Distribution Pattern of Spiders along an Elevational Gradient in Nelliyampathy Hill Ranges of the Western Ghats, Kerala, India

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Abstract: ***Systematics provides an essential foundation for understanding, conserving and using biodiversity. Spiders generally have humidity and temperature preferences that limit them to areas within the range of their physiological tolerances, which in turn makes them ideal candidates for land conservation studies. During the course of this study, a quantitative survey of spiders in the Nelliyampathy hill ranges of the Western Ghats was attempted along an elevation gradient, with an aim to investigate the patterns of spider species richness along the elevation gradient. Spiders were collected at a weekly interval for one month at three principal localities along an elevation gradient. The random transect method was used for spider sampling. Time was used as a measure of sampling effort to make the methods comparable. Complementarity and overlap of the spider assemblages at different elevations were assessed using distinctness and beta-diversity indices. This study resulted in the documentation of a total of 515 individuals of spiders belonging to 210 species, 153 genera and 37 families. Among the 210 species collected, 123 species were collected from an altitude of 515-575 m MSL. A total of 101 species were collected from 900-960 m MSL and a total of 51 species were collected from 1325-1375 m MSL. This study revealed that elevation had measurable effect on species richness, with the number of species at three elevations being different. Measures of distinctness and species overlap between elevations were significantly different especially between low elevation and high elevation samples. Analysis of the distribution pattern revealed that diversity varied between elevation gradient, indicating unique species compositions at each elevation. The elevation patterns of species richness are a consequence of many interacting factors, such as plant productivity, competition, geographical area, historical or evolutional development, regional species dynamics, regional species pool, environmental variables and human activity.***

Keywords: Spider, diversity, elevation, species overlap, Western Ghats.

1. Introduction

Systematics provides an essential foundation for understanding, conserving, and using biodiversity. Yet for many groups of organisms we lack even such basic information as the identity and numbers of species found in the Western Ghats, one of the biodiversity hotspots of the world. Spiders are an especially diverse and ecologically important group whose ecological dominance have been the subjects of intense study. Despite this long history of research and their ecological importance, considerable gaps remain in our understanding of spider fauna of the Western Ghats. A more complete inventory of spiders is essential to advance understanding of their ecology, evolution, and behaviour, and to take full advantage of their demonstrated value in conservation priority setting, biomonitoring and biological control (Magurran, 2004; Myers, 2000).

Spiders generally have humidity and temperature preferences that limit them to areas within the range of their physiological tolerances, which in turn makes them ideal candidates for land conservation studies (Noss, 1990). Therefore, documenting spider diversity patterns can provide important information on the biodiversity of this tropical forest ecosystem. It is expected that the study will expose the original diversity of spider fauna in this biodiversity hotspot and bring this otherwise neglected animal group onto the conservation radar screen. Since spiders as a group may even provide useful conservation tools as ecological indicators in rapid biodiversity measurement, there is an urgent need to provide taxonomic resources for groups from tropical ecosystems in the view of current global biodiversity crisis (Rosenzweig, 1995).

In this study, the first quantitative survey of spider in the Nelliyampathy hill ranges of the Western Ghats was conducted along an elevational gradient. This study was conducted with the aim to investigate the main patterns of spider species richness along elevation gradient in the Western Ghats.

2. Materials and Methods

The Western Ghats, locally known as the Sahyadri Hills, are formed by the Malabar Plains and the chain of mountains running parallel to India's western coast, about 30 to 50 kilometers inland between the latitudes 8º N to 20º N and longitudes 73º E to 77º E. They cover an area of about 160,000 km² and stretch for 1,600 kilometers from the country's southern tip to Gujarat in the north, interrupted only by the 30 kilometers wide Palghat Gap. The average height of the Ghats is 1500 m above sea level, but in the southern reaches, it rises up to 2000 m and to exceptionally higher peaks of 2500 m and above. This area is one of the world's ten "Hottest biodiversity hotspots" and atleast 325 globally threatened species occur here. Characteristic biota of the Western Ghats has attracted the attention of researchers for more than a century. Close similarities noticed in the biota of the Western Ghats with that of Southeast Asia and Africa by earlier workers reaffirm the status of Western Ghats as a biodiversity hotspot. Due to its fascinating plate tectonic history, the Western Ghats is considered as an “exchange spot” of biotic elements between Africa and Southeast Asia (Sudhikumar et al., 2009).

Nelliampathy hill ranges (10° 33'45-10° 32'34 N, 76° 38'27-76° 46'39 E) are the part of Peechi-Vazhani wild life sanctuary of the Western Ghats located at an altitude of 467 m to 1572 m above sea level, which spread over 82 km^2. The principal reason for selecting these as the study sites is due to the fact that this protected forest chiefly represent different forest types viz., tropical evergreen forest, moist deciduous forests, shola forest and thorny scrub forest respectively as their primary vegetation type. The climate of the region is very much influenced by the southwest monsoon that touches it in the months from June to September. There is good rainfall during the Northeast monsoon too in the months of October and November. July receives the highest rainfall while February is the driest month here. April and May are the hottest months and January and February are the coldest.

