# CHAPTER 5
# DISCUSSION

## 5.1. Spider inventory

Preserving biodiversity stands as a crucial aspect of worldwide conservation efforts, yet it's impossible to achieve without proper identification of the species involved (Sumesh, 2021). Taxonomy is the only approach to understand the countless species diversity of life (Kujur, 2019). Understanding and preserving the biodiversity of arthropods requires acknowledging their diversity. The present study represents the pioneering effort in understanding the diversity of spiders of Chirang Reserve Forest within the Jharbari Forest Range. Since there's no documentation on the Araneae fauna in Chirang Reserve Forest of Kokrajhar district (Assam), it's challenging to determine exactly how much of the total species richness the study managed to capture. A total of 1335 adult individuals from 100 known species across 83 genera and 19 familties was revealed during the study, which includes six newly published species viz., *Eriovixia kachugaonensis* Basumatary et al. (2019), *Meotipa ultapani* Basumatary and Brahma (2019), *Paraplectana mamoniae* Basumatary and Brahma (2019), *Vailimia jharbari* Basumatary et al. (2020), *Chinattus prabodhi* Basumatary et al. (2020), *Gravelyia boro* Basumatary and Brahma (2021), and additionally ten new records from India i.e. *Hyllus diardi* (Walckenaer, 1837), *Dexippus kleini* Thorell (1891), *Phrynarachne decipiens* (Forbes 1884), *Cyrtarahcne nagasakiensis* Stand (1918), *Hygropoda higenaga* (Kishida, 1936), *Dendrolycosa songi* (Zhang, 2000), *Philoponella alata* Lin and Li 2008, *Himalmartensus ausobskyi* Wang & Zhu 2008 and *Eriovixia pseudocentrodes* (Bösenberg and Strand 1906).

The study additionally resulted in the redescriptions of *Asianopis goalparaensis* (Tikader and Malhotra, 1978), as well as new genus records from India, namely *Chinattus* (Logunov, 1999) and *Vailimia* (Kammerer, 2006). Notably, there was a rediscovery after a century of *Deixippus kleini* Thorell (1891), which had been unseen for 129 years. Furthermore, both sexes of the genus *Vailima* Kamemerer (2006) were discovered after 113 years, previously known only by males. Similar study by Caleb (2015) revealed the presence of the Deinopidae family and the rediscovery of several obscure species, including *Araneus viridisomus* Gravely (discovered 93 years post its initial documentation), *Aetius decollatus* O. P. Cambridge (after 81 years), *Coenoptychus pulcher* Simon (after 84 years), *Loxosceles rufescens* (Dufour) (after 52 years) and *Sahydroaraneus collinus* (Pocock) (after 116 years) within the Madras Christian College (MCC) Campus (South India). The significant intervals between sightings and reports could be ascribed to either the species' rarity or the inadequate state of faunistic investigations in the subcontinent (Caleb, 2017). The study unveiled 17 species that are endemic to India viz., *Arachnura angura* Tikader (1970), *Guizygiella indica* (Tikader and Bal, 1980), *Eriovixia kachugaonensis* Basumatary et al. (2019), *Paraplectana mamoniae* Basumatary & Brahma (2019), *Chrysso urbasae* (Tikader 1970), *Chrysso angula* (Tikader 1970), *Meotipa ultapani* Basumatary and Brahma (2019), *Asianopis goalparaensis* (Tikader and Malhotra, 1978), *Pasilobus kotigeharus* Tikader (1963), *Camaricus khandalaensis* Tikader (1980), *Thomisus lobosus* Tikader (1965), *Oxytate greenae* (Tikader, 1980), *Tmarus jabalpurensis* Gajbe & Gajbe (1999), *Bowie sikkimensis* (Gravely, 1931), *Vailimia jharbari* Basumatary et al. (2020), *Chinattus prabodhi* Basumatary et al. (2020) and *Gravelyia boro* Basumatary and Brahma (2021). Additionally, the study also documented the first occurrence of 76 spider species from the state of Assam (Table 4.2.5).

The first recorded published genus and species viz., *Chinattus* (Logunov, 1999), *Vailimia* (Kammerer, 2006), *Hyllus diardi* (Walckenaer, 1837), *Cyrtarahcne nagasakiensis* Stand (1918), *Dexippus kleini* Thorell (1891) and *Phrynarachne decipiens* (Forbes, 1884) were previously known from Oriental regions (China, Malaysia, Indonesia) (WSC 2024). This may be due to the phenomenon called aerial dispersal or ballooning in spiders. They utilize a distinctive dispersal technique, relying on their own silk dragline, to migrate from one place to another and this process involves a "take-off" phase, succeeded by a "flight" phase during which individuals can soar up to 5 km above ground level, covering distances as extensive as 3200 km (Sheldon et al., 2015). The impulse for aerial dispersal seems to arise from conditions like overcrowding and food scarcity, as well as from a physiological necessity to seek out new habitats at specific stages in the life cycle of certain species, colonisation of newly created habitats, avoiding competition and cannnabalism from siblings and conspecific adults (Duffey, 1998, Blandenier, 2009, Sheldon et al., 2015). Additionally, geographically neighboring areas often host similar animal species, which could indicate the movement of spiders from nearby landmasses into the Indian mainland (Caleb, 2015).

