................….**Oedignatha**
1b. Clypeus without such hump……………………………………..……..………..**2**

2a. Legs spine present ………………………………………….……….….**Castianeira**
2b. Legs spine absent…………………………………………………...**Trachelas**

Genus Castianeira Keyserling 1879

Spiders of the genus Castianeira are usually found in leaf litter in shady deciduous forests; sometimes found under logs and stones in open habitats; also found commonly in association with ants. The carapace and opisthosoma are heavily sclerotised and shiny; dorsum of the opisthosoma often shows transverse bands of white scalelike setae. Carapace is oval to convex; well marked median furrow present. Lower margin of chelicerae is with two teeth. Labium is usually wider than long. Legs long and thin; tibia I and II have two or three pairs of ventral spines. Opisthosoma ringed or sometimes marked with white or other shiny colours. The egg sacs are shiny disks adhering to crumbs of soil or stuck to the undersides of logs or stones

Species recorded from NDBR:

Castineira zetes Simon 1897

Genus Trachelas C. L. Koch 1872

Spiders of the genus Trachelas are commonly found at the base of plants, in grasses and in ground debris. They are wandering hunting spider making no web but silk retreats spun in rolled leaves, under loose bark or on objects on the ground; carapaces shiny red and sterna that contrast strikingly with their pale opisthosoma. Carapace is longer than wide, with enlarged chelicerata. Opisthosoma is oblong, with darker markings on the dorsal side. Lateral constrictions in the palp-coxal lobes absent, they lack the procurved posterior eye row and trochanteral notch; posterior row of eyes recurved rather than straight. Leg macrosetae and ventral prominence on the male palpal femur are absent. Sometimes its bite and the venom cause local swellings and lesions with severe pain.

Species recorded from NDBR:

Trachelas sp.1; *Trachelas* sp.2; *Trachelas* sp.3

Genus Oedignatha Thorell 1881

Spiders of the genus Oedignatha are ground dwellers that inhabit mainly in leaf litter, dry grass or under rocks and often in disturbed habitat. Carapace is usually punctuate oblong; ventral fovea short; cephalic shield present. Chelicerae are large, prominent, and geniculate with inner margin provided with 5-9 teeth. Leg I and II with ventral spines on tarsi and metatarsi. The opisthosoma part is oblong covered with sclerotised dorsal shield ornamented by white spots. Female constructs a flat, white, disc-shaped egg sac of brittle silk, usually placed under a fallen log or under a piece of bark on a tree. A brush of dark hair present on the posterior lateral spinnerets. They are commonly parasitized by wasps.

Species recorded from NDBR:

Oedignatha sp.1

Family Dictynidae O. Pickard-Cambridge 1871 (Mesh web spiders)

Diagnostic Characters:

Very small, cribellate, entelegyne spiders. Carapace pyriform; cephalic region is usually relatively high, with longitudinal rows of white setae; fovea longitudinal. Eight eyes in two rows and AME often reduced or absent. Chelicerae vertical; margins usually toothed; gnathocoxae slightly to moderately converging. Legs moderately long; tarsi either without or with one or two trichobothria; tarsi three clawed; legs usually without spines. Calamistrum is uniseriate, usually long. Opisthosoma sub oval to oval; slightly overlapping carapace; bearing dense layer of seate; usually pale with dark pattern or chevrons. Six cylindrical spinnerets; anterior and posterior spinnerets are two segmented, distal segment short. PLS is as long as ALS or longer sometimes. Cribellum is bipartite or entire or absent. Epigyne is variable; weakly sclerotised; male palp without median apophysis, embolus long and slender.

They build nest like web retreats and are widely distributed in the world. They are represented by 50 genera, 565 species occurring worldwide (Platnick, 2011). In India it is represented by 8 genera and 11 species so far (Sebastian and Peter, 2009).

Genus Dictyna Sundevall 1833

Spiders of the genus Dictyna are widely distributed in the world. The entire body is covered with long hairs, longest in the carapace. Carapace markedly elevated in front, rows of light hairs run anterior from the fovea to the front of the head and converge slightly anteriorly and posteriorly. Well marked cervical groove divides the cephalic from the thoracic region. Eyes are even and widely spaced. Clypeus is wide. Chelicerae are long in male. Calamistrum is borne on the middle half of two thirds of the entire length of metatarsus IV. Tarsi and metatarsi are without trichobothria. Opisthosoma is ovoid; almost have different patterns, broad, median stripes running the length of the dorsal side. Epigynum is with more or less distinct posterolateral atrial grooves and lacking a spatulate scape. Tibia of male palp is provided with a conical lateral projection. They spin cribellate webs on plants, often in dry and dead vegetation.

Species recorded from NDBR:

Dictyna sp.1*; Dictyna* sp.2

Family Filistatidae Ausserer 1867 (Crevice weavers)

Diagnostic Characters:

Small to medium sized, ecribellate, haplogyne spiders. Carapace oval, flat with anterior projection; cephalic region distinctly narrowed anteriorly; clypeus long; fovea indistinct to absent; usually covered with fine setae. Eight eyes clustered in a compact group, situated on a small tubercle or a central mound. Chelicerae small with laminae; basally fused which differs this family from the other cribellate spider familles; no lateral condyle; fang short, fang furrow without teeth; gnathocoxae inclined inwards, strongly converging together in front of labium; labium as wide as long and fused with sternum. Legs are fairly long, especially in males; prograde with numerous spines, paired setae ventrally on tibiae and metatarsus; three dentate claws; autopasy at patella-tibia joint. Opisthosoma cylindrical to slightly flattened, posteriorly rounded; covered with soft, short dense hairs. ALS three segmented with three ampullate glands spigots; cribellum small, divided, sub-triangular to narrowly transverse; indiscernible by covered hairs; bearing claviform spigots; calamistrum short; spinnerets set slightly forward; median spinnerets two segmented with large basal spigot. Female gonopore region is not modified externally; male palp with cymbium; bulb simple and attenuated.

Filistatids are nocturnal, living in tubular silken lined retreats in crevices in rocks or walls. They are represented by 17 genera, 113 species occurring worldwide (Platnick, 2011). In India it is represented by 3 genera and 10 species so far (Sebastian and Peter, 2009).

Genus Pritha Lehtinen 1967

Spiders of the genus Pritha are sedentary, wandering nocturnal and usually found in crevices. Prosoma and opisthosoma elongated; well defined cluster of hairs present on the Prosoma; thoracic groove absent. Eyes close together in a group and occupy about one third of the width of the carapace. Tarsal claws without spines. Eyes are clumped together. Cribellum is triangular and divided; calamistrum bisegmented.

Species recorded from NDBR:

Pritha sp.1*; Pritha* sp.2

Family Gnaphosidae Pocock 1898 (Mouse spider)

Diagnostic Characters:

Small to medium sized, ecribellate entelegyne spiders. Carapace is pyriform to oval, smoothly convex at sides, gradually or abruptly narrowed toward front, rather low usually with distinct thoracic groove; fovea distinct. Eyes are small, arranged in two transverse rows of 4 each. Anterior or median eyes round, and remaining eyes round, ovoid or angular, depending on genus; PME modified, oval to flatten; irregular in shape. Chelicerae short; margins with teeth, keels, lobes or carinae rarely smooth, robust, tapered from base to tip, and hairy in front. Gnathocoxae with distinct oblique depression on the ventral surface and with serrula at tip. Legs prograde, moderately to slightly spined, usually rather short and stout, hairy; tarsi two clawed; tarsi I and II often with dense scopulae; tarsi occasionally with claw tufts; macrosetae rather short and sparse. Leg IV longest and leg III shortest; each tarsus with pair of toothed claws. Opisthosoma elongated, cylindrical, usually with dorsal scutum in adult males and with cluster of erect curved setae at anterior end; anterior scuta present in some males. Spinnerets one segmented; anterior spinnerets parallel, large and cylindrical; ALS cylindrical and widely separated at base; pyriform glands, spigots of anterior spinnerets greatly enlarged. Epigyne is variable; slightly sclerotised; spermathecae round, ovoid, elongate. Male palp are usually stout pointed retrolateral tibial apophysis; genital bulb usually convex, with conductor, terminal and median apophysis.

Gnaphosids are free living, nocturnal spiders found on the soil surface, with only a few living on plants. Most ground dwelling species construct a silk retreat under stones or surface debris within which they remain during non active period. They do not spin a web. They are represented by 115 genera, 2111 species occurring worldwide (Platnick, 2011). In India, it is represented by 28 genera and 139 species so far (Sebastian and Peter, 2009).

Keys to genera

1a. PME usually round, rarely oval, barely larger than PLE; PE nearly equidistant; PER straight, occasionally slightly procurved…………**Zelotes**

1b. Eyes arrangement otherwise……………………………..…………….…..…**2**

2a. Cheliceral retromargin with a serrated teeth; gnathocoxae usually rounded laterally…………………………………………………………….**Gnaphosa**

2b. Chelicerae otherwise………………………...……………………………**3**

3a. Trochanters deeply notched…………….………………..……….**Drassodes**

3b. Trochanters otherwise…………………………………………………….**4**

4a. Male palpus with embolus bearing enlarged base, median apophysis elongated, inconspicuous; female with spermathecae lacking terminal bulb……………………………………………….……………..**Herpyllus**

4b. Male palpus with embolus; sinuous lacking enlarged base, median apophysis hooked; female with spermathecae bearing terminal bulbs………………………………………….…..………………...**Scotophaeus**

Genus Gnaphosa Latreille 1804

Spiders of the genus Gnaphosa are predominantly ground dwelling and nocturnal remaining under stones and logs during the day. Carapace is dark in colour; cephalic area sightly elevated; thoracic groove longitudinal. Eyes eight, heterogenous and arranged in two rows. Body is depressed dorsoventrally. Opisthosoma oval, flattened, dark grey to black and covered with hairs but not greatly larger than the carapace. Legs are moderately short and spinose. Six spinnerets are present; anterior spinnerets are cylindrical, longer and more heavily sclerotised than posterior and widely separated from each other. They spin delicate silken sacs, within which they moult or mate; mature females are most often found guarding their characteristically flattened egg sac.

Species recorded from NDBR:

Gnaphosa poonensis Tikader 1973*; Gnaphosa sp.1*
Gnaphosa sp.2

Genus Herpyllus Hentz 1832

Spiders of the genus Herpyllus are small to large, commonly found in grasslands, riverbanks, forest floor also sometimes occurring in houses and old buildings. Carapace is elongated to oval, narrow in the anterior end; short recumbent setae present. Anterior eye row is slightly recurved, while posterior row is straight. Dorsal trichobothria are present. Males have long broad embolus and straight rod-like or hair-like median apophysis.

Species recorded from NDBR:

Herpyllus sp.1

Genus Drassodes Westring 1851

Spiders of the genus Drassodes are of medium size occurring under stones in alpine grasslands, pine forests and vegetation. Carapace is flat, broad in front with a fovea and covered with pubescence. Anterior eye row is procurved; medians slightly larger than laterals; posterior eye row longer, procurved, medians oval, slightly larger than laterals. Chelicera is strong, inner margin normally with two teeth each on inner and outer margin. Distinct ventral notch is present at the tip of each trochanter. Two dorsal spines on tibia IV; tibia I and II sometimes bear one ventral spine on the apical half. Opisthosoma longer than wide, narrow behind, covered with pubescence. Male palpal tibia is elongated and slender; short retrolateral apophysis and small hooked median apophysis present; embolus slender; spermathecae subdivided.

Species recorded from NDBR:

Drassodes sp.1

Genus Scotophaeus Simon 1893

Spiders of the genus Scotophaeus are medium to large and brown or reddish brown. Carapace is much narrower in font; fovea present. Eyes of the anterior medians larger than the laterals, the median are circular and anterior lateral elliptical. AME larger than ALE; posterior eye row slightly longer than anterior row, slightly procurved, eyes equal in size and equidistant from each other. Legs are without preening comb and trochanters with shallow notch; tibia IV with one or no dorsal macrosetae, chelicerae with a retromarginal tooth. Median apophysis hooked and epigynum with paired median ducts.

Species recorded from NDBR:

Scotophaeus sp.1; *Scotophaeus* sp.2

Genus Zelotes Gistel 1848

Spiders of the genus Zelotes are nocturnal agile and difficult to capture, often found in association with ants, commonly occurring in litter, around water bodies, under rocks and grasses. Carapace oval prominently narrowed in front and covered with fine hairs. Dorsum bears widening striae diverging from the short longitudinal fovea. Eyes grouped closely, posterior eye row a little longer than the anterior eye row. AE row slightly procurved viewed frontally, ALE larger than the AME. PE row straight, PME irregular in shape, sometimes larger than PLE and as far from adjacent PLE as from each other or equally spaced. Chelicerae are moderately strong, vertical, with hairs in the inner part of the promargin. Promarginal teeth vary from three to six, commonly three and retromargin has two or three occasionally one. Legs moderately long tibiae and metatarsi III and IV with or without ventral spines. Opisthosoma dark to black, covered with fine short hairs, and three pairs of spots or impressions dorsally. Presence of a preening comb on tarsi III and IV; and intercalary sclerite in the male palpus. They build transparent, lustrous webs.

Species recorded from NDBR:

Zelotes sp.1; *Zelotes* sp.2; *Zelotes* sp.3

Family Hahniidae Bertkau 1878 (Comb-tailed spiders)

Diagnostic Characters:

Small, ecribellate, entelegyne spiders. Carapace generally pyriform, longer than wide light to dark brown with dark pattern margined with black; narrowed in cephalic region; fovea longitudinal. Eight eyes of equal size arranged in two transverse row; both rows pro-curved. Chelicerae margins toothed with teeth on each side of the cheliceral furrow; basal boss present or absent; lateral side of the chelicerae with stridulatory organs. Labium is wider than long; gnathocoxae slightly convergent. Legs short robust with few setae; ventral scopulae usually absent; tarsi with three claws, claws tufts absent; tarsal with 2-3 dorsal trichobothria more or less reduced; trochanteral notches absent.

Calamistrum is in one row. Opisthosoma is usually oval. Six spinnerets in a single transverse row, posterior spinnerets long and two segmented; colulus present. Epigyne is complex; male palp long and curved, patella usually with a basal hook; embolus thin, median apophysis reduced.

They are widely distributed, usually found in leaf litter and under dead logs mostly in forested areas. They spin delicate sheet webs, usually hiding beneath it. They are represented by 26 genera, 241 species occurring worldwide (Platnick, 2011). In India it is represented by 3 genera and 4 species so far (Sebastian and Peter, 2009).

Genus Hahnia CL Koch 1841

Spiders of the genus Hahnia are well distributed in the world and commonly found in dry leaf litter. Carapace longer than wide, varying from light to dark brown, with grey to black pattern, and margined with black; cephalic region narrow. Eyes eight, in two rows, eye rows slightly procurved. AME is smaller than ALE and significantly reduced. Opisthosoma ovoid and slightly pointed posteriorly. It is overall grey with two elongated yellow areas alongside the cardiac mark and with five transverse, chevron shaped yellow bands posteriorly. Legs short with annulations. Lateral side of chelicerae with a stridulating organ. Opisthosoma is with oblique and transverse light markings on a gray background; femur of pedipalp almost as long as tarsus in the female. Tracheal spiracle is closer to spinnerets than to the epigastric furrow.

Species recorded from NDBR:

Hahnia sp. 1

Family Hersiliidae Thorell 1869 (Long-spinneret spiders)

Diagnostic Characters:

Medium sized, ecribellate, entelegyne spiders. Body colour varies golden brown to pure white, or almost black with mottles. Carapace ovoid and flattened; ocular area raised; longitudinal fovea narrow and radiating striae; densely covered with plumose setae. Eyes eight are in two strongly recurved rows. Chelicerae is weak; lacking boss, three promarginal teeth, series of denticles on retromargin, usually more than four. Labium rebordered; gnathocoxae inclined obliquely on the labium and strongly convergent. Legs prograde, very long and slender, especially in males; legs III shortest; tarsi three clawed; few macrosetae; trichobothria present. Opisthosoma flat; densely covered with plumose setae; wider behind than in front. Anterior spinnerets are cylindrical, slightly tapering distally; posterior spinnerets very long; inner surface with a series of long tubules providing thin silk threads. Colulus present. Female epigynum is with broad central septum; male palp lacking tibial apophysis.

Hersilids are extremely active hunters living on tree trunks, old walls or under stones sometimes building irregular webs. They are represented by 15 genera, 171 species occurring worldwide (Platnick 2011). In India it is represented by 3 genera and 6 species so far (Sebastian and Peter, 2009).

Genus Hersilia Audouin 1826

Spiders of the genus Hersilia are well distributed in the tropical and subtropical regions of the world. Carapace flat and laterally angulated; prominently high clypeus Ocular quadrangle parallel sided. Head flat, angular laterally. Clypeus is usually very high and prominent. Metatarsi II, III and IV bisegmented; tarsi of legs I, II, and III double-segmented; posterior spinnerets very long, much longer than opisthosoma; distinct colulus separates the anterior pair of spinnerets; and strongly recurved AE and PE rows. They do not build webs, while facing away from the prey, they circle and fix it to the bark with bands of silk emanating from the long spinnerets, which they rotate rapidly so as to encapsulate the prey. Egg sacs are attached to the bark and are camouflaged with bits of bark and debris.

Species recorded from NDBR:

Hersilia sp.1

Family Linyphiidae Blackwall 1859 (sheet web spiders)

Diagnostic Characters:

Small sized, ecribellate, entelegyne spiders. Carapace is variable; longer than wide; clypeus height usually exceeding that of the median ocular region. Eight subequal eyes arranged in two rows; anterior median eyes slightly darker. Chelicerae robust; margins toothed; usually with strong teeth on cheliceral furrow. Gnathocoxae is usually parallel. Lateral condyle absent; legs usually long, slender and provided with macrosetae especially on tibiae and metatarsi; tarsi usually cylindrical three claws. Opisthosoma is longer than wide; usually ovoid to elongate; with or without patterns dark or shiny; scutum present in some males. Anterior and posterior spinnerets are short and conical, concealing median pair. Colulus present. Epigyne is simple and highly variable; male embolus complex.

Linyphiids occur worldwide; especially they are well represented in the temperate and cooler regions of the world. They spin delicate sheet webs between branches of trees or shrubs in tall grass and sometimes close to the ground. They are sometimes also found in litter and debris. They are represented by 586 genera, 4378 species occurring worldwide (Platnick 2011). In India it is represented by 16 genera and 28 species so far (Sebastian and Peter, 2009).

Key to genera

1a. Lateral margin of carapace and front of chelicerae armed with teeth…………………………………………………………………….**Erigone**

1b. Lateral margin of carapace and front of chelicerae without teeth…………**2**

2a. Posterior eyes not closely set; Median ocular area not longer than wide…………………………..……………………………….**Linyphia** (in part)

2b. Posterior eyes closely set. Median ocular area longer than wide…..……………………………………………………………..……….**3**

3a. Carapace pale with dark stripe bifurcating anteriorly…………………..…..**4**

3b. Carapace markings otherwise……………………………….………….………**5**

4a. Dorsal stripes wider; terminal apophysis not spiral; palp with larger patellar apophysis………………………………..…………………..**Pityohyphantes**

4b. Dorsal spine on carapace narrow; terminal apophysis of palp twisted in a thick, tight spiracle; palp without patellar apophysis……………..…**Linyphia**

5a. Epigyum with both dorsal and ventral scapes; ventral scape may be very short or long but always with terminal pit…………..…...……**Bathyphantes**

5b. Epigynum otherwise………………………………………..……………..**6**

6a. Cephalic region with dorsal prominence……………………………**Atypena**

6b. Cephalic region otherwise…………………………………..……………**7**

7a. Terminal apophysis of palp twisted in a thick spiral…………………**Neriene**

7b. Terminal apophysis not spiral……………………………………………….**8**

8a. Embolus long and threadlike, making loop beyond confines of cymbium; carapace elongated in cephalic region; chelicerae elongated, angled posteriorly……………………………………….…………….**Microlinyphia**

8b. Embolus division with radix, embolus and lamella not fused……..**Agyneta**

Genus Bathyphantes Menge 1866

Spiders of the genus Bathyphantes closely resemble Lepthyphantes in appearance. Black markings present on the dorsal surface of the abdominal. Legs are long and thin; femora I-III each with a small dorsal spines; tibiae I-IV with two dorsal spines and one each of retrolateral and prolateral in tibiae I and II, metatarsi spineless and IV without a trichobothrium. Male palpal variable; female epigynum often elongated with a scape.

Species recorded from NDBR:

Bathyphantes sp.1

Genus Agyneta Hull 1911

Spiders of the genus Agyneta are distinguished by the distinct arrangement of a palpal bulb with embolus and radix; embolus and radix not fused. Opisthosoma is unicoloured or patterned.

Species recorded from NDBR:

Agyneta sp.1

Genus Atypena Simon 1894

Spiders of the genus Atypena are commonly found in grasslands, and low vegetation. Carapace is slightly high in the cephalic region and broadest between coxae II and III. Lateral eyes contiguous, AE row slightly recurved and PE row straight, PME largest and AME smallest, MOQ usually wider behind than in front. Clypeus is high. Epigynum simple; males have elevated head forming a transverse lobe bearing the PME, pit present in PME and PLE, area between PME and AME hairy, palpal organ complex with embolic portion rather wide apically. Tibia III and IV of both sexes bear single spines each. The eggs are usually covered with a thin layer of silk, laid in masses on dried leaf sheaths. They do not receive any maternal care.

Species recorded from NDBR:

Atypena adelinenae Barrion & Litsinger 1995*; Atypena* sp.1

Genus Erigone Audouin 1826

Spiders of genus Erigone are distributed worldwide and readily separated from the other members of the family by the presence of teeth in the margin of carapace and anterior of chelicerae; often dark brown or black spiders with smooth and shiny carapaces, male head elevated with no definite lobe; male maxillae with warts; metatarsus IV without trichobothrium; patella of male pedipalp bears a terminal ventral process, and tip of tibia deeply excavated, producing a deep pit; embolic division consists of a more or less elongate central body armed with three teeth; female epigynum simple, usually with a procurved rebordered posterior edge. They are often found near water where they place their square webs between the grasses.

Species recorded from NDBR:

Erigone sp.1*; Erigone* sp.2

Genus Linyphia Latreille 1804

Spiders of the genus Linyphia is distributed worldwide mainly occurring in the temperate regions. Eyes are small, widely spaced; Opisthosoma with dorsal patterns. Legs are usually long, metatarsi almost twice as long as tarsi. Paracymbium of male palp is very slender and conspicuous. They construct a web with a horizontal mat under which the spider hangs upside down. The sheet hangs on random vertical threads. Insect flying against these threads tumble down on the horizontal sheet web and are caught by the spider.

Species recorded from NDBR:

Linyphia sp. 1; *Linyphia* sp. 2; *Linyphia* sp. 3; *Linyphia* sp. 4

Genus Pityohyphantes Simon 1929

Spiders of the genus Pityohyphantes are distinguished by the presence of wide dorsal stripe on the carapace. Terminal apophysis is not spiral and large patellar apophysis on palp.

Species recorded from NDBR:

Pityohyphantes sp. 1

Genus Neriene Blackwall 1833

Spiders of the genus Neriene usually construct sheet webs in shrubs and low vegetation. Opisthosoma has a distinct waist and protruding rear. Terminal apophysis of palp twisted in a thick tight spiral.

Species recorded from NDBR:

Neriene sp.1*; Neriene* sp.2

Genus Microlinyphia Gerhardt 1928

Spiders of the genus Microlinyphia are distinguished by the elongated carapace in the cephalic region. Chelicerae elongated and angled posteriorly. Males usually have a tubular black opisthosoma with sometimes two white spots at the front end. Embolus long and thread like, making loop beyond confines of cymbium.

Species recorded from NDBR:

Microlinyphia sp.1

Family Lycosidae Sundevall 1833 (Wolf spiders)

Diagnostic Characters:

Small to large spiders, ecribellate, entelegyne spiders. Carapace is longer than wide; usually covered with short recumbent setae. Eyes eight all dark in colour; the posterior row of eyes recurved strongly; eyes arranged in 3 rows; anterior eyes small other eyes large. Chelicera long, robust, often hairy; with 3 prolateral and 2 to 4 retro lateral marginal teeth. Legs are long, usually strong with spines; tarsi bearing 3 claws, IV leg longest. Six spinnerets present; Colulus absent. Epigyne with well sclerotised median septum; male palp lacking tibial apophysis; females of this family carries the egg sac along with them attached to the spinnerets.

Lycosids are mostly free living ground wandering spiders that are well distributed in the world. They are represented by 118 genera, 2374 species occurring worldwide (Platnick 2011). In India it is represented by 17 genera and 126 species so far (Sebastian and Peter, 2009).

Keys to genus:

1a. Posterior spinnerets distinctly longer than anterior, with apical segments conical and as long as the basal…………………....………..……….**Hippasa**

1b. Posterior spinnerets only slightly longer than the anterior; apical segments hemispherical and very short…………………………………………..…………**2**

2a. Carapace with paired dark longitudinal streaks in pale area anterior to dorsal groove……………………………………………………...……**Trochosa**

2b. Carapace otherwise……………………………………………………………**3**

3a. Clypeus vertical; metatarsus IV longer than or as long as tibia and patella IV together..…………………………………………………...……..**Pardosa**

3b. Clypeus slanting; metatarsus IV shorter than tibia and patella together...……………………………………………………..……..….**Lycosa**

Genus Hippasa Simon 1885

Spiders of the genus Hippasa commonly occurs in slopes, vegetation and often found in disturbed habitats. Carapace longer than wide; cephalic region pronouncedly narrowed in front. AE row is slightly wider than the PME row; ocular quadrangle wider than long. Chelicerae is strong and retromargin with three teeth. Legs long thin and covered with spines and hairs. Leg IV exceptionally long while opisthosoma longer than wide with dorsal markings. Posterior spinnerets considerably longer than the anterior spinnerets and the apical piece of the posterior are as long as the basal piece. Epigyne is usually with a distinct process; and male pedipalp slender, like the cymbium. They make sheet-like webs with a funnel retreat over which they escape or run, similar to the family Agelenidae.

Species recorded from NDBR:

Hippasa agelenoides Simon 1884

Genus Trochosa C.L. Koch

Spiders of the genus Trochosa are widely distributed in the world. Possess rather thick bodies and legs. Carapace with paired dark longitudinal streaks between dorsal groove and posterior row of eyes; AE row straight or slightly procurved and as long as or shorter than PME row; AME distinctly larger than ALE; clypeus height less than one AME diameter; chelicerae with two or three retromarginal teeth; female fang is without excrescence; femur I with two spines; dorsal base of tarsus I is without trichobothrium. The males are easily distinguished by the presence or absence of palpal claw and sickle-shaped terminal apophysis. A marginal line present on the genital openings of epigynum. They are seldom seen in the open, as they apparently move little and prefer the relatively dark and moist spaces in deep grass or under surface litter. Females tend to make shallow nest holes in the top layers of soil to hold their round white egg sacs until hatching occurs.

Species recorded from NDBR:

Trochosa sp.1

Genus Lycosa Latreille 1804

Spiders of the genus Lycosa are commonly found to build open vertical burrows, often in rocky outcrops, under rocks or logs. It is a very large genus that includes a majority of species of wolf spiders. Carapace long, dark brown with a light wide longitudinal median stripe, facial area vertical and the sides of the face slanting four posterior eyes larger and arranged in a quadrangle, slightly wider behind than in front the labium is always longer than wider and the basal excavation is prominent, usually one third or more of the length of the labium. Clypeus is not vertical. Tibiae I and II armed with three pairs of ventral spines. Metatarsus IV is never longer than tibia and patella together. Opisthosoma is overall greyish with a dark median stripe, often breaking into chevrons, bars or dots. They do not spin a web. The larger forms live in a silk lined burrow and under stones, with the entrance covered by a thin sheet of silk. The female carries the cocoon attached covered by a thin sheet of silk. The female carries the cocoon attached to its spinnerets and after hatching the young ones swarm onto the mothers back.

Species recorded from NDBR:

Lycosa tista Tikader 1970*; Lycosa* sp.1*; Lycosa* sp.2

Genus Pardosa C.L. Koch 1847

Spiders of the genus Pardosa are one of the largest wolf spider genera. They are small to medium in size. Cephalic region elevated; clypeus vertical. Labium is usually wider than long with basal articular notches. AE is procurved row distinctly shorter than PME row while AME longer than wide, pale or dark. Legs moderately long, slender, pale or dark; scopulae sparse; femur I bears three dorsal and two prolateral spines, prolateral spines close to each other distally; tibia with two dorsal bristles, one or two prolateral, one or two retrolateral and six ventral spines; metatarsus I has a dorsal bristle, two or three prolateral, and two or three retrolateral, and seven ventral spines. Opisthosoma is generally ovoid, dark to pale in colour. Cymbium of male pedipalp has one to three short stout spines apically, terminal apophysis tooth-like, projected towards tip of embolus and conductor; embolus long to short, epigynum with distinct hoods. They are generally found in wet ground near ponds and steams. The egg sac is lenticular, usually greenish when fresh, changing to dirty grey when older.

Species recorded from NDBR:

Pardosa sumatrana Thorell, 1890*; Pardosa minuta* Tikader & Malhotra, 1976

Pardosa pseudoannulata Bösenberg & Strand, 1906

Pardosa sp.1; *Pardosa* sp.2

Family Mimetidae Simon 1881 (Pirate Spiders)

Diagnostic Characters:

Small to medium sized, ecribellate, entelegyne spiders. Carapace oval to pyriform; head region not distinct; sometimes with rows of long spines. Cephalic region varies from long and attenuated to short and sharply convex near middle. Eight eyes in two rows; anterior median eye usually largest; lateral eyes equal in size, contiguous and raised on a small common protuberance; well separated from median eyes; anterior median eyes frequently raised on small, square protuberance. Chelicerae relatively long; directed vertically; fused at base; inner side separated by a narrow, triangular, elongated, membranous fissure, cheliceral promargin with pep teeth. Labium as wide as long as or longer than wide. Gnathocoxae is long and almost parallel, ventrally with fairly short sub marginal teeth. Legs are long and slender with strong spines. Legs I and II are slightly longer; tibiae and metatarsi I and II with modified prolateral spination consisting of series of long, slightly curved spines. Opisthosoma varies in shape; sometimes with paired projections; integument usually with very strong isolated setae. Six spinnerets present; with peculiarly enlarged, rounded and incised cylindrical gland spigots; Colulus distinct. Epigynum distinct, usually covered by a broad flat sclerotised plate but relatively simple, usually with lobed posterior extension. Male palp is fairly long with strongly developed paracymbial process; bulb with strongly curved embolus.

