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A study on ecological distribution and community diversity of spiders in Gulmarg Wildlife Sanctuary of Kashmir Himalaya

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The present study was an attempt to assess and evaluate the distribution, diversity and occurrence of spider community in Gulmarg Wildlife Sanctuary. India has 59 of the 110 spider families and at least, 1442 formally described species of the 39,000 known worldwide. Documenting spider assemblages assumes greater importance in the context of current rate of loss and degradation of forests which is known to have detrimental effect on many invertebrate groups. In order to assess the diversity and distribution of spiders at four sites during the months of May, June, July, October and December 2012, standard protocol was used to collect the spider community across the study area. The spider community was found to be represented by 18 taxa. Araneidae was dominant family followed by Lycosidae, Linyphiidae, Pholcidae, Salticidae, Sparassidae and Clubionidae. Differences in vegetation cover or human use showed variation in diversity and composition of spiders between different sites. Forest sites showed relatively higher diversity as compared to meadow sites.

Key words: Spider community, diversity, Araneidae, Gulmarg.

INTRODUCTION

Spiders form a diverse group of invertebrates in varied ecosystems and are known to be sensitive indicators of environmental change (Hodge and Vink, 2010). India has 59 of the 110 spider families and at least 1442 formally described species of the 39,000 known worldwide (Siliwal et al., 2009). Spiders also have an added advantage of being conspicuous, amenable to capture by relatively cheap, easily deployable and replicable techniques. These attributes make spiders as a group, suitable for statistical appraisal, comparisons and monitoring of sites or habitats. 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 about 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; Van Hook, 1971; Moulder and Reichle, 1972; Edwards et al., 1976).

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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). They occupy a wide range of spatial and temporal niches, exhibit taxon and guild responses to environmental change, 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 because of their ability to suppress pest abundance in agro ecosystems. The population densities and species abundance of spider communities in agricultural fields can be as high as that in natural ecosystems (Riechert, 1981). 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). Spiders regulate decomposer populations (Clarke and Grant, 1968) and by doing so, they influence ecosystem functioning (Lawrence and Wise, 2000, 2004). Their high biomass also makes them a critical resource for larger forest predators such as salamanders, small mammals and birds. 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 have 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; 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). This paper intends to study the diversity of spiders at different vegetation types.

MATERIALS AND METHODS

Study area

The study was conducted at Gulmarg (Figure 1), Gulmarg literally means 'meadow of flowers'. Gulmarg is a town, a hill station and Kashmir's premier ski resort. It is located 56 km south west of Srinagar. Gulmarg's legendary beauty, prime location and proximity to Srinagar naturally make it one of the premier charming luxury hill resorts in the country. The study sites selected had relatively different vegetation and anthropogenic impacts. Site-1 represented Drang Forest with geographical coordinates of N 34° 02′ 04.0″ and E 74° 24′ 25″ and an elevation of about 2328 m. The site was having dominant tree cover of *Pinus wallichiana* and *Picea smithiana*, while *Taxus baccata* was less prominent. The prominent shrubs were *Viburnum grandiflora* and *Geranum wallicianum*. Site-2 represented Drang Meadow (N 34° 03′ 35.7″ and E 74° 25′ 31.7″; Elevation 2328 m). It was dominated by herbaceous vegetation but witnessed grazing and anthropogenic activities. Site-3 represented Gulmarg Forest (N 34° 02′ 41.6″ and E 74° 23′ 09.3″; Elevation 2684 m). This site had a mixed type of vegetation dominated by *Populous migra*, *Rolinia pseudacacia* and dotted with *P. wallichiana* trees also. Site-4 represented Gulmarg meadow (N 34° 02′ 51.6″ and E 74° 23′ 09.3″; Elevation 2687 m).

Spiders have been sampled using many methods, each with its own limitations, such as direct searches, pitfall traps, canopy fogging, vegetation beating, litter shifting or extraction, sweap net and suction sampling (Churchill and Arthru, 1999). Established sampling protocols for spider collection (Sorensen et al., 2002) were adopted in different sampling plots. The study was carried out using belt transects vegetation beating, pitfall traps and leaf litter extraction. Pitfall traps method was used to capture the spiders (Curtis, 1980; Kitching et al., 2000). The belt transects were of 10 m length and 2 m width with sampling restricted to the maximum height of 1 m. At each site, exercise was conducted for 30 min. Vegetation beating method is employed to collect spiders living in the shrub, high herb vegetation, bushes and small trees and branches (Coddington et al., 1996; Coddington and Levi, 1991). Spiders were collected by beating the vegetation with a stick and collecting the samples on a cloth (1 m²). The spiders were preserved in different vials filled with ethyl alcohol (75-80%) and marked using a piece of paper with the sample number.