The study recorded 19 families of spiders namely Agelenidae, Araneidae, Corinnidae, Ctenidae, Clubionidae, Cheiracanthidae, Deinopidae, Hersiliidae, Lycosidae, Nemesiidae, Oxyopidae, Pisauridae, Psechridae, Salticidae, Sparassidae, Tetragnathidae, Theidiidae, Thomisidae, Uloboridae from Jharbari Forest Range. Out of the total 19 families (Table 4.1), the highest number of species were recorded from the family Araneidae (n=33) followed by Salticidae (n=20). This corresponds with the findings of Gupta et al. 2015, who documented 17 families with Araneidae (n=14) as the dominant family in Protected Areas of Upper Assam. Similarly, Chetia & Kalita (2012) recorded 18 families with Araneidae (n=19) as dominant in Gibbon Wildlife Sanctuary (Assam), Basumatary and Brahma (2017) found 16 families with Araneidae (n=21) as the dominant family in Chakrashila Wildlife Sanctuary (Assam), and Singh and Goswami (2023) noted 15 families with Araneidae (n=17) as dominant in Barpeta (Assam). According to Sudhikumar et al. (2005), the families Araneidae, Tetragnathidae, Salticidae and Thomisidae exhibited maximum species diversity and the dominant family was Araenidae (n=17) from Mannavan Shola Forest, Kerala. Araneidae are well adapted with their habitat. Araneidae is the third largest family with great diversity in the tropics (Platnick, 2013). They have the ability to adapt and blend in with the surrounding environment. Spiders from this family are brightly coloured or with abdominal spines. Bright coloration may attract insect prey to the spider's web, potentially enhancing foraging success, while these markings could also serve as camouflage against background color variation, and spines on some spiders' abdomens act as defense mechanisms against vertebrate predators (Bush et al., 2008, Peckham 1889).

The second speciose family was Salticidae (n=20). Jumping spiders or Salticidae excel in camouflage and thrive in harmony with their surroundings. They are small, highly agile, adept at camouflage, mimic ants and typically reside in the undergrowth. Many species conceal themselves in crevices or rolled-up leaves, often mimicking ants, which are abundant and better protected, possibly shielding them from larger spider predators, highlighting a class of spiders whose mimicry serves as defense against various enemies including birds and other spiders (Peckham, 1889). According to Gajbe (2004), most spiders living on the ground vegetation exhibits some kind of protective colouration for camouflage. Abundance of different spider families in respect to their individual's numbers which prominently reflects Araneidae and Salticidae as more abundant through less diverse family in comparision to Hersiliidae, Clubionidae and Agelenidae (Ganesan and Shunmuavelu, 2012).

### 5.2. Abundance of spiders in different seasons

Seasonality plays a crucial role in studies discussing species richness and abundance (Kujur, 2019). The findings from the study indicates seasonal variation in the abundance of spider families, with the highest numbers of species recorded during the Pre-monsoon season, extending into monsoon, and exhibits decrease during winter seasons followed by sharp decline in post monsoon period (Fig 4.3.2). The family composition of the spider community exhibited significant variability from one season to another. This pattern indicates a seasonal impact on spider activity and population changes within the study area. Certain research has shown that seasonality affects the abundance, growth rate, and size of spiders (Kujur 2019). Deshmukh and Raut (2014) have postulated that spider population in different seasons exhibited variation in species abundance and composition. Moore (2013) also documented higher density of spiders during pre-monsoon season and gradually decreasing during monsoon period. Seasonal changes in animals may be influenced by abiotic factors viz., weather, rainfall, temperature, humidity.

Kujur (2019) postulates that diversity of spiders across the four seasons is expected to vary due to differences in temperature, humidity, rainfall, and other environmental factors that serve as limitations. In Pre-monsoon, the spider abundance soared to its highest point probably due to the ideal environment, including ample food supply and favorable weather conditions. During pre-monsoon, the onset of season's first rain helps seasonal plants to flourish thus attracting large number of insects (Bhat et al., 2013, Asalatha, 2019). The winter and post-monsoon periods involves cold weathers, very less precipitation and vegetation withering which marks the transition from wet to dry seasonal conditions. The winter season, with its colder temperatures and reduced water and nutrient availability, exhibits greater geographic variability compared to summer conditions, potentially exerting a more pronounced influence on biological processes, including individual performance, community composition, and ecological interactions (Potts, 2020). Being ectotherms, arthropods undergo significant impacts from fluctuations in ambient temperature during the winter season, directly influencing cellular health and locomotion capabilities, while also indirectly affecting energy reserves, metabolism, and growth rates, collectively determining their survival and overall fitness (Potts, 2020). Limited presence of flora and fauna during the winter season results in restricted nutrient availability in the environment, prompting many arthropods to build up energy reserves during the warmer growing seasons and enter a state of dormancy until favorable conditions return, meeting the energetic demands of overwintering (Potts, 2020). Food could serve as a significant limiting factor during specific times of the year (Lubin, 1978). Another probable limiting factor could be hibernation. Spiders can overwinter either as eggs, juveniles or adults where they employ various strategies, including utilizing hibernacula (shelters for overwintering), developing cold resistance, and adjusting their metabolism to mitigate the effects of cold; those inhabiting vegetation or soil utilize a range of hibernacula such as leaf litter, grass tussocks, rocks, caves, bird nests, upper vegetation, or bark crevices (Horváth, 2004). Some spiders hibernate in hollow plants, while others, particularly salticids, gnaphosids, and clubionids, retreat to a silken sac or burrow deeper into the leaf-litter layer during winter, lining their hibernation chambers with silk and remaining in the cocoon until spring. (Kirchner, 1987). Therefore, seasonal variation could be a significant factor influencing spider diversity.