Most mimetids are araneophagus, specialized predators of web living spiders. They are encountered in debris on the ground, in low vegetation or on the webs of other spiders. They are represented by 13 genera, 156 species occurring worldwide (Platnick, 2011). In India it is represented by 2 genera and 3 species so far (Sebastian and Peter, 2009).

Genus Mimetus Hentz 1832

Spiders of the genus Mimetus are specialised spider predators well distributed in the world. Carapace convex and attenuated towards front, with smooth and shiny surface, two longitudinal rows of long, black setae run along the top of the carapace. The distance between the anterior edge of the carapace and the anterior median eyes is about one-third to one-half of the distance between the anterior and posterior medial eyes. Opisthosoma long, oval, and convex, yellowish in colour and with four longitudinal rows of setae. Legs are spiny with the noticeable curved first tibiae and metatarsi, both carrying long erect spines and a row of numerous small spines, pale yellow in colour with light brown spots and annulations. Epigynum without lateral lobes; palpus without sickle- shaped terminal apophysis, if terminal apophysis sickle-shaped, then cymbium lacking apical projection. They do not spin webs and are slow moving, stalking or ambushing their prey. They feed on insects directly or prey on insects ensnared in webs belonging to other spiders. They also feed on eggs of other spiders.

Species recorded from NDBR:

Mimetus sp.1

Family Nephilidae Simon 1894 (Golden Orb Weavers)

Diagnostic Characters:

Carapace is longer than wide, general colour dark brown to grey. Eight eyes are in two rows, lateral eyes contiguous. Chelicerae are stout and strong, vertical, with finely striated boss, with teeth on both margins. Labium is wider than long. Legs long slender, tarsi three clawed with spines; trichobothria present on tibiae only, tarsus IV with sustentaculum. Opisthosoma are variable, elongated, flat or cylindrical or round to ovoid, in some species extending caudally beyond spinnerets, with sigilla; males with dorsal scutum. Anterior and posterior spinnerets are dissimilar in size. Epigyne is simple with completely or partially sclerotised genital plate. Male paracymbium usually flat and rectangular, sub-tegulum well developed, tegulum large and globular, embolus usually elongated with well developed embolic conductor. The members of this family occupy a variety of habitats in most tropical and subtropical regions of the world. Sexual dimorphism is extremely prominent; the females are many times larger than the males.

Genus Nephila Leach 1815

Spiders of the genus Nephila are commonly found in the tropical and sub tropical regions of the world. Cephalic region convex more elevated than thoracic region and usually armed posteriorly with one pair of tubercles. Labium longer than broad, ocular quadrangle nearly square or slightly wider behind, legs very long and strong with spines, tarsi and metatarsi together longer than tibia and patella together. Epigyne is heavily sclerotised. Usually builds huge orb webs in forests and grasslands.

Species recorded from NDBR:

Nephila clavata L. Koch 1878

Family Oecobiidae Blackwall 1862 (Star legged spider)

Diagnostic Characters:

Small to medium sized, ecribellate, entelegyne spiders. Carapace sub-circular, wider than long; fovea longitudinal, may be indistinct or absent; sides round. Eyes 6-8, heterogenous in two rows in a close group near the centre of the carapace; AME subcircular others oval to triangular; PME variable; circular or sub-circular or may be reduced in some genera. Chelicerae is short, slender, without fang groove or teeth; contiguous for full length; without lateral condyle or scopula; fang simple, curved, sharp. Labium free, wider than long. Gnathocoxae well developed, distal end convergent; without scopula. Legs sub equal in length, covered with plumose hairs; pectinate, spines few or lacking; tarsi three clawed; calamistrum biserrate in proximal half (lacking in male). Opisthosoma more or less flattened oval to round; slightly overlapping carapace. ALS and PMS contiguous; two segmented; anterior spinnerets short. Epigynum is simple but variable; male palpus lacking tibial apophyses.

Oecobiids are commonly found either under small star shaped mesh webs or multi-layered webs under stones. They are represented by 6 genera, 105 species occurring worldwide (Platnick 2011). In India it is represented by 3 genera and 4 species so far (Sebastian and Peter, 2009).

Genus Oecobius Lucas 1846

Spiders of the genus Oecobius are commonly found living in silken retreats or small flat webs over crevices in walls. Carapace with sides rounded; legs long, tibia I about 6-7times longer than wide; calamistrum extending 2/3 length of metatarsus IV; PLE largest, PME separated by 1-2 diameters Opisthosoma oval, whitish, with cardiac region dark. Legs lighter with dark patches. Anal tubercle is highly conspicuous by the presence of a fringe of long curved hairs.

Species recorded from NDBR:

Oecobius sp.1

Family Oxyopidae Thorell 1870 (Lynx Spiders)

Diagnostic Characters:

Small to large sized, ecribellate, entelegyne spiders. Carapace is narrow, sub acuminate, longer than wide and convex anteriorly. Clypeus is very high, vertical, usually with conspicuous stripes and spots. Integument clothed in thin setae and sometimes in iridescent scales. Eight eyes forming a compact sub circular group; AER recurved and PER procurved, producing the typical hexagonal arrangement; AME minute. Chelicerae basal segment long, not prominent, acuminate; fang short; fang groove unarmed or weakly armed. Gnathocoxae and labium are very long. Legs prograde, long, slender, armed with long spines, not scopulate; tarsi with three claws; trochanters notched. Opisthosoma generally oval to elongate, tapering to a point posteriorly. Spinnerets short sub-equal; small colulus present. Epigyne well sclerotised; varies between genera, median depression with scape like process or a deep pit in front with paired projections. Male palp is usually with tibial apophysis and paracymbium.

Oxyopids are mainly plant dwelling hunting spiders commonly found on grass, shrubs and trees. They are diurnal or nocturnal hunters with good vision, enabling quick detection of prey. The egg sac is fastened to a twig or leaf, or suspended in an irregular web. The eggs are guarded by the female. Oxyopids are represented by 9 genera, 430 species occurring worldwide (Platnick, 2011) while in India it is represented by 4 genera and 69 species so far (Sebastian and Peter, 2009).

Keys to genera

1a. Posterior cheliceral margin without teeth; ALE row wider than PME row; posterior eye row only slightly procurved; living specimens bright green in colour…….………………………………………….…………...**Peucetia**

1b. Posterior cheliceral margin with a single tooth; ALE row subequal to PME row or PME row much wider than ALE row; Posterior eye row strongly procurved; living specimens not green in colour……………….…………...**2**

2a. Legs IV robust, clearly longer than legs III; distance between PME subequal to distance between PME and PLE……………………...**Oxyopes**

2b. Legs IV small, subequal to or shorter than leg III; distance between PME much greater than distance from PME to PLE……….…….**Hamaltatliwa**

Genus Peucetia Thorell 1869

Spiders of the genus Peucetia are called green lynx spiders. Carapace narrow in the cephalic region, widening considerably posteriorly; face vertical, with sides of carapace and thoracic cavity is not very steep; eyes occupy a comparatively smaller area, ALE is the largest and AME smallest while PME and PLE subequal in size and are larger than AME. Labium is longer than wide; Retromargin of chelicerae without teeth. Legs are very long with numerous black spines. Opisthosoma is very elongated, nearly cylindrical, tapering gradually behind to the spinnerets male pedipalp with a prominent paracymbium process; epigyne highly variable in females. Predominant colour of integument is green or shades of green in the living spiders which changes rapidly in alcohol.

Species recorded from NDBR:

Peucetia sp.1

Genus Oxyopes Latreille 1804

Spiders of the genus Oxyopes are diurnal, usually found among the stems of woody plants such as pine, juniper, and sagebrush. Body covered with short scale-like recumbent irridescent setae. Carapace with nearly vertical anterior and lateral margins; cephalic area slightly elevated, sloping sharply at the thoracic declivity and laterally.; strongly procurved PE row, equidistant from each other; PLE and PME subequal in size, larger than AME but slightly smaller than ALE; AME smallest. Chelicera with one promarginal and retromarginal tooth each. Legs very long, spinous, and usually with longitudinal gray bands in venter of femora, spines long and thick. Opisthosoma elongate, widest behind base and tapering to the spinnerets. The egg sac is discoidal, flat, and attached to twigs and the female guards it until the youngs emerge.

Species recorded from NDBR:

Oxyopes javanus Thorell 1887*; Oxyopes shweta* Tikader 1970

Oxyopes sp.1*; Oxyopes* sp.2*; Oxyopes* sp.3*; Oxyopes* sp.4

Genus Hamaltatliwa Keyserling 1887

Spiders of the genus Hamaltatliwa are widely distributed in the world. Legs III and IV are subequal in length or III longer than IV. Mostly the median eyes are closer to the laterals than to each other in the posterior row.

Species recorded from NDBR:

Hamataliwa sp. 1*; Hamataliwa* sp. 2

Family Palpimanidae Thorell 1870 (Palp footed spider)

Diagnostic Characters:

Small to medium sized, ecribellate, entelegyne spiders. Carapace sub-oval in outline anteriorly slightly narrowed or truncated. Cephalic region evenly rounded, sloping gently towards thoracic region; fovea usually distinct, covered with a hard coriaceous, granular epidermis. Usually eight eyes in two rows; position varies between genera; lateral eyes either contiguous or widely separated, posterior median eyes small or large and irregular in shape. Chelicerae short and stout; cheliceral furrow weakly developed, true teeth may be present or retro margin but never numerous; promargin with pep teeth opposite tip of fang, which is short and stout. Labium is triangular; gnathocoxae converging and almost touching; serrula strong. Femur I usually expanded dorsally; patella about as long as tibia length; tibia, metatarsus and tarsus of leg I with scapulae on promargin but on tarsus scapulae limited to distal or middle part of the segment. Claws of anterior legs are small but those of posterior legs are normal in size. Opisthosoma oval, cuticle often coriaceous with epigastric region heavily sclerotised, forming a ring shaped scutum extending dorsally to encircle pedicel; scutum absent sometimes. Epigastric region is heavily sclerotised; internal structure of epigyne simple; male palp with an elaborate conductor and tibia frequently bulbous.

Palpimanids are free living ground dwellers occurring mostly in tropical and sub tropical regions. They are represented by 15 genera, 131 species occurring worldwide (Platnick, 2011). In India it is represented by 3 genera and 4 species so far (Sebastian and Peter, 2009).

Genus Palpimanus Dufour 1820

Spiders of the Genus Palpimanus are usually found in litter or under stones sometimes in old houses. Prosoma is more or less dark red and oval in shape. Eyes six, arranged in two rows on the front margin, first row strongly procurved and the second slightly recurved. Legs I are very strong. Opisthosoma is oval, light brown, with a ventral scutum covering the epigastric area.

Species recorded from NDBR:

Palpimanus sp.1

Family Philodromidae O. Pickard-Cambridge 1871 (Running Crab Spider)

Diagnostic Characters:

Small to medium-sized, ecribellate, entelegyne spiders. Carapace slightly flattened; as long as wide or elongated; clothed in soft recumbent setae. Eight eyes usually uniform in size and arranged in two transverse rows. Both rows of eyes recurved and posterior row strongly longer than wide. Chelicerae are short, slender, retromargin lacking teeth. Legs laterigrade; legs I, II, II and IV almost equal in length, leg II usually longer, sometimes much longer; tarsi three clawed, usually with scopulae and claw tufts. Opisthosoma elongated to oval, heart-shaped mark and a series of chevrons. Spinnerets is simple; Colulus absent. Epigyne small, usually with median septum; male palp with retrolateral tibial apophysis varying in shape, with or without ventral tibial apophysis; embolus short or long, usually curved along distal end of tegulum.

Philodromus are free living hunters commonly found in soil, plants or forested areas. Usually occurs on tree trunks, in low bushes and on herbages. They move about rapidly on plants, usually capturing prey by lying in ambush with legs extended. They are represented by 29 genera, 536 species occurring worldwide (Platnick 2011). In India, it is represented by 7 genera and 48 species so far (Sebastian and Peter, 2009).

Genus Philodromus Walckenaer 1826

Spiders of this genus Philodromus are extremely agile, commonly found on plant stems, foliage, and forest floor. Carapace flattened, smoothly convex at lateral sides, as long as wide to slightly longer than wide. Small eyes, uniform in size, PME closer to PLE than to each other. Laterigrade legs, long and slender, leg II usually the longest, I, III, and IV subequal in length and thickness; pedipalp of male with RIA and VIA; embolus hairlike, slender, and variable in length; female epigynum bears a flat median septum, lateral margins distinct, atrium modified to a small pair of depressions on the anterolateral of the median septum, spermathecae variable in shape, depending on the species; opisthosoma is oval and usually angulate laterally, moderately flat but dorsally it often bears heart-shaped markings and chevrons.

Species recorded from NDBR:

Philodromus chambensis Tikader 1980

Philodromus sp.1*; Philodromus* sp.2

Family Pholcidae C.L.Koch 1851 (Cellar spiders or Daddy long legs)

Diagnostic Characters:

Small to medium sized, ecribellate, haplogyne spiders. Carapace as long as wide; domed towards the thoracic region; oval narrow in front and rounded posteriorly with complex markings; cephalic region usually elevated on the sides with deep striations, thoracic region with deep median longitudinal fovea. Six to eight eyes present. ALE and posterior eyes forming triads; AME may be present or absent; fovea absent. Chelicerae without lateral condyle, fused at basal part, fang small. Labium as wide as long, fused to sternum, with slightly concave anterior margin; gnathocoxae converging. Legs long and slender, light covering setae; tarsi usually pseudosegmented, with three claws; spines absent; metatarsi longer than tarsi. Opisthosoma is broad, cylindrical to globular or oval; with light covering of dark setae; venter with chitinous depressions behind genital groove. Anterior spinnerets contiguous, slightly larger than other spinnerets; colulus large pointed with numerous setae. Female genitalia usually with sclerotised plate covering the internal genitalia; vulva paired with multiple spermathecae and scattered glands. Male palps are usually large; embolus basically slender; paracymbium often large and complex.

They occur in trees and rocks, leaf litter or plant debris, under stones and in dark places and ceilings of the houses or caves. They often construct webs that are irregular with long threads criss-crossing in an irregular fashion, more compactly in the centre sometimes. They hang upside down in the webs and when disturbed, vibrate so vigorously that they blur themselves in the eyes of the intruder. The females always carry the eggs in her chelicerae. They are represented by 84 genera, 1111 species occurring worldwide (Platnick 2011).

In India it is represented by 6 genera and 9 species so far (Sebastian and Peter, 2009).

Key to genera

1a. Opisthosoma cylindrical and elongated……………………………..**Pholcus**

1b. Opisthosoma short, oval, pointed dorso ventrally; with posterior prominence above the spinnerets……………..………...……**Crossopriza**

Genus Crossopriza Simon 1893

Spiders of the genus Crossopriza are widely distributed and usually found in corners of the houses. Carapace is circular with slightly raised and forwardly projected eye region; ocular quadrangle as long as wide and the posterior median eyes separated by space exceeding the diameter of an eye. Opisthosoma is short, ovate, posteriorly prominent and sloping abruptly away to the spinnerets and looks like a box. Opisthosoma is with dark patches and yellow spots. Legs spotted and streak. Male chelicerae with two pairs of distinctive apophysis; female genital plate with distinctive median sclerotised area

Species recorded from NDBR:

Crossopriza lyoni Blackwall 1867

Genus Pholcus Walckenaer 1805

Spiders of the genus Pholcus are cosmopolitan, usually found in old caves, forests, inside houses and old buildings. Carapace circular; slightly longer than broad; two triads of eyes are slightly raised. The distinguishing characters are extremely long legs with false segmentaion in the tarsi; median ocular area much broader than long and AME are closer to each other than to the ALE. The opisthosoma is cylindrical and elongated, approximately thrice as long as wide. Spinnerets are far removed from the epigastric fold. The male palpal tibia is swollen.

Species recorded from NDBR:

Pholcus phalangioides Fuesslin 1775; *Pholcus* sp.1; *Pholcus* sp.2

Family Pimoidae Wunderlich 1986 (False Linyphiids)

Diagnostic Characters:

Small to medium sized, ecribellate, nocturnal, entelegyne spiders. Carapace is pyriform, longer than wide; thoracic furrow a conspicuous ovate pit. Eyes eight, usually surrounded by pigment. Chelicerae are large, stridulatory striae present; labium free, wider than long. Legs long, often annulated, setose with many macrosetae; tarsi three clawed; autopsy at the patella-tibia junction; opisthosoma oval. Colulus is large and fleshy, with setae. Male palp with retrolateral integral paracymbium, a retrolateral cymbial sclerite articulated by means of membrane, and a dorsoectal cymbial process with cuspules and an alveolar sclerite. Conductor and median apophysis are present in most species. The embolus is continuous with the tegulum and has an elongated filiform or lamelliform embolic process. The epigynum protrudes more than its width, has a dorsal to lateral fold or groove with the copulatory openings at the distal end. The fertilization ducts are anteriorly oriented.

They are probably closest related to the family Linyphiidae and are Holarctic in distribution. They build large sheet webs close to the ground in hollow tree trunks, or under corners of banks, or caves. They are represented by 4 genera, 37 species occurring worldwide (Platnick 2011). In India it is represented by single genera and 3 species so far (Sebastian and Peter, 2009).

Genus Pimoa Chamberlin and Ivie 1943

Carapace is longer than wide with a conspicuous thoracic fovea. Anterior median eyes are very close together, larger than rest, which are roughly of the same diameter, anterior laterals and posterior laterals juxtaposed. Sternum longer than wide, pointed in the posterior region, slightly projecting between coxae IV. Chelicerae are large with three prolateral and three or four retrolateral teeth, stridulatory setae absent. Legs are slightly longer and slender in the adult male, femora through metatarsi usually with dark annuli. Male metatarsi I proximal third enlarged and sinuous, with a row of enlarged macrosetae. Tibiae I-IV with two dorsal spines, prolateral and retrolateral tibial spines present varying from one to two, ventral tibial spines varying from four to six; femora I-IV with dorsal spine in variable numbers, Metatarsal spines present in all legs. Opisthosoma ovoid, longer than wide, dark brown or grey with lighter marks and some guanine spots. Colulus is large and fleshy with setae. Male palp with retrolateral cymbial sclerite; palpal tibia usually round and lacking embolic flap.

Species recorded from NDBR:

Pimoa sp.1

Family Pisauridae Simon 1890 (Nursery Web Spiders)

Diagnostic Characters:

Medium sized to large, ecribellate, entelegyne spiders. Carapace is longer than wide; cephalic area distinct and often elevated. Eight eyes arranged in 2, 3 or 4 rows; at least one pair of eyes on lower tubercles. Cheliceral is lacking boss; fang furrow margins with teeth. Labium is longer than wide. Legs prograde, relatively long, sometimes laterigrade; with pairs of macrosetae on patellae, femora, tibiae and meta-tarsi; tarsi with trichobothria on the dorsal side; trochanters deeply notched and three clawed. Opisthosoma is oval to elongated, moderately high, tapering towards back; usually with plumosetae; with longitudinal bands or spots. Six spinnerets present. Epigyne is complex consisting of two integument folds, forming two lateral elevations with median area; Male tibial apophysis of palp prominent, cymbium usually elongated anteriorly.

They apparently have diverse lifestyle from being active hunters that are web building to free living. Some species can walk on water as well as land. Females carry the spherical egg sacs in their chelicerae. They are represented by 52 genera, 333 species occurring worldwide (world spider catalogue, 11.0). In India, it is represented by 9 genera and 20 species so far (Sebastian and Peter, 2009).

Keys to genera:

1a. Patella I-1V each with two dorsal spines …………………………….**Pisaura**

1b. Patella I-IV each with one prominent dorsal spine……………..**Perenethis**

Genus Perenethis C.L. Koch 1878

Spiders of the genus Perenethis are distributed in the Oriental, Australian, Ethiopian and Palearctic regions of the world. The genus is easily recognized from other genera in the family by the distinctly procurved AME and strongly recurved PLE; retromargin of chelicera with two teeth and promargin with three teeth; Prosoma and opisthosoma each with a distinct, moderately broad, and continuous longitudinal band.

Species recorded from NDBR:

Perenethis sp.1; *Perenethis* sp.2

Genus Pisaura Simon 1885

Spiders of the genus Pisaura are distributed worldwide. They are easily recognised by their slightly recurved anterior eye row; PME usually larger than anterior eyes; MOQ much wider behind than in front; dorsomedian band of Prosoma, if present, divided by a longitudinal narrow white stripe in the middle; chelicerae with three retromarginal and promarginal teeth each; patellae I-IV with two dorsal spines; tibia I bears four pairs of ventral spines; tibial apophysis of male's pedipalp distinctly developed.

Species recorded from NDBR:

Pisaura mirabilis Clerck 1757*;*

Pisaura sp.1*; Pisaura* sp.2

Family Psechridae Simon 1890 (Jungle cribellate spiders)

Diagnostic Characters:

Medium to large sized, cribellate, entelegyne spiders. Carapace pear shaped, with strongly narrowed cephalic region separated by the thoracic region. Eight eyes are arranged in two rows; both rows strongly procurved; posterior eye row wider than anterior eyes. Chelicerae is strong with distinct lateral condyle, boss prominent; promargin with three, retromargin with four strong teeth;

promarginal teeth with a longitudinal line of thin setae. Labium wider than long; gnathocoxae elongated; serrula present. Legs are long, leg formula 1423, longer in male; tarsi wider towards tip; with three toothed claws and a claw tufts; tarsi with a row of trichobothria; no scopulae. Opisthosoma is elongated, cylindrical; covered with setae. Six spinnerets, contiguous, two segmented, posterior pair longest; cribellum present, narrow and divided; calamistrum consists of three or four rows of equal, short, distally bent setae. Epigyne is simple, with median plate; male palpus tibia with apophysis or with modified setae; embolus present.

Psechrus are web building spiders, distributed from the South East Asia to the Australian region. They construct a horizontal sheet web provided with a funnel shaped retreat, moving on the under surface of the web. They are represented by 2 genera, 30 species occurring worldwide (Platnick 2011). In India it is represented by 2 genera and 5 species so far (Sebastian and Peter, 2009).

Genus Psechrus Thorell 1878

Spiders of the genus Psechrus are large, nocturnal, constructing horizontal cribellate webs, often found in caves in the Pacific regions of the world. Cephalic region is narrower, more prominently anteriorly. Eyes of anterior row recurved, median smaller than lateral, posterior row recurved, considerably behind the anterior row, quadrangle longer than wide. Legs long elongated, and with dark annulations. Ventrum of opisthosoma is provided with a median white line. Colulus present.

Species recorded from NDBR:

Psechrus himalayanus Simon 1906

Family Salticidae Blackwall 1841 (Jumping spiders)

Diagnostic Characters:

Small to medium sized, ecribellate, entelegyne spiders. They are recognised by unique anterior end of body broadly truncated, with 2 pairs of eyes on the face (anterior surface): large anterior median (AME), and smaller by half anterior lateral (ALE). Remaining two pairs of eyes (of II and III row) located on dorso-lateral edges of prosoma, restricted long quadrangle called eye field almost covering half of the prosoma. Body compact; carapace longer than wide, square-fronted; length varies from short to long; cephalic region high in some genera. Eye area frequently decorated with clusters of long setae. Eight eyes usually in three to four rows, occupying entire width of carapace; anterior four eyes directed forward, anterior median eyes very large; anterior laterals slightly smaller; posterior median eyes sometimes extremely small. Chelicerae are small to large, stout, Promargin with one tooth or several teeth; sometimes enlarged and projecting in males. Labium is rectangular or rounded and narrowed in front. Gnathocoxae fairly long, broadened distally with well-developed scopula and serrula. Legs short or slightly longer; prograde, I or IV leg longest; with two claws and usually with claw tufts. Short to oblong or elongated in some genera. Spinnerets are short, anterior and posterior pairs similar in length. Epigyne is variable; male palp with tibial apophyses; embolus variable in shape.

Salticids are diurnal, cursorial, hunting spiders with well developed vision and move by jumping and running; active hunters with complex behaviour. They are the largest family of spiders, abundant in tropics, occurring in a wide variety of habitats. Most salticids do not spin capture webs or use silk to catch prey. Silk is only used to build sac like retreats in which to moult, oviposit and sometimes mate. They are represented by 573 genera, 5337 species occurring worldwide (Platnick, 2011). In India it is represented by 66 genera and 192 species so far (Sebastian and Peter, 2009).

Salticidae are taxonomically extremely difficult group to study. The majority of the salticid subfamilies have not been properly defined, or diagnosed, and have undergone little or no change since they were first proposed by Simon (1901-03). However, his work possessed an extensive knowledge of the family Salticidae as he discussed the characters of his groups in details. Later on, Proszynski (1976) formulated modern keys to the salticids genera, especially of the Holarctic genera. The importance of Proszynski's study lies in its attempt at grouping these salticid genera solely on genitalic features.

Further, his study emphasized the point that salticid groups based on special genitalic features show little concordance with Simon's classification. Modern taxonomy of Salticidae regards classification based on genitalic features more authentic than non-genitalic features. The reliance on genitalic features in modern salticid systematics is exemplified by such currently recognized taxa as 'euophryines', 'dendryphantines', etc., which are defined exclusively on genitalic features. Here, I provide keys to the genera that have been collected in NDBR (mainly the Holarctic genera) and are described by Proszynski (1976) based on the genitalic characteristics.

Keys to genera

1a. Opisthosoma constricted, pedicel long and not hidden behind anterior part of opisthosoma (ant like body)……………….……………..…**Myrmarachne**

- In male, small coil of seminal receptacle in anterior half of round bulbus, embolus making 2 or more loops around the bulbus, tibial apophysis very small and hook like bent. Female epigynum with white membranous area located posteriorly, divided medially by internal sclerotized channels, prominently visible through membrane.

1b. Opisthosoma not constricted……………………………………………….**2**

2a. Prosoma long and low; Legs I strikingly larger than II and IV particularly in males………..……………………………………………….………….**Pseudicius**

- A row of stridulatory spines on tubercles under eyes lateral and corresponding micro-spines prolaterally on femur I, tibia I swollen medially with reduced rudimentary spines or devoid of them, and with several long a thin, usually bent sensory hairs, small spider.

2b. Prosoma high, if leg I larger, it is not very striking……….………..**Phlegra**

- Male bulbus relatively large oval, flattened - at least apically, embolus hidden beneath it with only tip protruding from under anterior edge, palpal tibia apophysis always bifurcated. In Females posterior openings are large and prominent located posteriorly, either medially or near posterolateral angle of epigynum and coiled spermathecae

2c. Prosoma giving no clear impression of being either high or low..…………...**3**

3a. Opisthosoma uniformly coloured, with or without white patterns…………**4**

3b. Opisthosoma with broad median light longitudinal streak……....**Plexippus**

- Male bulbus expanded laterally with short bent embolus anteriorly; Female epigynum sclerotized with posterior median groove; large or medium size spider.

4a. Abdomen uniformly black iridescent blue, violet or green, light reflecting due to colourless scales, in some species one or more pairs of small white marginal spots and a semi-crescent anterior line, legs often yellow, medium - small spiders……………………………………..…..**Heliophanus**

- Male pedipalpal femur with large horn like protuberance is single, bifurcated or trifurcated. Female epigynum with either single or two separate sclerotized depression round or transversally oval, sometimes partially or entirely surrounded by an elevated rim, copulatory openings usually located laterally or, more rarely postero-marginally, or hidden under rim, with channels and spermathecae short and simple.

4b. Abdomen dark with pairs of transversal or diagonal white stripes or their rudiments but no median line, in male chelicerae overgrown……**Salticus**

- Male palpal organ with large and broad apophysis, bag shaped bulbus and short embolus. Female epigynal depression extended by posterior elongate part, sometimes anteriorly hidden under a roof like rim, channels and spermathecae complex.

4c. Abdomen black with contrasting white line, continuous or interrupted, in some species there are one or two pairs of diagonal white lines marginally and thick anterior line, on cephalothorax in some species white spots behind eyes III and median white line..……………….…………....**Pellenes**

- Male bulbus oval with embolus usually bifurcated, tibial apophysis supported on some kind of swelling of cymbium. Female epigynum sclerotized with median ridge separating two semicircular grooves, location of vaginal opening varies from anterior to posterior in various species.

Genus Carrhotus Thorell 1891

Spiders of the genus Carrhotus are widespread mainly occurring in the Palaearctic, oriental and the tropical regions of the world. Usually they are small to medium sized spiders with a conspicuous, longer than wide prosoma with distinctly sloping posterior. Ocular quadrangle is wider than long with posterior median eyes midway between anterior lateral and posterior laterals. Legs are long and slender. Opisthosoma is perfectly oval, blackish general colouration with chevron pattern in some. Unident chelicerae present with two teeth on promargin and one on retromargin.

Species recorded from NDBR:

Carrhotus sp.1*; Carrhotus* sp.2*; Carrhotus* sp.3*; Carrhotus* sp.4

Genus Hyllus C.L. Koch 1848

Spiders of the genus Hyllus are widespread and their range stretches from Africa through the tropics to Australia, some Pacific islands, as well as China and Japan mainly occurring in the tropical regions of the world. Stout and hairy with dull coloured body. Carapace oval, broad, slightly longer than broad and truncated at the rear end; fairly high with long sloping thorax and steep sides; cephalus is relatively smaller and slightly convex. Ocular is quadrangle with virtually parallel sides, posterior eyes of moderate size, separated from the small eyes of the second row by more than the width of one posterior eye; small eyes of the second row. Legs long, stout dark in colour, with spines and hairs; front legs usually covered with dense fringes to thin black hairs; legs I longest. Opisthosoma oval, rounded at the front.

Species recorded from NDBR:

Hyllus sp.1; *Hyllus* sp.2

Genus Phintella Strand 1906

Spiders of the genus Phintella are wide spread mainly occurring in the paleartic region and from India and Srilanka to java and philipines. Prosoma and opisthosoma covered with scales. Opisthosoma is either dark with medium light streak or spotted, sometimes with contrasting transverse belts. Anterior edge of opisthosoma is in some species divided by a shallow furrow. Palpal organs with two prolonged tibial apophysis, both of which may be developed and reduced in different degree in which they resemble Pseudicius. Bulbous is simple, embolus fleshy extension of main body of bulbus, gradually tapering, and its narrow part usually very short. Epigyne is in a form of simple depressed weakly sclerotised plate with simple straight or gently bent channels and spherical spermathecae. Femur I and tibia I are increased in length without distinct swelling of any other segment. Femur also provided with darkened ventral prolateral surface in a form of line or spots. Spination of tibia I consists of 2-3 pairs of ventral spines. Hairs on tibia I is normal in some specimen with sparse ventral brush of very thin short setae extending along patella.