Statistical analysis

No single index encompasses all characteristics of an ideal index, that is, high discriminate ability, low sensitivity to a sample size, and ease in calculation (Margurran, 1988). Therefore an observation of the different indices reflecting species evenness, dominance and diversity heterogeneity provide some valid viewpoints. Shannon's index of diversity (Price, 1997) reflects both evenness and richness (Colwell and Huston, 1991) and is commonly used in diversity studies (Krebs, 1989). It is calculated as $H = -\sum(ni/N)Ln(ni/N)$; i =1–n; where n is the number of species and Pi is the proportion of the ith species in the total. Index of dominance is calculated as $= \sum(ni/N)^2$ where ni is the number of individuals of a species and N is the total number of individuals of all species. Evenness indicates the degree of homogeneity in abundance between species and is based on the Shannon index of diversity. Shannon evenness [$E = H/H_{max} = H/\ln S$; where H is the Shannon diversity index and S the number of species in the community] ranges from 0 to 1.

RESULTS

Taxonomical diversity

The spider community (order Araneae) was found to be represented by 18 taxa. Araneidae was a dominant family followed by Lycosidae, Linyphiidae, Pholcidae, Salticidae,

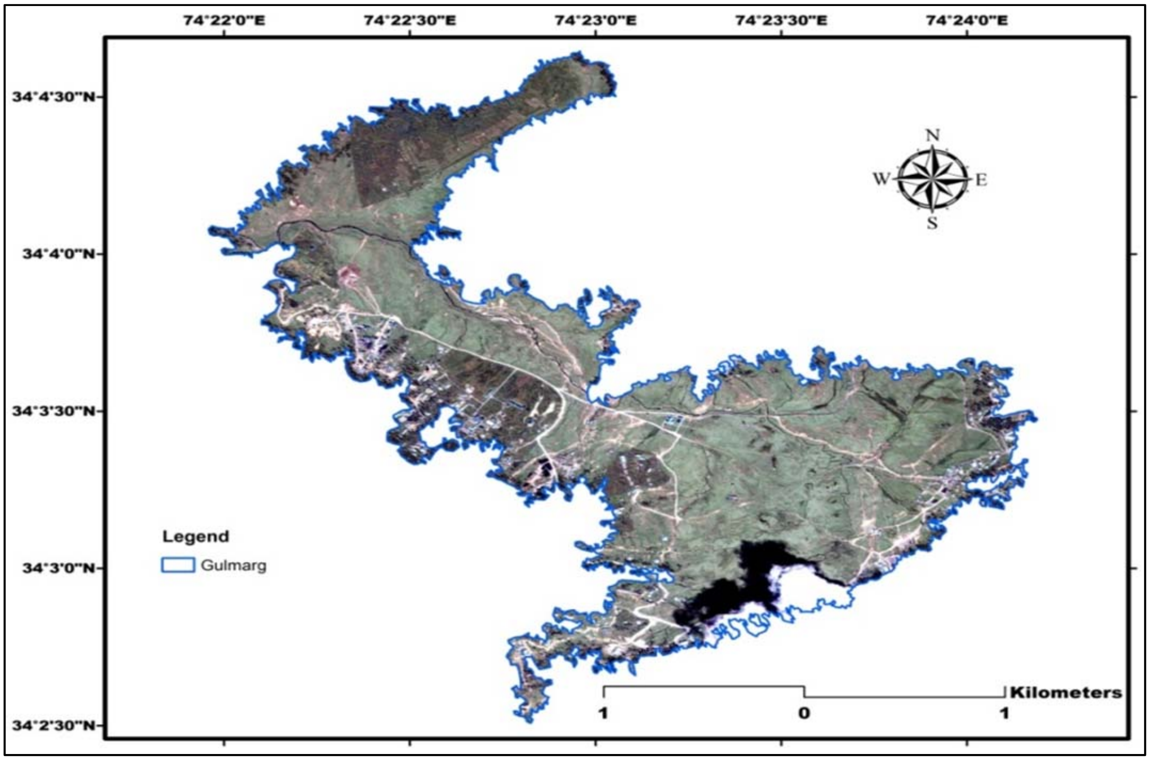

Figure 1. Satellite image of the study *area* (Gulmarg).

Table 1. Monthly variation in spider community density (Ind./m^2) at site I from May 2012-December 2012.

