



Spider (Arachnida, Araneae) diversity at Godrej mangroves, Vikhroli, Mumbai, Maharashtra, India

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ABSTRACT: Among the varied aquatic and terrestrial invertebrate diversity of mangrove ecosystem, spiders are considered to be an important bioindicators of ecological health. Studies on the spider diversity in the mangroves at Vikhroli, Mumbai, Maharashtra conducted resulted in the documentation of a total of 38 spider species belonging to the 33 genera under 12 families. Salticidae was found to be the dominant with 10 species from 10 genera, followed by Araneidae (9 species and 7 genera). The survey done in three mangrove zones revealed that zone II with moderate mangrove density resulted in the highest diversity ($H=0.89$) of spiders. Guild structure analysis revealed six different guilds. Stalkers (Salticidae and Oxyopidae) were the predominant feeding guild (34.00%). Seasonal (pre monsoon, monsoon and post monsoon) analysis showed more species diversity in the month of June to September.

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KEY WORDS: Species, bioindicators, mangrove density, guild structure, seasons

INTRODUCTION

Spiders are ubiquitous organisms belonging to order Araneae of class Arachnida under phylum Arthropoda. Worldwide there are 49,720 species of spiders belonging to 4,232 genera and 129 families. India represents about 1,799 species under 448 genera and 59 families (Caleb, 2020; World Spider Catalog, 2020). Mumbai, the financial capital of Maharashtra, has a history of luxuriant mangrove vegetation. But increasing extensive anthropogenic burden has created a threat to the mangroves and has caused depletion of about 40 per cent of all mangroves in the past, putting coastal region at risk. Despite of such pressures, today still mangrove

forests are seen along the Vasai creek, Thane creek, Manori and Malad, Mahim - Bandra, Versova, Sewree, Mumbra-Diva, Vikhroli and Bhandup (Sarkar, 2017). A significant credit for the conservation and maintenance of mangrove forest of Mumbai goes to the Godrej mangroves, Vikhroli, and it acts as an ideal bionetwork and harbors around 82 butterflies, 209 birds, 13 crabs, 7 prawns and 20 fish species. Spiders have proved to be good bio (Mangroves App, 2017) indicators of anthropogenic disturbance. Not much studies have been made on the spider diversity of mangrove forest of Mumbai region and its outskirts; except some valuable studies done from the Mumbai zones

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by (Mirza and Sanap, 2010; Sanap *et al.*, 2017) contributing the significant data about spider research. According to Mirza and Sanap (2010) the faunal diversity of Aarey milk colony, Mumbai includes 19 families of spiders (Infra-Order-Araneomorphae). According to Wise (1993), spiders are generalist predators playing an important role in terrestrial ecosystem. With this objective, current study has been carried out explicitly in the Godrej mangroves, Vikhroli (Mumbai), Maharashtra to understand spider status in overall invertebrate diversity of mangrove habitat.

MATERIALS AND METHODS

The study was conducted at Godrej Mangroves which is a private land owned by Godrej and Boyce Mfg. Co. Ltd and Soonabai Pirojsha Godrej Foundation located along the Eastern Express Highway at Vikhroli, Mumbai, Maharashtra (19°06'37.47"N; 72°56'32.16"E to 19°03'53.39"N; 72°5'33.66"E). Thousands of acres of this land comprise of mangrove forest, which includes 16 species of mangroves and their associate species that are being maintained by the Godrej for the past 65 years. The survey was done from June 2017 to May 2018. The study area was divided into the three zones based on density of mangrove namely zone I - dense mangroves (1- KN post area, 2- Pond near post and 3- KN road); zone II - moderate mangroves (4- KT Post to Tower-2 road, 5- KT road, 6- Medicinal garden, 8- Butterfly garden and 9- BMC road area) and zone III - sparse mangroves (7- Jetty road, 10- RC road and 11- Link road).