Species recorded from NDBR:

Phintella sp.1

Genus Phlegra Simon 1876

Spiders of the genus Phlegra are widespread in the Palaearctic and in Africa. In South East Asia it is known only from Vietnam and Hong Kong. Prosoma is brown with the eye field black brown. There are two, parallel, longitudinal lines, pale whitish grey streaks on the thorax and along the lateral margins. The opisthosoma is grey brown to dark grey in colour with orange spots anteriorly. These gradually change to grey, posteriorly and vanish. Legs are greyish dark brown in colour and carry numerous light brown spines. Usually they occur in warm, stony or bare areas. Female's posterior openings are large and prominent located posteriorly, either medially or near posterolateral angle of epigynum and coiled spermathecae, medial, with internal convoluted chambers. In male, bulbus relatively large oval, flattened - at least apically, embolus hidden beneath it with only tip protruding from under anterior edge, palpal tibia apophysis always bifurcated.

Species recorded from NDBR:

Phlegra sp.1

Genus Pseudicius Simon 1902

Spiders of the genus Pseudicius is very widespread but according to Proszynski is absent from the New World. Carapace is more or less oblong, about twice as long as wide. The sides are slightly curved and the rear margin is wide and truncated. The long opisthosoma has similar proportions to the carapace, with the sides rather more curved, truncated and wide anteriorly and curving to a point near the spinnerets. A row of stridulatory spines on tubercles under eyes lateral and corresponding micro-spines prolaterally on femur I, tibia I swollen medially with reduced rudimentary spines or devoid of them, and with several long and thin, usually bent sensory hairs. The femora, patella and tibia of legs I are enormously swollen compared with all the other leg segments. The legs of the female are not particularly long, but legs I of the male are very long compared with its other legs. Legs have reduced, variable spines, with one short, robust spine and two minute strong spines on the inside of tibiae I and a few weak spines here and there on the other legs.

Species recorded from NDBR:

Pseudicius sp.1; *Pseudicius* sp.2

Genus Siler Simon 1889

Spiders of the genus Siler is commonly found from Malaysia and Sumatra to Japan and Papua New Guinea in the east. Carapace has flat cephalus, with the long thorax sloping steadily from the rear eyes to the posterior edge and almost vertical sides. In plan the carapace U Shaped, briefly flared near the front lateral eyes and has moderately truncate posterior margin. The opisthosoma is elongated oval, widest in the rear half and truncated anteriorly. The moderately spiny legs are quite long and slender, with legs I more robust than the other and legs IV noticeably the longest. The femora and patella of legs I are squarish yellow and tibia are brown. Above and below the tibia I there are dense fringes of black hairs and to a lesser below femora I and patella I.

Species recorded from NDBR:

Siler sp.1; *Siler* sp.2

Genus Plexippus C.L. Koch 1846

Spiders of the genus Plexippus are distributed in the belt bounded by southern Central Asia to Japan in the north and by Africa to Papua New Guinea in the south. Most of the species recorded in the New World and Australia have been transferred to other genera. Body colour in female dull sand yellow; male dark brown to brownish black in general background colouration. Carapace oblong, longer than wide, truncate at posterior and curved upwards towards the front row of eyes. Ocular quadrangle is wider than long, dark brown. Anterior row of eyes moderately recurved. Males are usually with a conspicuous white or dull white dorso-median band from the lower margin of ocular quadrangle to posterior end of Prosoma. Legs spiny, light brown with tibia and metatarsi of legs I darker. Opisthosoma is elongated, roughly oval, with hunched shoulders anteriorly; broad median light longitudinal streak and posteriorly with a pair of lateral spots and a few chevrons. Palpal organ in male thick, sclerotised, dark brown with almost rectangle bulbus and sharply pointed, slightly curved inwards; bulbus expanded laterally with short bent embolus anteriorly. Tibia with a tuft of long hairs. Cymbium is broad, flat and hairy. Epigyne appears as with a transverse base and median upward canal; sclerotized with posterior median groove

Species recorded from NDBR:

Plexippus paykulli Audouin 1826*; Plexippus* sp.1*; Plexippus* sp.2

Genus Rhene Thorell 1869

Spiders of the genus Rhene are widespread occurring mainly in the Oriental regions of the world from Africa to Japan, Philippines and Sulawesi. There are a few species recorded from Central America and Brazil. They are often found on low vegetation and plant foliage. Carapace is oblong, wider than long, posterior portion of prosoma wider than anterior; Clothed with conspicuous thick hair. Small conspicuous eyes; posterior eyes situated far behind the anterior row of eyes, with. The sides and most of the thorax are vertical, with the rear margin very wide and truncate. The opisthosoma is oval, small, with broad base and blunt tip; slightly truncate at the front and slightly pointed at the rear. The legs are fairly sturdy with the femora, patellae and tibiae noticeably swollen. Legs are small, sturdy, tibia of first pairs broad and flat. Leg I more robust and hirsute than legs II-IV. Palpal organ is with swollen bulbus and short curved conductor. Epigyne is not very conspicuous.

Species recorded from NDBR:

Rhene flavigera C.L. Koch 1846; *Rhene danielli* Tikader 1973; *Rhene* sp.1

Genus Myrmarachne MacLeay 1839

Spiders of the genus Myrmarachne are ant mimics, well distributed in the world. Myrmarachne occurs in the tropical belt from Africa to Australia, but several species also occur in the warmer parts of the Old World and in the tropics and warmer parts of the New World. Body, long and narrow; colour varies from reddish orange, to brown and black. Carapace elongated roughly rectangular with a flat ocular quadrangle, separated from the thoracic region by a constriction. Ocular trapezium is nearly as along as broad and distinctly elevated above opisthosoma. Chelicerae with several teeth on inner margin; chelicerae very long and strong developed in male. Chelicerae are swollen and generally elongated. Opisthosoma is also elongated, oval or spherical according to the ant model. Legs are slender with long segments. Palpal organs are with round and swollen bulbus and long coiled embolus. Cymbium is roughly oval in shape. Epigyne sclerotised with usually kidney shaped spermathecae and anteriorly projecting copulatory ducts; white membranous area located posteriorly, divided medially by internal sclerotized channels, prominently visible through the membrane. In male, small coil of seminal receptacle in anterior half of round bulbus, embolus making 2 or more loops around the bulbus, tibial apophysis very small and hook like bent.

Species recorded from NDBR:

Myrmarachne orientales Tikader 1973; *Myrmarachne* sp.2;

Myrmarachne sp.3

Genus Stenaelurillus Simon 1885

Spiders of the genus Stenaelurillus are widespread in Africa while single species recorded from Tibet, India, Myanmar and China. Carapace is oblong, slightly narrower in front and slightly curving to broadly truncated rear; two white longitudinal stripes on the carapace. Basically black in colour with a dense black pubescence, the cephalus is rust coloured and there is a whitish, curved, wide stripe on each side. The opisthosoma has a wide transverse whitish band in front and a narrower one near the spinnerets. In between, the opisthosoma is clothed with black pubescence, surrounding two whitish, circular spots and some other white marks. The legs are black except for the tarsi. Ocular area is with strong bristles, present in both sexes. Male palp with a short, more or less straight, not coiled, visible embolus. Tegular apophysis is visible, simple, finger-like, and situated some distance from embolus.

Species recorded from NDBR:

Stenaelurillus sp.1

Genus Thiania C.L. Koch 1846

Spiders of the genus Thiana are widespread occurring from India and Sri Lanka, throughout our region and on to Papua New Guinea. Carapace flat, rather broad but still rather longer than broad. In plan, sides are almost straight, converging very slightly to very wide anterior and curving to a wide truncated posterior. The opisthosoma elongated, rounded at front and converging steadily to the spinnerets. Typically the cephalus is black or dark brown and followed by broad, crescent shaped band of iridescent, bronze coloured squamose hairs, the sides and the rest of the thorax are brown. Leg I swollen and larger than others. Legs I and II are brown while III and IV are yellow except for brown femora.

Species recorded from NDBR:

Thiania sp.1

Thiania sp.2

Genus Salticus Latreille 1804

Spiders of the genus Salticus are largely Palaearctic in distribution with some species reaching the Mediterranean region and southern Asia. Usually found on rocks and tree trunks in the open where the sun can reach. Prosoma is dark with pairs of transversal or diagonal white stripes or their rudiments but no median line. Carapace is fairly flat, long and U-shaped. In male the chelicerae is overgrown. The legs may have long black and white stripes. Metatarsi I is without macrosetae. The opisthosoma is oval and about twice as long as broad. It is greyish-white in colour. Opisthosoma are typically marked with a black and white pattern. Mature males have characteristically long and stout, forward pointing chelicerae on which they rest their long, thin palps. Female epigynal depression extended by posterior elongate part, sometimes anteriorly hidden under a roof like rim, channels and spermathecae complex.

Male palpal organ with large and broad apophysis, bag shaped bulbus and short embolus.

Species recorded from NDBR:

Salticus sp.1

Genus Pellenes Simon 1876

Spiders of the genus Pellenes are commonly found on warm walls, rocks and tree trunks in the open. Opisthosoma usually black with contrasting white line, continuous or interrupted, in some species there are one or two pairs of diagonal white lines marginally and thick anterior line. In some species prosoma has white spots behind eyes III and median white line. Male embolus short, hidden by tegular apophysis; latter never elbowed, arising laterally to distally. Distal cymbial groove not transverse; lacking conspicuous courtship ornaments. Female epigynum with copulatory openings on surface posterior to surface; sclerotised bars absent; also sclerotized with median ridge separating two semicircular grooves.

Species recorded:

Pellenes sp.1*; Pellenes* sp.2

Genus Heliophanus *C*. L. Koch, 1833

Spiders of the genus Heliophanus are dark brown to black in colour, often with a metallic sheen. Carapace is moderately high and, in plan, is an elongate, broad oval, widest towards the rear and slightly truncated at the front. Legs short, stocky lighter in colour, sometimes being bright yellow, and contrast markedly with the dark body; few spines present. There is often a white narrow band running along the anterior edge of the opisthosoma and often two small white spots set transversely across the opisthosoma near the spinnerets. Opisthosoma elongated, broad oval, rounded anteriorly and somewhat tapering posteriorly. Spinnerets are small and located at the extreme tip of the opisthosoma. Large femoral apophysis present on palps. Epigynum with either single or two separate sclerotized depression round or transversally oval, sometimes partially or entirely surrounded by an elevated rim, copulatory openings usually located laterally or, more rarely postero-marginally, or hidden under rim, with channels and spermathecae short and simple. In male, pedipalp femur large horn like protuberance which are single, bifurcated or trifurcated present.

Species recorded from NDBR:

Heliophanus curvidens Pickard-Cambridge O., 1872

Family Scytodidae Blackwall 1864 (Spitting spiders)

Diagnostic Characters:

Very small to medium sized, ecribellate, haplogyne spiders. Carapace convex, short, broad and almost circular, domed towards the thoracic region; fovea absent; cephalic region usually raised. Six eyes are arranged in three groups, strongly recurved; the anterior median small and black, forming a group; the rest are large and white. Chelicerae is chelate, weak, basally fused and cylindrical in shape; fangs very short; conspicuous chitinous lamina. Legs are long and slender; metatarsi longer than tarsi; spines absent; three claws. Opisthosoma shape is variable, broad, oval with large, pointed with numerous setae. Six spinnerets, small, contiguous with reduced spigots; anterior spinnerets long and cylindrical; colulus large. Epigyne simple, with sclerotised modifications posterior to epigastric furrow; male palpal tarsus apically attenuated; bulb spherical with simple or with apical projection embolus.

They are unique, nocturnal, cursorial, wandering spiders, in their prey capture methods, as they spit strands of glue from their fangs on the prey. Females build silken retreats for laying eggs. They are represented by 5 genera, 228 species occurring worldwide (Platnick 2011). In India it is represented by 1 genus and 9 species so far (Sebastian and Peter, 2009).

Genus Scytodes Latreille 1804

Spiders of the genus Syctodes are nocturnal, usually found under bark and leaf litter. They are widely distributed in the temperate and tropical regions of the world. Carapace high lacks fovea or thoracic impressions, hump posteriorly, pale yellow with numerous black mottles forming irregular lines or patterns. Six small eyes are arranged in three widely spaced diads, all AME pair much ahead of the laterals eyes. Labium fused to sternum. Chelicerae chelate with very, short squat fang and conspicuous chitinous lamina on the outer margin of the basal segment. Legs annulated, long and slender with hind coxae widely separated. The opisthosoma is ovoid to subglobular, mottled like carapace, venter with an indistinct median tracheal spiracle nearer to the spinnerets than to the epigastric furrow. Spinnerets are small; colulus slightly conical. Epigyum absent, represented by oblique sclerotised pits. Female carries its spherical egg cocoons in its chelicerae held against the sternum.

Species recorded from NDBR:

Scytodes thoracica Latreille 1802*; Scytodes* sp.1

Family Segetriidae Simon 1893 (Tube web spiders)

Diagnostic Characters:

Medium sized, ecribellate, haplogyne spiders. Carapace is rectangular to elongate and nearly cylindrical; longer than wide. Fovea is a small depression. Six eyes are in three groups, all white; PER in straight to slightly procurved row. Chelicerae free, long and slender, fang small; cheliceral furrow with few teeth; promargin with three teeth and retromargin with one or two teeth. Labium much longer than wide; gnathocoxae parallel, longer than wide, well developed. Serrula well developed in a single row. Legs I, II and III directed forward; tibiae and metatarsi I with double row of spines ventrally; no trichobothria; curved with series of 6-8 teeth. Opisthosoma is longer than wide, cylindrical or elongated; without pattern or with pattern. Six spinnerets present; anterior lateral spinnerets conical and contiguous; posterior spinnerets small. Colulus present. Female gonopore region is swollen with some sclerotised anterior margin; male palpal tarsus short and long.

Segistriids are nocturnal, sedentary hunters. Most spiders are living under stones, in trees, holes and rocks crevices, making tube with both ends open. They are represented by 3 genera, 111 species occurring worldwide (Platnick 2011). In India it is represented by 2 genera and 2 species so far (Sebastian and Peter, 2009).

Genus Segestria Latreille 1804

Spiders of the genus Segestria are distinguished by the presence of median dark stripes on the opisthosoma which are broken into chevrons and with lateral and ventral spots. Legs banded, relatively long; chelicerae retromargin with two teeth; male palpus tarsus long and apically attenuated; male metatarsus I straight and lacking lateral processes

Species recorded from NDBR:

Segestria sp.1

Family Selenopidae Simon 1897 (Flat bodied spiders)

Diagnostic Characters:

Small to large, ecribellate, entelegyne spiders. Carapace dorsoventrally flattened, sub circular; cephalic region distinct, thoracic region laterally convex; fovea longitudinal. Eyes are eight in two rows wide with six eyes near edge of carapace, posterior row with two fairly large eyes, one on each side. Chelicerae is geniculate, robust, with teeth on both margins of the furrow; fangs large. Labium is usually wider than long; gnathocoxae straight with dense scopulae and fine serrula. Legs laterigrade; anterior legs provided with strong, paired setae on tibiae and metatarsi I and II; two smooth claws; tarsi two clawed and scopulae present; trichobothria present on all the leg segments. Opisthosoma flattened, round to oval; mottled, clothed in dense setae; slightly truncated posteriorly. Six spinnerets present; anterior pair adjacent, short, in compact group; Colulus absent. Epigyne is complex with central septum, spermathecal openings at the caudal end of the median guide; male palp with retrolateral tibial apophysis, rigid conductor and short embolus.

They are free living, agile spiders found on rocks, tree trunks and walls of houses. They are able to move into narrow crevices because of their extremely flattened bodies. They are represented by 5 genera, 196 species occurring worldwide (Platnick 2011). In India it is represented by 1 genus and 6 species so far (Sebastian and Peter, 2009).

Genus Selenops Latreille 1819

Spiders of the genus Selenops are nocturnal wandering spiders found in forest floor in litter or near habitations. Body is extremely flat and move sidewise. Prosoma almost circular with cephalic part projecting forwards and the wide posterior margin smoothly indented. Six eyes in the front row spread out in the edge of the projected area. Posterior eyes located just behind the extreme eyes of the anterior row. Opisthosoma flat, as wide as long and it is widely truncated at the front and then gently curving and divergent until near the rear where it curves in abruptly towards the spinnerets. Legs long, strong and laterigrade with strong spines mostly on the ventral surface, scopulae underneath tarsi I to III and under metatarsi I and II.

Species recorded from NDBR:

Selenops radiatus Latreille 1819

Family Sparassidae Bertkau 1872 (Huntsman spiders)

Diagnostic Characters:

Medium to very large sized, ecribellate, entelegyne spiders. Carapace is broadly oval, as long as wide, narrower in front. Fovea is present, longitudinal, covered with dense layer of fine setae. Eight eyes in two rows; size of anterior eyes varies between genera, median eyes usually largest; posterior eye row evenly spaced. Condyle is present. Labium is free, short, never beyond the half length of gnathocoxae; rebordered distally; gnathocoxae with thick scopulae; serrula present. Legs long, laterigrade; trochanters notched; apex of metatarsi with soft trilobate membrane; metatarsi and tarsi with scopulae; two claws with dense tufts. Opisthosoma longer than wide, dorsoventrally flattened, round to oval, often with dark, median, heart shaped mark; clothed in dense layer of fine setae. Colulus is absent. Epigyne is sclerotised and conspicuous; usually with anteriorly bordered atrium. Male palp is with strong tibial apophysis.

Sparassids are free living, nocturnal, wandering and ambushing spiders with diverse life styles. They do not spin webs, only build silk retreats. The female of some species carry their egg sac underneath the body by clasping it with their pedipalp. They are represented by 85 genera, 1109 species occurring worldwide (Platnick 2011). In India it is represented by 11 genera and 85 species so far (Sebastian and Peter, 2009).

Keys to subfamilies

1a. Possess three anterior and four posterior teeth with denticles on the margins of cheliceral furrow, and the teeth of female palpal claw are long and curved.....……………………………………………………………**Heteropodinae**

1b. Possess two cheliceral teeth on the promargin……………......**Sparassinae**

Subfamily Heteropodinae Thorell 1873

Key to genera:

1a. Male palp with membranous conductor, embolus at least in its proximal part broadened, tegulum as long as bulb, RTA arising in a mesial or basal position…………………………..…………………..……………….**Pseudopoda**

1b. Male palp with sheath like conductor, embolus filiform, RTA arising in a distal position ……………………………………………………….……….**Heteropoda**

Subfamily Sparassinae Bertkau 1872

Diagnostic Characters:

Key to genera

Presence of a retro-lateral tegular apophysis and distal loop of embolus in male; posterior row of eyes procurved; lateral eyes not very prominent; tibia I with 2 pairs of ventral macrosetae..…………………………………………...**Olios**

Genus Heteropoda Latreille 1804

The genus Heteropoda is pantropical in distribution. Carapace nearly as long as wide, upper surface nearly flat or sometimes very high posteriorly; cephalic part slightly depressed in front. Posterior row of eyes recurved, the lateral eyes larger and prominent; eyes of anterior row straight or little procurved, anterior lateral larger than median. Ocular quadrangle longer than wide, narrow in front. Femora not provided with fringed bristles. Opisthosoma mostly longer than wide, dorsum with marks more prominent posteriorly. Epigynum provided with a pair of lobes usually separated by a median septum; male pedipalp with developed RTA, embolus short or long, tegulum without apophysis; sheath-like conductor present; ejaculatory duct prominent; female epigynum with a pair of lobes, separated by a median septum.

Species recorded from NDBR:

Heteropoda venartoria Latreille 1804*; Heteropoda* sp.1*; Heteropoda* sp.2

Genus *Pseudopoda* Jäger 2000

Spiders of the genus Pseudopoda are distributed mainly in the mountain areas of Asia; usually occurring in leaf litter, forest floor, bark of trees, under logs and rocks. Opisthosoma dorsally mostly with bright transversal band in the posterior half, opisthosoma ventrally mostly with dark patch in front of the spinnerets. Femora with spines. Epigynum is with lateral lobes extending distinctly beyond the epigastric furrow and covering the median septum. Male palp with membranous conductor, embolus at least in its proxima part broadened, mostly whole embolus broadened and flattened tegulum as long as bulb.

Species recorded from NDBR:

Pseudopoda prompta O. Pickard-Cambridge 1885

Pseudopoda sp.2; *Pseudopoda* sp.3; *Pseudopoda* sp.4

Genus Olios Walckenaer 1837

Spiders of the genus Olios are mostly distributed in the Australasian and Neotropical regions also found in Southern Europe and Africa. Olios species have anterior median eyes as large as or larger than the anterior laterals; clypeus lower than the diameter of an anterior median eye; and tibia I usually with only two pairs of ventral spines, none at the distal end of the segment.

Species recorded from NDBR:

Olios sanguinifrons Simon 1906

Olios sp.1*; Olios* sp.2

Family Tetragnathidae Menge 1866 (Long jawed orb weavers)

Diagnostic Characters:

Small to very large, cribellate, entelegyne spiders. Carapace is longer than wide; cephalic region narrow. Eight eyes arranged in two rows, lateral eyes contiguous or apart. Chelicerae variable, short and stout or long and well developed with rows of large teeth and projecting spurs. Labium longer than wide, gnathocoxae longer, narrower, distally widened. Legs long and slender, with or without spines; leg I longest; tarsal three clawed. Opisthosoma is variable, elongated and cylindrical or rounded to ovoid. Spinnerets are six in number, with aggregate glands producing viscid silk; anterior and posterior spinnerets similar in size. Colulus present. Epigastric furrow is nearly straight; spinnerets unmodified, anterior and posterior pairs similar in size.

Tetragnathids are orb weavers occupying a variety of habitats constructing their webs in moist areas of vegetation near or above streams or ponds. Occurring sometimes also in ground litter, hollow stems, under stone, dead wood or leaves. They are represented by 46 genera, 951 species occurring worldwide (Platnick, 2011). In India it is represented by 10 genera and 47 species so far (Sebastian and Peter, 2009).

Keys to genus

1a. Opisthosoma cylindrical or tapering; more than twice as long as wide…………….....…………………………………………………………………….**2**
1b. Opisthosoma oval or globular……………………………….**Dyschiriognatha**

2a. Chelicerae enlarged with 5-9 teeth; gnathocoxae divergent; epigynum absent……………………………………………………………........**Tetragnatha**
2b. Chelicerae and epigynum otherwise………………………………………….**3**

3a. Epigyne with no scape having spiral openings on ventral side…………………………………………………...……………**Guizygiella**
3b. Epigyne with scape having spiral openings on ventral side……………………………………………………………………………..**4**

4a. Opisthosoma with or without humps; anterior part not overhanging the carapace……………………….…………..……………………..……...**Leucauge**

4b. Opisthosoma widest anteriorly; chelicerae retromargin with three teeth…………………….……………….………………………..……**Metellina**

Genus Metellina Chamberlin & Ivie 1941

Spiders of the genus Metellina build their small to moderately large orb webs in open shrubs, fields, forest or gardens. They are distinguished by the presence of the large paracymbium; small slender embolus apophysis, and by the moderately large, bilobed and well-separated spermathecae. The web varies in orientation, even within species, from nearly vertical to nearly horizontal and has an open hub. When hunting, the spider often wraps its prey, hangs it in the web, and returns for an interval of time to the hub before feeding.

Species recorded from NDBR:

Metellina sp.1

Genus Dyschirognatha Simon 1893

Spiders of the genus Dyschirognatha are distributed in Palaearctic, Ethiopian, Neotropical and Oriental regions of the world. They are distinguished by their globose silvery opisthosoma with or without dorsal spots; cephalic region higher than thoracic region, heavily sclerotised sternum extended posteriorly between coxae IV; rough and moderately stout chelicerae with teeth, sub equal eyes except small PLE. MOQ often square, AME slightly projected anterior to clypeus, legs without spines, female tracheal spiracle between epigastric fold and spinnerets, male palp with a strongly rounded bulb, slender paracymbium without or with a reduced prolateral process, embolic division with sclerotised and membranous structure apically with serrated row of teeth.

Species recorded from NDBR:

Dyschirognatha sp.1

Genus Leucauge White 1841

Spiders of the genus Leucauge are builders of large webs in low shrubs, plant foliage, trees and open habitats, in damp places such as marshes or rainforests. They can be distinguished by the cluster of long trichobothria on femur IV; broadly elliptical silvery opisthosoma and the transverse depression anterior to the dorsal groove. Carapace constricted laterally towards the cephalic area, producing a prominently broad thoracic area and truncate anteriorly. Fovea is deep and directed posteriorly. Legs I and II are long and slender, femora IV with a double fringe of hairs or trichobothria prolaterally in the basal one half. Opisthosoma is twice as long as wide, blunt at both ends and ornamented with bands or spots of silvery pigment with or without pairs of tubercles. Epigastric plate is without any furrow. Small hooklike paracymbium is present. Males and females differ little in size. Spins webs that are often large vertical to almost horizontal also occasionally reusing the frame and anchor lines.

Species recorded from NDBR:

Leucauge decorata Blackwall 1864*; Leucauge celebesiana* Walckenaer 1841
Leucauge sp.1*; Leucauge* sp.2

Genus Tetragnatha Latreille 1804

Spiders of the genus Tetragnatha are moderately large inhabitants of trees, shrubs and tall grass in meadows; often constructing orb webs usually in vegetation near or above steams and ponds. Body prominently long and narrow, several times longer than wide. Carapace oval, widest near the middle, flattened above, with a conspicuous thoracic groove. Prosoma is longer than wide, eyes arranged in two rows, lateral eyes nearly contiguous; chelicerae very long, especially in the male. Opisthosoma long and narrow and bears the spinnerets near its end. Eye rows either parallel or converge; each eye surrounded by a black ring. Chelicerae well developed, especially in the males, margins of fang furrow provided with numerous teeth. Males have a strong projecting clasping spur that may or may not be bifid at its tip. Maxillae parallel, long and dilated at the distal ends. Opisthosoma at least twice as long as wide in females, often swollen at base and overhangs the prosoma. Epigynal slit posterior to lungs slits in the procurved epigastric furrow, spinnerets usually terminal or almost so. Legs and palpi very long and thin, but proportion differs in various species. These are orb weaving spiders;

common on grass and on low plants. The webs are usually inclined from the vertical, sometimes horizontal, hub is often open.

Species recorded from NDBR:

Tetragnatha maxillosa Thorell 1895

Tetragnatha sp.2*; Tetragnatha* sp.3

Genus Guizygiella Zhu Kim & Song 1997

Spiders of the genus Guizygiella are nocturnal orb webs builders, usually found on shrubs, tree trunks, and plant foliage. They are distinguished from those of other orb-weaver genera by the plump ornamented smooth, elliptical opisthosoma, also by the flattened paracymbium. Carapace is usually higher than the thoracic region with very few hairs. Anterior median eyes large; Ocular quadrangle as long as it is wide in front and slightly narrower behind than in front. Legs are usually with annulations. Opisthosoma is with no humps and with patterns of paired dark patches. Epigyne variable with a posterior median depression may or may not have scape; scape when present not wrinkled. Palpal patella of male is with a single large spine like hair, femur of palp lacking proximal ventral teeth. They build vertical orb webs with many radii which feature a vacant sector in the upper half, a signal line extends from the hub through the vacant sector to the retreat. Usually hides in a curled leaf retreat, with its front legs on a signal thread running to the centre of the web.

Species recorded from NDBR:

Guizygiella sp.1; *Guizygiella* sp.2; *Guizygiella* sp.3

Family Theridiidae Sundevall 1833 (Cob web weavers)

Diagnostic Characters:

Very small to medium, sized ecribellate, entelegyne spiders. Carapace variable, usually longer than wide, clypeus is usually high. Eight eyes are in two rows usually encircled by brownish rings. Chelicerae are weakly sclerotised, usually without retromarginal teeth. Anterior margin of labium not thickened, gnathocoxae are longer than wide and converging distally. Legs variable, moderately long to very long; tarsi three clawed, usually tapering towards tip. Tarsi IV is with a series of serrated bristles forming a comb on its ventral side. Opisthosoma is variable in shape from oval to round. Six spinnerets, colulus often absent. Epigyne is variable; 1 or 2 pairs of spermathecae; male palpal tibia conical, often short; palp with or without paracymbium.

They are widely distributed, constituting a diverse group of spiders occurring in a variety of habitats, building space-webs radiating in different direction. Aggregate silk glands are present in Theridiids. Sticky silk is used to wrap prey. They are represented by 113 genera, 2310 species occurring worldwide (Platnick, 2011). In India it is represented by 19 genera and 58 species so far (Sebastian and Peter, 2009).

Key to genera

1a. Colulus and paired setae absent…………………………………….….…….**2**
1b. Colulus large to small or reduced to pair of seate only…………………….**4**

2a. Opisthosoma longer than wide, high with distinct, long spines postero dorsally above spinnerets, sometimes sub-triangular in lateral view…………………………………………………………………...**Chrysso**
2b. Opisthosoma without distinct long spines posterodorsally……........……**3**

3a. AME diameter greater than PME; PE row usually straight to slightly recurved…..……………...………………………………………… **Parastaetoda**
3b. AME diameter equal to or smaller than PME; PE row commonly straight and LE contiguous……………..……………………….……………**Theridion**

4a. Carapace bears a deep and transverse groove in the thoracic area; opisthosoma extended above and posterior to spinnerets, placing spinnerets almost midway between pedicel and distal end of opisthosoma………………………………………………………......**Argyrodes**
4b. Carapace without transverse groove in the thoracic area………...……..**5**

5a. Opisthosoma with tubercle on each side…………………….……**Theridula**
5b. Opisthosoma without distinct tubercle……………………………….…..…..**6**

6a. Opisthosoma longer than wide, widest posteriorly with median posterior or lateral humps…………………………..…………………………..**Episinus**

6b. Opisthosoma sub-triangular, pointed behind……………………..….. **Euryopis**

7a. Opisthosoma divided into diluted transverse spots of white lines………………………………………………….…………….……**Phylloneta**

7b. Opisthosoma otherwise…………………………………………...…………**8**

8a. Female without teeth on cheliceral retromargin; male chelicerae as in female; paracymbium dorsal in cymbium, usually hidden behind bulb….…...**Steatoda**

8b. Female with tooth on cheliceral retromargin; male chelicerae larger than females; palpal paracymbium on margin of cymbium; coloration various……………………………………………….……….….…**Enoplognatha**

Genus Phylloneta Archer 1950

Spiders of the genus Phylloneta are mainly Holarctic in distribution and prefer usually dry and open areas for building its web. Opisthosoma is round, light yellow in colour with dark brown bands and white stripes with black dots at the sides and prominent dark yellow colour in the centre. Dark bands on the opisthosoma divided into diluted transverse spots of white lines. Females measure about 4-4.5mm in length while the males are smaller about 3-3.5mm length. Prosoma is brownish yellow in colour margined with black lining and a black central band. Legs are thin, slender with dark patches at the joints. Webs of this genus are typical of Theridiidae tangle web, with the egg sac in the centre and irregular threads spun around it. The egg sacs are round and dirty grey in colour. Each egg sac may contain about 50-100 eggs. Female guards the cocoon and remains in the centre of the web hidden in the irregular mesh of silk. When the spiderlings emerge out they are initially cared by the mother and after staying for sometime in the web they disperse from the web.