Araneidae was the dominant family throughout the four seasons, followed by Salticidae. This family's ability to adapt with the environmental conditions of study area might have enabled them to establish throughout the seasons. Sumesh (2021) have also reported that the abundance and richness of the Araneidae and Salticidae families remained consistent between wet and dry seasons. Most of the Araneid spiders are colourful orb-web weavers and are visually appealing. Studies have proposed that the colouration of diurnal orbweaving spiders can attract hymenopteran prey (Václav and Prokop, 2006). They employ various strategies to attract prey such as luring prey by placing smelly organic debris on the web, building silk decorations that reflect ultraviolet light and intense body colouration (Václav and Prokop, 2006). Thus increasing their chances of survival. Salticidae also consistently maintained its dominance across season back to back alongside Araneidae. Salticidae maintained its dominance throughout the year, as it feeds opportunistically on various prey items such as insect nymphs, larvae, and adults, which are available year-round (Deshmukh and Raut, 2014).

**5.3. Species accumulation curve**

Species accumulation curves are used to illustrate how the number of species increases with the sample size. They are a valuable tool for estimating species abundance and understanding the species composition of survey plots. These curves are extensively employed in surveys of communities and biodiversity. It is employed to determine the species richness and assess how adequate the sample was (Longino, 2000; Qiao et al., 2009b). Based on the features of the curve, one can use the species accumulation curve to determine if the sampling amount is adequate. According to Longino (2000), Qiao et al. (2009b) and Ugland et al. (2003), a sharply rising, almost linear species accumulation curve indicates insufficient sampling that needs to be increased, while a curve that becomes asymptotic after a sharp rise and then increases slowly signifies sufficient sampling, allowing for data analysis to proceed. The stability (asymptote) observed in the species accumulation curve over four years of survey indicates that the sampling effort was sufficient to capture a representative portion of the spider diversity in the study area (Fig. 4.3.1). Moreover, the species accumulation curve of the eight habitats for four consecutive years resulted in the establishment of study area's accumulation curve. As an asymptope or a plateau with a curved reach, it indicates that most of the species from the study area have been collected throughout the sampling effort (Figures. 4.4.2 to 4.4.9)

**5.4. Diversity of spiders in different habitats**

The Shannon-Weiner and Simpson diversity indices as well as species richness and evenness show variation across the eight different habitats. Diversity analysis showed the highest diversity in Shrubs. The complex physical structure of shrubs with numerous branches, leaves and different layers of foliage creates variety of microhabitats with varying levels of temperature, moisture and light exposure which may be able to accommodate different species of spiders having their own specific niches where some might prefer the dense inner parts of shrubs and others might thrive on the outer branches. Richness of spider are influenced by habitat pattern, structure and microclimatic factors (Bhattacharya et al., 2017, Samu et al., 1999). The intricate structures and dense foliage might offer spiders with numerous hiding spots which can allow them to evade predators and protect themselves from harsh weather conditions thus increasing their survival and high species diversity. This vegetation structures benefits the spiders by providing refuge and foraging site (Uetz, 1991).

Vegetation shading, high light intensity and susceptibility to wind can also affect spider communities (Gallé and Schweger, 2014, Avila et al., 2017). Shrubs often harbor a high density of insect prey due to the rich plant matter they provide, creating an abundance of food resources that supports larger populations of spiders including both generalist and specialist predators. Vegetational diversity can have a profound effect on herbivore insects' movement and it significantly implicates the herbivore density (Harmon et al., 2003). Habitats with diverse vegetation are likely to offer a wider range of resources for herbivorous invertebrates, leading to their increased abundance and subsequently providing more prey for predators such as spiders (Asalatha, 2018). Additionally shrubs offer numerous attachment points for web-building spiders with a variety of branch thicknesses providing ideal conditions for different types of webs i.e. from orb webs to sheet webs thus accommodating a wide range of spider species. The relationship between spider assemblages and vegetation structure may be due to the numerous microhabitats in the vertical zones of emergent vegetation and the spiders' ecological flexibility, with the extensive vertical surfaces provided by plants fostering strong dependence between spiders and these microhabitats which are essential for web fastening, brood care, mating, and reducing competitive exclusion and cannibalism (Avila et al., 2017).

The diversity of plant species within the shrub layer can affect spider diversity. The presence of specific shrub species in the study area such as *Melastoma malabathricum*, *Clerodendrum imfortunatum*, *Chromalaena odorata*, *Maesa indica*, *Dendrochnide sinuate* might significantly influence spider diversity. *M. malabathricum* has a dense, bushy growth that provides numerous niches for spiders and web attachment points, while its flowers attract various insects serving as prey. As spider rely heavily on infrastructure for hunting, areas with diverse flora will often provide foundation for diverse spider populations (Lewark, 2019). *C. imfortunatum* featured large leaves that created shade, humid environments favourable for spiders and attracts pollinators, increasing prey availability. As an invasive species, *C. odorata* was dominating the area, creating dense microhabitat where some spiders exploit and its flowers attract insects, offering ample food resources. *M. indica* had dense foliage that provided hiding spots and web-building sites, with its fruits attracting insects and arthropods as prey. Lastly, *D. sinuate* known for its stinging hairs that detered herbivores and reduced disturbance which created a stable environment. Spider may avoid negative interactions such as predation, competition, etc. (Avila et al., 2017).

