Comparative Diversity of Aerial and Web-borne Spiders in an Urban, Semi Urban and Rural Gradient in Ernakulam District, Kerala, India

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ABSTRACT

A study was conducted to study the compare the diversity and species richness of arieal and web-borne spiders in an urban, semi urban and rural gradient and the effect of urbanization on the aerial spiders. The present study was also proposed to make an in-depth study on the diversity and abundance of spiders in relation to different habitat types - Mangalavanam, Hill palace, and Thevackal landscape in Ernakulam District Kerala, India. The study was extended for a period of six months from February to July 2014. The study documented 56 species of spiders belonging to 46 genera and 14 families from Mangalavanam, Hill palace and Thevackal. One species, recorded from the study area is endemic to Kerala. A total of 4 species are endemic to Western Ghats-Sri Lanka region. The araneo fauna in the selected study sites bear affinities mainly to Oriental and Palearctic regions, as well as to the fauna of Sri Lanka. Analysis of the faunal composition revealed that Araneidae was the taxonomically dominant family. Analysis of the beta diversity revealed that Thevackal recorded the highest values for most of the diversity indices, as well as species richness. An important finding of this study was the sighting of the green cribellate spiders, *Nigma walckenaeri* Rower, 1951 at Thevackal. This is the first report of this species from India. Analysis of the guild structure revealed that orb web weavers were the dominant feeding guild. The overall trends in abundance of spider community showed correlation with seasons. The study of spiders was conducted between two seasons, namely summer and monsoon (February to July). This study found that overall spider species richness was significantly higher in the rural site-Thevackal compared to the urban area- Mangalavanam and sub urban area- Hill palace. The ratio of forest species was significantly higher in the rural sites than in the suburban and urban ones, suggesting that forest species are indeed sensitive to the disturbance caused by urbanization. Analysis revealed that the species composition changed remarkably along the urbanization gradient.

Keywords: Urbanization, urban-semi urban-rural gradient, biodiversity, spiders

INTRODUCTION

Among all organisms, spiders form the seventh largest animal order and are common predatory arthropods in all terrestrial and many aquatic ecosystems. Spiders are ancient animals with a history going back over 350 million years. They are abundant and widespread in almost all ecosystems and constitute one of the most important components of global biodiversity. Spiders have a very significant role to play in ecology by being exclusively

predatory and thereby maintaining ecological equilibrium. Spider venoms are being studied for possible uses in medicine and pest control. Currently 43,244 valid described species of spiders in 3879 genera and 111 families have been described (Platnick 2012). The estimated total extends of world spider species can only be guessed at; Codington and Levi (1991) commented that up to 170,000 species could exist.

About 40 families of spiders are recorded from Kerala. However, no studies on their diversity have ever been undertaken here; with the result that many of them still remain unnamed and unrecorded. Further, deforestation and environmental pollution have led many species to the verge of extinction. Out of the 59 families recorded in Indian region, 38 families are discovered from Kerala. This represents 73% of the total families recorded in India. Diversity of families proves to be important because they bear close association with the diversity of habitats. Some rare families like Prodidomidae, Mimetidae, Stenochilidae, Cryptothelidae, and Oonopidae are recorded from Kerala.

Like many other 'little things that run the world', spiders remain peripheral to mainstream conservation research and action. Their high relative abundance, ease of collection, and diversity in habitat preferences and foraging strategies allows for effective monitoring of site differences. This ubiquity, diversity and ecological role of spiders make them a promising focal group for invertebrate conservation and useful indicators of the effects of land management on local biodiversity. Spiders also show potential as a group to be used for higher taxonomic surveys. In order to know how and where to protect biodiversity, it is imperative to know the patterns of diversity of terrestrial arthropods, which may comprise 80% or more of the earth's surface but have been too often neglected by the resource managers and conservation planners.