Species recorded from NDBR:

Phylloneta impressa C.L. Koch 1881; *Phylloneta* sp.1

Genus Enoplognatha Pavesi 1880

Spiders of the genus Enoplognatha are medium sized usually found on shrub or foliage. Carapace slightly longer than wide; male carapace bears a stridulating area on the lateral sides of the pedicel; cephalic region slightly raised and narrower than thoracic region. Eyes subequal in size or anterior medians slightly smaller; AE row straight viewed frontally and PE row straight as seen from above; coxae IV separated by about one half their diameter. Chelicerae well enlarged in male and female chelicerae each with teeth in promargin and a tooth in the retromargin; leg I is as long as IV, III shortest; opisthosoma globular slightly flattened dorsoventrally, male opisthosoma with a rasp of setae on a more or less sclerotised carina above pedicel; colulus between anterior spinnerets, two setae at base or sides of colulus. Male pedipalp has a distinct ventral radix supporting embolus; non-functional conductor projecting above radix; female epigynum heavily sclerotised with a pair of seminal receptacles. They are usually white or light-colored, while the ground or litter forms are dark-colored building irregular webs near to the ground level vegetation.

Species recorded from NDBR:

Enoplognatha sp.1; *Enoplognatha* sp.2

Genus Euryopis Menge 1868

Spiders of the genus Euryopsis are widely distributed in world. Opisthosoma usually triangular, widest anteriorly; male palpus without median apophysis; male carapace not modified ; fourth leg commonly longer than first dorso-ventrally flattened ; fourth legs longer than first, lacking comb setae; two pairs of seminal receptacles in female.

Species recorded from NDBR:

Euryopis sp.1; *Euryopis* sp.2

Genus Parasteatoda Strand 1829

Spiders of the genus Parasteatoda are cosmopolitan in distribution. AE row slightly procurved; PE row slightly recurved or straight; subequal eye diameter; median ocular area square in shape; opisthosoma higher than long; colulus and paired setae absent; moderately long legs with spines and many hairs. The web appears as irregular networks of fine threads built commonly in hidden or sheltered habitats amongst trees and along walls. Their webs sometimes contain a leaf or other debris that is used as shelter. The male and female may occupy the same web for some time before mating occurs. After mating the female constructs up to eight pear-shaped papery brown egg-sacs. These spiders feed on all kind of insects, even on ants.

Species recorded from NDBR:

Parasteatoda sp.1; *Parasteatoda* sp.2

Genus Argyrodes Simon 1864

Spiders of the genus Argyrodes occur world-wide. Carapace flat ; low posteriorly in the thoracic area; transverse fovea present; high clypeus and ocular region; Chelicerae bears two or three promarginal teeth and one or two in the retromargin, tarsus IV bears no tarsal comb, replaced by few serrated bristles; middle claw longer than outer claws. Opisthosoma bears tubercles, extended, sub triangular to very long, higher than long, and rarely globular, anterior border with stridulating ridges in both sexes. Colulus small, bears short setae. Male pedipalp with poorly sclerotised median apophysis; radix, sometimes arm-like sclerite between embolus and cymbium, or prominent ventral plate above median apophysis and conductor present; embolus varies in shape from a complex sclerite, sub triangular or with a distal thread-shaped portion; cymbium spoon-shaped to truncate. Female epigynum a sclerotised plate covered with resinous material; two ovoid to globose receptacles, tube-shaped in some groups. Spins tiny webs of their own but they are more found in the webs of other spiders. While hanging in these webs with their legs closely drawn to their body, they resemble debris, like twigs, straws, scales, bits of leave, and are so camouflaged that they are completely lost.

Species recorded from NDBR:

Argyrodes gazedes Tikader 1970*; Argyrodes* sp.1; *Argyrodes* sp.2

Genus Chrysso O. Pickard-Cambridge 1882

Spiders of the genus Chrysso are well distributed. Carapace longer than wide; AE row slightly procurved, PE row straight or slightly procurved or recurved; AME separated from each other by one AME diameter or more and set closer to ALE than to each other; PME moderately closer to each other than to laterals. Eyes subequal in size or AME slightly larger or smaller than the rest; clypeus height and shape of carapace variable; chelicera length almost as long as clypeus height, anterior margin of chelicerae with two large teeth; sternum truncate between posterior coxae. Leg I longest; patellae I-IV with a retrolateral tubercle; tarsus IV bears a tarsal comb; opisthosoma longer than width and height, extended beyond spinnerets laterals with furrows or stripes and dorsolateral spines, usually sub triangular in lateral view; female epigynum a sclerotised plate with no distinct orifice; sacs present ventrally.

Species recorded from NDBR:

Chrysso sp.1; *Chrysso* sp.2

Genus Theridion Walckenaer 1805

Spiders of the genus Theridion is well distributed worldwide. Carapace longer than wide; without stridulating structures; fovea indistinct; AE row straight or procurved as viewed frontally; PE row straight as seen dorsally; eyes subequal in size, with AME either slightly larger or smaller than others. Chelicerae enlarged in males; female chelicerae each with one or two teeth in the promargin and retromargin bears no teeth. Legs long; patella I and tibia I longer than carapace; leg II longer than IV in males. Opisthosoma is usually spherical; longer than high, sub triangular, without plates or tubercles; colulus absent. Epigynum in females weakly sclerotised with indistinct openings; one pair of seminal receptacles present; male pedipalp with distinct median apophysis, conductor and radix, though vary in positions.

Species recorded from NDBR:

Theridion sp.1*; Theridion* sp.2*; Theridion* sp.3

Genus Steatoda Sundevall 1833

Spiders of the genus Steatoda are moderately large Theridiids. Lateral eyes contiguous; AME the largest; larger than ALE, and MOQ slightly broader in front than behind or a square; clypeus height about as wide as ocular area; sternum pointed behind, produced between coxae IV; males with punctated carapace and sternum, punctations slight in female sternum; retromargin toothless; opisthosoma with well-developed stridulating organ in males; legs relatively short. Male chelicerae are never large. Paracymbium hook not on edge of male palpal cymbium. They build irregular tangle web of sticky silken fibres.

Species recorded from NDBR:

Steatoda sp.1; *Steatoda* sp.2

Genus Episinus Latreille 1809

Spiders of genus Episinus can be easily identified from the peculiar triangular shape of their opisthosoma with two horny projections at the posterior end of the opisthosoma. Carapace is usually oval and slightly longer than wide. Clypeus is usually projecting. Eyes eight, arranged on tubercles with distinct black markings around them. Eyes region roundly elevated or projected anteriorly. Chelicerae are usually small, anterior margin of fang furrow with or without tooth while the posterior margin is always without tooth. Opisthosoma longer than wide, dorso-ventrally flattened, widest posteriorly with median posterior or lateral posterior humps Colulus replaced by two setae. Legs are long and slender. They are often found on bare twigs under bushes. Usually dusty in colour (dirty grey to pale brown). They make very simple H or Y-shaped web near ground level. The sticky ends of the threads are attached to the ground and plants above the spider and are held by the spider.

Species recorded from NDBR:

Episinus affinis Bösenberg and Strand 1906

Episinus sp.1; *Episinus* sp.2

Family Thomisidae Sundevall 1833 (Crab Spiders)

Diagnostic Characters:

Small to large, ecribellate, entelegyne spiders. Carapace varies from convex or semicircular, ovoid to elongated; usually with scattered, simple or clavate, erect setae; some species with strong protuberances or eye tubercles. Eight eyes in two rows, both rows recurved, posterior row curved strongly; lateral eyes usually situated at eye tubercles, much larger than medians. Chelicerae free, boss usually present, cheliceral teeth absent, sometimes cusps or small denticles on promargin, retromargin indistinct and unarmed, scopulae poorly developed. Legs strongly laterigrade; legs I and II much longer than III and IV; femora I and II considerably stouter than those of legs III and IV and often with several strong erect macrosetae; tarsi two clawed, lacking claw tufts and scopulae. Opisthosoma oval or rounded slightly flattened dorsoventrally, with colulus. Epigyne is with deep atrium, often with a round and deep vestibulum, usually with hook; intromittent canal usually short; male palp with retrolateral tibial apophysis and ventral tibial apophysis; embolus variable.

Thomisids occur more commonly wandering or ambushing themselves on plants, flowers and foliages, sometimes under rocks. They are represented by 117 genera, 2146 species occurring worldwide (Platnick, 2011). In India it is represented by 38 genera and 164 species so far (Sebastian and Peter, 2009).

Key to genera

1a. Lateral eyes on strong conical protuberance………………………………..**2**
1b. Lateral eyes not on conical protuberance……………..……………………**3**

2a. Opisthosoma as wide as or wider than long; protuberance between ALE and PLE well-developed……………………..………………………**Thomisus**
2b. Opisthosoma much longer than wide; protuberance between ALE and PLE small…………………………..……………………………..……**Runcinia**

3a. Integument clothed with clavate setae……………..………………..**Ozyptila**
3b. Integument not clothed with clavate setae………………………………….**4**

4a. Cephalic region as wide as thoracic region……………………..…**Camaricus**
4b. Cephalic region narrower than the thoracic region………….……………**5**

5a. Anterior eyes nearly equidistant…………………….……………….**Misumena**
5b. Anterior eyes not equidistant…………………………………….…..……….**6**

6a. Body covered with conspicuous spines…………………..…………....**Diaea**
6b. Body not covered with conspicuous spines……………….………………**7**

7a. Anterior median eyes closer to the lateral eyes than to each other…………………..……………………………………………...**Xysticus**
7b. Anterior median eyes not closer to lateral eyes……………………………..**8**

8a. Tarsal claws of leg I with 6-12 teeth…………………………………**Synema**
8b. Tarsal claw of leg I without teeth…………………………………………..….**9**

9a. Clypeus with a distinct, white transverse carina; carapace flat……………………………………………………………….….. **Henriksenia**
9b. Clypeus without white transverse carina; carapace not flat………………**10**

10a. Anterior lateral eyes larger than the median eyes…………..**Misumenops**
10b. Anterior lateral eyes not larger than the median eyes……………………**11**

11. Opisthosoma longer than wide; embolus of male palp short and thick; spermathecae of female epigynum large……………………………**Lysiteles**

Genus Camaricus Thorell 1887

Spiders of the genus Camaricus are mostly found in the tropical countries of the world. Carapace moderately high, square like parallel sided, wider apart and closer to LE than to each other; MOQ wider behind than in front; clypeus height distinctly large; sternum longer than wide; labium slightly longer than broad; legs moderately short with less developed spines; opisthosoma oblong to subglobular with dorsal markings.

Species recorded from NDBR:

Camaricus sp.1

Genus Misumena Latreille 1804

Spiders of the genus Misumena are distributed widely in the world. Small to medium sized spiders Carapace smooth, moderately low and convex along lateral margins and bears few erect setae dorsally; eyes in two transverse recurved rows, PE more recurved than AE row. Legs long, powerful, and laterigrade; Legs I and II longer and more robust than III and IV, without dorsal spines, with few prolateral spines and several ventral spines; all legs without scopulae. Opisthosoma is broad, moderately flat, yellowish white with median and paired longitudinal bands. Male embolus is short and twisted;

female epigynum slightly sclerotised, with shallow atrium and small hood, and widely ovoid spermathecae. The females usually stand guard with their egg sacs. The egg sacs are fastened to the vegetation and are usually flat.

Species recorded from NDBR:

Misumena menoka Tikader 1963; *Misumena* sp.1; *Misumena* sp.2

Genus Runcinia Simon 1875

Spiders of the genus Runcinia occur worldwide. Carapace flat, nearly as long as wide lined with short hairs and head with short setae. Eyes small; laterally projected tubercle present between LE;. MOQ is wider than long, narrower in front than behind. Labium is longer than wide; chelicerae without teeth. Leg I more than twice the length of leg IV, spines present but weak; tibiae I and II bear no lateral spines; tarsal claws with two or three teeth. Opisthosoma is longer than wide, truncated to tapered posteriorly beyond spinnerets. Male pedipalp bears a long RTA with sclerotised tip and very small VTA; bulb simple without apophysis; tegulum rounded; embolus moderately long and filiform; epigynum in female with short intromittent canal, a small central hood, and ovoid to globular spermathecae.

Species recorded from NDBR:

Runcinia sp.1

Genus Thomisus Walckenaer 1905

Spider of the genus Thomisus are distributed mainly in Palaeotropical regions. Carapace truncated in front, with upper corners strongly diverging; as long as wide without setae. Eyes small, subequal in size, and poorly developed, ALE largest; MOQ wider than long; wider behind than in front; clypeus almost as wide as AME. Labium is longer than wide and chelicerae without teeth. Legs long, I and II longer than III and IV. Leg spines not strongly developed and tibiae I and II bear ventral spines. Opisthosoma is wider than long. Male pedipalp with RTA, ITA and VTA, RTA long and developed, ITA strongly sclerotised; simple bulb without apophysis; short embolus, filiform or spiniform; female epigynum simple, less developed, without hood, and bears short intromittent canal, and globular spermathecae with a gland. The members are sexually dimorphic, with male darker than female.

Species recorded from NDBR:

Thomisus onustus Walckenaer 1805*; Thomisus* sp.1

Genus Ozyptila Simon 1864

Spiders of the genus Ozyptila are commonly found in plant litter, under surface soil, crevices beneath stones and rocks. Carapace flattened; legs are rather short, stout, and laterigrade. These spiders have been said to resemble diminutive toads. Eyes in two transverse rows, with the lateral eyes on large conjoined tubercles; distance from anterior lateral eye to posterior lateral eye on one side equal to or slightly less than, distance from anterior median eye to posterior median eye. Legs rather short, stout, colored like carapace, without scopulae or claw tufts. Legs I and II longer and stouter than legs III and IV, and usually with femur I distinctly swollen on prolateral side; tibia I with one short dorsal clavate macrosetae, and with two pairs of nonclavate ventral macrosetae (neither pair terminal); distitarsus I with two or three (rarely four) middorsal trichobothria in distal half; tarsi with two claws. Opisthosoma rotund, flattened, often transversely wrinkled, covered dorsally with curved rows of short clavate setae. Palpal tibia of male with retrolateral, ventral and sometimes intermediate apophysis is present. Embolus short, usually arising simply on distal or prolaterodistal margin of tegulum, usually pressed to margin of cymbium; tegulum rather flat, nearly circular, usually with hard apophysis at or near its centre. Epigynum of female usually with hood and shallow atrium, and with transversely wrinkled area posterior to hood; copulatory openings located laterad in atrium. Spermathecae is usually in two parts with the posterior part bulbous, but occasionally without divisions. By having a carapace that is distinctly higher at the level of coxa II than at the level of the posterior row of eyes, and usually less than four mid-dorsal trichobothria on basitarsus I

Species recorded from NDBR:

Ozyptila sp.1; *Ozyptila* sp.2

Genus Xysticus C.L. Koch 1835

Spiders of the genus Xysticus are common inhabitants of forest litter, open fields, and meadows. They are hard-bodied, rather bristly, slow-moving with typical crablike appearance and locomotion; widely distributed in the world. Their powerful forelegs are used to grab prey at close range, and their colours blend with the dull yellows, browns and reds of the ground cover in which most of them live. Carapace is almost as long as wide, moderately convex and not flattened, wide head with strong setae and thoracic part with short setae. Posterior eyes are nearly equidistant; median eyes smaller than lateral eyes; MOQ wider than long; clypeus height large; chelicerae toothless; sternum and labium longer than wide. Legs with strong spines, claw tufts and scopulae less developed; tarsal claw with five or six isolated teeth. Opisthosoma is as wide as long in the female, longer than wide in male, often prominent markings. Male pedipalp tegulum simple without apophysis; epigymum heavily sclerotised, lacks guide pocket, often with median septum, short intromittent canal present and large spermathecae.

Species recorded from NDBR:

Xysticus joyantius Tikader 1966; *Xysticus kali* Tikader & Biswas 1974

Xysticus minutus Tikader 1960; *Xysticus croceus* Fox 1937

Xysticus sp.1; *Xysticus* sp.2

Genus Diaea Thorell 1869

Spiders of the genus Diaea are mostly found in Africa, Asia and the Australian regions of the world. Carapace is slightly longer than wide; long setae present. Eyes prominent; LE developed on tubercles; MOQ longer than wide, wider behind than in front. Labium and sternum are both longer than wide; chelicerae without teeth. Legs are with well developed spines. Opisthosoma is ovoid, longer than wide and lined with strong hairs. Male pedipalp bulb is simple without apophysis; embolic division long; female epigynum with a guide pocket borne on a soft median protuberance; intromittent canal long and winding; spermathecae small and ovoid to globular. They usually hide between vegetation, especially in or nearby a flower as their colour is well adapted to its surrounding.

Species recorded from NDBR:

Diaea sp.1; *Diaea* sp.2

Genus Synema Simon 1960

Spiders of the genus Synema is cosmopolitan in distribution but commonly found in temperate and tropical zones. Carapace is with long setae, almost as long as wide; Eight eyes small; LE on separate tubercles; MOQ wider than long; sternum and labium both longer than wide. Legs with strong spines and claw tufts poorly developed. Opisthosoma globular in female and ovoid in male; long hairs present in both sexes and abdominal dorsum with or without markings. Male pedipalp bulb is simple, without apophysis; embolus long, filiform; female epigynum with a sclerotised median plate, median hood present beneath the plate; soft intromittent canal distinct; spermathecae small.

Species recorded from NDBR:

Synema decoratum Tikader 1960

Genus Lysiteles Simon 1895

Spiders of the genus Lysiteles typically found inhabiting grasses, low vegetation, shrubs, tree foliage and leaf litter. Carapace is longer than wide, high and bearing long setae. Eyes are arranged in two rows with PE more recurved and longer than AE row; median ocular quadrangle wider than long and narrower in front than behind; clypeus height large. Labium is longer than wide. Chelicerae with two promarginal teeth and zero or one weak retromarginal tooth. Leg spines strong; tarsal claw tufts weakly developed. Opisthosoma is longer than wide with dorsal markings. RIA and VIA present in male's pedipalp, RIA strongly sclerotised, apophysis absent in the bulb, short, thick, and twisted embolus present; epigynum of the female bears a sclerotised fold housing the intromittent orifices; spermathecae subglobular.

Species recorded from NDBR:

Lysiteles brunetti Tikader 1962*; Lysiteles niger* Ono 1979

Lysiteles sp.1; *Lysiteles* sp.2; *Lysiteles* sp.3

Genus Misumenops F.O. Pickard-Cambridge 1900

Spiders of the Misumenops are composition in distribution. This genus is closely related with Misumena but differs from it by having large and prominent spines on the femora I and II and on the upper surface of tibia I and II. ALE is larger than AME. LE larger than the ME, tubercles of lateral eyes united; MOQ wider than long, narrow in front but wide behind; sternum and labium longer than wide. Tarsal claws with two to five teeth; spines developed, tibiae I and II often without lateral spines. Small spines present on the surface of the carapace and opisthosoma; opisthosoma pear-shaped, as long as wide in female; longer than wide in male, with long hairs. Male pedipalp often with a dorsal tooth; tegular apophysis absent; embolus filiform, short, and sometimes curved apically; female epigynum with central hood, intromittent orifices at both sides of the hood; small tubular spermathecae.

Species recorded from NDBR:

Misumenops sp.1; *Misumenops* sp.2

Genus Henriksenia Lehtinen 2005

Spiders of the genus Henriksenia are found in India to Philippines, Sulawesi, New Guinea. Carapace relatively flat; clypeus vertical, with a white carina; smoothly convex towards lateral margins, and bears a few setae. Eyes in two transverse recurved rows, PE more recurved than the AE row; lateral eyes with strong projecting processes. Legs I and II are much longer and robust than III and IV, without prolateral or dorsal spines but bearing ventral spines; tarsi I and II without prolateral spines; tarsi with two claws. Opisthosoma is broad lacking erect setae. Male pedipalp is with short embolus; epigynum of female slightly sclerotised with shallow atrium, broadly elevated hood and broader than long spermathecae.

Species recorded from NDBR:

Henriksenia hilaris Thorell 1877

Family Trochanteriidae Karsch 1879 (Scorpion spiders)

Diagnostic Characters:

Small to medium sized spiders ecribellate, entelegyne spiders. Body dark brown to grey; opisthosoma is uniform or with pale markings. Carapace flattened, much wider than long in some species; strongly narrowed in the ocular area. Eight eyes in two rows, posterior row wider than the anterior row, both rows almost straight; posterior median eyes flattened, irregular; all eyes except posterior median eyes encircled with black pigment. Chelicerae is weakly armed; enlarged, laterally divergent, with long curved fangs; dentition variable. Labium as long as wide; narrowed and rebordered distally; gnathocoxae obliquely depressed serrula absent or present. Legs completely laterigrade, coxae of legs long, the posterior widely separated; leg I short than the rest; II longest, no scopulae or ungual tufts; anterior legs armed with erect spiniform bristles; claws two in number and toothed. Opisthosoma is ovoid and flattened. Anterior spinnerets sclerotised, conical and widely separated at base; Colulus consists of a few setae. Epigyne is variable; male palp with retrolateral apophysis; embolus of variable length.

Trochnteriids are free living wanderers. Mainly living in narrow crevices under bark, on rocks or in old buildings. They are represented by 19 genera, 152 species occurring worldwide (Platnick, 2011). In India it is represented by 1 genera and 5 species so far (Sebastian and Peter, 2009).

Genus Plator Simon 1880

Spiders of the genus Plator are represented by only five species from India, usually found in old buildings in cracks and crevices. They are distinguished by their semicircular carapace; rectangular eye region projecting forwards for a short distance. No fovea, thoracic part appears to be circular, four linear depressions on each side, radiating to the lateral margins. Long and slender legs are about equal in length. Opisthosoma is circular with an oval pattern and three transverse dark lines.

Species recorded from NDBR:

Plator indicus Simon 1897

Family Uloboridae O. Pickard-Cambridge 1871 (Hackled-Orb-web spiders)

Diagnostic Characters:

Small to medium sized, cribellate, entelegyne spiders. Carapace is variable, long and narrow, pear shaped or triangular. Eyes are usually eight but sometimes four in some genera. Chelicerae is without prominent condyle; cheliceral furrow with cluster of small teeth or with one or more large teeth;

venom glands absent. Labium and gnathocoxae long and distally pointed. Legs I and IV are longer than other, femora of legs with dorsal trichobothria; metatarsus IV ventrally with long setae straight; curved, laterally compressed, calamistrum present; tarsi three clawed. Opisthosoma shape variable, from oval to peaked to cylindrical, with 1 to 4 pairs of dorsal humps. Anterior spinnerets having 3 segments; a large basal segment; median spinnerets unsegmented and posterior spinnerets with two cylindrical segments; cribellum undivided in front of spinnerets. Female epigyne with paired or unpaired caudal projections; Female palp with denticle claw; male with palpal tibia modified, short, disc to conical; embolus, circular; cymbium with 2 apical setae.

Uloborids are distinguished by all other spiders by the lack of poison glands, constructing orb webs which may be complete or reduced ranging from a section of an orb to a single line. They are represented by 18 genera, 265 species occurring worldwide (Platnick, 2011). In India it is represented by 5 genera and 22 species so far (Sebastian and Peter, 2009).

Key to genera:

1a. Carapace pear shaped or oval; Eight eyes of similar size distributed in two rows, PLE not on prominent tubercles, constructs orb webs that are usually horizontally oriented…………………………..……………………………..….**2**

1b. Carapace rectangular or with an abruptly narrowed cephalic region, constructs triangular webs or irregular webs of a few strands; PLE on tubercles that extend to carapace margin, ALE very small or entire anterior eye row absent.....……………………………………………….………………..**3**

2a. First tibia with prominent setae; epigynum with two weakly sclerotised posterior lobes Opisthosoma with two prominent humps…………**Uloborus**

2b. First tibia without conspicuous setae, epigynal lobes with distal sclerotization; humps on opisthosoma may or may not be present; Female has a single much flatter hump on the opisthosoma; epigynum with broad median lobes, conductor in males absent …...……………………...……..**Zosis**

3a. Carapace trapezoidal with abruptly narrowed cephalic region, anterior eye row present, but ALE very small, opisthosoma nearly round, female calamistrum extends along proximal half of metatarsus IV, leg I short and stout, male tibia I with or without dorsal macrosetae, constructs triangular webs……………………..……………………………………………..**Hyptiotes**

3b. Carapace rectangular, anterior eye row absent, opisthosoma cylindrical, female calamistrum restricted to proximal one-third of metatarsus IV, legs elongated, male tibia I with dorsal macrosetae, spider constructs an irregular web of a few strands ……………………………..……**Miagrammopes**

Genus Miagrammopes O. Pickard-Cambridge 1870

Spiders of the genus Miagrammopes are usually found in bushes and shrubs. They have a prominently longer than wide Prosoma and elongated opisthosoma; four eyes in a transverse row with PLE on a lateral tubercle; the first row may be poorly developed, thus giving the impression that they have only four eyes. AE row absent; sternal suture developed; coxa II closer to I than to III; cribellum and calamistrum present; tarsi shorter than metatarsi and tarsus IV bears ventral row of macrosetae; pedipalps of female with tarsal claw and males have tibial projection. Opisthosoma is very long and thin, almost tubular and five times as long as wide. Miagrammopes spiders do not spin orb-webs; they build webs made up of one or more sticky threads connected to a non sticky resting thread. They build a single-line snare made of woolly silk which is fastened to a twig on one end and held taut by the first pair of legs at the other end. When an insect lands and hits the thread, the spider releases the line which springs back and entangles the insect.

Species recorded from NDBR:

Miagrammopes sp.1; *Miagrammopes* sp.2*; Miagrammopes* sp.3

Genus Zosis Walckenaer 1842

Spiders of the genus Zosis, are a small group of feather legged spiders. Eight eyes in two rows, PE slightly recurved and PLE not on tubercles; cribellum and calamistrum present; femora II and III with trichobothria; tibia I without brush of hairs; Tarsus IV with ventral row of macrosetae and sternum undivided. Epigynum has no ventral atrium or paired lobes. Male pedipalp without a conductor but with a long, broad and flat tegulum spur functioning as an embolus guide; paracymbium absent; cymbial setae developed; femoral tubercle visible.

Species recorded from NDBR:

Zosis geniculatus Opell 1979

Genus Uloborus Latreille 1806

Spiders of the genus Uloborus build fully developed horizontal orb webs having a sticky spiral, usually built in low bushes, in crack of houses and rocks. Carapace broader in dorsal view, but slightly longer than wide with moderately curved sides, anterior end narrowed. Eight small eyes are present. Leg I is much longer and more robust than others. Male tibiae of I with six to seven dorsal spines, almost in the form of teeth while dorsal and ventral surface of tibia I of the female have substantial fringes of hairs. Laterally, the opisthosoma of female has a hunch-backed appearance. Opisthosoma longer than broad, spear shaped, rounded at front and pointed at rear. At the widest part, there are two substantial but well separated humps giving the impression of shoulders. Anal tubercle prominent in the female, diminished in male. Egg sacs are suspended in the web. Most species occur in the tropics and subtropics.

Species recorded from NDBR:

Uloborus krishnae Tikader 1970; *Uloborus* sp.1; *Uloborus* sp.2; *Uloborus* sp.3

Genus Hyptiotes Walckenaer 1837

Spiders of the genus Hyptiotes are distinguished by their abruptly narrowed carapace, the straight anterior eye row, and the short first femur. Carapace approximately as wide as long, rather low, abruptly narrowed anteriorly, deeply indented at posterior margin; front broadly convex. Anterior row of eyes nearly straight with lateral eyes minute dorsally; posterior row of eyes strongly recurved, with median eyes situated near lateral margins of carapace and lateral eyes situated on conspicuous tubercles, also at lateral margins of carapace. Chelicerae are small; promargin of fang furrow with 3 teeth and retromargin with 2 teeth. Legs short, rather stout, in males with strong macrosetae; femur I equal to or shorter than carapace length; leg IV with calamistrum; calamistrum composed of single row of curved bristles. Opisthosoma convex dorsally, overhangs carapace, in females often with paired dorsal setose tubercles, with large undivided cribellum. Male palpus cymbium is small and hairy; tegulum large; conductor and median apophysis large, extending full length of genital bulb; conductor with long curved hornlike distal process. Epigynum is broad, rectangular, with rounded or angulated median tubercle. They build triangular webs with four radii, in the lower branches of coniferous trees, often among dead twigs, may be found in the under brushes or rocks.

Species recorded from NDBR:

Hyptiotes sp.1; *Hyptiotes* sp.2

Family Zodariidae Thorell 1881 (Armoured spiders)

Diagnostic Characters:

Small to large, ecribellate, entelegyne spiders. Carapace generally oval or pyriform, narrow in front; Cephalic region and clypeus high; fovea usually well developed and deep, sometimes absent. Eyes eight, in two rows; anterior eye row slightly procurved, posterior eye row straight to strongly procurved. Chelicerae usually strong and with a lateral condyle; margins sometimes lacking teeth or with distal cusps; fangs very short. Labium longer than wide; gnathocoxae convergent, lacking serrula; Legs prograde, with or without spines, spination usually well developed if present; legs formula 4123 or 4132; trichobothria in rows; scopulae replaced by dense short spines; tarsi three clawed. Opisthosoma usually ovoid, sometimes twice as long as wide; or higher at back than in front; scutum present in some genera. Anterior spinnerets long, median and posterior spinnerets reduced. Epigyne is variable, often a central plate with copulatory ducts originating medially.

Zodariids are typically ground dwelling spiders and mostly burrowing spiders. They are represented by 69 genera, 820 species occurring worldwide (Platnick, 2011). In India it is represented by 7 genera and 20 species so far (Sebastian and Peter, 2009).

Genus Zodarion Walckenaer 1826

Spiders of the genus Zodarion are small spiders usually found in ground litter and forest floor. AME with twice the diameters as others; PER strongly procurved; gnathocoxae elongated; legs without spines; opisthosoma dark. From the side, the opisthosoma is more oval, protrudes forward covering the pedicel and part of the thorax. Legs are long and slender with legs IV being the strongest. Zodarion feed on ants. They catch their prey during the cool of the day when ants are active.

Species recorded from NDBR:

Zodarion sp.1

4.7 New Records of Genus and Species

Himalayan spider fauna is diverse but poorly documented especially in NDBR. There were several new records of spiders possibly few new species to science have been collected from this region. Most of these new records are Palearctic genera that confirm that NDBR has affinities both with Palearctic and Oriental region. Here, we documents 10 genera and four species that are new records to India and four species that are new to science (Fig. 4.6 - 4.10).