Herb habitat with a Shannon diversity index of 3.4 ranked second in terms of diversity. Herbs with different leaf shape and sizes may provide a rich and diverse vegetation structure close to the ground. It accommodates ground dwelling and low web building spiders. With low lying vegetation it has a moist dense foliage and shaded areas, thus increasing the habitat heterogeneity and in turn supports diverse species. Some of the herb species were *Azeratum conizoides*: this plant has a dense and buhsy growth, *Mikania micrantha*: a climbing herb and aids with vertical structure to the habitat, *Persicaria hydropiper*: found in wet areas and contributes to the moisture level of the habitat, *Leucas* *lavandifolia*: herbaceous plant with its flowers attracts insect prey, *Diplazium* esculentum: as a fern it aids to the unique habitat structure with its fronds and also helps in maintaining moisture. Both shrubs and herbs habitats contribute significantly to spider diversity through their unique structures, prey availability, stable microclimatic condition and varied microenvironments. Habitat complexity also reduces cannibalism among spiders due to lower encounter rates (Butt and Tahir, 2010). Temperature and humidity have been shown to be critical factors influencing microhabitat selection for number of spider species and similar associations have been found with areas of high prey availability (Canning et al., 2014). The more structurally complex habitats have a greater diversity of species at the local scale that habitats with less complex structure (Avila et al., 2017). Asalatha (2018) also reported similar high diversity in shrubs and herbs from Western Ghats Malabar Region. While shrubs offer adequate structural diversity and stability, herbs provide a rich ground level microhabitat supporting a wider range of spider species. These complementary qualities might help explain the high spider diversity found in both habitat types.

The lower spider diversity in grasses (1.49), tree bark (1.47) and forest stream (1.29) habitats might be related to the structure, resource availability and environmental factors. A habitat with low emergent vegetation may provide a limited, less sheltered niche, resulting in fewer species establishing there due to higher predation risk and reduced foraging opportunities (Avila et al., 2017). There has been report from grass habitat where coccinellid beetle was found to predate on spiders (Roy et al., 2021). Grasses have simpler structure and are less complex in comparison with shrubs and herbs, they have fewer anchoring points for web building and it grows tall uniformly without any vertical layers unlike found in shrubs and herbs resulting in fewer microhabitats and hiding spots. Grasses specific spiders species are *Dexippus kleini*, *Larinia phthisica*, etc. Tree bark comprises of simple flat surface with lack of structural diversity where only specialized spiders' viz., *Hersilia savignyi*, *Herennia multipuncta*, etc. that are morphologically adapted to it. The dorsoventrally flattened morphology of these spiders confers an adaptive advantage in this type of habitat (Villanueva-Bonilla et al., 2017). Forest stream present a challenging environment where there are abundant resources during flooding, however as streams are prone to drying there may be drastic changes in environmental conditions. The dry period is considered a constraint for the aquatic fauna, causing lower taxa richness (Boix et al., 2016). Only few spider species such as *Nilus albocinctus*, *Hygropoda higenaga* are able to thrive. As the vegetation structure around forest stream is limited to banks or submerged under water it might not provide many niches. Moreover, spiders have a larger dispersal ability compared to ground and may move more frequently between micro habitats (Bergholz et al., 2023), and subsequently decreasing the spider species in this habitat.

The lowest spider diversity was seen under rocks (0.91) and burrow habitats (0.25). The space under rocks is confined having limited entry of light and with its own stable, non-variable microclimatic conditions as compared to above the ground habitats and this may probably support only a limited numbers of spider species that are suited for this environment. Canning et al. (2014) discovered that the burrow sites with at least partial protection from sun exposure which limited the fluctuations were favoured over those with minimal protection from environmental elements such as temperature and humidity. The lack of sufficient light limits the growth of plants which in turn probably reduces the prey diversity. Due to limited space and resources there might be competition among spiders and other insects coupled with high susceptibility to predators like scorpions and beetles that take refuge under rocks. Predation can also have population-level effects on invertebrates (Boix et al., 2016). The space constraints limits the foraging area compared to open spaces and may restrict ability to find sufficient food, plus the type of substrate available under rocks may be suited only for specific spiders that prefer such for building retreats or laying eggs. The burrows are used for protection against predators and parasites, for the protection of eggs and developing spiderlings, protection during ecdysis, for the capture of prey and for the control of thermal stress (Canning et al., 2014). Similar to under rocks habitats, burrows are also characterized by confined space, low light conditions, limited air flow, specialized prey availability and also pose risks from predation and competition both from spiders and other burrowing animals or insects. Burrowing spiders need specific morphological adaptations as well considerable energy for digging and maintaining their burrows, which further limit the number of species that can inhabit these environments.

### 5.5. Guild structures and composition

Spiders are a dominant group with different morphological and ecological characteristics differentiated into terrestrial, some freshwater and few marine individuals (Juario et al. 2016). Spiders can be assigned to different guild, which are related to the complexity of the ecosystem and the resource availability, and constitutes an important ecological component in aquatic and terrestrial food webs (Avila et al., 2017). Although some species are characterized by active movement in soil and vegetation, with ambush strategies to capture prey, other species have different feeding strategies, building orbicular or three dimensional webs (Cardoso et al., 2011, as cited in Avila et al.2017). Web type or hunting methods primarily determine the division of spider families into guilds (Cardoso et al., 2011).