The purpose of this study is to analyze the impact of urbanization on species diversityof spiders on three land gradients in Ernakulam District with the following objectives: To identify the species diversity of arieal and web-borne spiders in urban, semi-urban and rural landscapes (Mangalavanam, Hill Palace and Thevackal); to analyze the comparative diversity of spiders between different study areas; to document micro-habitat associations, abundance, guild structure and seasonality of spiders in the different study sites; to document unique and rare species and to identify the effect of urbanization on aerial and web-borne spiders.

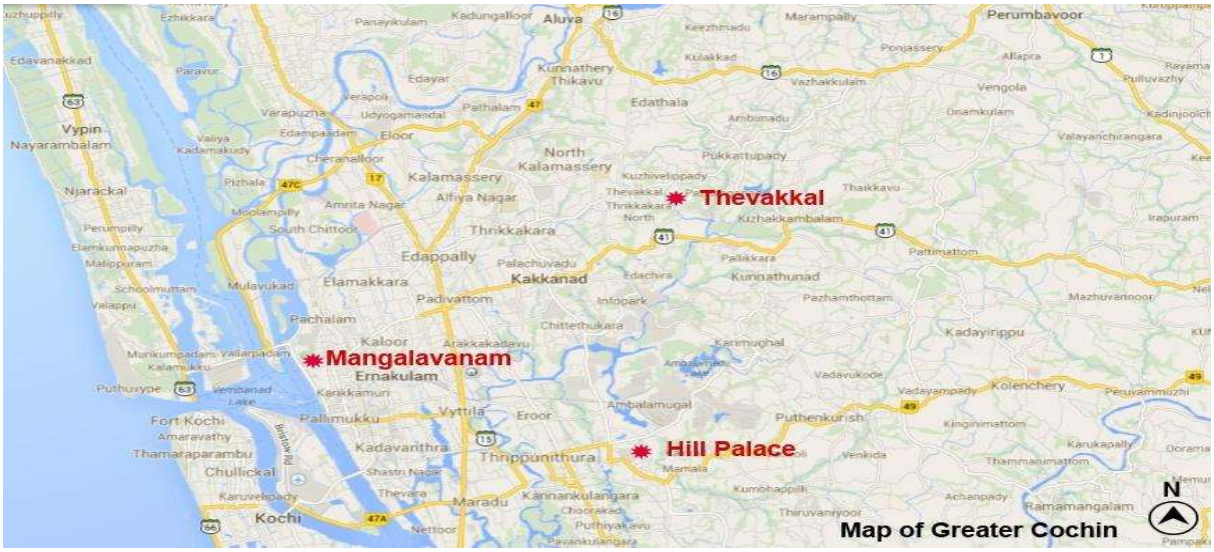
MATERIALS AND METHODS

The study area consisted of an urban forest - Mangalavanam, which lies in the heart of Kochi city; a semi urban forest – the forested premises of Hill Palace Museum, Thripunithura; and a rural forest – a privately owned forest in Thevakkal village (Fig.1). The sites comprise an approximately 21 km long urban-semi urban-rural gradient The study was conducted for a period of 6 months from February to July 2014.

Spiders were collected by visual search hand collection method. This method employs a combination of aerial hand collection and beating. Aerial sampling involves searching leaves, branches, tree trunks, and spaces in between, from knee height up to maximum

overhead arm's reach. Beating consists 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. The collected specimens were preserved in 70% alcohol in separate tubes with labels containing information regarding the collection.

Figure 1. Map of the study area



The collected spiders were identified with the help of expertise available at the Division of Arachnology, Sacred Heart College, Thevara, Kochi, Kerala using diagnostic keys and other literature (Tikader, 1987; Barrion and Litsinger, 1995; Dippenaar-Shoeman and Jocque, 1997; Deeleman-Reinhold; 2000) using stereoscopic microscopes (Leica MS5, Olympus SZ112). Adult males and females collected from the fields were identified up to the species level whereas immature spiders were identified up to generic level.