4.7.1 First record of Genera from India reported from NDBR

- Draconarius Ovtchinnikov 1999
- Himalmartensus Wang and Zhu 2008
- Agyneta Hull 1911
- Pityohyphantes Simon 1929
- Pseudicius Simon 1902
- Stenaelurillus Simon 1885
- Metellina Chamberlin and Ivie 1941
- Phylloneta Archer 1950
- Episinus Latreille 1809
- Zodarion Walckenaer 1826

4.7.2 First record of Species from India reported from NDBR

- *Cheiracanthium gyirongense* Hu and Li 1987
- *Heliophanus curvidens* Pickard-Cambridge O. 1872
- *Phylloneta impressa* C.L. Koch 1881
- *Episinus affinis* Bösenberg and Strand 1906
- *Lysiteles niger* Ono 1979

4.7.3 New Species reported from NDBR

- *Trachelas* sp.nov
- *Pseudicius* gen nov. sp.nov.
- *Draconarius* sp.nov
- *Himalmartensus* sp.nov

4.8 Discussions

The present study is the first comprehensive documentation of the spider fauna in NDBR. A total of 244 species belonging to 108 genus and 33 families were recorded during the entire sampling period. It represents 16.1% of total species, 28.6 % generic and 56.7% family diversity reported from India (Sebastian et al., 2009). The most dominant family reported was Araneidae 18% (44 species); followed by Salticidae and Thomisidae 11.5% (28 species); Linyphiidae 7.4 % (14 species); Uloboridae and Tetragnathidae 4.5% (11 species); Theridiidae 8.6% (21 species); Gnaphosidae, Oxyopidae, Sparassidae and Lycosidae 4.1% (10 species). Some rare spiders such as *Plator indicus* (Family: Trochanteriidae) and *Eriophora himalayensis* (Araneidae) were collected during the study. As the Himalayan region falls in the transition zone of both Palearctic and Indo-Malayan realms, I recorded some families that represent the Paleartic genera viz., Heliophanus, Pseudicus, Pellenes and Phlegra (Family: Salticidae); Phylloneta and Episinus (Family: Theridiidae); Draconarius and Himalmartensus (Family: Amaurobiidae) and Pityohyphantes (Family: Linyphiidae). Five species and ten genera were recorded as new records from Indian region. Four species were confirmed by experts as new species to science. However, there are a good number of species that probably are new species but cannot be described due to lack of full literature on these genera. The high number of species recorded indicates the rich spider diversity of this region.

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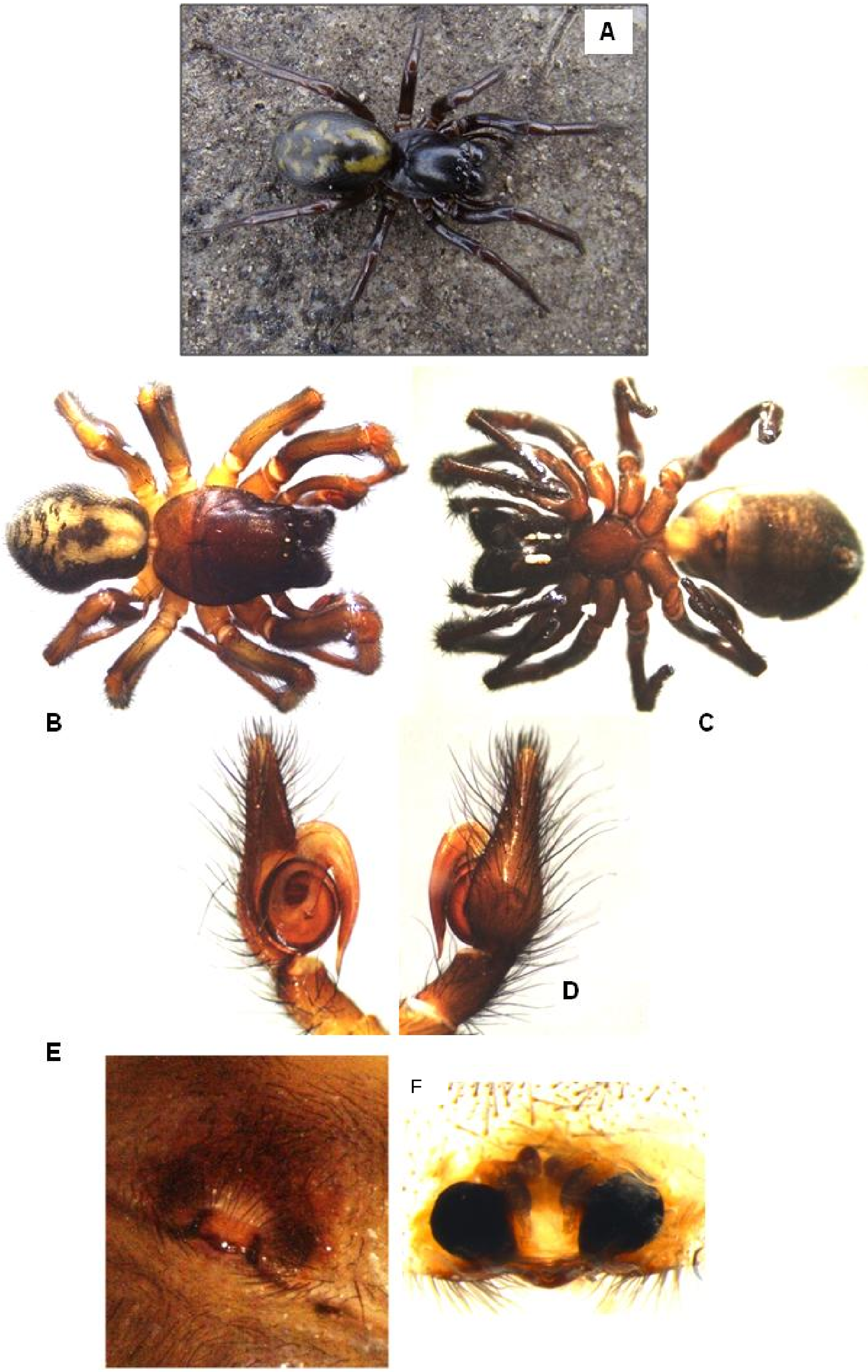

Fig . 4.6 *Himalmartensus* sp.nov A-B. Dorsal view of the female; C. Ventral view; D. Male genitalia (pedipalp). E. Epigynum; F. Internal genitalia.

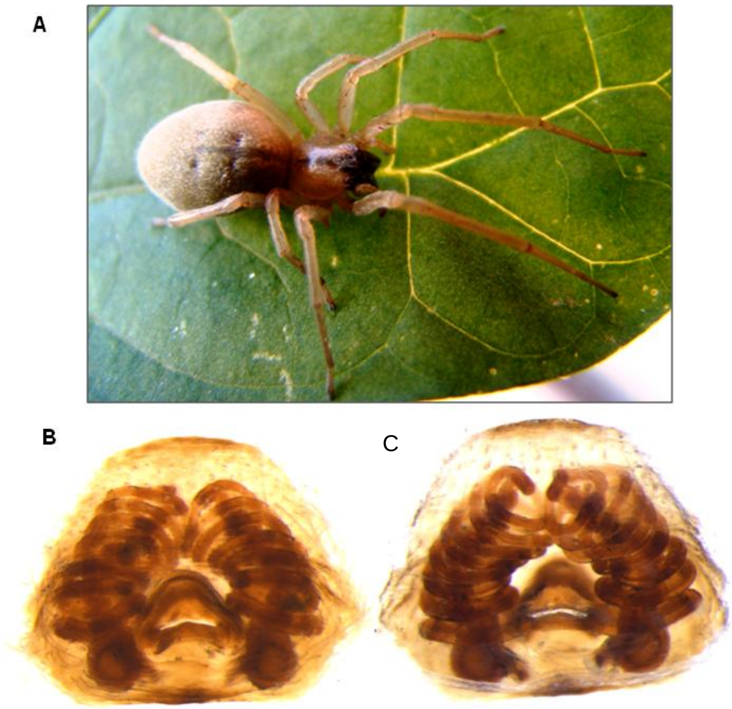

Fig . 4.7 *Cheiracanthium gyirongense* A. Dorsal view of the female; B. Epigynum; C. Internal genitalia.

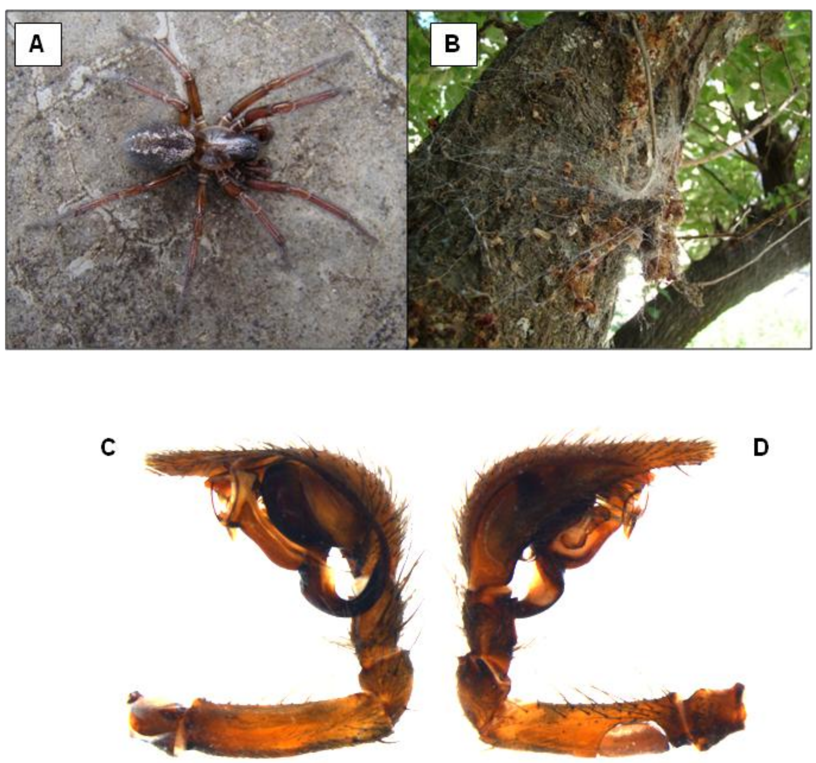

Fig . 4.8 *Draconarius* sp. nov A. Dorsal view of the male; B. Web structure; C- D. Male genitalia (pedipalps).

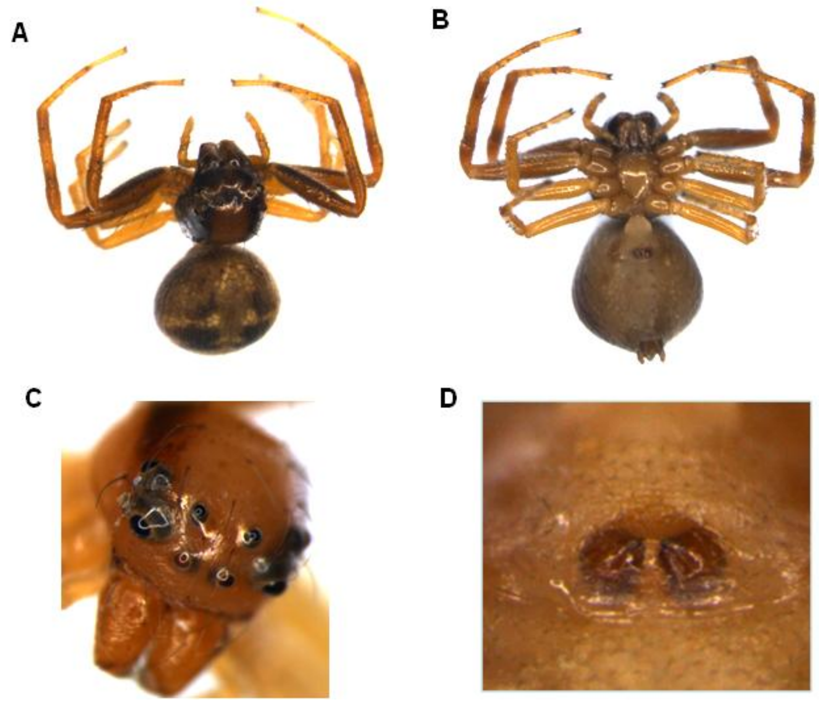

Fig . 4.9 ***Lysiteles niger*** **A. Dorsal view of the female; B. Ventral view of female; C. Eye arrangement; D. Female genitalia.(epigyne).**

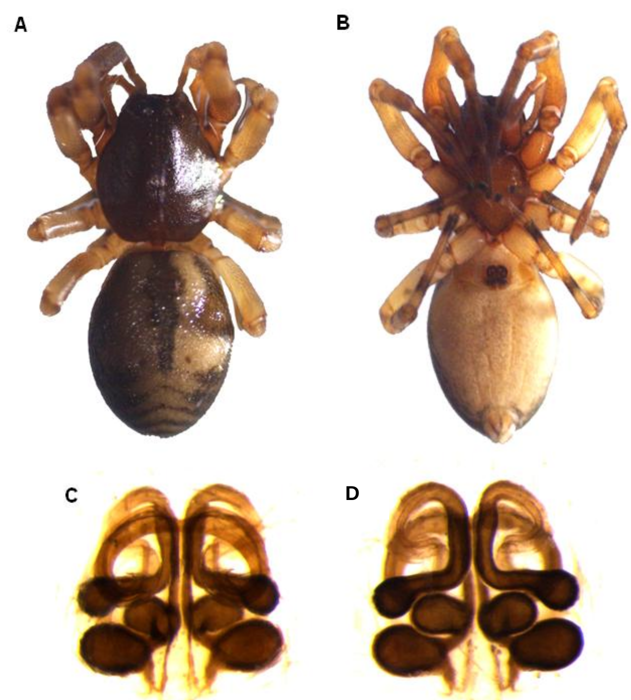

Fig . 4.10 ***Trachelas*** **sp. nov A. Dorsal view of the female; B. Ventral view of female; C. Epigynum; D. Internal genitalia.**

Table 4.1 Species and morphospecies of spiders captured during entire field work according to Sebastian and Peter (2009)

Family	Genus	Species
Agelenidae C.L. Koch 1837	Agelena Walckenaer 1805	*Agelena* sp.1
Amaurobiidae Bertkau 1873	Amaurobius C.L. Koch 1837	*Amaurobius* sp.1
		Amaurobius sp.2
	Draconarius Ovtchinnikov 1999	*Draconarius* sp. nov
	Himalmartensus Wang & Zhu 2008	*Himalmartensus* sp. nov
Anyphaenidae Bertkau 1878	Anyphaena Sundevall 1833	*Anyphaena* sp.1
Araneidae Simon 1895	Argiope Audouin 1826	*Argiope anasuja*, Thorell 1887
		Argiope sp.1
		Argiope sp.2
	Cyclosa Menge 1866	*Cyclosa insulana*, Costa 1834
		Cyclosa confraga, Thorell 1892
		Cyclosa hexatuberculata Tikader1982
		Cyclosa sp.1
		Cyclosa sp.2
		Cyclosa sp.3
		Cyclosa sp.4
	Neoscona Simon 1864	*Neoscona achine* Simon 1906
		Neoscona mukerjei Tikader 1980
		Neoscona biswasi
		Neoscona nautica L. Koch 1875
		Neoscona theisi Walckenaer 1841
		Neoscona vigilans Blackwall 1865
		Neoscona shillongensis Tikader & Bal, 1981
		Neoscona sp.1
		Neoscona sp.2
	Araniella Chamberlin & Ivie 1942	*Araniella* sp.1
		Araniella sp.2
	Araneus Clerck 1757	*Araneus bilunifer*, Pocock 1900
		Araneus ellipticus, Tikader & Bal 1981
		Araneus mitificus, Simon 1886
		Araneus nympha, Simon 1889
		Araneus sp.1
		Araneus sp.2
	Chorizopes O. Pickard-Cambridge 1870	*Chorizopes* sp.1, Tikader, 1975
	Cyrtophora Simon 1864	*Crytophora moluccensis,* Doleschall, 1857
		Crytophora sp.1
		Cyrtophora sp.2
	Eriophora Simon 1864	*Eriophora himalayensis* Tikader 1975
		Eriophora sp.1
		Eriophora sp.2
		Eriophora sp.3
	Parawixia O. Pickard-Cambridge 1904	*Parawixia dehaani* Doleschall 1859
		Parawixia sp.1

Family	Genus	Species
		Parawixia sp.2
		Parawixia sp.3
		Parawixia sp.4
	Eriovixia Archer 1951	*Eriovixia* sp.1
	Cyrtarachne Thorell, 1868	*Cyrtarachne* sp.1
		Cyrtarachne sp.2
	Thelecantha Hasselti 1882	*Thelecantha brevispina,* Doleschall 1857
Clubionidae Wagner 1888	Clubiona Latreille 1804	*Clubiona Drassodes* O. Pickard-Cambridge, 1874
		Clubiona sp.1
		Clubiona sp.2
	Cheiracanthium C.L. Koch 1839	*Cheiracanthium gyirongense* Hu & Li 1987
		Cheiracanthium sp.1
		Cheiracanthium sp.2
Corinnidae Karsch 1880	Castianeira, Keyserling 1879	*Castianeira zetes* Simon 1897
	Trachelas C. L. Koch, 1872	*Trachelas* sp.nov
		Trachelas sp.2
		Trachelas sp.3
	Oedignatha Thorell 1881	*Oedignatha* sp.1
Dictynidae O. Pickard-Cambridge 1871	Dictyna Sundevall 1833	*Dictyna* sp.1
		Dictyna sp.2
Filistatidae Ausserer 1867	Pritha Lehtinen 1967	*Pritha* sp.1
		Pritha sp.2
Gnaphosidae Pocock 1898	Gnaphosa Latreille 1804	*Gnaphosa poonensis* Tikader 1973
		Gnaphosa sp.1
		Gnaphosa sp.2
	Herpyllus Hentz 1832	*Herpyllus* sp.1
	Drassodes Westring 1851	*Drassodes* sp.1
	Scotophaeus Simon 1893	*Scotophaeus* sp.1
		Scotophaeus sp.2
	Zelotes Gistel 1848	*Zelotes* sp.1
		Zelotes sp.2
		Zelotes sp.3
Hahniidae Bertkau 1878	Hahnia CL Koch 1841	*Hahnia* sp. 1
Hersiliidae Thorell 1869	Hersilia Audouin 1826	*Hersilia* sp.1
Linyphiidae Blackwall 1859	Bathyphantes Menge 1866	*Bathyphantes* sp.1
	Agyneta Hull 1911	*Agyneta* sp.1
	Atypena Simon 1894	*Atypena adelinenae* Barrion and Litsinger 1995
		Atypena sp.1
	Erigone Audouin 1826	*Erigone* sp.1
		Erigone sp.2
	Linyphia Latreille 1804	*Linyphia* sp. 1
		Linyphia sp. 2
		Linyphia sp. 3
		Linyphia sp. 4
	Pityohyphantes Simon 1929	*Pityohyphantes* sp. 1
	Neriene Blackwall 1833	*Neriene* sp.1
		Neriene sp.2
	Microlinyphia Gerhardt 1928	*Microlinyphia* sp.1
Lycosidae Sundevall 1833	Hippasa Simon 1885	*Hippasa agelenoides*, Simon, 1884

Family	Genus	Species
	Trochosa C.L. Koch	*Trochosa* sp.1
	Lycosa Latreille 1804	*Lycosa tista* Tikader, 1970
		Lycosa sp.1
		Lycosa sp.2
	Pardosa C.L. Koch 1847	*Pardosa sumatrana* Thorell, 1890
		Pardosa minuta Tikader & Malhotra, 1976
		Pardosa pseudoannulata Bösenberg & Strand, 1906
		Pardosa sp.1
		Pardosa sp.2
Mimetidae Simon 1881	Mimetus Hentz 1832	*Mimetus* sp.1
Nephilidae Simon 1894	Nephila Leach 1815	*Nephila clavata* L. Koch 1878
Oecobiidae Blackwall 1862	Oecobius Lucas 1846	*Oecobius* sp.1
Oxyopidae Thorell 1870	Peucetia Thorell 1869	*Peucetia* sp.1
	Oxyopes Latreille 1804	*Oxyopes javanus* Thorell, 1887
		Oxyopes shweta Tikader, 1970
		Oxyopes sp.1
		Oxyopes sp.2
		Oxyopes sp.3
		Oxyopes sp.4
		Oxyopes sp.5
	Hamaltatliwa Keyserling 1887	*Hamataliwa* sp. 1
		Hamataliwa sp. 2
Palpimanidae Thorell 1870	Palpimanus Dufour 1820	*Palpimanus* sp.1
Philodromidae O. Pickard-Cambridge 1871	Philodromus Walckenaer 1826	*Philodromus chambiensis* Tikader 1980
		Philodromus sp.1
		Philodromus sp.2
Pholcidae C.L.Koch 1851	Crossopriza Simon 1893	*Crossopriza lyoni* Blackwall 1867
	Pholcus Walckenaer 1805	*Pholcus phalangioides* Fuesslin 1775
		Pholcus sp.1
		Pholcus sp.2
Pimoidae Wunderlich 1986	Pimoa Chamberlin and Ivie 1943	*Pimoa* sp.1
Pisauridae Simon 1890	Perenethis C.L. Koch 1878	*Perenethis* sp.1
		Perenethis sp.2
	Pisaura Simon 1885	*Pisaura mirabilis* Clerck 1757
		Pisaura sp.1
		Pisaura sp.2
Psechridae Simon 1890	Psechrus Thorell 1878	*Psechrus himalayanus* Simon 1906
Salticidae Blackwall 1841	Carrhotus Thorell 1891	*Carrhotus* sp.1
		Carrhotus sp.2
		Carrhotus sp.3
		Carrhotus sp.4
	Hyllus C.L. Koch 1848	*Hyllus* sp.1
		Hyllus sp.2
	Phintella Strand 1906	*Phintella* sp.1
	Phlegra Simon 1876	*Phlegra* sp.1
	Pseudicius Simon 1902	*Pseudicius* sp.1
		Pseudicius sp.2
	Siler Simon 1889	*Siler* sp.1

Family	Genus	Species
		Siler sp.2
	Plexippus C.L. Koch 1846	*Plexippus paykulli* Audouin 1826
		Plexippus sp.1
		Plexippus sp.2
	Rhene Thorell 1869	*Rhene flavigera* C.L. Koch 1846
		Rhene danielli Tikader 1973
		Rhene sp.1
	Myrmarachne MacLeay 1839	*Myrmarachne orientales* Tikader 1973
		Myrmarachne sp.1
		Myrmarachne sp.2
	Stenaelurillus Simon 1885	*Stenaeurillus* sp.1
	Thiania C.L. Koch 1846	*Thiania* sp.1
		Thiania sp.2
	Salticus Latreille 1804	*Salticus* sp.1
	Pellenes Simon 1876	*Pellenes* sp.1
		Pellenes sp.2
	Heliophanus C.L.Koch 1883	*Heliophanus curvidens* C.L. Koch 1833
Scytodidae Blackwall 1864	Scytodes Latreille 1804	*Scytodes thoracica* Latreille 1802
		Scytodes sp.1
Segetriidae Simon 1893	Segestria Latreille 1804	*Segestria* sp.1
Selenopidae Simon 1897	Selenops Latreille 1819	*Selenops radiatus* Latreille 1819
Sparassidae Bertkau 1872	Heteropoda Latreille 1804	*Heteropoda venatoria* Latreille 1804
		Heteropoda sp.1
		Heteropoda sp.2
	Olios Walckenaer 1837	*Olios sanguinifrons* Simon 1906
		Olios sp.1
		Olios sp.2
	Pseudopoda Jäger 2000	*Pseudopoda prompta* O. Pickard-Cambridge 1885
		Pseudopoda sp.1
		Pseudopoda sp.2
		Pseudopoda sp.3
Tetragnathidae Menge 1866	Metellina Chamberlin & Ivie 1941	*Metellina* sp.1
	Dyschirognatha Simon 1893	*Dyschirognatha* sp.1
		Leucauge decorata Blackwall 1864
	Leucauge White 1841	*Leucauge celebesiana* Walckenaer 1841
		Leucauge sp.1
		Leucauge sp.2
	Tetragnatha Latreille	*Tetragnatha maxillosa* Thorell 1895
		Tetragnatha sp.1
		Tetragnatha sp.2
	Guizygiella Zhu Kim & Song 1997	*Guizygiella* sp.1
		Guizygiella sp.2
Theridiidae Sundevall 1833	Phylloneta Archer 1950	*Phylloneta impressa* C.L.Koch 1881
		Phylloneta sp.1
	Enoplognatha Pavesi 1880	*Enoplognatha* sp.1
		Enoplognatha sp.2
	Euryopis Menge 1868	*Euryopis* sp.1
		Euryopis sp.2

Family	Genus	Species
	Parasteatoda Strand 1829	*Parastaetoda* sp.1
		Parastaetoda sp.2
	Argyrodes Simon 1864	*Argyrodes gazedes* Tikader 1970
		Argyrodes sp.1
		Argyrodes sp.2
	Chrysso O. Pickard-Cambridge 1882	*Chrysso* sp.1
		Chrysso sp.2
	Theridion Walckenaer 1805	*Theridion* sp.1
		Theridion sp.2
		Theridion sp.3
	Steatoda Sundevall 1833	*Steatoda* sp.1
		Steatoda sp.2
	Episinus Latreille 1809	*Episinus affinis* Bösenberg & Strand, 1906
		Episinus sp.1
		Episinus sp.2
Thomisidae Sundevall 1833	Camaricus Thorell 1887	*Camaricus* sp.1
	Misumena Latreille 1804	*Misumena menoka* Tikader 1963
		Misumena mridulai Tikader 1962
		Misumena sp.1
		Misumena sp.2
	Runcinia Simon 1875	*Runcinia* sp.1
	Thomisus Walckenaer 1905	*Thomisus onustus* Walckenaer 1805
		Thomisus sp.1
	Ozyptila Simon 1864	*Ozyptila* sp.1
		Ozyptila sp.2
	Xysticus C.L. Koch 1835	*Xysticus joyantius* Tikader, 1966
		Xysticus kali Tikader & Biswas 1974
		Xysticus minutus Tikader 1960
		Xysticus croceus Fox 1937
		Xysticus sp.1
		Xysticus sp.2
		Xysticus sp.3
	Diaea Thorell 1869	*Diaea* sp.1
		Diaea sp.2
	Synema Simon 1960	*Synema decoratum* Tikader 1960
	Lysiteles Simon 1895	*Lysiteles brunetti* Tikader 1962
		Lysiteles niger Ono 1979
		Lysiteles sp.1
		Lysiteles sp.2
		Lysiteles sp.3
	Misumenops F.O. Pickard-Cambridge 1900	*Misumenops* sp.1
		Misumenops sp.2
	Henriksenia Lehtinen 2005	*Henriksenia hilaris* Thorell 1877
Trochanteriidae Karsch 1879	Plator Simon 1880	*Plator indicus* Simon 1897
Uloboridae O. Pickard-Cambridge 1871	Miagrammopes O. Pickard-Cambridge 1870	*Miagrammopes* sp.1
		Miagrammopes sp.2
		Miagrammopes sp.3
	Zosis Walckenaer 1842	*Zosis geniculatus* Opell 1979
	Uloborus Latreille 1806	*Uloborus krishnae* Tikader 1970
		Uloborus sp.1

Family	Genus	Species
		Uloborus sp.2
		Uloborus sp.3
		Uloborus sp.4
	Hyptiotes Walckenaer 1837	*Hyptiotes* sp.1
		Hyptiotes sp.2
Zodariidae Thorell 1881	Zodarion Walckenaer 1826	*Zodarion* sp.1

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Species account of spiders across the study area

Plator indicus

Zodarion sp.1

Uloborus krishnae

Uloborus sp.1

Uloborus sp. 2

Uloborus sp. 3

Species account of spiders across the study area

Myrmarachne orientales

Myrmarachne sp.1

Rhene flavigera

Rhene danielli

Plexippus paykulli

Pellenes sp.1

Species account of spiders across the study area

Miagrammopes sp.1

Zosis geniculatus

Hyptiotes sp.1

Agelena sp.1

Anyphaena sp.1

Mimetus sp.1

- Plate 10 -

Species account of spiders across the study area

Olios sp.1

Olios sanguinifrons

Pseudopoda prompta

Pseudopoda sp.2

Heteropoda venatoria

Heteropoda sp.1

Species account of spiders across the study area

Psechrus himalayanus

Crossopriza lyoni

Pholcus phalangioides

Segestria sp.1

Philodromus sp.1

Philodromus chambaensis

- Plate 12-

Species account of spiders across the study area

Misumena menoka

Misumena mridulai

Misumena sp.1

Synema decoratum

Runcinia sp.1

Xysticus joyantius

- Plate 13 -

Species account of spiders across the study area

Siler sp.2

Siler sp.1

Pseudicius sp.1

Pseudicius sp.2

Stenaelurillus sp.1

Phlegra sp.1

- Plate 14 -

Species account of spiders across the study area

Xysticus croceus

Xysticus kali

Xysticus kali

Xysticus sp.1

Xysticus sp.2

Xysticus sp.3

- Plate 15 -

Species account of spiders across the study area

Oxyopes javanus

Oxyopes shewta

Oxyopes sp.1

Oxyopes sp.2

Oxyopes sp.3

Oxyopes sp.4

Species account of spiders across the study area

Oxyopes sp.5

Peucetia sp. 1

Hamataliwa sp. 1

Hamataliwa sp. 2

Hersilia sp.1

Palpimanus sp.1

- Plate 17 -

Species account of spiders across the study area

Episinus affinis

Episinus sp.1

Parastaetoda sp.1

Parastaetoda sp.2

Phylloneta impressa

Phylloneta sp.1

Species account of spiders across the study area

Chrysso sp.1

Chrysso sp.2

Enoplognatha sp.1

Steatoda sp.1

Theridion sp.1

Theridion sp. 2

- Plate 19 -

Species account of spiders across the study area

Argiope anasuja

Argiope sp.1

Argiope sp.2

Cyclosa sp.1

Cyclosa confraga

Cyclosa insulana

Species account of spiders across the study area

Scytodes thoracica

Selenops radiatus

Draconarius sp. 1

Himalmartensus sp. 1

Linyphia sp.1

Castineira zetes

Species account of spiders across the study area

Neoscona biswasi

Neoscona shillongensis

Neoscona theisi

Neoscona mukerjei

Neoscona achine

Neoscona sp.1

Species account of spiders across the study area

Araneus bilunifer

Araneus nympha

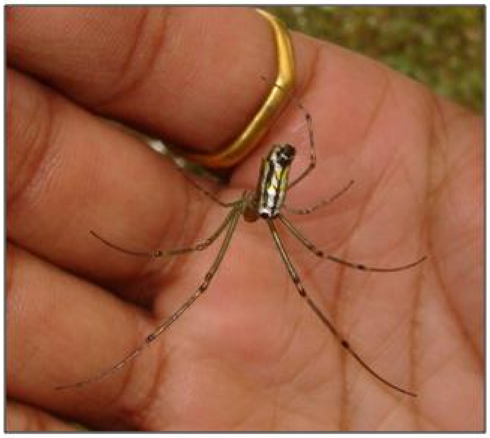
Araneus sp.1

Crytophora moluccensis

Eriophora himalayensis

Parawixia dehaani

Species account of spiders across the study area



Leucage decorata

Metellina sp.1

Tetragnatha sp.1

Atypena adelinenae

Pityohyphantes sp. 1

Neriene sp.1

Species account of spiders across the study area

Pardosa pseudoannulata

Pardosa sumatrana

Pardosa minuta

Pardosa sp.1

Hippasa agelenoides

Lycosa sp.1

Species account of spiders across the study area

Oedignatha sp.1

Nephila clavata

Clubiona sp.1

Cheiracanthium gyirongense

Gnaphosa sp.1

Perenethis sp.1

CHAPTER 5
DIVERSITY OF SPIDERS ALONG ALTITUDINAL GRADIENT

5.1 Introduction

Global species diversity patterns are likely to change across spatial gradients in response to changes in climate, area, latitude, altitude, productivity, available resources and habitat complexity (Mac Arthur, 1972; Rosenzweig, 1995; Trevelyan and Pagel, 1995). As altitudinal gradients are usually characterized by rapid environmental changes over short horizontal distances, they are thus known to be ideal to investigate diversity patterns (Hodkinson, 2005). The patterns of species diversity of invertebrates along the elevation gradient have long been a contentious topic. The two general patterns that emerge are monotonic decrease in species richness with increasing elevation (Mac Arthur, 1972 and Stevens, 1992) or a humped shaped relationship with a peak at intermediate elevations (Rahbek, 1995). Studies have been conducted on several taxa along elevation gradients, which reveal that there is large variation in diversity patterns. Both patterns have been documented in a variety of habitats and taxa (Terborgh, 1977; Stevens, 1992; Brown, 1995; Rahbek, 1995; and Rosenzwig, 1995). However, the two most commonly observed patterns of species richness along altitudinal gradients are a steady decline in diversity with increasing elevation and a unimodal pattern (Rahbek, 2005; Nogués-Bravo et al., 2008). It is observed that diversity generally decreases at higher elevations in plants (Hamilton and Perrott, 1981; Kessler, 2001; Pócs, 1991; Kessler, 2001; Hemp, 2002) and animals (Rahbeck, 1995; Gaston, 2000).