The spider guilds showed significant differences, with orb weavers (n = 40) being the most frequent, followed by other hunters (n = 30), space web weavers (n = 11), ambush hunters (n = 8), nocturnal ground ambushers (n = 5), ground hunters (n = 3), sheet web weavers (n = 2), and sensing web weavers (n = 1). Juario et al. 2016 documented similar pattern of guild types from Tawi-Tawi and Basilan Philippines where Orb weavers (58%) were the most prevalent guild type followed by stalkers (24%), sheet web weavers (7%), ambushers (6%), foliage runners (4%) and least being ground runners (1%). Araneidae are a diverse family which includes many orb weavers with a large number of genera and species. This high species rate may contribute to the large number of orb weaving spiders found in various habitats. They can thrive in a wide range of microhabitats ranging from forest canopies to grasslands, which might allow them to exploit diverse niches. The circular and sticky silk of orb-weavers are highly efficient at capturing flying insects which are reliable source of food. Orb web weavers have high reproductive rates and produce large offspring which greatly increases the population sizes. Spiders have ballooning strategy where they disperse to colonize new areas and orb weavers are very efficient in it. They also exhibit niche partition at varying height, location and timing of web construction and this might allow greater number to coexist in the same area. The habitats in the study area are diverse such as shrubs, herbs, grasses, etc. and may offer numerous locations suitable construction site for construction of orb webs which indirectly supports high number of orb-weaving species.

Other hunters which comprises of the families Salticidae, Oxyopidae and Ctenidae employ various hunting strategies like ambush, pursuit and stalking, and this flexibility might allow them to hunt different types of prey and explore diverse environment. Different foraging strategies can be used in distinct vegetation structures, since habitats with high complexity had a high diversity of prey (Avila et al., 2017). They habit both ground and plant vegetation. The spider of these families have exceptional vision alongwith well-developed mechanoreceptors on the body as well trichobothria on legs that helps in sensing vibrations and movements which greatly increases the efficiency of hunting prey. They are usually agile, fast or move stealthily while some can even jump such as Salticids. Spiders from this guilds are known to have mutual relationship with other arthropods or mimic them to avoid predation. Salticids of the genus Phintella have been reported to gain protection from predatory spitting spiders viz., Scytodes sp. by living with territorial weaver ants, building nests near active ants whose specific airborne olfactory compounds repel the spiders, and constructing unusually tough and dense silk nests that are ant-proof, these tactics, along with their ability to mimic the ants' chemical scent, grant Phintella and the myrmecomorphic genus Myrmarachne a higher survival rate compared to other genera that only rely on defensive behaviour ( Labanon and Nuñeza, 2020). Hunting spiders are generalist predators where they move and hunt actively looking out for new prey as well as habitats. They also produce numerous offspring and even some exhibit parental care by guarding young spiderlings (Salticidae), carrying egg sacs (Oxyopidae) and even carry their spiderlings on the back of the abdomen (Ctenidae). All these factors might contribute to the significant presence among the species surveyed.

Space web weavers build three dimensional webs which allows them to capture wide range of prey, however there may be niche overlapping occupied by them with other spiders and  they might also face competition from other web building orb weavers spider.

They might require specific microhabitats or structural support for their webs which may not be available in all areas. Lower numbers of Ambush hunters (n=8), nocturnal ground ambushers (n=5) and ground hunters (n=3) may be associated to their specific hunting strategies which might restrict them to particular microhabitats and prey type. The spiders of theses guild type are mostly nocturnal. With spiders' main predator being active during daylight hours, hunting requires them to risk as well as ambush bunting demands significant energy and necessitates leaving safe locations (Lewark, 2019). As they are ground dwellers, they can be more vulnerable to predators thus limiting their numbers. Active hunting and ambush tactics might not always yield consistent result where prey is less abundant or harder to catch.

The presence of sheet web weavers (n=2) and sensing web weavers (n=1) in the study were least in numbers. Sheet web weavers such as the families Amaurobiidae and Psechridae may require specific vegetation structure or substrate to anchor their delicate sheet webs. These spiders catch prey that only falls onto their webs rather can capturing, and such if the environment does not support such prey these spiders may be less successful. They may also be outcompeted by others spiders that are efficient at capturing prey. Natural disturbances such as strong winds or rain may significantly destroy their webs which will impact in their survivality and numbers. Further, sensing web weavers such as Hersiliidae have specific web structures such as trip lines or draglines to detect prey and this webs requires particular habitat conditions and anchoring points. They also occupy very specialized ecological niche, as such the specific requirements for their web structures, hunting methods as well as competition from other hunting efficient spiders will probably reduce their numbers.

### 5.6. Community perception

Nonhuman animal studies have a long history of exploring encounters between humans and nonhuman animals and other than humans (Lemelin et al., 2017). The present study noted the positive and negative aspects of human encounter with spiders. The survey revealed diverse attitudes towards spiders among respondents. While some felt spiders should be killed upon sighting them and did not attribute any importance to them, others expressed a desire to save spiders due to their perceived usefulness. Attitudes towards nonhuman animals arise from a complex interplay of factors involving social, cultural, biological, morphological and physiological attributes such as bright colors, large sizes, etc. (Lemelin et al., 2017). There was also a distinction made between non-venomous spiders, which are generally considered harmless, and venomous ones which elicited fear and were seen as a potential threat. The majority of people find invertebrates to be scary, disgusting, dangerous and ugly, and this is problematic for invertebrate conservation because negative attitude towards specific groups of organisms have been shown to adversely impact people's willingness to support the preservation of those organisms (Lorenz et al., 2014), especially how they value the conservation of Araneae (Manriquez et al., 2024).