Spiders were collected in a weekly interval for one month from 5th December 2011 to 10th January 2012 at three principal localities along an elevational gradient. The inventories were conducted at the following sites and habitats: 1. Elevation zone 515-575 m MSL (103336.8N 764302.7E, evergreen forest), 2. Elevation zone 900-960 m MSL (103201.2N 764051.8E, evergreen forest), 3. Elevation zone 1325-1375 m MSL (103228.4N 764415.1E, moist deciduous forest).

The random transect method was used for spider sampling. This technique involved a combination of four collection methods to assess the diversity of spider fauna namely, ground hand collection, aerial hand collection, beating and sweeping. Time was used as a measure of sampling effort to make the methods comparable. One sample unit equaled one hour of uninterrupted time during which all spiders encountered were collected. Ground collection involved searching mostly on hands and knees, exploring leaf litter, logs, rocks, and plant surfaces below knee level. Aerial sampling involved searching leaves, branches, tree trunks, and spaces in between, from knee height up to maximum overhead arm's reach. Beating consisted of striking vegetation with a 1 m long stick or shaking the vegetation with hands and catching the falling spiders on an inverted umbrella held below the vegetation and later transferring them to the fixative. Sweeping method was mainly employed in grasslands. Sampling was conducted weekly in the selected study sites. The collected specimens were preserved in 75% alcohol in separate flat bottomed tubes with labels containing information regarding the collection. Voucher specimens were deposited in a reference collection lodged with the Centre for Animal Taxonomy and Ecology, Department of Zoology, Christ College, Irinjalakuda, Kerala, India.

Complementarity and overlap of the spider assemblages at different elevations were assessed using distinctness and beta-diversity indices (Chao et al, 2000). Complementarity of spider assemblages at different elevations was assessed using the proportion of all species in two sites that occurred at only one site. Complementarity was calculated using the Marczewski-Steinhaus (M-S) distance index: $C_{MS} = (a + b – 2j)/(a + b – j)$ where j = number of species found at both elevations, a = number of species at elevation A, and b = number of species at elevation B. C_{MS} was chosen because of its simple and statistically valid approach to comparing two biotas, ranging from a value of 0 where there is less distinctness between the communities, to a value of 1 when there is high distinctness between the communities. Beta-diversity (species overlap between elevations) was calculated by Sørensen's similarity index. β = 2c/s1 + s2 where, s1= the total number of species recorded in the first community, s2= the total number of species recorded in the second community, and c= the number of species common to both communities. The Sørensen’s index is a very simple measure of beta diversity, ranging from a value of 0 where there is no species overlap between two communities, to a value of 1 when exactly the same species are found in both communities. The number of species unique to an elevation and the number of species shared between elevations were also compared (Chao et al, 2000; Hall & Greenstreet, 1998; Smith et al., 1996).

3. Results

Taxonomic survey of the spider fauna in three different locations in the Nelliyampathy ranges of the Western Ghats resulted in the documentation of a total of 515 individuals of spiders belonging to 210 species, 153 genera and 37 families. The most dominant family was Araneidae with 32 species and second dominant family was Salticidae with 27 species. Thomisidae (20), Lycosidae (14), Theridiidae (14), Sparassidae (13) and Tetragnathidae (10) were the other dominant families. Monotypic families included Agelenidae, Amaurobiidae, Barychelidae, Deinopidae, Dictynidae, Hahniidea, Hersiliidae, Liocranidae, Mimetidae, Oecobiddae, Palpimanidae, Selenopidae, Scicariidae and Theraphosidae. *Cyclosa mulmeinensis* of family Araneidae was the numerically dominant species (11 individuals) and the second dominant species was *Leucauge celebesiana* (10 individuals) of family Tetragnathidae.

Among the 210 species collected, 123 species were collected from an altitude of 515-575 m MSL. A total of 101 species were collected from 900-960 m MSL and a total of 51 species were collected from 1325-1375 m MSL. Out of the 123 species collected from 515-575 m MSL, 38 species were shared with 900-960 m MSL and 2 species were shared with 1325-1375 m MSL. Out of the 101 species collected from 900-960 m MSL altitude, 6 species were collected both from 515-575 m MSL and 1325-1375 m MSL and 17 species were shared with 1325-1375 m MSL. Among the 51 species collected from the topmost elevation, 23 species shared with mid elevation and 8 species with lowest elevation studied. This study revealed that elevation had measurable effect on species richness, with the number of species at three elevations being different. The number of species unique to lowest elevation was 77 and number of unique species was 40 and 20 respectively in mid elevation and high elevation.

Measures of distinctness (C_{MS}) and species overlap (β) between elevations were significantly different especially between low elevation and high elevation samples. C_{MS} value was 0.795, 0.821 and 0.951 respectively between elevation 1-2, 2-3 and 1-3. Value of β was 0.339, 0.302 and 0.091 respectively between elevation 1-2, 2-3 and 1-3. This analysis revealed that the greatest species distinctness (C_{MS}) and the lowest species overlap (beta) was between low elevation and high elevation compared to low elevation – mid elevation and mid elevation – high elevation.