The negative effect of altitude (Stevens, 1992; Brown et al., 1996) is explained as a consequence of the wider ecological forbearance of organisms at higher elevations. It is a crucial characteristic which has to be possessed in order to withstand the wider climatic fluctuations to which they are exposed. The effect of elevation on species richness can be attributed to the following reasons: (i) reduction in productivity with elevation; (ii) reduction in total area;

(iii) reduction in resource diversity; and (iv) harshness and unpredictability of the conditions prevailing at higher elevations (Lawton et al., 1987). Colwell and Lees (2000) have suggested the mid domain effect i.e. the peak in species richness at mid elevations, due to the increasing overlap of species ranges towards the centre of a domain or minor peaks at transitions between elevational communities, to be very robust among different taxa. Another phenomenon associated with negative effect of altitude is the 'rescue effect' i.e. the reduced likelihood of a population at higher elevations to be rescued by individuals dispersing from other zones when compared with populations at lower elevations (Brown and Kodric-Brown, 1977). Thus, it could be that, the species richness is overblown in lower altitudes by the emigration of high-altitude species at the margins of their ranges due to wider tolerance, while taxa from lower elevations cannot expand their upper limit of elevation range as immigration rates also decrease with elevation (Stevens, 1992).

For insects, the empirical evidence for both peaks in species richness at low elevations (Wolda, 1987; Fernandes and Price, 1988; Mc Coy, 1990; Kearns, 1992; Stevens, 1992; Olson, 1994 and Sparrow et. al., 1994) and peaks in species richness at intermediate elevations has been established through several studies (Janzen, 1973; Mc Coy, 1990; Olson, 1994; Sanchez-Rodriguez and Baz, 1995; Fleishman et al., 1998 and Sanders, 2002). Most studies revealed a hump shaped distribution (Holloway et al., 1990; McCoy, 1990; Olson, 1994; Holloway, 1997; Pyrcz and Wojtusiak, 2002), whereas, Wolda (1987) found a general decrease with increasing elevation. Although several invertebrate groups have been studied across altitudinal gradients, for example butterflies, moths, ants, dragonflies and beetles, only few studies have been conducted so far on spiders which are even more deficient in the Indian Subcontinent. Waide et al. (1999) considered spiders as model taxa for investigating the effects of spatial gradients on species assemblages on a scale of 200-4000km. As they are ubiquitous, abundant and easily collectible and also sensitive towards fine-scale environmental changes and therefore can be used to reflect ecological change. Thus, they easily respond to changes in habitat heterogeneity (Downie et al., 1995), temperature, and humidity (DeVito et al., 2004), making them suitable to assess the species assemblage patterns at regional scale. Chatzaki et al. (2005) in Crete Greece found that the species richness of ground dwelling spiders (Gnaphosidae) followed a hump shaped pattern. Maurer and Hänggi (1991) presented the altitudinal variation of spider species in Switzerland, reporting a more or less linear decline and an abrupt decrease in the number of species above the timberline. An ecological survey of ground spiders along altitudinal gradients in Norway (Otto and Svensson, 1982) found the same pattern of species decline from 0 - 800m altitude.

This study intends to describe the species diversity patterns along the three altitudinal gradients (sites) of NDBR (region). The objectives of the study are:
(1) to describe the regional species diversity and composition
(2) to inspect if species composition changes along altitudinal gradient
(3) to examine the altitudinal patterns of species diversity. Under this objective I asked the following research questions: (i) Is there a general trend of altitudinal species diversity or does it vary between sites; (ii) thus to describe the most parsimonious yet robust species diversity pattern; and (iii) are these altitudinal trends of diversity similar between guilds? The three alternative hypotheses that I tested were (a) altitudinal species diversity pattern follows a general trend at regional scale; (b) altitudinal species diversity pattern follows similar trends in the region but with random site effects and (c) altitudinal species diversity pattern differed between sites. Further I tested (d) whether this altitudinal diversity is linearly declining or unimodal. As spiders are also adapted to a rather narrow set of abiotic factors such as temperature, humidity and pH, I also tested (e) whether these factors influenced local diversity.

5.2 Methods

5.2.1 Spider Sampling

Selected sites with substantial altitudinal range were sampled in the Nanda Devi Biosphere Reserve (NDBR). As spiders are diverse in their ways of life, in order to collect them from all habitats, sampling required a combination of methods, so I used six different collection techniques *viz*., pitfall trapping, vegetation beating, litter sampling, ground hand collection, aerial hand collection, and sweep netting (Coddington, 1996). To collect mainly the ground dwelling spiders nine pitfall traps (cylindrical plastic bottles of 9cm diameter and 11cm depth) were arranged within the quadrates in three horizontal and three vertical rows, each at 5m distance from the nearest neighbour, thus forming four smaller grids of 5m×5m within the sampling plot (Fig. 5.1). Traps were filled with liquid preservative (69 % water, 30% ethyl acetate and 1% detergent). Other methods were applied to collect web builders, ambushers, and ground runner spiders. The details of the collection techniques are described in Chapter 3. Specimens were identified up to family, genus and species level when possible. Sampling was carried along the altitude, in three sites; Site 1 Lata Kharak (2000-4000m); Site 2 Bhyundar Valley (1800-4100m) and Site 3 Malari (3000-4000m). In all these sites 106 square quadrate plots (10m×10m) were laid randomly along the altitudinal gradient (Lata Kharak-40; Malari- 40 and Bhyundar Valley- 46) (Fig. 5.2-5.5)

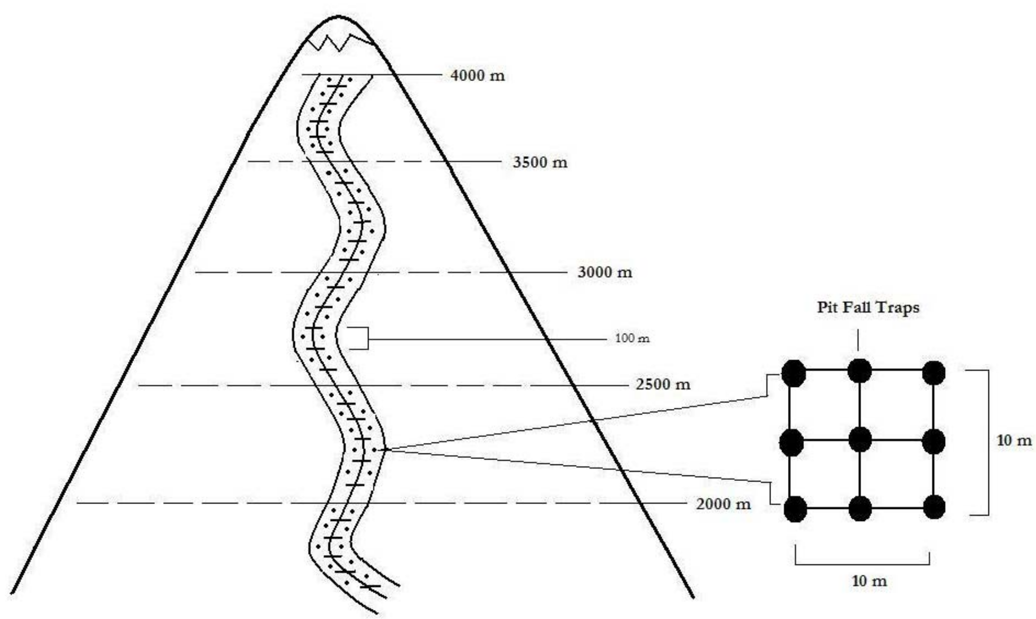


Fig. 5.1: Sampling design

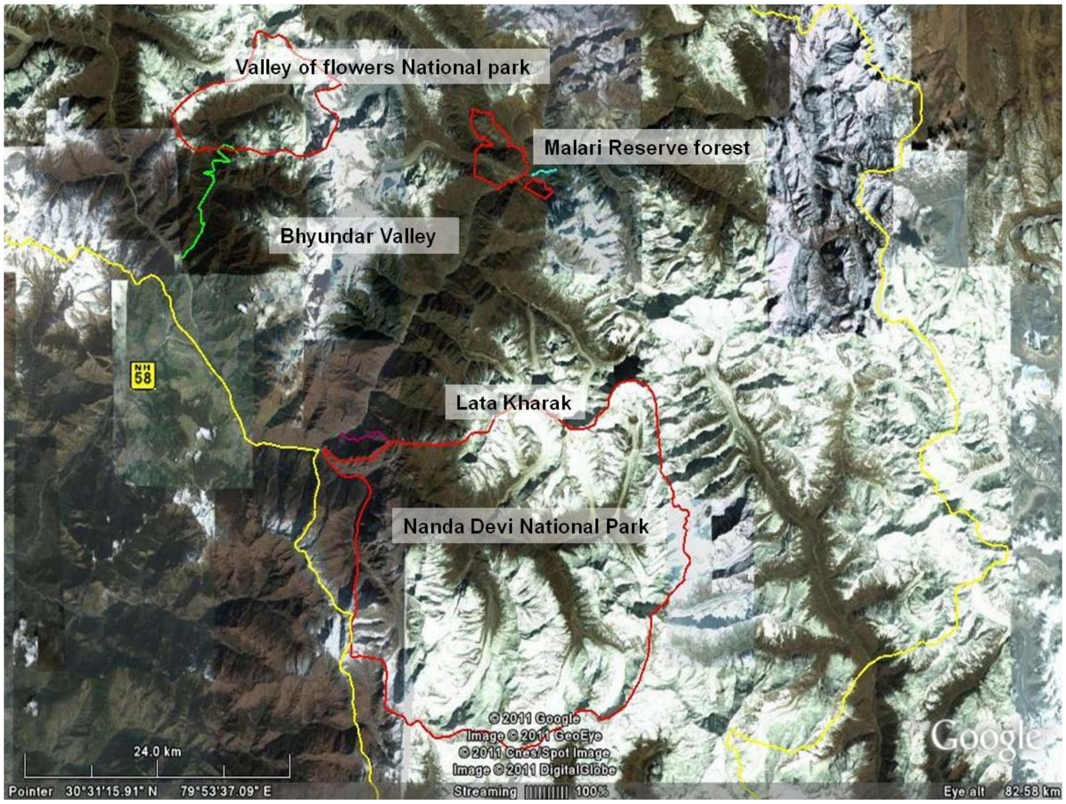


Fig. 5.2: Sampling Sites in Nanda Devi Biosphere Reserve

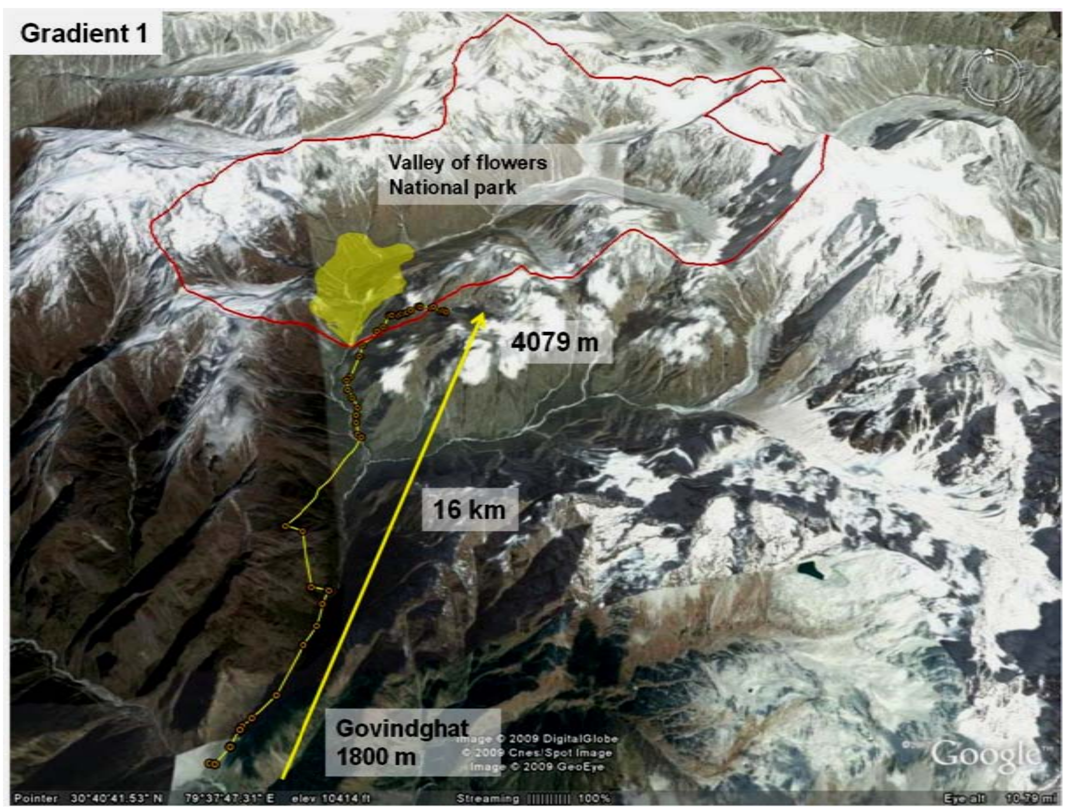


Fig. 5.3: Sampling plots in Bhyundar Valley (1800-4079m)

Fig.5.4: Sampling plots in Bhyundar Valley (2089-4013m)

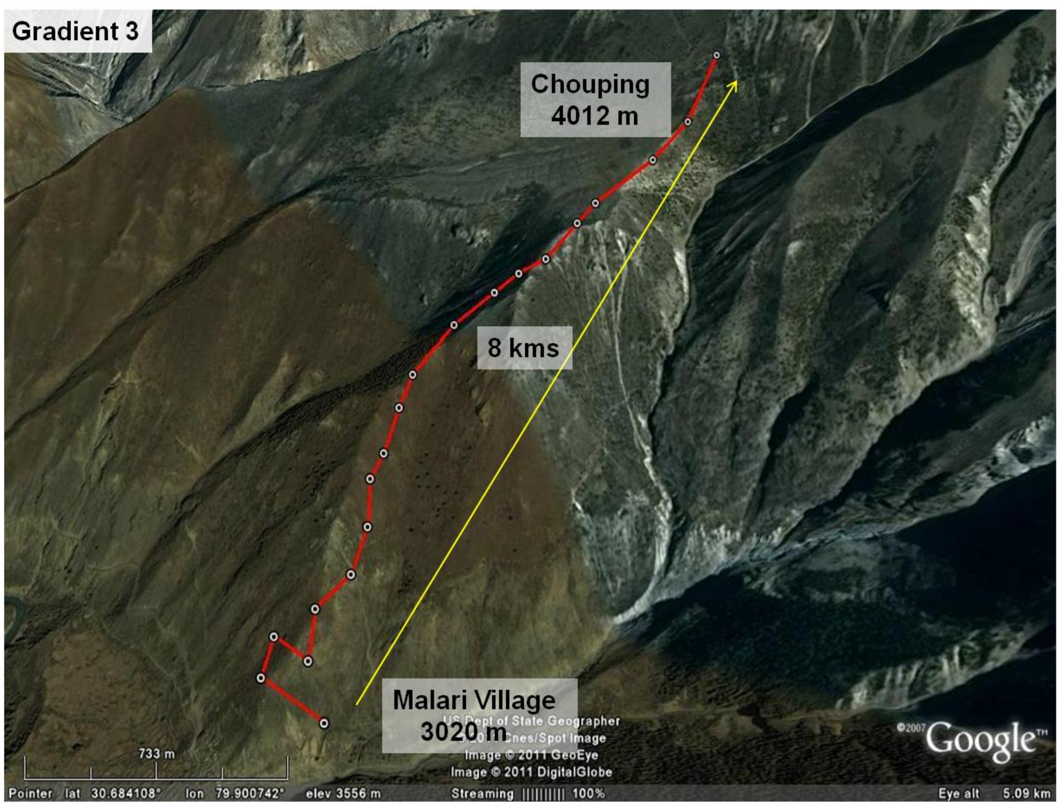


Fig.5.5: Sampling plots in Malari (3020-4012m)

5.2.2 Data Analysis

Spider samples captured by pitfall traps and other semi-quantitative methods were subjected to estimation of community parameters in a hierarchal fashion (plot to site to region). First, I examined sampling adequacy from species accumulation curves. For this I pooled data across plots for each site and generated rarefaction (by numbers) curves from 100 randomizations in EstimateS 8.0(Colwell, 2006). To estimate site species richness I used nonparametric estimators Chao1 and Jacknife2. Chao1 gives an estimate of absolute number of species in an assemblage based on number of rare species (singletons) in a sample. Chao1 estimate is recommended for inventory completeness values, completeness being the ratio between observed and estimated richness (Sørensen et al., 2002; Scharff et al., 2003). Jacknife2 has been found to perform well in extrapolation of species richness, with greater precision, less bias and less dependence on sample size than other estimators (Palmer, 1990, 1991; Brose et al., 2003; Petersen et al., 2003). So, I derived Chao 1 and Jacknife2 estimates on 100% and 50% of the sample plots and selected the best species richness estimator between the two based on the consistency of estimates across sub samples.

Second, I examined the spider community composition in the three sampling sites along the altitude. For this I used non-metric multidimensional scaling (NMS) (Kruskal, 1964) in program PC-ORD version 4.17 (McCune and Mefford, 1999). This technique calculated Bray-Curtis (Sørensen index) similarity matrix between sites based on species assemblages. Thereafter, it generated synthetic axes, reconstructed the distance matrix, and calculated stress as the difference between original and synthetic similarity matrices. It reiterated the process until a best possible solution was reached in terms of minimizing stress through minimum number of axes. Finally, I used scatter plots to inspect the distribution of sampling plots in the reduced species space (NMS axes), grouping plots into eco-climatic classes.

Third, I examined the patterns of species diversity along eco geographical gradients (primarily altitude and secondarily pH, humidity, ground cover etc). For this, I estimated species diversity for each plot using Shannon Wiener index. This index is sensitive to changes in abundance of rare species in a community and is based on the number of species in a taxa and the total number of species in a sample (Magurran, 1988). Then I formulated alternative ecological hypotheses on species diversity patterns corresponding to my research questions. For this, I modelled species diversity at plots alternately with altitude (linear and quadratic functions) and sites as random or fixed (additive and interactive) effects along with pH and humidity. I used linear and linear mixed models in Program SPSS version 16 release 2.0 (SPSS Inc., Chicago, IL, USA) and compared candidate models by the Bayesian Information Criteria (BIC). This exercise described the most robust and parsimonious species diversity pattern in this region.

Lastly, I examined the effect of altitudinal gradient on the species diversity across guilds. For this, I grouped species into functional groups or guilds. These guilds were grouped based on the available information on their habitat preferences and predatory methods. Thus, I classified them into three major guilds (PW-plant wanderers; GW-ground wanderers; WB-web builders). Similarly as above I estimated species diversity at plots using Shannon Wiener index and regressed them with altitude at different sites. Alongside I examined the altitudinal patterns of shrub and herb diversity. However, tree diversity was not quantified, as canopy spider diversity was beyond the scope of this study.

5.3 Results

5.3.1 Spider Diversity and Composition

A total of 244 species belonging to 108 genus and 33 families were collected during entire sampling period. It was observed that the family with the highest number of total species was Araneidae 18% (44 species); followed by Salticidae and Thomisidae 11.5% (28 species), Linyphiidae 7.4 % (14 species), Uloboridae and Tetragnathidae 4.5% (11 species), Theridiidae 8.6% (21 species), Gnaphosidae, Oxyopidae, Sparassidae and Lycosidae 4.1% (10 species) (Fig. 5.6). The species accumulation curve (pooled for each site) reached an asymptote for both Chao1 and Jacknife2 estimators indicating that sampling efforts were adequate at regional level for all the three sites to catch most of the species that occur there (Fig. 5.7). The estimated total species richness using abundance based Chao1 predicted richness for the three sites as 153.43±0.9 (Lata Kharak), 162.75±1.24 (Malari) and 206.43±0.9 (Bhyundar Valley). This indicated that the inventory was complete at the regional scale (91%).

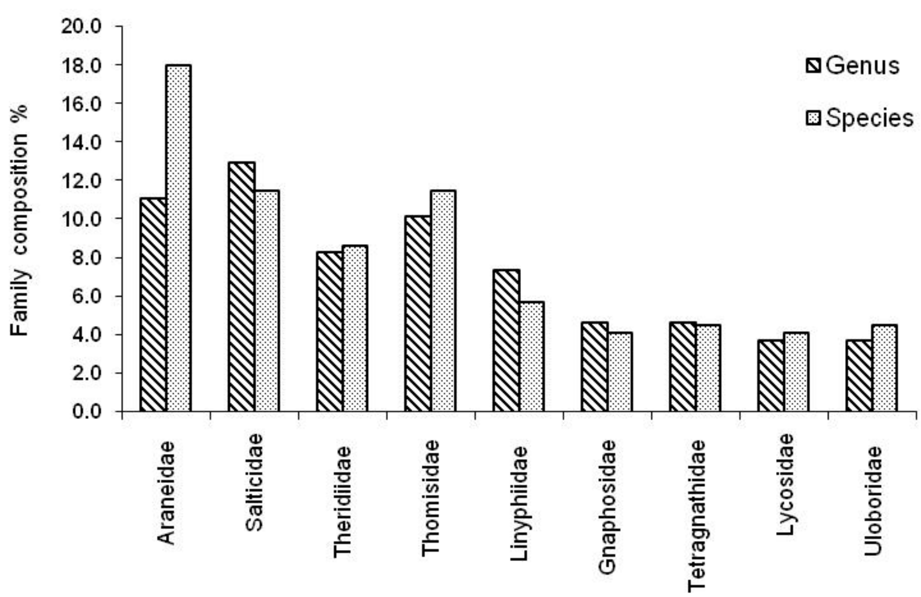


Fig 5.6: The composition of family of spiders (>4.0%) in NDBR in terms of total number of genus and species recorded during the entire sampling period expressed in percentage.

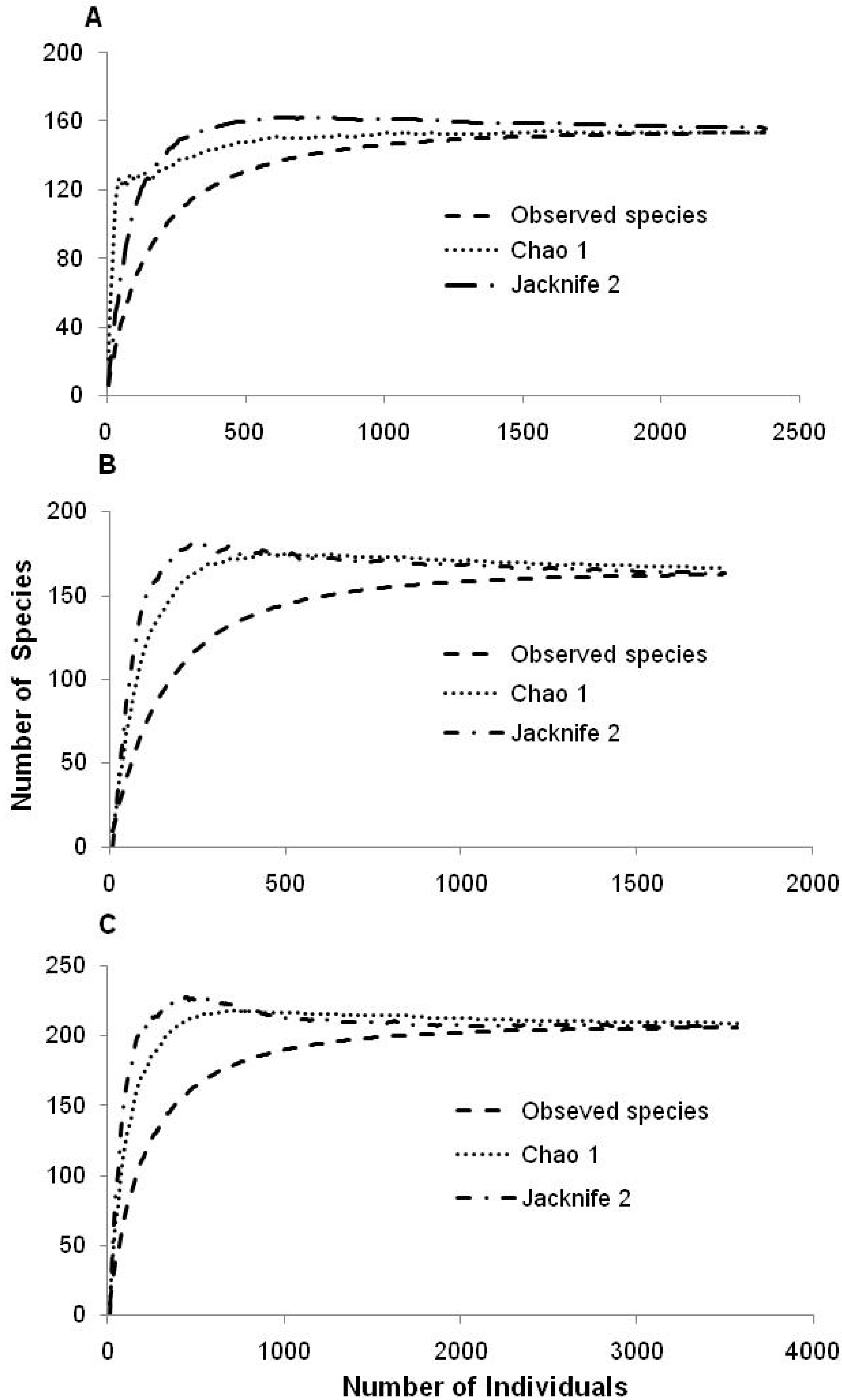


Fig. 5.7: Species-Accumulation curve and estimation curves Chao1 and Jacknife 1, for A. Lata Kharak, B. Malari and C. Bhyundar Valley (all samples pooled for each site) dataset.

5.3.2 Community Composition

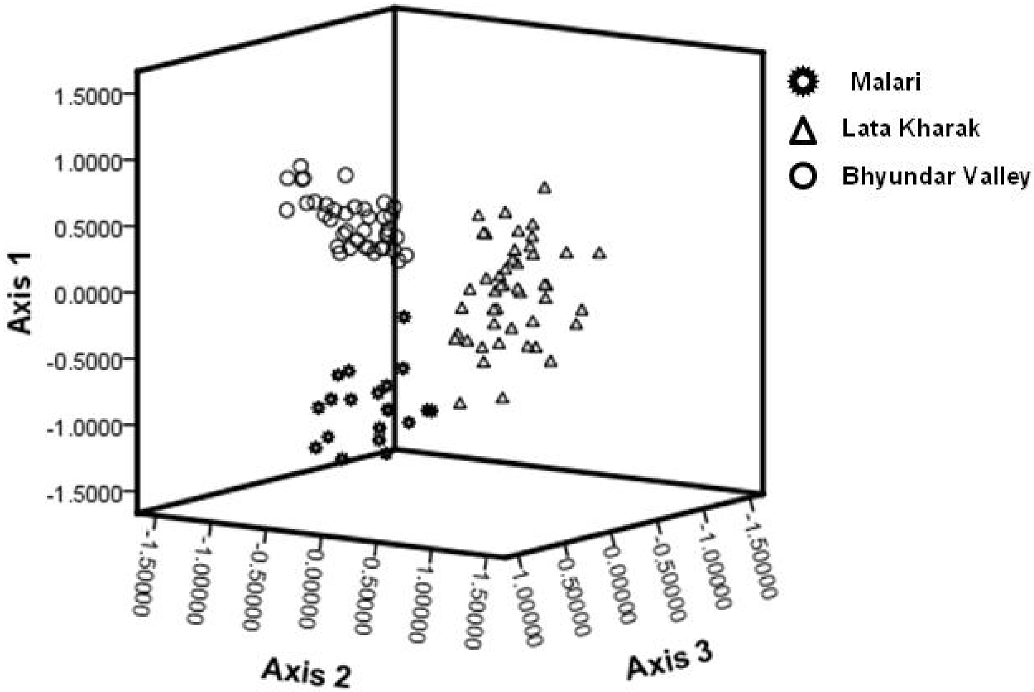


Fig. 5.8: NMDS graph showing spider species composition across the three sampling sites (Stress: 17.32; Number of iterations: 400).