The present study revealed that 94% of the respondents from the fringe villages of Jharbari Forest Range could recognize spiders. This might be due to the prevalence of spider webs in homes, gardens and surrounding areas that may serve as reminder of spiders' presence. The role of spiders as food in traditional delicacies can be significant in influencing recognition, subsequently farmers or individuals involved in agriculture may recognize the importance of spiders in controlling pest and even for those who do not directly consume spiders are aware of their role in ecosystem as predators of insects and pest, all of which could contribute to the high recognition of spiders. Gerdes et al. (2009) demonstrated that there is a substantial difference in the subjective response to various arthropod groups where spiders were rated highest on fear and disgust (emotional) as well as on danger (cognitive), followed by bees and wasps. Fear of spiders' ofen occurs in species that are completely harmless to humans. Hauke and Herzig (2017) report that only 0.5% of all spider species are potentially life threatening to humans. In contrast, Skokan and Herman (1999) pointed out that only about 50% of spider genera have chelicerae large enough to penetrate human skin. The proportion of individuals showing no fear of spiders were highest with 43%. This is in contrary to the previous research findings. It could be due to several reasons specific to local context where individuals living near the forest range are likely to have frequent encounters with spiders due to the proximity to natural habitats and thus reducing fear, residents near the forest fringe villages may have a deeper understanding of the ecological role of spiders play in the ecosystem, individuals within the closely linked communites may share positive experiences and perceptions towards spiders and early childhood experiences with spiders such as positive encounters can have lasting impact on attitudes towards them which might influence their fear levels.

In terms of the types of spider, results showed that the respondents were more familiar with species of Araneidae (33%) (Fig. 4.5.3). The spiders of the family Araneidae such as *Nephila pilipes*, they build large webs and *Argiope pulchela* are brightly coloured with distinct whitish markings on its web. As such they are more attractive to the people, and the reason of which of their higest sightings. These spiders are also more visible to people because of their time of activity (have both nocturnal and diurnal representatives), abundance and guild classification (Uetz, Halaj and Cady 1999). The relatively equal sighting of Pholcidae (21%) and Salticidae (21%) could probably be attributed to the similar habitat preferences within the environment surrounding the fringe villages of the Jharbari Forest Range. Both Pholcidae and Salticidae exhibit behaviours that could lead to frequent sightings where Pholcidae are often found in indoor environments and Salticidae are known for their active jumping behaviour and agile. They are known to inhabit human dwellings and also exhibit a degree of tolerance to human presence. The lack of significant difference in the sighting frequencies of Araneidae, Lycosidae, Pholcidae and Salticidae suggests that multiple factors such as similar habitat conditions like vegetation type, availability of prey that are equally favourable for all spider families, similar behaviours in terms of hunting and activity pattern i.e. diurnal or nocturnal as well as equal adaptation to the local environment, all of which might contribute to a balanced presences of the Araneidae, Lycosidae, Pholcidae and Salticidae in the surveyed area.

The highest number of spiders observed by respondents were indoors (55%) followed by home garden (26%) (Figure 4.5.4). This might be due to the reason as the respondents spend much of their times in household chores, plus the spiders from the family Araneidae, Salticidae and Pholcidae are generalist and cosmopolitan. Plus the indoor environment such as houses have numerous nooks and cranies where spiders can shelter and are also protected from various environmental factors such as rain and wind. Home gardens provide a rich habitat for spiders with plenty of insects like flies and mosquitoes, plants and structures for web-building but they might still be less stable compared to indoor environments thus leading to a lower proportion of sightings compared to indoors. Studies have shown that women are more likely to report a fear of spiders (arachnophobia) compared to men and this could make them more attentive to the presence of spiders, leading to more frequent reporting of sightings. There is consistent pattern in the literature on the phobia of spiders among different genders, with females scoring higher than males (Becker et al., 2007, King et al., 1998, Moracco and Camilleri, 1983, Polák et al., 2016, Zsido et al., 2018, Zsido et al., 2022). Least species was observed in forest (11%) and paddy field (8%). Many spiders have evolved to blend into their natural surroundings. Forests and paddy fields have dense vegetation which maked it more challenging to spot the spiders. It is also to be mark that forest and paddy fields might be less acceseed by the residents with people generally spending less time in forest and paddy fields compared to indoor and home garden.

The respondents sighted the highest numbers of spiders during monsoon (31%) and pre-monsoon (28%) period (Fig. 4.5.5). This might be in relation to increase in insect prey populations due to high humidity and availability of water which in turn spiders build new webs to capture their prey, thus making spiders' active and making them visible. During heavy rains spiders seek refuge in human shelters and subsequently people also spend more time indoors or in gradens, thus increasing the chances of being seen. Winter (7%) and post-monsoon (3%) were the least sighted season. Many spiders are ectothermic and colder winter temperatures may reduce their movement and activity, making them less visible. The harsh dry winter may lead to dessication of spiders' webs, some may dismantle their webs and seek shelters to avoid harsh conditions futher decreasing their visibility. Reduction in vegetation may also lead to decreasing their numbers. People might spend less time outdoors during the cold months and spiders might also be in deeper hiding, leading to fewer sightings even inside homes. The fact that 30 % of respondents were unaware of spider sightings could be due to some individuals may not pay close attention to their surroundings or might be busy with their schedule to notice little things and those who have fear of spiders might avoid looking spiders. Individuals who live in more closely sealed homes and frequently clean their homes and garden might remove spiders or prevent their establishment, thus may have fewer chances of encountering with spiders. Some respondents may lack the knowledge to identify spiders or might probably be unaware of spider habitats and behaviours, and there are also chances that they have limited interaction with outdoor activities. All these factors highlights the individual awareness and observationa habits.

