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ASSESSING THE IMPACT OF ANTHROPOGENIC AND CLIMATE CHANGE ON SPIDER DIVERSITY IN GARHWAL HIMALAYA

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ABSTRACT

The state of Uttarakhand in India was created in the year 2000 with Dehradun as its capital, prompting increased human activity in the Doon Valley and dramatic shifts in land use patterns. Spiders are good indicator species for habitat quality and they can offer insights into disturbances in habitat either due to anthropogenic activities or climate change phenomenon. To assess the impact of anthropogenic activity in the Doon Valley, we conducted a long-term study, comparing it with Uttarkashi District. The study revealed 31 species and 28 genera of spiders across 13 families in the Doon Valley, while Uttarkashi District exhibited 37 species and 31 genera across 17 families, including the rare Asian Tarantulas (*Haplocosmia himalayana*, Pocock, 1899), a member of the Theraphosidae family. Pholcidae and Salticidae were consistently found in both regions, with Araneidae predominating. Changes in species distribution, influenced by anthropogenic activities and climate variations, indicate ongoing ecosystem shifts.

Key words: Doon Valley, Uttarkashi, Garhwal Himalaya, Spider, anthropogenic activity, Biodiversity, Indicators, Arachnids, Asian Tarantula, Climate change

The state of Uttarakhand, nestled in the northern snow-clad Himalaya (Chauhan and Saini, 2016), has been identified as one of the Indian biodiversity hotspots (Singh, 2004), encompassing 53,483 sq km of land. The Doon Valley (situated between Ponta Sahib, Vikas Nagar, and Nepali Farm near Rishikesh), has witnessed rapid urbanization due to population growth and industrial expansion (Gupta and Goyal, 2014) after it was named the capital of Uttarakhand state (Gupta, 2013). This urban sprawl has contributed to a concerning reduction in agricultural and forested lands. Moreover, climate change has made its mark, with rising temperatures impacting land use and vegetation patterns (Mishra and Garg, 2023). In this changing landscape, spiders emerge as crucial indicators of ecosystem health. Their adaptability, short lifespans, and predacious nature make them responsive to environmental shifts (Clausen, 1986). Spiders, key players in insect population control, are especially relevant in agricultural ecosystems (Birkhofer and Klaus, 2018). They not only influence predator-prey dynamics but also serve as significant food resources. However, anthropogenic activities and climate change threaten these intricate balances. Habitat loss from deforestation, urbanization, and pollution, coupled with the disruptions caused by climate change, have complex implications for spider diversity. In the last two decades, research on the Indian Himalayan region Araneae has emphasized inventories and taxonomy, neglecting ecology, biogeography, and phylogeny (Sarkar et al., 2023). This study endeavours to delve into these dynamics by comparing spider diversity between the Doon Valley and Uttarkashi, shedding light on the profound impacts of human actions on these intricate ecosystems. As Uttarakhand grapples with urbanization, altered land use and shifting weather patterns, this research seeks to illuminate the evolving relationship between human activities, climate change, and spider diversity.

MATERIALS AND METHODS

The study area extended across 12 diverse sites within Doon Valley (30.31°N, 78.03°E) and five high-altitude treks in Uttarkashi district (30.72° N, 78.43° E), Uttarakhand, India. Doon Valley is witnessing increasing anthropogenic activities. In 2021 alone, Doon Valley attracted 2,867,782 visitors (UTDB, 2022), raising concerns for its ecosystems. Spider specimens were systematically collected from varied sites in Doon Valley to unravel diversity, distribution, and their response to low, moderate, and high traffic conditions.

Altitude variations further complicated the study's terrain. Uttarkashi, situated in the formidable Himalaya, spans 8016 square kilometers. Sampling sites were rich in vegetation like Bay-berry (*Myrica esculata*), Himalayan cherry (*Prunus cerasoides*), Deodar (*Cedrus deodara*), Chir-pine (*Pinus roxburghii*), Oak (*Quercus semecarpifolia*), and Rhododendron trees. Contrasting with Doon Valley, Uttarkashi displayed lower pollution due to limited development. Sampling in Uttarkashi covered five high-altitude treks.

The spider collections were carried out in diverse landscapes, including expansive meadows, dense woodlands, tranquil riverbanks, and areas adorned with living and fallen plant branches. The study included sampling sessions across all three seasons - winter, monsoon, and summer. Each season comprised 3 to 4 sampling sessions, with each session lasting 4 to 6 hours. Spider diversity monitoring was conducted at both sites spanning from March 2019 to April 2023. Beyond collection, a holistic approach was taken, documenting habitats and intricate web patterns. Spider capture techniques such as aerial hand Collection, ground hand collection, and vegetation beating (Coddington et al., 1991, 1996), were employed. While some challenging-to-identify immature species were observed and photographed in situ, others were carefully preserved in 70% alcohol solution within labeled falcon tubes, bearing vital collection information. Identification involved a multidisciplinary strategy, combining morphological examination.