The mean altitudes of the three sampling sites viz. Lata Kharak (2.78±0.57 km), Bhyundar Valley (3.13±0.62 km) and Malari (3.53±0.32 km), differ significantly from each other ($F_{2, 103}$=12.78 and p<0.001; Fig. 5.8). The plots sampled in three sites were plotted in a three dimensional space resulted from the Non-metric multidimensional scaling (NMS) in the programme PC-ORD. The plotting was done mainly to interpret the dissimilarities between the plots of the three sites based on the spider species composition recorded from each plot. The NMS graph shows distinct clusters of the sampled plots for the three sites which reveals that the three sites are different from each other in terms of species composition. The three sites having different altitudinal ranges acted as three distinct habitats with different species composition. Thus, different altitudinal ranges influence spider species composition as a whole in NDBR landscape.

5.3.3 Patterns of Spider Diversity across Altitudinal Gradient

Species diversity declined linearly across the three sampling sites (Fig. 5.9).

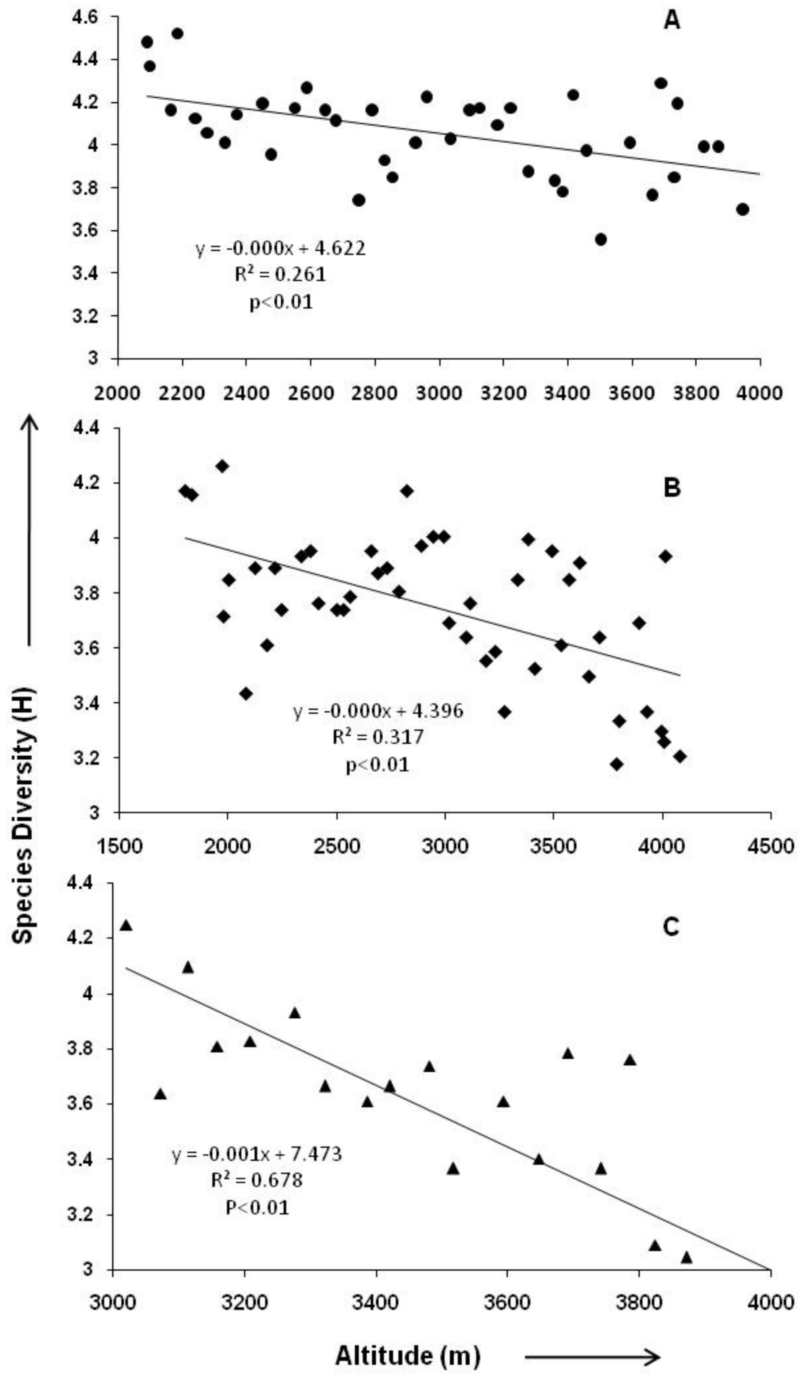


Fig. 5.9 Patterns of species diversity along the altitudinal gradient in the three sampling sites A. Lata Kharak; B. Bhyundar Valley and C. Malari

Pearson's correlation matrix at the regional scale indicated that species diversity was negatively related to altitude. However the explanatory variables were not correlated. (Table.5.1)

Table 5.1: Pearson Correlation matrix for the habitat covariates and regional species diversity (sites combined) as the dependent variable

Variables	Diversity	Altitude (km)	Temp (°C)	Ground cover%	Humidity	Litter depth (mm)	pH
Diversity	1	-0.476	-0.04	0.056	-0.113	-0.029	-0.244
Altitude (km)	-0.476*	1	-0.011	-0.171	0	0	0
Temp (°C)	-0.04	-0.011	1	-0.193	0.033	-0.031	0.152
Ground cover%	0.056	-0.171	-0.193	1	-0.11	0.069	-0.014
Humidity	-0.113	0	0.033	-0.11	1	-0.223	0.074
Litter depth (mm)	-0.029	0	-0.031	0.069	-0.223	1	0.097
pH	-0.244**	0	0.152	-0.014	0.074	0.097	1

*. Correlation is significant at the 0.001 level
**. Correlation is significant at the 0.05 level

Table.5.2: Comparison of alternate candidate models to describe species diversity (D) using information theoretic approach; model parameters,-2 loglikelihood value, Akaike's Information Criterion (AIC), and Bayesian Information Criterion (BIC)and ∆BIC have been reported. The best fit model predicted spider species diversity to be an interactive function of region and altitude.

Model	Parameters#	-2 Log L	AIC	BIC	∆BIC
D ~1	2	75.6	79.6	84.9	43.6
D ~1+alt	3	48.4	54.4	62.4	21.1
D ~1+alt+alt²	4	48.3	56.3	66.9	25.6
D ~(1/site)+alt	4	35.3	43.3	54	12.7
D ~(1/site)+alt+alt²	5	35.3	45.3	58.6	17.3
D ~1+site+alt	5	25.2	35.2	48.6	7.3
D ~1+site+alt+alt²	6	25.2	37.2	53.2	11.9
D ~1+site*alt	**7**	**8.6**	**22.6**	**41.3**	**0**
D ~1+site*alt²	8	5.9	21.9	43.2	1.9
D ~1+site*alt+pH	8	6.3	22.3	43.6	2.3
D ~1+site*alt+humidity	8	8.4	24.4	45.7	4.4

The regional species diversity patterns could be explained most parsimoniously and robustly as an interactive effect of site and altitude (Table. 5.2).

Table. 5.3: Parameter Estimates for the Best Fit Model

Parameter	ß	Std. Error	T	Sig.
Intercept	6.70	0.63	10.60	0.01
Lata Kharak	-2.20	0.66	-3.31	0.00
Bhyundar Valley	-2.68	0.66	-4.05	0.00
Altitude_km	-0.89	0.18	-4.97	0.00
Lata Kharak * Alt(km)	0.73	0.19	3.80	0.00
Bhyundar Valley * Alt(km)	0.80	0.19	4.24	0.00

The best fit model indicated that species diversity linearly declined by 0.89 units with unit increase in altitude (Km). In contrast to Malari, species diversity of Lata Kharak and Bhyundar Valley were less by >2 units. However, when compared to Malari, the rate of altitudinal decrease of species diversity was less in Lata Kharak and Bhyundar Valley (Table.5.3).

5.3.4 Guild diversity pattern along altitudinal gradient

From the results of the guild wise analysis across the elevation, I observed that out of the three guilds (GW,PW,WB) the ground dwelling spiders showed a hump shaped decline in all the three sampling site. Response of other two guilds, PW and WB to the altitudinal gradient differed in all three sampling sites. Where in Malari and Lata Kharak the distribution first gradually increased with altitudinal gradient and was maximum at the moderate elevation and then it again decreased gradually with further increase in the altitude. However in the third site (Bhyundar Valley) both the guilds did not show any distinguishable trend (Fig.5.10). Similarly, I also tested the patterns of herb and shrub diversity. It was observed that in Lata Kharak and Bhyundar Valley the herb diversity increased with the increase in elevation whereas the pattern of shrub diversity was not very clear (Fig. 5.11 & 5.12).While in Malari both the herb and shrub diversity showed a declining pattern with the increasing altitude (Fig. 5.13).

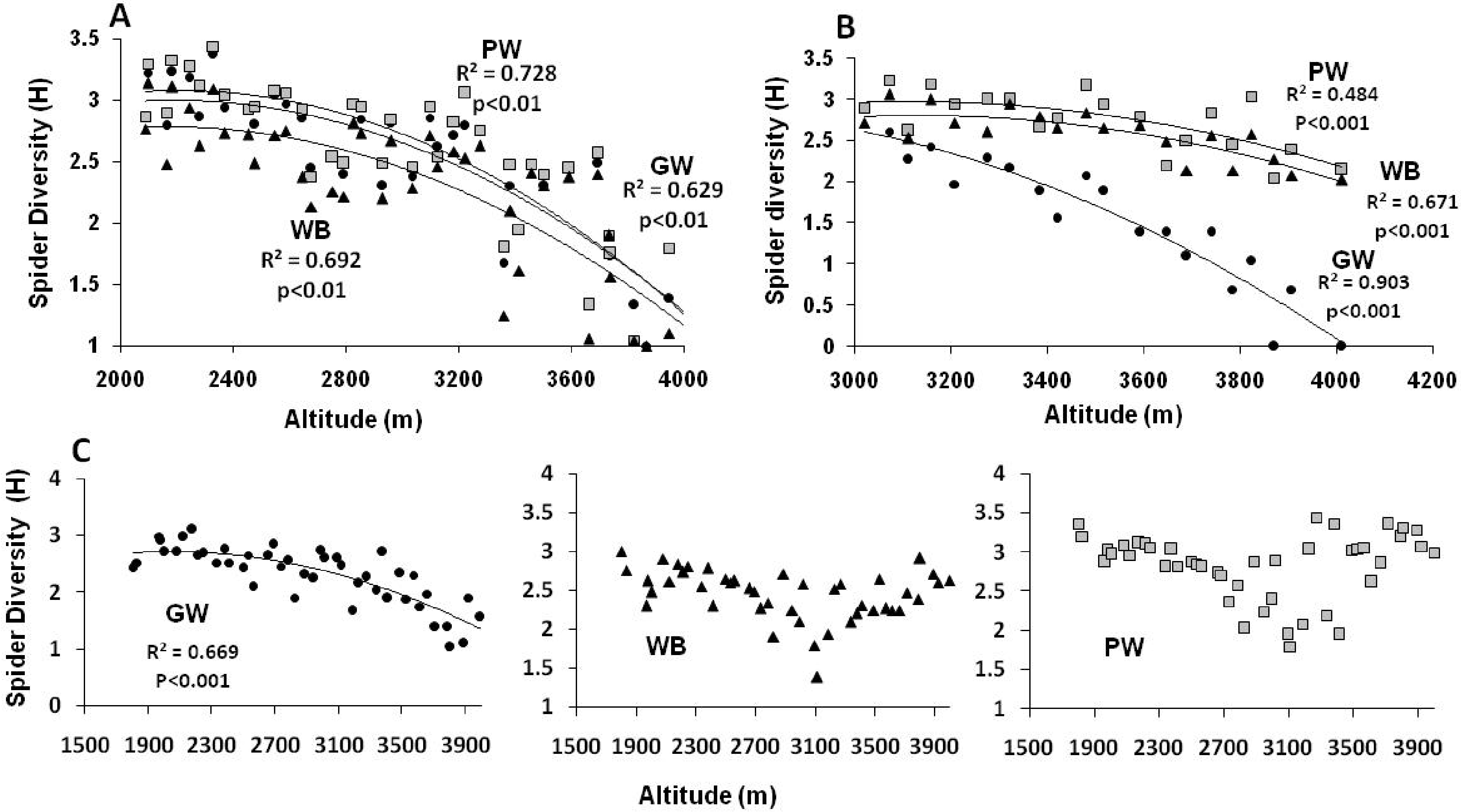


Fig 5.10: Guild Diversity Patterns in the three sites: A. Lata Kharak; B. Malari; C. Bhyundar Valley

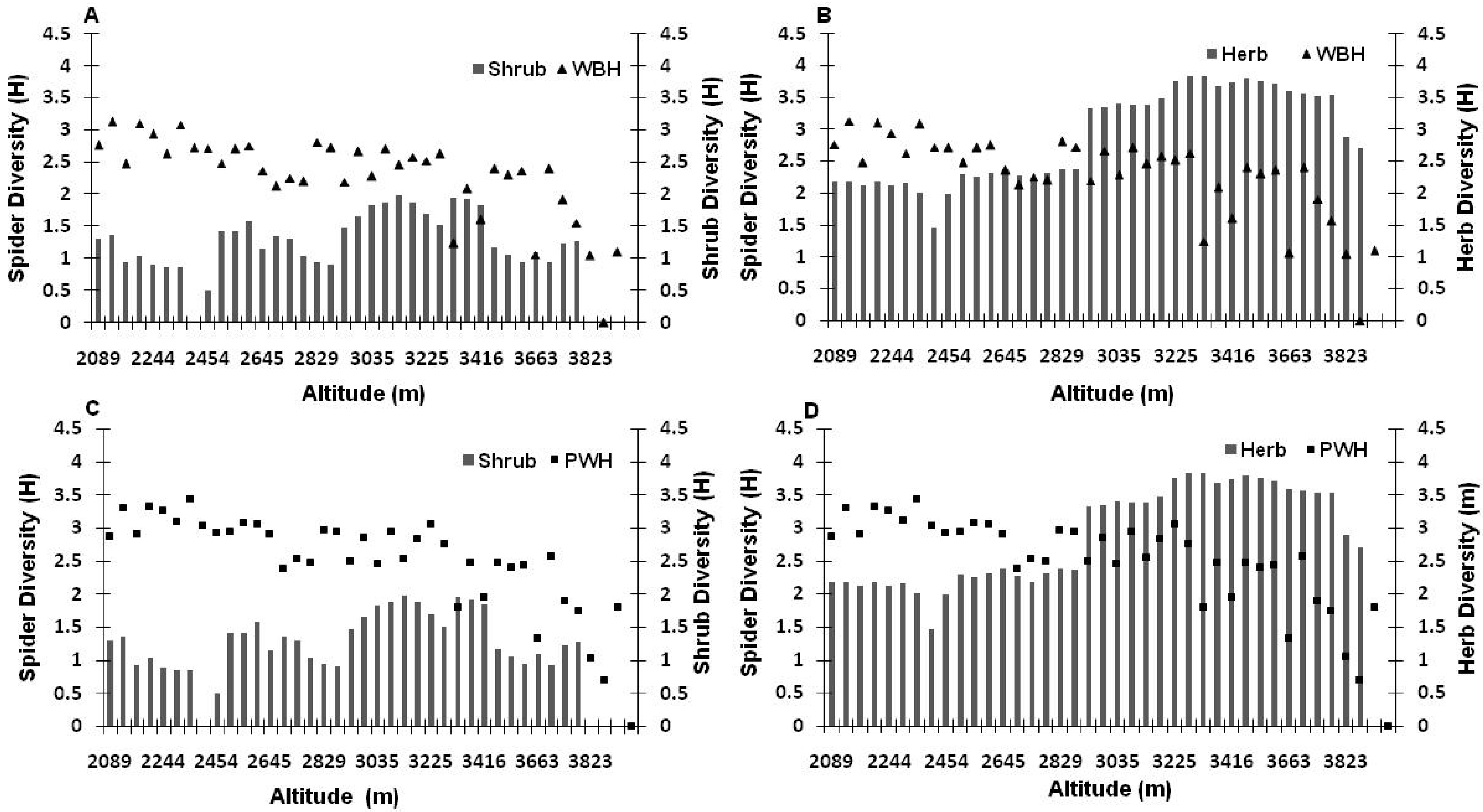


Fig 5.11: Patterns of Guild Diversity of Spiders (A-B: WB-Web Building spiders& C-D: PW-Plant wandering) along with herb and shrub diversity in Site. 1 (Lata Kharak)

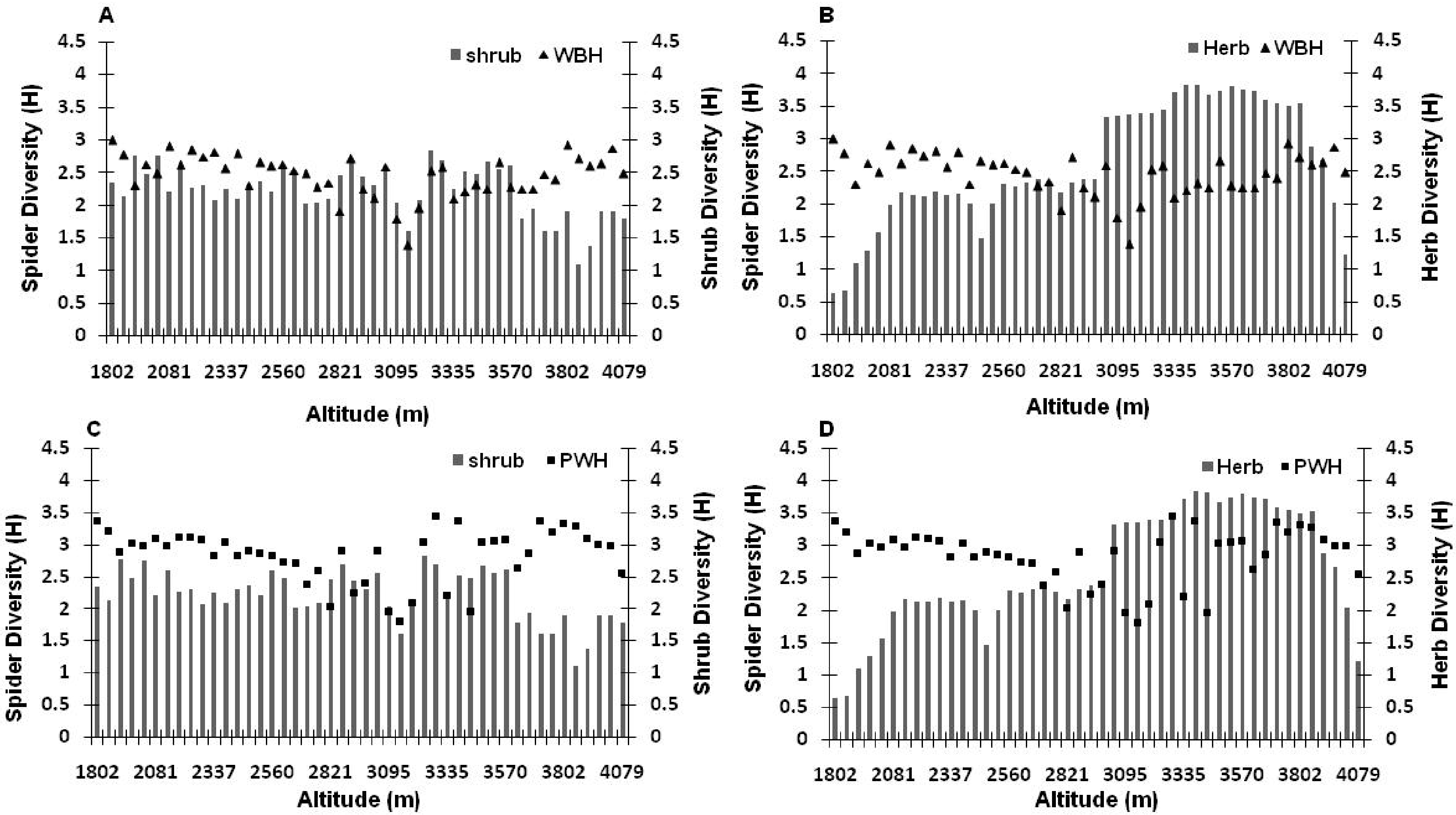


Fig 5.12: Patterns of Guild Diversity of Spiders (A-B: WB-Web Building spiders& C-D: PW-Plant wandering) along with herb and shrub diversity in Site. 2 (Bhyundar Valley)

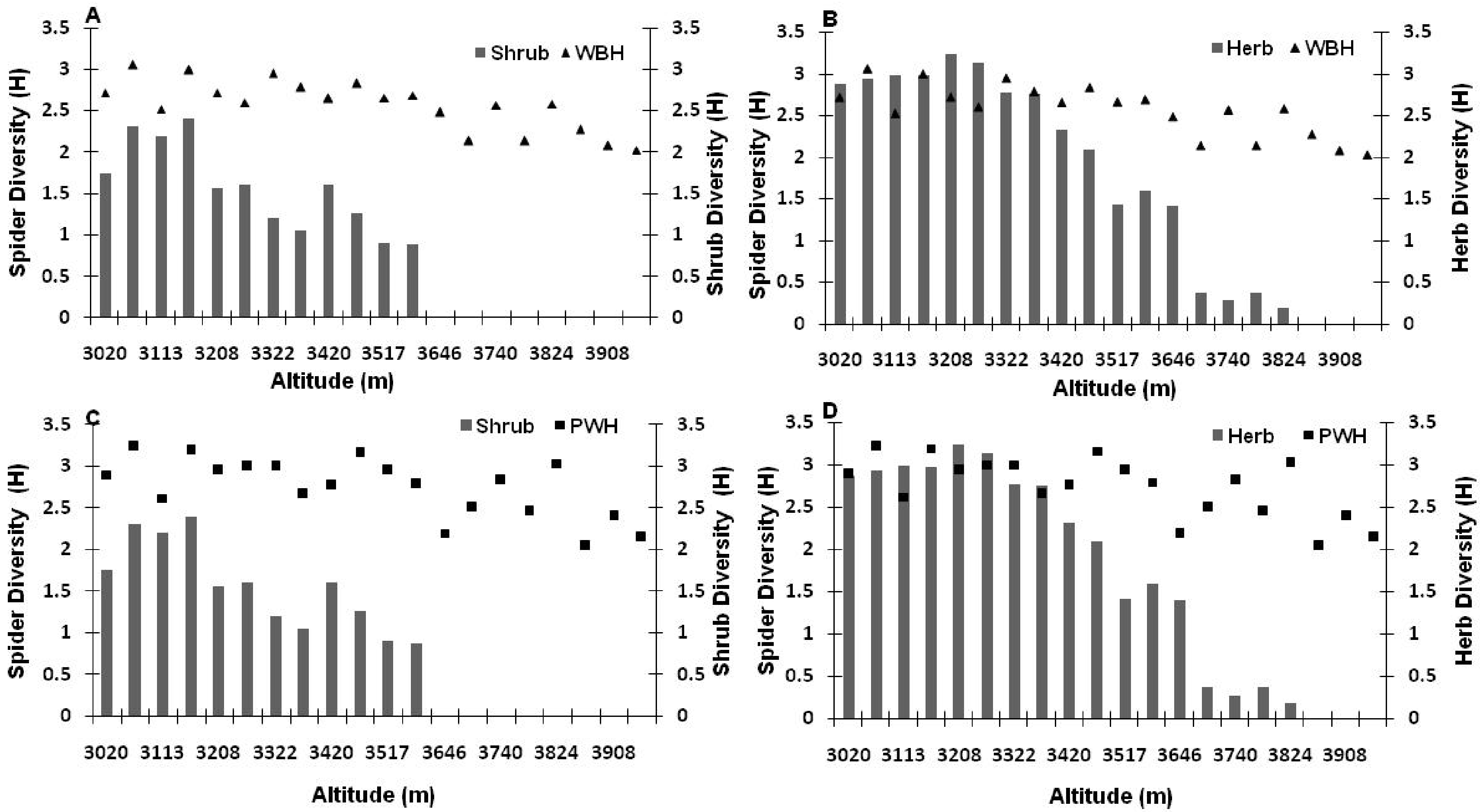


Fig 5.13: Patterns of Guild Diversity of Spiders (A-B: WB-Web Building spiders& C-D: PW-Plant wandering) along with herb and shrub diversity in Site. 3 (Malari)

5.4 Discussion

It is increasingly important to understand patterns of species diversity in the high altitudinal regions of Indian Himalaya and obtain baseline data with which to compare future changes resulting from spatial shifts in climate and habitat. This study quantifies spider assemblages and shows that spider partition's space and habitat according to the niche they occupy along elevational gradients. I documented a total of 244 species belonging to 108 genus and 34 families during the entire sampling period. This represents 16.1% of total species, 28.6% generic and 56.7% family diversity reported from India (Sebastian et al., 2009). Though, I observed some of these families and species with limited distributions, it may be because they are cryptic or have patchy distribution and thus may not have been adequately sampled.

The results showed that the species diversity decreased with the increasing altitude in all the three sampling sites. As spiders are sensitive to small changes in the environment, especially, vegetation, topography and climatic changes, patterns of linear decline may also be probably related to more severe climatic conditions, terrain and landscape of NDBR, leading to species decline and absence of the less tolerant species. Similar results of spider abundance declining linearly with elevation were observed in the studies of Otto and Svensson (1982) and Mc Coy (1990). Along the altitudinal gradient of NDBR two main patterns are evident firstly a steady decline in family diversity and then a hump shaped decline of species. Species are gradually filtered out depending on their tolerance and appropriate habitats and in most cases they are not replaced by others. From the results of the guild across the elevation, it was observed that the ground dwelling spiders showed a hump shaped decline in all the three sampling site. Chatzaki et al. (2005) also found similar results in Crete that along a broad elevational gradient, ground dwelling spider richness shows a hump-shaped response to changes in elevation. However, I found similar hump-shaped responses of plant wanderers and web builders in Lata Kharak and Malari, but no response of elevation on these guilds in Bhyundar Valley. The hump shape could be possibly being the result of greater habitat diversity and stability of environmental factors as compared to higher altitudinal zones.

For ground dwelling spider timberline does not play any major role (Chatzaki et al., 2005). Because they live on the ground, the changing vegetation above the timberline does not affect them directly but only through the decline of food availability which results from the reduction of habitat diversity and complexity. However, in other spider families which are probably dependent on the vegetation type of their habitat due to their way of life and foraging, the vegetation plays significant role in shaping these communities. In particular, the formation of ground vegetation and the resulting microclimate are most likely to affect the diversity and distribution of ground dwelling spider species and this is probably a major reason for the formation of specific species assemblages in a habitat (Bultman and Uetz, 1982; Hurd and Fagan, 1992; Gibson et al., 1992). Pattern of species diversity decline and species composition are probably related to more harsh climatic conditions (like extremes of temperature, humidity, precipitation, wind intensity) and to the landscape, leading to species decline and absence of less tolerant species. Species richness is supposed to peak at mid-elevation via primary productivity, which is considered to peak at mid elevations. However, Jimenez-Valverde and Lobo (2007) found that spider richness was more strongly correlated with habitat complexity and maximum temperature than with elevation at a regional scale of investigation. Earlier works suggest that species diversity is correlated with structural complexity of habitat (Uetz, 1979; Mac Arthur, 1964; Pickett et al.1991; Androw, 1991; Hawksworth and Kali-Aroyo, 1995; Rosenzweig, 1995). As habitat structure and complexity changes with increasing altitude, shift in composition of potential prey species is also expected to occur; supporting a dual process that is probably determining spider assemblages in the area. However some families like Lycosidae which are more tolerant and overcome harsh conditions were also collected from higher elevations.

Changes along spatial gradients associated with changes in habitat can have significant effects on the structure of spider assemblages, but responses vary among different altitudinal sites. Studies conducted by Samu et al. (1999) in agricultural ecosystems found that spider abundance/diversity and environmental (including microclimate, habitat, and disturbance) diversity were, in general, positively and variably correlated at different scales. In Terai Conservation Area, Hore and Uniyal (2010) found that habitat heterogeneity is mediated largely by structural diversity of the vegetation rather than microclimate variation. Structural changes in vegetation tend to override imminence much before any microclimatic change takes effect in space. Studies have confirmed that residence time is related to disturbance or web destruction (Enders, 1976; Hodge, 1987), microhabitat features such as temperature or humidity (Biere and Uetz, 1981), growth of the spider and an appropriate change in the structural requirements of web construction (Lubin et al., 1993), and prey capture success (Bradley, 1993; McNett and Ryptra, 1997).

From the ordination analysis using NMS, it was revealed that the species composition differed in different mountain systems. It may be possible that with the increase in altitude, resource gets limited and only the tolerant species are able to cope with the changes with altitude. NMS has been used as a tool for descriptive multivariate data analysis, and the principles and mechanics have been well documented (McCune and Grace, 2002). NMS is well suited to community data, particularly when β diversity is high (i.e., the data matrix contains many zeroes) (Faith et al., 1987) and provides robust analysis of many data types. In analyses of simulated data with known gradients, NMS has shown superior ability to recover underlying data structure compared to principal components analysis, principal co-ordinates analysis, and reciprocal averaging (Fasham, 1977; Minchin, 1987).

There are several other environmental factors that may also affect spider species diversity apart from altitude and seasonality viz., spatial heterogeneity, competition, predation, habitat type, environmental stability and productivity (Rosenzweig, 1995). Other factors are important in influencing spider diversity and richness in the Himalayan ecosystem *viz*., intra - and inter-specific competition, surrounding habitats and climatic factors. However, the role of biotic factors cannot be ruled out, as food availability and processes such as dispersal may also significantly influence the dynamics and structuring of spider assemblages. Shifts in vegetation structure are also expected to assist changes in diversity and abundance of arthropods as spiders depend heavily on arthropod prey, dynamic shifts in the prey base are likely to limit the spider assemblage.

Nanda Devi Biosphere reserve is interestingly diverse in spider fauna. Similar research in other parts of the Biosphere Reserve will surely supplement information in this direction. It is also important to note that spider fauna is ubiquitous in nature and their diversity cannot be explained by quantifying one aspect of the environment. It does depend on many other factors or a combination of factors, apart from altitudinal variation and habitat structure. Looking into these factors would surely bring in more interesting results which can be relevant to maintenance and management of this diversity.