4. Discussion

This study revealed that the spider fauna in these ranges is very rich both qualitatively and quantitatively. The 37 spider families recorded from this region represent 52% of the total families reported from India. The number of species reported is higher than the number recorded from any other regions surveyed in India. For instance, Sivaperuman and Rathore (2004) recorded 28 species of spiders belonging to 13 families and 21 genera from Desert National Park in Rajasthan and studies of Sudhikumar et al (2005) reported 72 species of spiders belonging to 57 genera of 20 families from the Mannavan shola forest of the Western Ghats. The present investigation is comparable to the study by Siliwal et al (2003) who recorded 116 species belonging to 66 genera and 25 families from Purna Wildlife Sanctuary, Dangs, Gujarat and the study of Sunil et al (2008), they reported 147 species of spiders the Parambikulam Wildlife sanctuary of the Western Ghats, which is the highest number of species reported from an area in India. From these results, it can be summarized that the spider fauna of Western Ghats of Kerala is rich and diverse when compared to any other region in India. Because of the complex interaction of various climatic factors like high rainfall and humidity, with diverse topographical features, this region possesses many smaller but diverse environmental niches that can support a diverse spider fauna.

Analysis of the diversity pattern revealed that diversity varied between elevational gradient, which indicating that each elevation has unique species compositions. Among the three elevations studied, the lower elevation recorded the highest value of diversity. In this elevation, tropical evergreen forests form the chief vegetation type, which is more complex in nature compared to other vegetation types. This supports the correlation that exists between spider species diversity and habitat types (Otto & Svensson, 1982). This result further supports the hypothesis that structural complexity of plants influences spider species richness, and corroborate other studies on the influence of habitat structure on species richness and species composition of spider assemblages (Wise, 2004). Habitat structural complexity is, in fact, one of the main factors used to explain species diversity (Willig et al., 2003) and habitats with high microsite diversity have greater species richness, since different microsites can have characteristic species associated with them (Noss, 1990). The higher elevation recorded lower diversity and species richness. Compared to low elevation and mid elevation, this area occupied by moist deciduous forest, which support less spider diversity than evergreen forest. So the low spider diversity and richness in the higher elevation could be attributed to the nature of forest type in this region (Fisher, 2002).

An analysis of the faunal composition of spiders in these ranges in the Western Ghats revealed that Araneidae was the taxonomically dominant family. Araneidae is the largest family of spiders that construct orb-webs. Dominance of this family in the study area is directly consequential to the vegetational architecture. Vegetational architecture plays a major role in the species composition found within a habitat (Rypstra et al., 1999), and vegetation which is structurally more complex can sustain a higher abundance and diversity of spiders (Andrew & Hughes, 2004). It is apparent that tropical forests possess the congenial environment for the construction of orb webs. In a study conducted in Costa Rica, Greenstone (1984) found that vegetation structure but not prey availability significantly determined the diversity of web spiders. Since the abundance of orb-weavers are influenced by the physical structure of the vegetation and the availability of web sites (Hawksworth & Kalin-Arroyo, 1995), the undisturbed bushes and sparse ground-layer vegetation in primary forest might be able to support a larger population of orb-weaving spiders which require larger spaces for web construction.

A fundamental characteristic of mountain ecosystems is the drastic change in vegetation as well as in climate from the base to the summit of mountain. Elevation gradients create varied climates, along with resultant soil differentiation; promote the diversification of both flora and fauna (Sanders, 2002). Many studies have investigated species richness along elevation gradient across habits and taxa as part of efforts to understand ecosystem effects on biodiversity and conservation of biodiversity (Rahbek, 1995). Furthermore, the observable associations between species distribution and elevation bands may help to understand the possible effects of climate change, e.g., by providing baseline information from which to measure or gauge the effect of climate change and anthropogenic changes on ecosystem (Naniwadekar & Vasudevan, 2007). The elevational patterns of species richness are a consequence of many interacting factors, such as plant productivity, competition, geographical area, historical or evolutional development, regional species dynamics, regional species pool, environmental variables, and human activity (Fu et al., 2006; Willig et al., 2003).

Despite being one of the most diverse groups of organisms, spiders have largely been ignored by the conservation community and taxonomists alike (Sebastian Peter, 2009). The human tendency is to favour some organisms over others of equal importance because the latter lack a universal appeal. Many threats to spider diversity have been documented. The primary threat is habitat loss and degradation due to deforestation, agriculture, grazing and urbanisation. A large number of species have become endangered due to urban development, land-use management techniques, air and groundwater pollution caused by use of pesticides and fertilisers, the introduction of invasive alien species, and in some cases, collection and trafficking for the pet trade. Many of these species are on the threshold of extinction, attracting the attention of conservationists. The major obstacle for spider conservation is an absence of public support, arguably due to fear and ignorance. Conservation of spiders will thus necessitate a greater understanding by the general public, scientists, land use managers and conservationists about the importance of conserving these fascinating creatures.

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