S/N	*Taxa*	May	June	July	October	December	Mean (n_i)
	Site I (Drang Forest)						
1	*Lycosa* sp.	6	4	0	0	1	2.2
2	*Araneus* sp.	2	4	4	3	2	3
3	*Obscuriphantes* sp.	0	2	0	0	0	0.4
4	*Stegodyphus* sp.	0	1	0	3	0	0.8
5	*Sparassus* sp.	0	0	2	4	0	1.2
6	*Lepthyphantes* sp.	0	0	1	0	0	0.2
7	*Pholcus* sp.	2	1	2	0	0	1
8	*Microlinphia* sp.	0	0	0	6	0	1.2
9	*Pardosa* sp.	0	0	0	2	1	0.6
	Total	10	12	9	18	4	10.6

Sparassidae and Clubionidae. Among the four sites selected, site I (Drang forest) showed the maximum number of taxa followed by site III (Gulmarg Forest), II (Drang meadow) and IV (Gulmarg meadow). At site I (Drang Forest) *Araneus* sp. was found to be dominant taxa throughout the study period. *Araneus* sp. recorded its maximum density (4 individual/m^2) in the month of July 2012 and lowered to 2 individual/m^2 in the month of December 2012. While the *Lepthyphantes* sp. was least dominant at site I having a maximum density (1 individual/m^2) in the month of July and was not recorded in the month of December (Table 1). At site II (Drang Meadow) *Lycosa* sp. and *Padosa* sp. were two dominant taxa throughout the sampling. In the month of June, *Lycosa* sp. showed the highest dominance (10 individuals/m^2) and was totally absent in the month of July. While *Salticus* sp. and *Thomisius* sp. were present only in the month of December (Table 2). At site III (Gulmarg Forest), *Lycosa* sp. was found to be dominant taxa throughout the study period. In the month of June,

Table 2. Monthly variation in spider community density (Ind. /m^2) at site II from May 2012-December 2012.

S/N	Taxa	May	June	July	October	December	Mean (n_i)
	Site II (Drang Meadow)						
1	*Lycosa* sp.	4	10	0	2	4	4
2	*Pardosa* sp.	4	6	0	4	0	2.8
3	*Microlinphia* sp.	0	0	3	4	0	1.4
4	*Salticus* sp.	0	0	0	4	0	0.8
5	*Thomisius* sp	0	0	0	6	0	1.2
	Total	8	16	3	20	4	10.2

Table 3. Monthly Variation in Spider Community Density (Ind./m^2) at Site III from May 2012-December 2012.

S/N	*Taxa*	May	June	July	October	December	Mean (n_i)
	Site III (Gulmarg Forest)						
1	*Lycosa* sp.	3	4	2	1	1	2.2
2	*Araneus* sp.	2	2	4	2	1	2.2
3	*Clubiona* sp.	1	0	2	0	0	0.6
4	*Dictyna* sp.	2	0	2	0	0	0.8
5	*Microlinyphia* sp.	0	0	2	0	0	0.4
6	*Salticus* sp.	0	0	4	0	0	0.8
7	*Loxosceles* sp.	0	0	4	0	0	0.8
8	*Pholcus* sp.	1	2	3	1	0	1.4
	Total	9	8	23	4	2	9.2

Table 4. Monthly variation in spider community density (Ind./m^2) at site IV from May 2012-December 2012.

S/N	Taxa	May	June	July	October	December	Mean (n_i)
	Site IV (Gulmarg Meadow)						
1	*Lycosa* sp.	15	2	2	1	0	4
2	*Pardosa* sp.	4	4	6	2	0	3.2
	Total	19	6	8	3	0	7.2

Lycosa sp. showed the highest dominance (4 individual/m^2) and lowest (1 individual/m^2) in the month of December. While *Clubiona* sp. was least dominant at site III having a maximum density (2 individuals/m^2) in the month of July and lowered to 0 individual/m^2 in the month of December (Table 3). At site IV (Gulmarg Meadow), only *Lycosa* sp. and *Pardosa* sp. were observed, out of which *Lycosa* sp. was found to be more dominant. In the month of May, *Lycosa* sp. showed the highest dominance (15 individual/m^2) but no individuals were recorded during December. *Pardosa* sp. was dominant in the month of July (6 individual/m^2) while no individuals were encountered in the month of December (Table 4). At site I (Drang Forest), *Araneus* sp. was found to be dominant taxa throughout the study period. *Araneus* sp. recorded its maximum density (4 individual/m^2) in the month of July 2012 and lowered to 2 individual/m^2 in the month of December 2012. While *Lepthyphantes* sp. was least dominant at site I having a maximum density 1 individual/m^2 in the month of July and was not recorded in the month of December.