The sampling methods include – all out search method involving visual searching in spider supporting microhabitats as far as, distinct vision is possible and ground search under litter, fallen or dry leaves and wood. In each zone, visual observation was done for about two hours in the morning (8.00am to 10.00am). All the individuals recorded from the above three zones were photographed using Nikon D7200 camera and dedicated macro lens: - Nikon AF micro 200mm F4. Nikon flash R1C1 used for macro shoots. Adult specimens were identified up to genus level and species wherever possible (Jocqué and Dippenaar-

Schoeman, 2007; Sebastian and Peter, 2009; World Spider Catalog, 2020).

Statistical analyses were worked out as –

$H_{\max} = \ln(S) = \text{Maximum diversity possible (S = Sample count)}$

Shannon's diversity index (H) = $H = - \sum (p_i \ln p_i)$

Where,

H = General diversity index.

p_i = Proportion of the *i*th species such that ($p_i = N_i/N$)

N_i = Number of individuals in the *i*th species,

N = Total number of individuals of all species in the community

Evenness: $E = H/H_{\max}$

RESULTS AND DISCUSSIONS

A total 38 spider species has been documented belonging to the 33 genera and 12 families from the study area; representing 20.34 per cent of total 59 families reported from India (World Spider Catalog, 2019-2021). Among all the families, Salticidae was found to be dominant (10 genera and 10 species), followed by Araneidae (7 genera and 9 species) (Table 1, Plate 1). However, in terms of abundance, Araneidae representing 32 total individuals ranked first, whereas Salticidae (22), Oxyopidae (18), Thomisidae (8) were on second, third and fourth position respectively (Table 2).

Guild analysis discovered total six different guilds; stalkers (34%), orb-web weavers (32%), ambushers (18%), ground runners (5%), space web builder (3%), and foliage hunters (8%) (Uetz *et al.*, 1999). Among stalkers Salticidae and Oxyopidae found to be the dominant. Zone-wise distribution of spiders (Table 4) showed that zone-II having moderate mangrove vegetation had the highest richness (53%) as well as abundance of spiders (57 individuals from all 12 families). Major contribution to the zone II in terms of abundance has been done by Araneidae (29.82%) and Salticidae (17.54%). Zone III showed

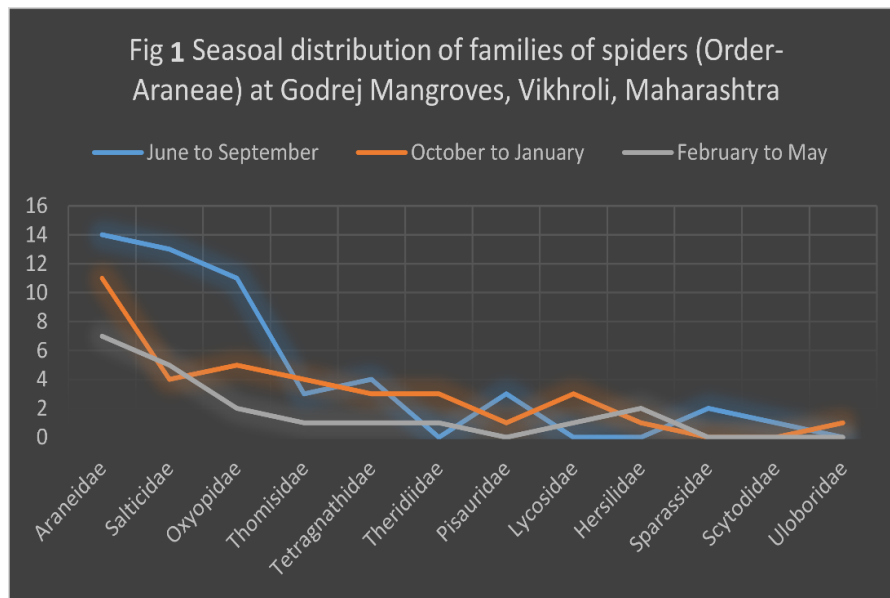
Table 1. Total number of Family, Genera and Species of spiders along with guild structure at Godrej Mangroves, Vikhroli, Maharashtra