The diversity, richness, and evenness indices of spider communities were computed using Primer6 software. The two main diversity indices used were the Shannon-Wiener index, which is sensitive to changes in the abundance of rare species in a community, and the Simpson index, which is sensitive to changes in the most abundant species in a community (Solow, 1993). Shannon –Wiener index, which increases with the number of species in the community, is an ordinal scale. A diversity index incorporates both species richness (the total number of species) and evenness (how equally abundant the species are), in a single value (Magurran, 1988).

In order to evaluate whether or not different habitats differed markedly in community composition, hierarchical cluster analysis was performed. The Bray-Curtis similarity index (Bray and Curtis, 1957) was used to construct similarity matrices between samples and formed the basis for cluster analysis

The spider guild classification was done based on the families collected during the study. Designation of spider guild was based on the ecological characteristic known for the

family (Young and Edwards, 1990). Ecological characteristics relating to foraging manner, nature of web, prey species, microhabitat use, site tenacity and daily activity were subjected to guild classification. Output of the analysis was organized into tabular form and subsequent guild designations were based on the relative similarity of spider foraging modes.

Monthly sampling data were prepared with detailed information on the occurrence of mature male, female and juvenile spiders. These data were used to deduce the population dynamics and seasonality of spiders across the study sites.

RESULTS

A total of 56 species of spiders belonging to 46 genera and 14 families were sampled from Erankulam District. From Mangalavanam, 29 species of spiders belonging to 27 genera, 12 families, from Hill palace, a total of 39 species of spiders belonging to 32 genera and 13 families and from Thevackal a total of 48 species belonging to 42 genera, 14 families were recorded (Tables 1, 2 & 3). The sighting of a rare species *Nigma walckenaeri* Rower, 1951 (Family Dictynidae) at Thevackal is an important finding of this study. This species is being reported for the first time from India.

The various ecological indices (Shannon-Weiner index, Simpson's index, Margalef's index, Hill's evenness index,Brillouin Index(H),and Fisher's Alpha), as well as species richness for the three different habitat types were computed and the results are given in Table 4.

Table 1. Abundance data of spiders recorded from Mangalavanam.

Guild	Family	No. of Genera	No.of Species	No. of individuals sampled
ORB WEB BUILDERS	Araneidae	6	6	101
	Tetragnathidae	2	2	27
	Uloboridae	1	1	7
STALKERS	Salticidae	5	5	64
	Oxyopdae	1	1	21
SPACE WEB BUILDERS	Pholcidae	2	3	31
	Theridiidae	3	3	25
FOLIAGE HUNTERS	Clubionidae	1	1	10
	Miturgidae	1	1	9
	Pisauridae	1	1	11
	Scytodidae	1	1	12

Table 2. Abundance data of spiders recorded from spiders recorded from Hill Palace

Guild	Family	No. of Genus	No. of Species	No. of individuals sampled
ORB-WEB BUILDERS	Araneidae	7	9	112
	Tetragnathidae	3	3	40
	Uloboridae	1	2	14
STALKERS	Salticidae	6	7	74
	Oxyopdae	1	1	23
SPACE WEB BUILDERS	Pholcidae	4	4	37
	Theridiidae	2	4	42
FOLIAGE HUNTERS	Clubionidae	1	1	5
	Miturgidae	1	1	30
	Pisauridae	1	1	15
	Scytodidae	1	1	12
AMBUSHERS	Hersiliidae	1	1	13
	Thomisidae	3	4	14

Among the three land gradient types, Thevakkal (rural area) recorded the highest Shannon-Weiner and Margalef's richness indices of and respectively. This habitat type also recorded the highest species richness value of 48. Mangalavanam (urban gradient) and Hill palace (semi urban gradient) recorded the Simpson's index of 0.95, 0.96 respectively. Thevakkal recorded the highest Simpson's index of 0.97. Thevakkal recorded the highest Evenness index of 41.76. The lowest species richness (29) was recorded in Mangalavanam. Mangalavanam, Hill palace and Thevakkal shows the Brillouin Index as 3.01, 3.18, 3.56 respectively and also The Fisher's Alpha as 7.54, 10.41, and 12.68.