At site II (Drang Meadow), *Lycosa* sp. and *Padosa* sp. were two dominant taxa throughout the sampling. In the month of June, *Lycosa* sp. showed the highest dominance (10 individual/m^2) and was totally absent in the month of July. While *Salticus* sp. and *Thomisius* sp. were present only in the month of December.

At site III (Gulmarg Forest), *Lycosa* sp. was found to be dominant taxa throughout the study period. In the month of June, *Lycosa* sp. showed the highest dominance

(4 individual/m^2) and lowest (1 individual/m^2) in the month of December. While *Clubiona* sp. was least dominant at site 3 having a maximum density (2 individual/m^2) in the month of July and was absent in the month of June, October and December.

At site IV (Gulmarg Meadow), only *Lycosa* sp. and *Pardosa* sp. were observed, out of which *Lycosa* sp. was found to be more dominant. In the month of May, *Lycosa* sp. showed the highest dominance (15 individual/m^2) and lowered to 0 individual/m^2 in the month of December. While *Pardosa* sp. was dominant in the month of July (6 individual/m^2) and lowered to 0 individual/m^2 in the month of October and December.

Araneus sp. and *Lycosa* sp. were two dominant taxa throughout the study period; they are cosmopolitan in distribution and have high species diversity. However, the families like Lycosidae and Araneidae are more tolerant and overcome harsh climatic conditions and can survive in low temperature.

Also, site I (Drang forest) has high diversity than site III (Gulmarg forest), this may be due to the fact that the site I is away from the dwelling areas and its natural conditions while the site III which is a tourist spot is in a relatively more stress.

Also site II (Drang meadow) showed high diversity than site IV (Gulmarg meadow), the reason may be that in site IV, there is high anthropogenic and more biotic interferences taking place.

DISCUSSION

Spider community of the study area was found to be represented by 18 genera belonging to order Araneae. Araneidae was the dominant family followed by Lycosidae, Linyphiidae, Pholcidae, Salticidae, Sparassidae and Clubionidae. Among arthropods, spiders are the most abundant predators in many terrestrial ecosystems, playing an important role in ecosystem functioning throughout habitats (Van Hook, 1971). While spiders in forest ecosystems contribute to the maintenance of insect community equilibrium, the distribution of species and the composition of assemblages are significantly influenced by environmental conditions (Ziesche and Roth, 2008). Spiders seem well suited to discriminate habitat type and quality, since they play important role as diverse and abundant invertebrate predators in terrestrial ecosystems. Despite their ecological role in many ecosystems, high diversity, documented threats and the known imperilment of some species, spiders have received little attention from the conservation community (Skerl, 1999). While this lack of attention may be related to negative public attitudes towards spiders (Kellert, 1986), a paucity of compiled information on spider conservation status and distribution may be a more important issue. However, it is important that imperiled and vulnerable spiders and other invertebrates are not left out of conservation planning efforts, as they may have unique ecological requirements or require particular site selection and management activities.

The diversity of spiders in the two forest sites was noted to be higher as compared to the two meadow sites. This may be due to the increased anthropogenic stress in the meadow areas which lead to the decrease in biodiversity and also the less availability of food in the meadow. Meadows are open areas in which there are high chances of predation. There are several other environmental factors that may also affect spider species diversity such as, spatial heterogeneity, competition, predation, habitat type, environmental stability and productivity (Rosenzweig, 1995). On the other hand, forests have large number of microhabitats which help spiders to escape there predators. Availability of food also effects diversity. In forests, food is available in abundance which is another reason why forests show high diversity as compared to meadow.

Also, the results showed that the number of individuals recorded from the sampling sites linearly decreased with the increasing altitude and also found that the family diversity showed a constant negative value with altitude. As spiders are sensitive to even 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 study site. Similar results of spider abundance and declining linearly with elevation were observed in the studies of Otto and Swenson (1982) and McCoy (1990). Diversity is supposed to peak at mid elevation via primary productivity, which is considered to peak at mid elevations. The study provides information on spider community in different ecosystems and the effects of both biotic and a biotic factors, as well as anthropogenic impacts on diversity and distribution of these spiders. Different sites with differences in either vegetation cover or human use showed variation in diversity and composition of spiders. The number of individuals recorded from the sampling sites linearly decreased with the increasing altitude and also found that the family diversity showed a constant negative value with altitude. As was observed from the results of the study, altitude, habitat type and temperature play an important role in distribution and composition of spiders. Forests showed highest diversity as compared to meadow.

Gulmarg Wild Life sanctuary is interestingly diverse in spider fauna. During study, it was found that there have been less attention towards spiders in the state and therefore similar research in other parts of the Kashmir valley will surely provide 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 for maintenance and management of spider diversity of this region.

Conflict of interests

The authors did not declare any conflict of interest.

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