Within the study area, spider were known by names that are recognized by the respondents' viz., Beyma (Boro), Makura (Nepali), Bindi (Santhali) and Mokora (Assamese). The study uncovered folklore beliefs surrounding spiders, one such is the belief that the common giant household spider, *Heteropoda venatoria*, could lick ear at midnight during sleep and cause swelling and inflammation with its venom. Additionally, respondents using the molted skin mixed with mustard oil as an ointment for minor injuries, reflecting traditional medicinal practices associated with spiders. From the findings, the following measure for the conservation of spiders have been suggested as interactive spider identification programs should be organized in schools and village libraries, awareness programs on the importance of spiders and their conservation among local communities, promoting awareness of venomous and non-venomous spiders, promoting research, awareness program to debunk the spider related myths and for preventive/medical measures for spider bite. Incidents of spider bite: The survey documented incidents of spider bites occurring across a wide age range, from 8 to 80 years old. Symptoms reported by victims included swelling and inflammation, suggesting potential allergic reactions or venom toxicity. Numerous incidents of spider bites have occurred, with 11.3% of affected individuals viewing them unfavorably and often feeling ill, while young individuals are more frequently affected by allergic reactions to these bites (Manriquez et al., 2024). Only 0.5% of all spider species are potentially lifethreatening to humans and about 50% of spidee genera have chelicerae large enough to penetrate human skin (Hauke and Herzig, 2017, Skokan and Herman, 1999). Even among the rare spider species capable of producing more potent venoms, the resulting symptoms are typically localized and mild (Hauke and Herzig, 2017, as cited in Manriquez et al., 2024). Preventive measures taken by individual following spider bites included mantra chanting by local healers, painkillers medication and to some extent, the use of human saliva as a remedy.

Overall findings from the study highlights the complex relationship between humans and spiders, and has uncovered a wide range of attitudes, beliefs and preceptions. They underscore the importance of understanding local perceptions and traditional knowledge systems when studying human-spider interactions and designing outreach and education programs aimed at fostering coexistence and conservation efforts.

### 5.7. Limitations of the study

Present study was conducted during the period of armed conflict which started from the late 90s, a period when the forest areas, including the Chirang Reserve Forest under Haltugaon Forest Division in Kokrajhar district of BTR, were largely controlled by insurgent group named National Democratic Front of Bodoland (NDFB). The NDFB was seeking sovereign statehood for the Bodo people. The issue of protection of tribal land and forests was a prominent demand of the All Bodo Student Union's (ABSU) agitation for the creation of a separate state of Bodoland, which turned violent in the later part of 1980s after the formation of insurgent groups (Dutta, 2018). This quest for sovereignty led to escalating tensions and conflicts with government forces and other ethnic groups, which lead to numerous army operations and counter-insurgency measures in the region and also within the forest. During the armed conflict, counter-insurgency operations within the forest were conducted by Assam state police and the central government's national army (Dutta, 2018). Camps were set up inside these reserved forests by army and para-military as outposts for counter-insurgency purposes and the forest also served as temporary rehabilitation sites for victims of ethnic violence (Dutta, 2018). These operations and the ongoing conflict made it difficult to cover many areas. Even though permission was granted to carry out the study inside the reserved forest, security concerns led the Army and local police outpost to restrict access to the dense areas of the forest, specifically the Ride 6, 7 and 8 compartments. This limitation persisted until a new peace agreement was signed on January 27, 2020, between the Government of India, the Government of Assam, the NDFB, the All Bodo Students' Union, and the United Bodo People's Organisation.

### 5.8. Threat factors

A global analysis considering several land management scenarios found that species richness was affected by forest fragmentation, logging, farmland abaondonment including other pratices such as ploughing, cutting and fire, while spider abundance was affected by forest fragmentation, fire, conventional farming, insecticidesm grazing, with negative effects of these practices were attributed to direct killing of spiders, negavtice effects on habitat heterogeneity and prey populations (Branco and Cardoso, 2020). The pristine habitat of Chirang Reserve Forest is threatened by various anthropogenic disturbances viz., large scale deforestation for illegal timber and encroachment, cattle grazing, livestock rearing, invasive species and forest burning, as discussed below:

#### 5.8.1. Deforestation

Illegal tree felling is a major factor for habitat degradation of this RF. The trees are felled for timber which is later smuggled. Illegal enroachments has led to indiscriminate clearing of forest for habitation and agriculture practices, which has significantly reduced the forest cover. At a global level, the threat most often perceived as "most relevant" to spiders was agriculture, livestock farming & forestry, followed by climate change, urbanisation, and pollution, all four statistically similar and with significantly higher average scores than all other threats (Branco and Cardoso, 2020). The total area of Chirang RF is 46287.12 Ha, of which 16255.88 Ha. is under encroachment (Assam Forest Department, unpublished).