In order to evaluate whether or not different habitat types differed markedly incommunity composition, hierarchical cluster analysis was performed. The Bray-Curtis similarity indices were calculated and the resulting dendrogram is shown in Fig.1 . Cluster analysis showed that Hill palace and Mangalavanam had similar faunal composition by clustering together in the dendrogram.

The seasonal occurrence of Ariel and web-borne spiders in the selected study sites over a period of six months is represented graphically in Fig 3. The highest species occurrence was recorded in the pre-monsoon months (February to May) and the least occurrence was during the monsoon period (June to July).

Table 3. Abundance data of spiders recorded from spiders recorded from Thevackal.

Guild	Family	No. Genus	No. of Species	No of individuals sampled
ORB- WEB BUILDERS	Araneidae	10	11	142
	Tetragnathidae	4	5	54
	Uloboridae	1	2	19
STALKERS	Salticidae	7	8	78
	Oxyopdae	2	3	36
SPACE WEB BUILDERS	Dictynidae	2	2	9
	Pholcidae	3	3	42
	Theridiidae	5	6	58
FOLIAGE HUNTERS	Clubionidae	1	1	16
	Miturgidae	1	1	13
	Pisauridae	1	1	14
	Scytodidae	1	1	17
AMBUSHERS	Hersiliidae	1	1	9
	Thomisidae	3	3	39

Table 4. Species diversity measures of spiders recorded from Mangalavanam, Hill palace and Thevackal.

	Species Richness (S)	Total Individuals (N)	Margalef's Richness Index (d)	Shannon-Weiner Index ($H'(\log_e)$)	Simpson Index (1-Lambda)	Brillouin Index (H)	Fisher's Alpha	Hill's Evenness Index (N1)
Mangalavanam	29	345	4.79	3.17	0.95	3.01	7.54	23.78
Hill Palace	39	431	6.26	3.35	0.96	3.18	10.41	28.56
Thevakkal	48	546	7.46	3.73	0.97	3.56	12.68	41.76