RESULTS AND DISCUSSION

India currently harbors a documented total of 1,990 spider species, spread across 502 genera and encompassing 62 families (WSC, 2024, Caleb and Sankaran, 2024). During the investigation in Doon Valley, a total of 13 spider families, 26 genera, and 30 species were identified. Species belonging to the Salticidae and Pholcidae families exhibited resilience to anthropogenic impacts within the Valley. In earlier studies, Gupta and Siliwal (2012) reported the presence of 23 spider families at the Wildlife Institute of India campus and Pooja et al., (2019) reported a total of 14 spider families Navdanya farm in the Doon Valley. Intriguingly, our study observed a conspicuous absence of 5 spider families across 12 regions in the Doon Valley, including the previously recorded Cheiracanthidae and Theridiidae. These families are consistently observed across all five treks in Uttarkashi (Fig. 1). The absence of these families in the Valley prompts questions about potential influencing factors including environmental shifts, habitat fragmentation, and human activities. Our study in District Uttarkashi reports 37 spider species belonging to 31 genera and 17 families. A total number of 54 species, 43 genera, and 17 families are being reported from our study sites in both districts (Table 1). The Araneidae family predominates in both districts and thrives abundantly. Cheiracanthiidae and Theridiidae families previously reported in the Doon Valley were absent at all 12 locations. On the contrary, a discovery of *Selenops radiatus* (Latreille, 1819) from the Selenopidae family was documented for the first time in Doon Valley, marking a unique contribution to the field. A similar study conducted in the Nanda Devi Biosphere Reserve, Chamoli, identified a total of 33 spider families (Uniyal et al., 2011; Quasin and Uniyal, 2011).

Trichonephila clavata (L. Koch, 1878) a spider species well-known for its propensity to weave thick webs during the monsoon, exhibits intriguing behaviour. This behaviour is more prevalent in Chaurangi,