#### 5.8.2. Cattle grazing

Grazing poses a significant threat to Chirang RF. The fringe villagers of the RF depend on cattle and buffaloes for livelihood by selling milk. They let the cattles to freely graze inside the RF. The grazing is in two forms: one is allowing cattle to graze freely from villages and another is by cattle camps locally known as "Khuti" and this has caused damage and destruction of naturally growing seedlings and the undergrowth thar are important for forest ecology (Assam Forest Department, unpublished). Overgrazing in wildlife habitats leads to soil compaction, decreased soil productivity, and weed invasion, altering natural vegetation composition and ultimately degrading the structure, composition, and dynamics of the habitat, making it less suitable for wildlife (Nazrul, 2021). Spiders play an important role in natural biological control and they are sensitive to tillage, seeding, harvesting, pesticide application, grazing practices, and plant cover removal, and the intensification of grazing can alter microhabitats and increase the fragmentation and dispersion of the litter, which reduces the diversity of araneofauna (Freiberg et al., 2020).

### 5.8.3. Livestock rearing

There is encroachment of forest patches by the fringe villagers residing near the boundary of Chirang RF for livestock rearing such as goat and piggery. Goats often prefer to overconsume certain palatabale plant species, thus reducing plant diversity and degradation of natural vegetation structure which may lead to soil erosion. Agriculture, livestock farming and forestry were commonly identified as key threats to spiders by experts on every biogeographic region (Branco and Cardoso, 2020). The waste from piggery livestock might lead to changes in soil chemistry which might effect the plant growth patterns. The presence of such livetosck animals can cause continuous disturbances and stress within the habitat.

### 5.8.4. Invassive species

The degraded parts of the RF were overgrown with invasive plant species such as Mikania micrantha and Lantana camara. These invasive species, with their high growth rates and tolerance to variable environmental factors, disrupt natural ecological processes and degrade suitable wildlife habitats (Islam et al., 2021). The introduction of exotic species, including other spiders, animals, plants or fungi, may come at a cost to native spiders, directly or indirectly (Branco and Cardoso, 2020).

### 5.8.5. Forest burning

At present there is no record of natural forest fire, however, the new settelers inside these RF carries out widespread burning of forests patches in order to clear out the area for illegal settlement. Although Jhum cultivation is not practiced, there are significant encroachments in Chirang Reserved Forests (RFs), primarily by dependents of recognized forest villagers, extended families, and outsiders from Kokrajhar district and other areas, with the communities being heterogeneous (Assam Forest Department, unpublished). Fragmentation, destruction and conversion of natural habitats that precedes and accompanies these threats, often in the form of deforestation and burning (Branco and Cardoso, 2020).

## 5.9. Conservation measures

Chirang Reserve Forest possesses rich floral and faunal diversity which includes many significant threatened, endemic plants species (Basumatary, 2023), and it is also an Important Bird and Biodiversity Areas (Birldife International, 2024). Saving Chirang RF is essential for conserving biodiversity, preserving critical wildlife habitats, regulating climate and water cycles, providing ecosystem services, supporting local communities, enabling scientific research and offering economic benefits.

At a global level, the conservation measures most often perceived as "most relevant" for spiders were land protection, and education & awareness, followed by land management and law & policy (Branco and Cardoso, 2020).

### 5.9.1. Habitat protection

The current status of Chirang RF needs to be upgraded to Protected Area (PA) i.e. National Park so as to enhance the legal status and enforcement of conservation laws to prevent illegal activities like tree felling, encroachment, livestock grazing and forest burning, thus preventing further destruction of the habitat. Most spiders benefit from a low human footprint and protected areas are the most obvious and often efficient way to guarantee such conditions, where the protected areas might prevent or mitigate effects of several threats such as wildfires, exotic species from spreading, as these have been found to have a negative effect on the area richness (Branco & Cardoso 2020).

### 5.9.2. Habitat management

Afforestation by planting of native trees in degraded areas of forest so as to restore habitat structure. This can be further aided by regular monitioring and removal of invasive plant species that threatened native species. Studies have shown that habitat structure is more important to spider assemblages than plant species composition, with spider diversity positively correlated with vertical structure diversity in Germany (Hemm and Höfer, 2012, as cited in Branco & Cardoso 2020). Similarly, in the Atlantic Forest in Brazil, protecting large areas containing all forest stages has been identified as the best way to safeguard regional spider richness (Raub et al., 2015, as cited in Branco and Cardoso, 2020).

### 5.9.3. Community engagement and livelihood aspects

Involving the local communities of the forest fringe villages in the management and protection of forest resources will empower the residents to take active roles in conservation and sustainable use of forest resources. The majority of forest fringe villagers of Chirang RF are agrarian, with agriculture being the major livelihood sources alongwith few numbers of livestock rearer. Their dependency on agriculture makes them vulnerable to market fluctuations, unpredictable climatic conditions, pest outbreaks, etc. which may lead to economic instability and increases the pressure on natural resources. Capacity building training should be imparted for creation and promotion of sustainable alternative livelihood sources.

### 5.9.4. Education and awareness

Educating the general public especially the local communities about the importance of Chirang RF and its inhabitants i.e. spiders. Awareness programs and educational workshops needs to be conducted at schools of the forest fringe villages. Citizen science initiative may foster a sense of responsibility and connection to nature by raising awareness about environmental issues and also educating about local biodiversity. Greater participation from non-professionals could potentially lead to spider research and conservation through citizen science initiatives (Branco and Cardoso, 2020).