Figure 1. Dendrogram based on cluster analysis

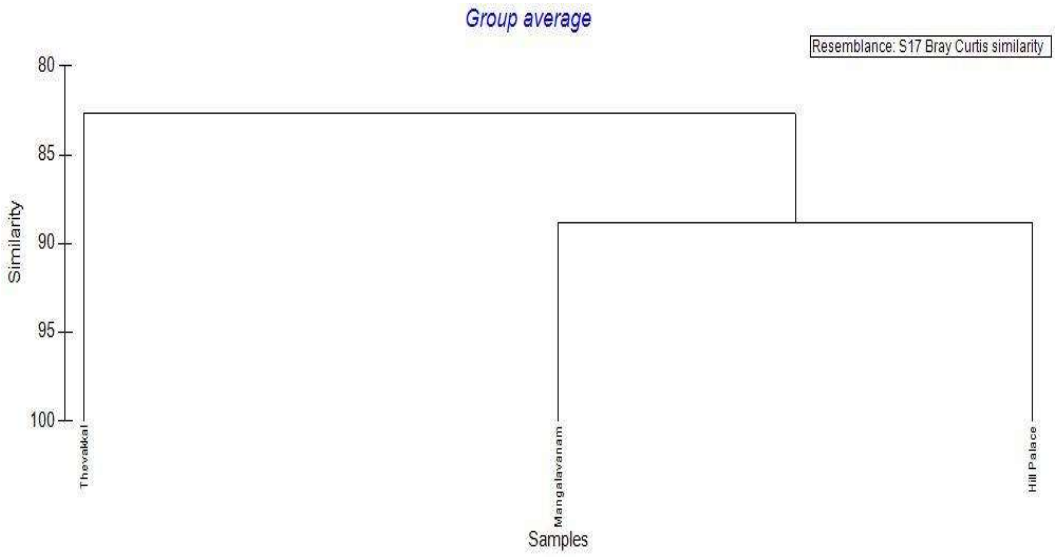


Figure 2. Guild structure of spiders at three study sites

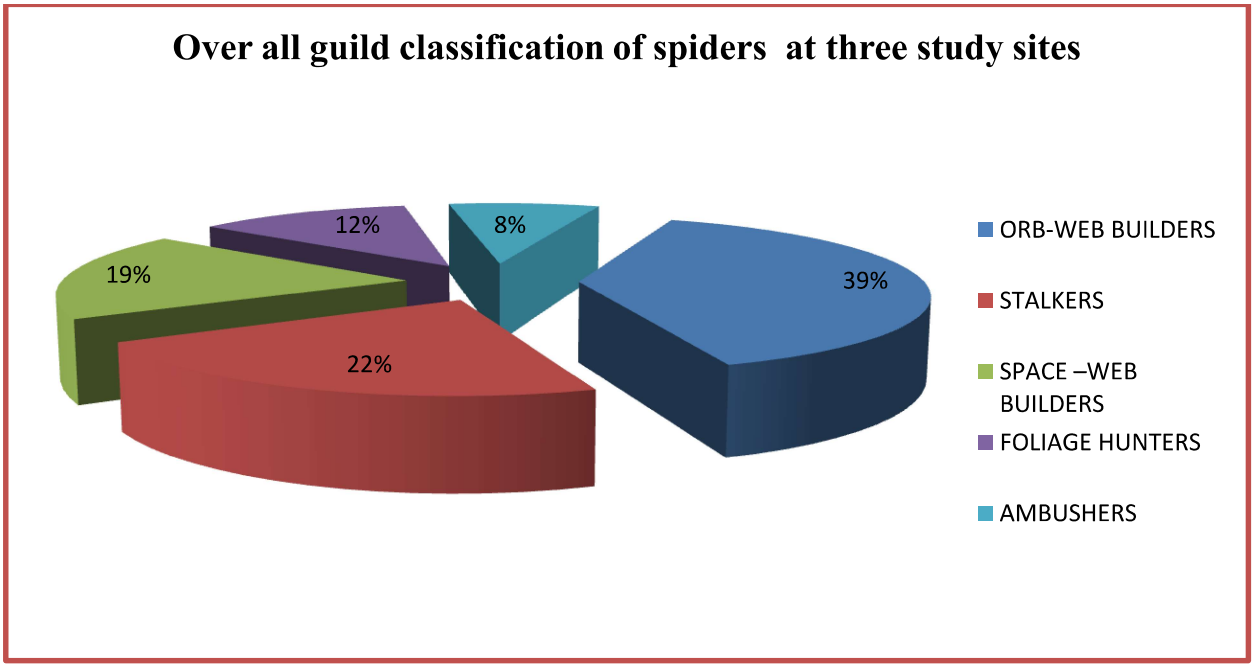
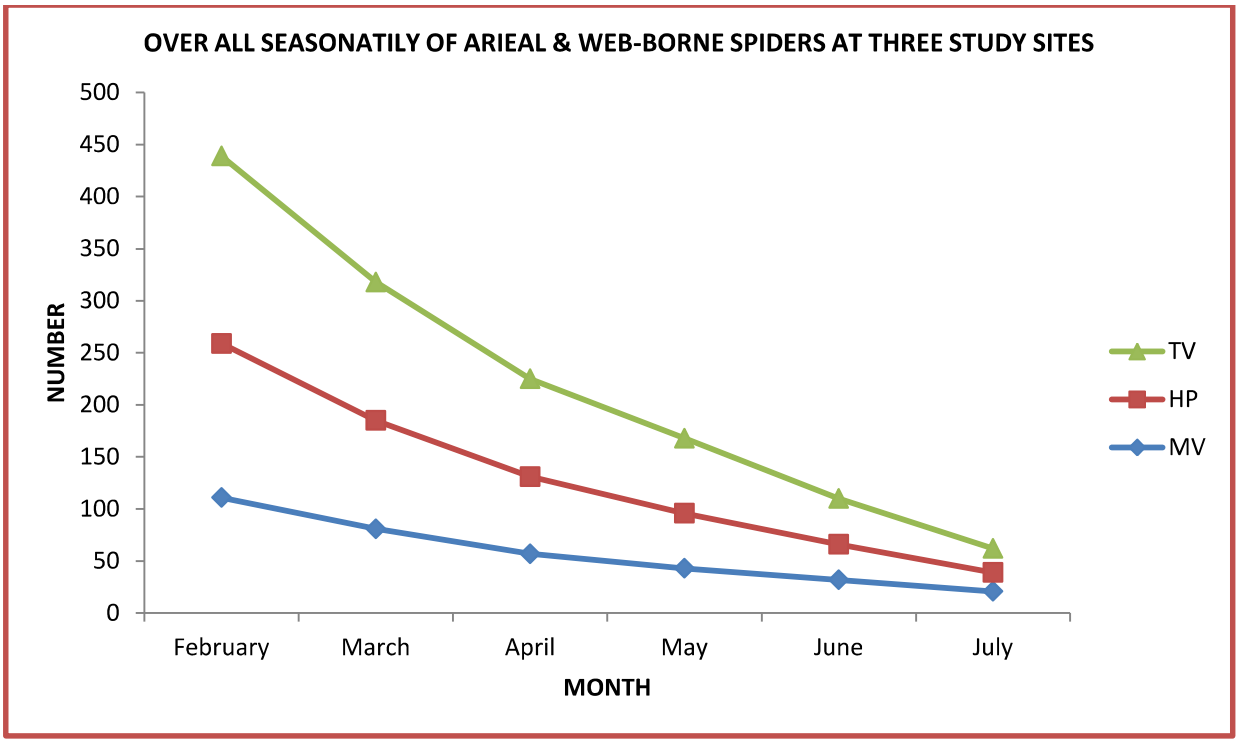