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CHAPTER 6

ASSESSMENT OF MORPHOMETRIC CHANGES IN SPIDERS ACROSS GUILDS AND THE ALTITUDE

6.1 Introduction

Large-scale systematic patterns of variation in morphology are central to organismic biology and have been repeatedly studied. They are most obvious in context of body size, probably the single most important quantitative trait of an individual. This is because body size influences virtually all physiological (e.g., metabolic rate) and fitness traits (e.g*.,* fecundity or mating success), producing strong but not necessarily well understood allometric relationships within and among organisms (Wootton, 1979; Peters, 1983; Calder, 1984; Schmidt-Nielsen, 1984; Shine, 1988; Reiss, 1989; Honek, 1993; Andersson, 1994; Blanckenhorn, 2000). Several parameters, from physiological processes to environmental pressures, cumulatively determine body size and related morphological traits. Along with a wide range of factors, ontogenesis, biomechanical constraints, sexual selection, fecundity, size-specific predation, resource quality and availability, overcrowding, competition and temperature have been reported as the most prominent ones (Angilletta and Dunham, 2003; Berven and Gill, 1983; Juliano, 1986). Most of these factors may vary from one habitat to another and such geographic variations in body size have been studied extensively (Boggs and Freeman, 2005; Schmidt- Nielsen, 1984).

From the mid 19th century, a number of ecological and evolutionary patterns or ‘‘rules’’ dealing with body size have been described over the years (Bergmann, 1847; Atkinson and Sibly, 1997; Ashton et al., 2000; Ashton, 2002a and b, 2004, Ashton and Feldman, 2003). At a large geographic scale, clinal variation of morphological parameters within species from different taxa has been found (Blanckenhorn and Demont, 2004; Hallas et al., 2002). The nature of such variation has been addressed frequently along altitudinal and/or latitudinal climatic gradients (Arthur et al., 2008; Blanckenhorn et al., 2006). Body size and body size proportions tend to follow some eco-geographical patterns, such as Bergmann's or Allen's rules (Bergmann, 1847; Allen, 1877). Bergmann's rule asserts that geographic races of a species possessing smaller body size are found in the warmer parts of the range, and races of larger body size in cooler parts**.** Although Bergmann's rule was originally proposed for homeotherms, Bergmannian (and converse Bergmannian) clines occur in invertebrate and vertebrate ectotherms (Honek, 1993; Atkinson, 1994; Arnett and Gotelli, 1999a, b; Huey et al., 2000; Smith et al., 2000; Trussell, 2000; Ashton, 2001, 2002a; Ashton and Feldman, 2003; Heinze et al., 2003; Blanckenhorn and Demont, 2004; Schauble, 2004; Bidau and Marti, 2007b). Converse Bergmannian clines are much more frequent in ectotherms than in endotherms, especially in insects (Brennan and Fairbairn, 1995; Mousseau, 1997; Fischer and Fiedler, 2002; Blanckenhorn and Demont, 2004; Bidau and Marti, 2007b). In some cases the changes observed in the body size are directly associated with latitude while are negatively related with altitude (Arnett and Gotteli, 1999a, b). Changes in morphological traits along elevational gradients in arthropods are often interpreted in terms of the temperature-size rule, which states that the body size of organisms increases under low temperatures, and is therefore expected to increase with elevation and latitude. This subject has received considerable research and attention in recent years (Ray, 1960; Blackburn et al., 1999; Ashton, 2001; Millien et al., 2006). Furthermore, changes in the physical environment occurring rapidly can profoundly alter the biological communities across elevational gradients. Arthropods encounter different environmental conditions along elevation gradients that could possibly alter body size either directly through forced effects or indirectly as a result of selection pressures changing with environmental conditions (Mousseau and Dingle, 1991; Blanckenhorn and Demont 2004).

Spiders are important predators in most terrestrial habitats (Wise, 1993), also exhibiting considerable variation in their body size. As generalist predators, the important resource for spiders is arthropod prey. Important distinctive characteristics exhibited by spiders are probably foraging methods, niche, and the range of prey, vertical distribution and body size. Body sizes within spider families are highly variable. In the light of the existing knowledge, I consider body size and morphometric traits to be influenced by altitude and species guilds/niche.

In this study, I used data based on measurements of spider body parts, range and mid-altitude of occurrence. Interestingly, within arthropods, the size of each organ, appendage or body region bears a specific relationship to overall body size (Shingleton et al., 2007). Variation in morphological characters of the spider species was assessed by measuring prosoma length-width, opisthosoma length-width, measurements of the leg dimensions and absolute body length. From the data collected, I generated three guilds (GW-ground wanderers, PW-plant wanderers and WB-web builders) based on the niche they occupy. The guilds used here were broadly classified on the basis of foraging methods, also assuming that differences in spider hunting behavior indicated differences in potential prey used, since prey are differentially susceptible to predator capture methods (Turnbull, 1973). Based on the understanding of possible relationships between body size, altitude and niche, I made certain predictions on morphometric characters of spiders and their changes with altitude. I examined these predictions by combining morphometric variations into principal components (PCs) and then regressing them against the above variables.

6.2 Methods

6.2.1 Measurements

I studied the morphometry of body and appendages of spider samples collected between 1800m and 4000m in NDBR. Fourteen morphometric measurements were recorded from 357 adult spider (both sexes) specimens. These were (a) Total body length (BL); (b) Opisthosoma width and length (AW, AL); (c) Prosoma width and length(CW,CL); (d) length of four left legs and (e) average of all leg segments for each leg. All measurements were taken in millimeters (mm) using a binocular dissecting microscope (Leica DFC 290) with an eyepiece scale calibrated with a slide micrometer.

6.2.2 Data Analysis

I derived 17 variables from these measurements for further analysis. These derived variables represented variables represented as absolute and relative morphometric aspects. The derived variables were the ratios of 1) the total body length, 2) Prosoma width to length, 3) Prosoma width to body length, 4) opisthosoma width to length, 5) opisthosoma width to body length, 6-10) average of each of the five leg-segments (coxa-trochanter, femur, patella, tibia, tarsus-metatarsus) across the four legs, 11-13) coefficients of variance (CV=Standard Deviation/Mean, see Zar 1999) of the leg segments across the four legs and 14-17) the ratios of total length of four legs to the body length (see Chapter 4 for diagrammatical representation of the spider morphometry). Normality of derived variables was tested through the Kolmogorov Smirnov test (Zar 1984) and data was Z-standardized, which linearly transforms the variable by centering it on the mean and scaling it by one standard deviation. I computed a pair wise Pearson's correlation matrix between z-standardized morphometric variables (Appendix 6.1). Variables were subjected to Principal Component Analysis (hereafter PCA) using VARIMAX (variance-maximizing) rotation through Kaiser Normalization in Program SPSS version 16 release 2.0 (SPSS Inc., Chicago, IL, USA). This approach generated principal components representing the morphometric space in reduced dimensions. Scores of principle components for spider samples were then used as the response variables in correlation/regression tests to investigate the influence of the average and range of altitude (in km), and niche on spider morphometry. First, I used MANOVA exploratory analysis with the five principal morphometric components, range, niche, interaction of niche with mid- altitude and range, this helped to screen out the variables that were not important. Then, I modeled individual principal morphometric components with the fixed and interaction effects of the above explanatory/predictor variables using Gaussian Generalized Linear Models (GLM). Here the expected value of the response variable was estimated as a linear combination of the predictors through an identity link function (Guisan et al., 2002) assuming normal error distribution. I tested alternative *a-priori* ecological hypotheses regarding the mechanisms underlying the observed morphometric pattern in spiders.

6.3 Results

The Principal Component Analysis synthesized 17 variables into five components with eigen value >1 that explained 75% of the variance in data. The first principal morphometric component (hereafter, PMC) explained 33.6% variance in data followed by the second PMC (12.1%), third PMC (11.2%), fourth PMC (9.9%), and fifth PMC (8.4%). I observed that (1) average size of coxa-trochanter, femur and patella (leg components I, II & IV) and leg size to body length ratio of all four legs were positively related to the PMC 1; (2) average size of coxa-trochanter, femur and patella and total body length was found to be positively related to the PMC 2; (3) opisthosoma width to length ratio and opisthosoma width to total body length ratio were positively related to the PMC 3; (4) prosoma width to length ratio and prosoma width to body length were positively related to PMC 4; and (5) coefficients of variance for coxa-trochanter, patella and tarsus-metatarsus were positively related with the PMC 5.

Table 6.1: Summary of Principal Component Analysis, showing coefficients (loadings) of spider morphometric characters on the five principal components; with ecological interpretations and functions of these components

Variables	**PMC1**	**PMC2**	**PMC3**	**PMC4**	**PMC5**
Body length		.92			
Prosoma width: length				.96	
Opisthosoma width: length			.95		
Prosoma width: body length				.73	
Opisthosoma width: body length			.94		
Average size of coxa-trochanter	.65	.69			
Average size of femur		.75			
Average size of patella	.57	.76			
Average size of tibia	.70	.53			
Average size of leg tarsus-metatarsus		.89			
CV of coxa-trochanter between legs					.78
CV of femur between legs					.66
CV of tarsus-metatarsus between legs					.62
Length of leg 1: body length	.90				
Length of leg 2: body length	.86				
Length of leg 3: body length	.88				
Length of leg 4: body length	.75				
% Cumulative variance	**33.6**	**45.7**	**56.9**	**66.8**	**75.18**
Ecological interpretation	Absolute basal (I-III) leg component lengths and relative leg lengths (+ve)	Absolute body and leg component lengths (+ve)	Relative opisthosoma width (+ve)	Relative prosoma width (+ve)	Inter leg variance of important leg components (+ve)
Ecological function	Related to mobility	Adaptability to climatic conditions	Gender related	Related to foraging strategy	Functional flexibility
References	Cushman et al., 1993	Bergmann, 1847	Wise 1993	Uetz et al.,1999	

*Empty cells indicate variables with absolute loadings <0.5 on Principal components.

Table.6.2 Multivariate analysis of variance to explore (a) influences of mid-altitude, altitudinal range and guild of spider samples on their morphometric components and (b) tests of between subject effects

(a)

Response variables	F	df	p-value
PC1	5.65	6	<0.001
PC2	8.25	6	<0.001
PC3	0.76	6	<0.6
PC4	6.83	6	<0.001
PC5	5.76	6	<0.001

(b)

Response variables	Altitude (df=1)	Range (df=1)	Niche (df=2)	Altitude*Niche (df=2)
PMC1	NS	NS	F=11.83, p=0.001	F=10.2, p=0.001
PMC2	NS	F=19.5, p=0.009	F=13.23, p=0.001	F=6.8, p=0.001
PMC4	F=6.8, p=0.009	NS	NS	NS
PMC5	F=8.7, p=0.008	F=10.85, p=0.001	F=3.96, p=0.002	F=6.8, p=0.003

NS: non-significant

Based on exploratory multivariate analysis of variance, the effect of altitude and niche on PMC3 was found to be non-significant; hence this component was screened out from further analyses. Moreover, there were no apparent explanations to patterns of PMC4 and PMC5 against altitude or niche, hence they were also screened out from further analysis (Table. 6.2a). I constructed minimal adequate models on the first two principal morphometric components (response) with four predictors: mid-altitude, altitudinal range, niche and niche*mid-altitude interaction effects

Table 6.3: Summary Statistics of regression models for principal morphometric component 1; Regression ß-coefficient, Wald Chi Square and p-value of predictors are reported.

PMC1	B	SE	Wald ^{2}	p-value
(Intercept)	3.047	0.6884	19.597	0.001
Mid-altitude (km)	-0.626	0.2933	4.562	0.033
Ground Wanderers	0.943	0.9172	1.056	0.304
Plant Wanderers	-4.295	1.119	14.735	0.001
Ground Wanderers * mid altitude	-0.206	0.3708	0.307	0.579
Plant Wanderers * mid altitude	1.744	0.4662	13.985	0.001

The minimal model with PMC1 as the response variable indicated significant influence of niche and interaction of niche with mid-altitude (X^2= 32; df=5; p<0.001; Table 6.3). In contrast to web builders, plant wanderers had significantly less PMC1 scores. However, the PMC1 score of plant wanderers increased with increasing altitude at a higher rate than that of web builders.

Table 6.4: Summary Statistics of regression model for principal morphometric component 2; Regression ß-coefficient, Wald Chi Square and p-value of predictors are reported.

PMC2	B	Std. Error	Wald ^{2}	P-value
(Intercept)	-2.206	0.746	8.744	0.003
Ground Wanderers	2.855	0.9815	8.462	0.004
Plant Wanderers	5.746	1.1943	23.145	0.001
Mid-altitude (km)	1.142	0.334	11.689	0.001
Range of altitude (km)	-1.176	0.2821	17.378	0.001
Ground Wanderers * mid-altitude	-1.106	0.3975	7.737	0.005
Plant Wanderers * mid-altitude	-2.535	0.5005	25.646	0.001

The minimal model with PMC2 as the response variable showed significant influence of niche, mid-altitude, range of altitude and interaction of niche with mid-altitude (X^2= 44.1; df=6; p<0.005; Table 6.4). In contrast to web builders PMC2 score of plant wanderers and ground wanderers were significantly higher. PMC2 score increased with mid-altitude while it decreased with altitudinal range. In contrast to web builders, PMC2 score of plant wanderers and ground wanderers decreased with increasing altitude.

6.4 Discussion

The strongest pattern in spider morphometry was differences in relative leg lengths and absolute lengths of coxa to patella. The next strong pattern was observed in absolute body and leg sizes. Species segregated most widely along these gradients; hence I analyzed if altitude influences these gradients. Results indicated significant differences in body and leg sizes across guilds and altitude. Length of legs related to the body as well absolute length of coxa to patella was less in plant wanderers than the other two guilds. Ground wanderers had to move larger distances and larger leg size to body might facilitate that in comparison to web builders. I observed this pattern, however the factors governing it was not well understood due to lack of parallel studies. The general body size increased (PMC2) with mid altitude. This result was coherent with Bergmann's rule that predicts larger body sizes at higher altitudes to adapt to more severe climatic conditions. As the mid-altitude of species distribution increased, their altitudinal range of distribution increased simultaneously. However, spiders with larger distribution range had smaller body and leg sizes. One explanation to this might be that larger ranges allow seasonal migration to avoid severe climatic conditions for which ballooning might be an easier alternative that would require smaller body sizes (Cushman et al., 1993). There were morphometric patterns among spiders in terms of prosoma size and inter leg variance of leg components, although weaker than the above two explained patterns, and explained 20% cumulative variance. Due to the paucity of relevant literature, however, I did not extend my analysis to modeling these patterns with altitude and guild, since there was no apparent explanation underpinning these patterns, even if they existed.

Along with guild and altitude, foraging strategies shaped by local food resources and gender might possibly influence spider morphometry. In natural situations, this is particularly significant in many predatory arthropods, where often food limitations are often observed (Bommarco, 1998; Pearson and Knisley, 1985). It is also important to note that elevation has significant effects on spider composition, species richness and overall abundance, but species-specific responses differed along the gradient. Body size is a crucial determining factor for organisms and varies continuously because of the effects of natural selection on the size-dependency of resource acquirement and mortality rates.

Numerous physical parameters that influence arthropod physiology vary substantially with altitude, including temperature, air density, and oxygen partial pressure. It is also possible that in contrast to it being a direct effect of altitude, spider body size is also indirectly determined by several other biotic interactions. As spiders are generalist predators, their body size may depend on prey availability and/or size, which in turn may be influenced by different climatic conditions (Nentwig and Wissel, 1986). As food quality and quantity are two main factors determining adult body size in arthropods, alteration of the available resources may thus affect predators' morphology. Furthermore, spiders are themselves predated by numerous other animals (e.g. wasps, parasites, parasitoids, birds, lizards and spiders; Wise, 1993). If large sized spiders are less susceptible to natural enemies, the observed body size distributions in spiders may be determined by predation pressure. However, the effect of predation pressure on prey body sizes is dependent on additional factors such as food availability for prey (Abrams and Rowe, 1996). In contrast, interference competition clearly favours large-bodied species (Eichenberger et al., 2009). Body size is a phylogenetically conservative trait, which means that species have only a limited potential to change body size compared with other ecological traits such as habitat preference (Entling et al., 2007). Thus, the distribution of large and small bodied species among habitats and also across altitude results from family sorting according to environmental conditions.

Previous studies have been conducted on spider body size along the latitudes in European countries and islands show a decreasing pattern towards the higher latitudes, body size decreased from warm to cooler environments

(Opell et al., 2007). Few studies have examined discrepancy in the expression of morphological traits at local geographical scales, where resources and competition appear as primary determinants of adult size and morphology.

In this work I tested the changes and effect of altitude on morphometry of spider in high altitude, and explored how these gradients influence the spiders living at high altitude. However, other physical factors such as oxygen, air density, humidity, and solar radiation may also be crucial in shaping high-altitude arthropod communities, but have been largely ignored. Although, body size altitude relationships of spiders are found to be variable, it cannot be ruled out that there are other environmental factors especially climatic variations also governing it. Further studies needs to be conducted to get more information.

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CHAPTER 7
GENERAL DISCUSSION AND CONCLUSION

7.1 Introduction

To conserve terrestrial arthropod biodiversity, it is imperative to understand the patterns of diversity of such organisms. Spiders are one of the dominant macro-invertebrate predator groups in most terrestrial environments, playing important role in ecosystem functioning (Van Hook, 1971; Ferris et al., 2000). Spider communities are spatially and temporally variable in response to a range of biotic and abiotic factors, thus they have long been considered as ecological indicators to evaluate human disturbance on ecosystem processes. Furthermore, as generalist predators, they contribute significantly in the regulation of insect populations in forest communities (Lawrence and Wise, 2000). Because of their high abundance and insectivorous foraging, spiders are considered as the major agent controlling insect populations (Riechert and Lockley, 1984; Nyffeler and Benz, 1987). These characteristics make spider good indicator for comparing the biodiversity of various environments and for assessing the effects of disturbances on biodiversity. Spiders also predate upon pests like thrips, caterpillars, aphids, plant bugs, leafhoppers, flies etc. In spite of this, they have usually not been treated as an important biological control agent because little is known about their taxonomy and distribution. Hence, the knowledge on the diversity of spiders is important for implementation of integrated pest management system. This study aimed to bridge that information gap, focussed on developing a spider inventory.

An initial database of spider fauna was produced based on the field sampling. One of the primary objectives was to explore the patterns of spider diversity along the altitudinal gradient in response to microclimatic variables and vegetation. This study also intended to detect differences in the species assemblage and guild compositions between altitudinal sites and determine environmental factors that are linked with changes in spider distributions at local and regional scales. A comprehensive documentation of the species and its diversity with appropriate baseline information on status, distribution and abundance, is crucial, for better understanding of Indian Himalayan Region ecosystems and incorporating such knowledge into management and conservation of Himalayan biodiversity. This study will help in assessing understand the conservation significance of high altitude spiders and identifies fields for future research in Himalaya.

7.2 Systematics and Distribution of Spiders in NDBR

Taxonomy and systematics clarify organization among organisms by analysis of relationships, classification, and nomenclature. This study provides the first comprehensive inventory of the spider diversity of the study area. A total of 244 species belonging to 108 genera and 33 families from NDBR with supplementary information on distributional range, microhabitat, natural history and web structures were recorded.

Even though the Himalayan region falls in the transition zone of both Palearctic and Oriental realms, earlier studies in this region had primarily reported genera that belonged to the Oriental realm (ZSI, 1997). This study was able to establish that NDBR is indeed in the transition zone as families representing the Paleartic genera *viz.*, Heliophanus, Pseudicius, Pellenes and Phlegra (Family: Salticidae); Phylloneta and Episinus (Family: Theridiidae); Draconarius and Himalmartensus (Family: Amaurobiidae) and Pityohyphantes (Family: Linyphiidae) as well as those of the Oriental realm such as Clubiona, Araneus, Hippasa, Rhene were also recorded. Simultaneously, several genera such as Neoscona, Castianeira, Hersilia, Cheiracanthium, Lysiteles, Tetragnatha, which are endemic to India and South East Asia were recorded from this area. Based on the estimated richness the study inventory was almost complete at the regional scale (91%). However, because of very few fragmented works (ZSI, 1997) it was not possible to ascertain this claim and additional sites needs to be sampled in future.

7.3 Diversity of Spider along Altitudinal Gradient

Effective biodiversity conservation actions in altitudinal landscapes are often impeded by paucity of relevant taxonomic and ecological information. In the present study, I documented spider diversity in NDBR and investigated the role of altitude in structuring community to validate observed distribution patterns with contending theories, for spider conservation in Western Himalaya. Results showed that species diversity was negatively related to altitudinal gradient and also altitude was influencing the species diversity on a regional scale. It was also observed that the regional species diversity patterns could be explained most prudently and robustly as an interactive effect of site and altitude. As spiders are sensitive to small changes in the environment especially vegetation, topography and climatic changes, patterns of linear decline may be related to more severe climatic conditions, terrain and landscape of NDBR.

Species composition was also tested in space through a multi-dimensional scaling based on the average altitude of each site (Lata Kharak, Bhyundar Valley and Malari). It was observed from the results of the ordination that species composition of the three sites formed separate clusters indicating that each site was composed of species that were specific to that altitudinal zone. Thus, different altitudinal ranges bears different species composition.

Furthermore, from the results of the guild-wise analysis along the elevation, it was observed that out of the three guilds (Ground wanderers-GW, Plant wanderers-PW, Web builders-WB) the ground dwelling spiders showed a curvilinear decline in all the three sampling sites. Reason for such a response is that for small spiders living near the ground, apart from altitude, habitat choice is usually strongly dependent upon temperature and humidity preferences (Turnbull, 1973; Riechert, 1974). For such spiders the microclimatic conditions provide a very diverse environment even at high altitudes, hence reducing the effects of a more homogeneous spatial structure there. Response of other two guilds, PW and WB to the altitudinal gradient differed between three sampling sites. In Malari and Lata Kharak the distribution first gradually increased with altitudinal gradient becoming maximum at the moderate elevation and then decreased gradually with further increase in the altitude. However in the third site (Bhundyar valley) both the guilds did not show any distinguishable trend.

Field observations indicates that out of all three sites, Bhundyar valley was the most disturbed by anthropogenic activities (profound influx of people for pilgrimage, pastoralist activities etc.) which could be playing an influential role in shaping up the spider habitat. Studies across the world have proved that anthropogenic practices modify the habitat to great extent and thereby influence the biotic communities. Therefore, in this study, weakening of the relationship between altitude and spider guild diversity in Bhundyar valley can be possibly attributed to habitat modification by human activities. But as quantification of disturbance was out of the scope of this study therefore it becomes difficult to conclude disturbance as a variable influencing the spider diversity.

As altitudinal gradients are usually characterized by rapid environmental changes over short horizontal distances, they are thus known to be ideal to investigate such changes (Hodkinson, 2005). However, other factors such as productivity, available resources and habitat complexity, latitudinal gradient and size of the regional species pool which are considered to influence species richness (Huston, 1994; Gaston and Blackburn, 1996) could not be investigated due to the limited period of the study as well as limited resources. Thus, future studies should focus on the effects of these factors with respect to spider diversity and community structure, and this study can serve as a baseline for exploration.

7.4 Assessment of Morphometric Changes in Spiders across Guilds and Altitude

Spiders are important predators in terrestrial habitats (Wise, 1993) and show considerable variation in body size. To understand possible relationships of spider body size with altitude, I compiled predictions of body size patterns from the literature that may apply to assemblages of spiders as well as to other ectotherm predators. Of the mechanisms considered, guild structure and predatory mechanism characterise altitudinal influence on morphometry of the spider.

The key findings suggested that guild, elevational range and mid altitude have significant influence on spider morphometry. Samples differed strongly in their leg dimensions and absolute body length as reflected by principal morphometric components. The general body size increased with mid altitude, in accordance to Bergmann's rule, which predicts larger body sizes at higher altitudes to adapt to more severe climatic conditions. I detected significant effect of altitude on leg dimensions. The mid-altitude of species distribution and their altitudinal range of distribution increased simultaneously, possibly larger ranges allow seasonal migration to avoid severe climatic conditions. However, spiders with larger distribution range had smaller body and leg sizes. The influence of altitudes on guilds was mostly related to their predatory methods. The body size differs among populations because of distinct resource accessibility or foraging strategies, and in natural situations, this is particularly significant where often food limitations are observed. However, other physical factors viz., biotic and abiotic may also be crucial in shaping high-altitude arthropod communities, but have been largely ignored. It is possible that in contrast to being a direct effect of altitude, spider body size is also indirectly determined by several other biotic interactions. Environmental factors governing these patterns need to be studied for further understanding.

7.5 Spiders in future Management

Among arthropods, spiders are the most abundant predators in many terrestrial ecosystems, playing an important role in ecosystem functioning (Van Hook, 1971). While spiders in forest ecosystems contribute to the maintenance of insect community equilibrium, the distribution of these spider species and composition of various assemblages are significantly influenced by environmental conditions (Ziesche and Roth, 2008). Studies have proved that a spider kills as much as 50 times the number of prey it actually consumes thus helping in limiting the initial pest population (Kajak, 1978). Spiders seem well suited to discriminate habitat type and quality. They have a high potential to act as biological indicators for changing environments (Skerl, 1999). Although, efforts to characterize the ecological value of spiders, examine their potential as ecological indicators, document threats to spider diversity, and develop effective conservation programmes, have recently commenced, spiders have, till now, received little attention from the conservation community, despite their ecological role in many ecosystems (Skerl, 1999). Therefore, it is important that imperilled and vulnerable spiders and other invertebrates are not left out of conservation planning efforts, as they may have unique ecological requirements or require particular habitat and management activities.

Management practices often lead to changes in community structure and composition of different animal groups (Gram et al., 2001; Dunn, 2004; Drever et al., 2008), by the modification of forest structure that causes changes in environmental conditions, nesting sites and food resource availability. Forest management practices determine forest structures. Typical management practices such as clearings or plantations reduce the predominance of old-growth structures characterized by vertical and horizontal heterogeneity, wide range of age classes, presence of large trees and dead wood. Compared to naturally regenerating forests, succession in managed forests includes accelerated successional cycles and decreased vegetation heterogeneity (Essen et al., 1992; Buddle et al., 2006). Conservation issues mostly focus on the ecological impact of management practices, as their aim is to provide practical background for sustainable management (Spence, 2001; Aubert et al., 2003; Oxbrough et al., 2005).

NDBR has a history of forest management including timber felling, raising of plantations, and habitat management practices viz., (i) rehabilitation of degraded forests, (ii) distribution of fruits and medicinal plants, (iii) soil conservation works, (iv) popularization of non-conventional sources of energy, (v) water management, and habitat restoration through protection. It also supports the welfare of the local communities residing in this region through (i) supporting for local wool industry for income generation, (ii) social welfare activities and (iii) education training and awareness programs (UKFD, 2004).

However, most of the conservation plans have focussed on the charismatic flora and fauna and the development of the local communities wherein invertebrate conservation has large been overlooked.

A comprehensive knowledge of spiders and their habitat specificity is the pre-requisite for the success of any conservation action plan. Without a complete checklist of the existing species, it is impossible to monitor the decline or increase of any population and the causal agents behind such trends. Even as we speak species might already be pushed over the brink of extinction, hence the present study was of great importance as few works were available on the diversity and distribution of spiders from NDBR. The current study developed the first comprehensive listing of the spider fauna with the status of their distribution from the region. The three sites sampled, show very site-specific species composition thus emphasizing the importance of differential management interventions for different species. Even though the current study was unable to quantify disturbances which might affect spider distribution, investigating factors like anthropogenic disturbance, grazing pressure which can effectively alter spider habitat negatively can be a key element in preserving spider niche. Such vital information can be used for more efficient management practices, which will ultimately aid in monitoring the ecosystem as a whole. Considering the fact that a substantial proportion of the overall Indian spider species is found in this region, efforts should be continued to ensure that the area is conserved, not only for the large vertebrates (which attract considerable attention), but also for the invertebrates.

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Appendix 6.1: Pair wise Pearson's correlation analysis between morphometric variables

	BL	CW:CL	AW:AL	avg_leg_1	avg_leg_2	avg_leg_3	avg_leg_4	avg_leg_5	cv_leg_1	cv_leg_3	cv_leg_5	leg1:BL	leg2:BL	leg3:BL	leg4:BL	CW:BL	AW:BL
BL	1.0	0.0	0.0	.559**	.521**	.633**	.434**	.714**	-0.1	-.127*	0.1	0.1	-.161**	0.1	.122*	-.171**	-0.1
CW:CL	0.0	1.0	0.1	0.0	0.0	-0.1	-.143**	0.0	0.0	-0.1	-0.1	0.0	-.292**	0.0	-0.1	.610**	0.0
AW:AL	0.0	0.1	1.0	0.1	0.1	0.0	0.0	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	.140**	.806**
avg_leg_1	.559**	0.0	0.1	1.0	.676**	.917**	.791**	.817**	-.311**	0.1	.173**	.778**	.519**	.725**	.592**	.198**	0.0
avg_leg_2	.521**	0.0	0.1	.676**	1.0	.724**	.556**	.731**	-.248**	0.0	.257**	.468**	.239**	.425**	.524**	.146**	0.0
avg_leg_3	.633**	-0.1	0.0	.917**	.724**	1.0	.758**	.814**	-.226**	0.0	.163**	.732**	.453**	.660**	.583**	0.0	-0.1
avg_leg_4	.434**	-.143**	0.0	.791**	.556**	.758**	1.0	.623**	-.219**	0.0	.123*	.632**	.568**	.633**	.839**	.110*	0.0
avg_leg_5	.714**	0.0	0.1	.817**	.731**	.814**	.623**	1.0	-0.1	0.0	.322**	.497**	.231**	.441**	.388**	.132*	0.0
cv_leg_1	-0.1	0.0	-0.1	-.311**	-.248**	-.226**	-.219**	-0.1	1.0	.315**	.267**	-.207**	-.146**	-.307**	-.246**	-.176**	0.0
cv_leg_3	-.127*	-0.1	0.0	0.1	0.0	0.0	0.0	0.0	.315**	1.0	0.1	.316**	0.0	0.1	0.0	-0.1	0.0
cv_leg_5	0.1	-0.1	0.0	.173**	.257**	.163**	.123*	.322**	.267**	0.1	1.0	.187**	.227**	.150**	.171**	0.0	0.0
leg1:BL	0.1	0.0	0.0	.778**	.468**	.732**	.632**	.497**	-.207**	.316**	.187**	1.0	.712**	.898**	.661**	.277**	0.0
leg2:BL	-.161**	-.292**	0.0	.519**	.239**	.453**	.568**	.231**	-.146**	0.0	.227**	.712**	1.0	.719**	.483**	.172**	0.0
leg3:BL	0.1	0.0	0.0	.725**	.425**	.660**	.633**	.441**	-.307**	0.1	.150**	.898**	.719**	1.0	.676**	.328**	0.0
leg4:BL	.122*	-0.1	0.0	.592**	.524**	.583**	.839**	.388**	-.246**	0.0	.171**	.661**	.483**	.676**	1.0	.139**	0.0
CW:BL	-.171**	.610**	.140**	.198**	.146**	0.0	.110*	.132*	-.176**	-0.1	0.0	.277**	.172**	.328**	.139**	1.0	0.1
AW:BL	-0.1	0.0	.806**	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).