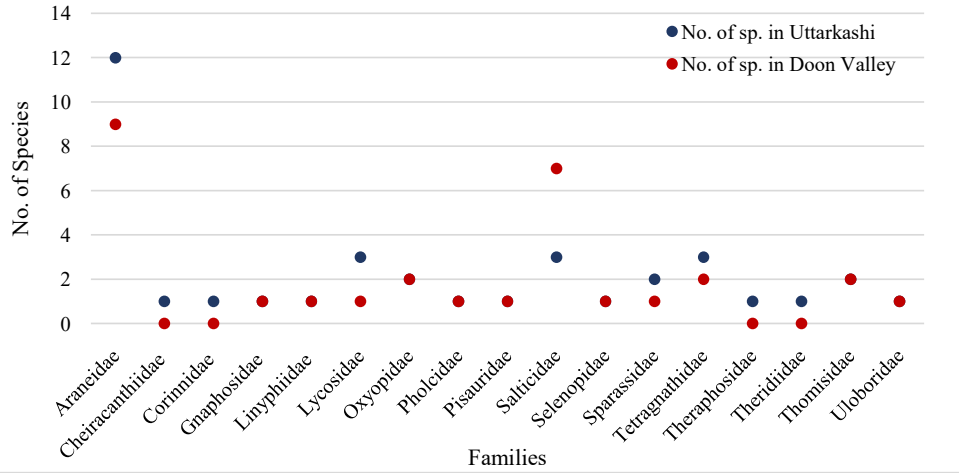

Fig. 1. Distribution of spider families- Uttarkashi and Doon Valley

Table 1. Spider species recorded from both of the districts

Sl. No.	Family	Genus/Species	Remarks
1	Araneidae (Clerck 1757)	*Araniella* sp	*
		Araneus sp1	*
		Araneus sp2	*
		Argiope anasuja	*#
		Argiope pulchella	*#
		Bijoaraneus mitificus	#
		Cyclosa bifida	#
		Cyrtophora moluccensis	*
		Gea subarmata	#
		Herennia multipuncta	#
		Neoscona mukerjei	*
		Neoscona nautica	*
		Neoscona punctigera	*
		Neoscona sp1	*
		Nephila pilipes	#
		Thelacantha sp1	*#
		Trichonephila clavata	*#
2	Cheiracanthiidae (Wagner 1887)	*Cheiracanthium* sp1	*
3	Corinnidae (Karsck 1880)	*Castianeira* sp1	*
4	Gnaphosidae (Banks 1892)	*Zelotes* sp1	*#
5	Linyphiidae (Blackwall 1859)	*Neriene* sp1	*
		Neriene sp2	#
6	Lycosidae (Sundevall 1833)	*Hippasa* sp1	*#
		Trochosa	*
		Wadicosa fidelis	*
7	Oxyopidae (Thorell 1869)	*Hamataliwa* sp1	#
		Oxyopes sp1	#
		Oxyopes javanus	*
		Oxyopes sp2	*
8	Pholcidae (Koch C.L. 1850)	*Pholcus* sp1	*#
9	Pisauridae (Simon, 1890)	*Dendrolycosa* sp1	#
		Perenthis venusta	*
10	Salticidae (Blackwall 1841)	*Aelurillus* sp1	*
		Carrhotus sp1	#
		Hasarius adansoni	#
		Menemerus bivittatus	#
		Myrmarachne sp1	#
		Myrmarachne sp 2	*#
		Plexippus paykulli	*#
		Telamonia dimidiata	*#
11	Selenopidae (Simon 1897)	*Selenops radiatus*	*#
12	Sparassidae (Bertkau 1872)	*Heteropoda venatoria*	*#
		Olios sp1	*
13	Tetragnathidae (Menge 1866)	*Leucauge decorata*	*#
		Metellina sp1	*
		Tetragnatha sp1	*
		Tetragnatha sp2	#
14	Theraphosidae (Thorell 1869)	*Haplocosmia himalayana*	*
15	Theridiidae (Sundevall 1833)	*Achaearanea* sp1	*
16	Thomisidae (Sundevall 1833)	*Oxytate* sp1	#
		Thomisus sp1	*#
		Xysticus sp1	*
17	Uloboridae (Thorell 1869)	*Cyclosa spirifera*	#
		Zosis geniculata	*

Abbreviations used: - * Reported from Uttarkashi, # - Reported from Doon Valley

Uttarkashi, compared to the Mussoorie area of the Doon Valley, despite both regions sharing similar altitudes. The difference in web-building activity may be attributed to the higher population density in Mussoorie, resulting in increased human activities (Fig. 2). While the species was not spotted during the winters in Mussoorie, it left remnants in Uttarkashi. Some live spiders were even inactive after descending from heights, suggesting their ability to endure low temperatures to a certain extent. Similar observations about this species have been reported by Davis and Frick (2022).

Another spider species, *Nephila pilipes* (Fabricius, 1793) found in Doiwala and Lachhiwala of the Doon Valley, constructs intricate webs during the monsoon only and these webs disappear in winter. Despite minimal traffic and encroaching/urbanization, these widespread webs draw attention in the Doon Valley. *Hippasa*, a species frequently observed along the roadsides of Uttarkashi, displays reduced prevalence in multiple sites across the Mussories section of Doon Valley and both locations have almost similar altitudes. The escalating factors of pollution, climate fluctuations, deforestation, and population density are adversely impacting numerous spider species, posing a potential threat to their diversity in the near term (Fig. 3). The study also sheds light on a rare species, *Haplocosmia himalayana* (Pocock, 1899) belonging to the Theraphosidae family, collected from the district Uttarkashi (Fig. 4). This diverse family houses 167 genera (WSC, 2024). *Haplocosmia himalayana*, was also reported in newspapers in 2020 from the Doon Valley and Kotdwara region (Kukreti, 2022). Intriguingly, two other *Haplocosmia* species were previously found in Nepal in 1996 (Li, 2020), while

Fig. 2. *Trichonephila clavata* weaves an elaborate web encircling the entire area

Fig. 3. Dense webs formed by *Hippasa* sp. in Uttarkashi

Fig. 4. *Haplocosmia himalayana* reported from Uttarkashi

Haplocosmia sherwoodae was identified in China (Lin et al., 2022). We are reporting this species for the first time from Uttarkashi district however this needs further verification using molecular markers.

Spider species face threats from agriculture, livestock farming, forestry, climate change, urbanization, pollution, and pesticides (Branco and Cardoso, 2020). Urbanization disrupts natural habitats, affecting spider communities and ecological balance (Rodriguez et al., 2015). Urban areas show significant functional divergence, impacting spider community structures (Sharma et al., 2024). The Doon Valley experiences adverse effects on spiders due to habitat alterations and reduced productivity (Cohen, 2006). The biodiversity of district Uttarkashi remains largely untouched, but local communities lack awareness of its value, highlighting the need for conservation efforts. Raising awareness about habitat preservation and the importance of spiders is crucial for environmental stewardship. Prioritizing habitat preservation and reducing anthropogenic activities is essential for a sustainable future that values and protects natural ecosystems.

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AUTHOR CONTRIBUTION STATEMENT

Madhu Thapliyal and Ashish Thapliyal designed experiments. Deepak Rana conducted the experiments. Madhu Thapliyal, Ashish Thapliyal, and Deepak Rana assisted experiments. Madhu Thapliyal, Ashish Thapliyal, and Deepak Rana wrote the original manuscript. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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