Figure 3. Seasonality of spiders at three study sites



DISCUSSION

The sighting of a rare species *Nigma walckenaeri* Rower, 1951 (Family Dictynidae) at Thevackal is an important finding of this study. This species is being reported for the first time from India. Discovery of rare species, for the first time from India indicates the biological wealth of this region and further points out the necessity of more detailed exploration in order to comprehensively understand the biodiversity of this region. Discovery of any new species is significant considering the fact that biodiversity is disappearing from our planet at an astonishing rate. One species, *Gasteracantha geminata* (Fabricius, 1798 (Family Araneidae), recorded from the study area is endemic to Kerala. Further, 3 species are endemic to Western Ghats-Sri Lanka region. These are *Uloborus krishnae*Tikader, 1970 (FamilyUloboridae); *Neoscona mukerjei* Tikader, 1980(Family Araneidae) and *Thomisu projectus* Tikader, 1960 (Family Thomisidae).

Faunistic survey of the araneofauna in the various landscapes (urban, semi urban and rural) of Eranakulam resulted in the documentation of 56 species of spiders belonging to 46 genera and 14 families (Tables 1, 2, 3). The araneid spiders represent 39% (figure 3.2) of the total individuals reported from the study. Species richness of spiders in Thevakkal region is higher than that recorded from other regions.

From the results, it can be summarized that the spider fauna of Thevackal region is richer and more diverse when compared to any other regions. Because of the complex interaction of various climatic factors like high rainfall and humidity, with diverse

topographical features, this region possess many smaller but different environmental niches that can support a diverse spider fauna. Sighting of *Nigma walckenaeri* for the first time from India indicates the biological wealth of this region and further points out the necessity of more detailed exploration in order to comprehensively understand the biodiversity of this region.

Analysis of the faunal composition revealed that Araneidae was the taxonomically dominant family. Araneidae is the largest family of spiders that construct orb-webs (wheel-shaped two-dimensional webs) and are often found in gardens, fields and forests. 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 (Scheidler 1990), and vegetation which is structurally more complex can sustain a higher abundance and diversity of spiders (Hatley and MacMahon 1980). It is apparent that rural areas possess the congenial environment for the construction of orb webs. The abundance of orb-weavers are influenced by the physical structure of the vegetation and the availability of web sites (Greenstone 1984 and Wise 1993), 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.

An analysis of the various indices (Table 3) revealed that diversity values varied, although minimally in most cases, between the different study sites indicating that all sites have unique species compositions. Among the various habitat types surveyed in Ernakulam District, Thevackal recorded the highest values for most of the diversity indices, as well as species richness. This habitat type mostly occurs in a rural; countryside village. Microsite diversity has greater species richness, since different microsites can have characteristic species associated with them (Magurran1988). The high species diversity in this habitat type could be attributed to the favorable microclimatic conditions prevailing in this tract. Sacred grooves, rural villages probably offers the most stable microclimate to support life as there would not be any extremes of climatic conditions that would be detrimental for survival. This assumption is supported by the fact that the least species richness values were recorded from Mangalavanam. This habitat type is mostly found in places that have effects of urbanization.

The overall trends in abundance of spider community showed correlation with seasons. The highest species occurrence was recorded in the pre-monsoon months (February to May) and the least occurrence was during the monsoon period (June to July).Thus, it is clearly evident that seasonality of spiders is directly related to season. This might be attributed to prevailing environmental conditions such as temperature, rainfall and wind, which affect the availability of prey and occurrence of natural enemies of spiders like parasitic wasps.

It might be expected that climatic changes through seasons would influence the abundance of spiders (Kato et al. 1995). Most spiders are limited to a certain extent by environmental conditions. In general, different species have varying humidity and temperature preferences and are limited to those parts of the habitat which offer a microclimate within the range of their physiological tolerances. The least spider abundance

observed in the monsoon period, which is characterized by heavy rains, could be attributed to the unavailability of insects during this season due to incessant rains. Furthermore, inclement weather conditions could have limited the foraging opportunities of spiders themselves forcing them to undergo a period of inactivation.

CONCLUSION

Urbanization is a common type of habitat loss that entails a relatively thorough transformation from the economy of nature to the human economy. Economic growth proceeds at the competitive exclusion of biodiversity, including nonhuman species in the aggregate. Microeconomic and micro ecological approaches to biodiversity conservation in and around urban areas may be taken, but the results should be viewed as short-term compromises and perhaps an inefficient use of economic growth, while principles scarce conservation resources.

Many threats to spider diversity have been documented. The primary threat is habitat loss and degradation due to deforestation, agriculture, grazing and urbanization. A large number of species have become endangered due to urban development, landuse management techniques, air and groundwater pollution caused by use of pesticides and fertilizers, the introduction of invasive alien species, and in some cases, collection and trafficking for the pet trade.

The ecological importance of spiders as general predators in natural terrestrial ecosystems is undisputed, but spiders also play a major predatory role in agroecosystems, and therefore their diversity is also of economic importance. Despite being one of the most diverse groups of organisms, spiders have largely been ignored from a conservation perspective. The 2012 IUCN Red Data Book (IUCN, 2012) lists 30 species of spiders as threatened. Many species may be threatened, endangered or extinct, but research on them is lacking. Unfortunately, due to this limited information on distribution, population and conservation status of spiders, it is difficult to get them listed under national or international legislation.

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.

The synthesis of these findings is that urbanization is somewhat of a red herring in the debate of economic growth vs. biodiversity conservation. As long as economic growth remains a primary policy goal, and to the extent such policy is effective, urbanization and biodiversity loss will continue. The only long-lasting approach to biodiversity conservation appears to be macroeconomic: i.e., the establishment of a steady state economy.

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