No.	Family	Genus	Species	Guild
1	Salticidae	10	10	Stalker
2	Araneidae	07	09	Orb-web weaver
3	Thomisidae	03	04	Ambushers
4	Oxyopidae	01	03	Stalker
5	Lycosidae	02	02	Ground runners
6	Tetragnathidae	02	02	Orb-web weavers
7	Theridiidae	01	01	Space web builder
8	Sparassidae	01	01	Foliage hunters
9	Pisauridae	03	03	Ambushers
10	Uloboridae	01	01	Orb-web builder
11	Scytodidae	01	01	Foliage hunters
12	Hersiliidae	01	01	Foliage hunter
Total	12	33	38	

Table 2. Zone wise number of spiders at Godrej Mangroves

No.	Species	Godrej mangroves Zone			
		I	II	III	Total
Family: Araneidae					
1	<i>Argiope aemula</i>	01	04	01	06
2	<i>Argiope pulchella</i>	-	02	03	05
3	<i>Neoscona</i> sp1	-	01	-	01
4	<i>Neoscona</i> sp2	-	-	01	01
5	<i>Cyrtophora</i> sp	01	06	08	15
6	<i>Cyclosa</i> sp	-	01	-	01
7	<i>Thelacantha</i> sp	-	01	-	01
8	<i>Araneus</i> sp	-	01	-	01
9	<i>Eriovixia</i> sp	-	01	-	01
Total	09	02	17	13	32
Family: Salticidae					
1	<i>Rhene flavicomans</i>	01	01	-	02
2	<i>Hyllus semicupreus</i>	02	-	01	03
3	<i>Phintella vittata</i>	02	01	-	03
4	<i>Icius alboterminus</i>	-	-	01	01
5	<i>Hasarius adansoni</i>	-	01	01	02
6	<i>Carrhotus viduus</i>	01	02	02	05
7	<i>Telamonia dimidiata</i>	-	02	-	02

8	<i>Thyene imperialis</i>	-	01	01	02
9	<i>Asemonea tenuipes</i>	-	01	-	01
10	<i>Phlegra</i> sp	-	01	-	01
Total	10	06	10	06	22
Family: Oxyopidae					
1	<i>Oxyopes shweta</i>	02	02	-	04
2	<i>Oxyopes pankaji</i>	01	04	06	11
3	<i>Oxyopes javanus</i>	-	03	-	03
Total	03	03	09	06	18
Family: Thomisidae					
1	<i>Thomisus</i> sp 1	-	02	01	03
2	<i>Thomisus</i> sp 2	01	01	-	02
3	<i>Oxytate virens</i>	-	02	-	02
4	<i>Xysticus</i> sp	01	-	-	01
Total	04	02	05	01	08
Family: Tetragnathidae					
1	<i>Tetragnatha</i> sp	01	03	01	05
2	<i>Leucauge decorata</i>	01	02	-	03
Total	02	02	05	01	08
Family: Theridiidae					
1	<i>Argyrodes</i> sp	01	03	-	04
Total	01	01	03	00	04
Family: Pisauridae					
1	<i>Nilus</i> sp	0	02	-	02
2	<i>Perenethis</i> sp	0	01	-	01
3	<i>Pisaura</i> sp	0	01	-	01
Total	03	00	04	00	04
Family: Lycosidae					
1	<i>Lycosa</i> sp	01	02	-	03
2	<i>Hippasa</i> sp	01	00	-	01
Total	02	02	02	00	04
Family: Hersiliidae					
1	<i>Hersilia</i> sp	01	01	01	03
Family: Sparassidae					
1	<i>Olios lamarcki</i>	-	-	02	02
Family: Scytodidae					
1	<i>Scytodes</i> sp	00	00	01	01
Family: Uloboridae					
1	<i>Miagrammopes</i> sp	00	01	00	01
Total Abundance		19	57	31	107



29 per cent abundance of spiders, while zone I had only 18 per cent.

In the seasonal documentation, the species abundance was predominant during monsoon (June to September) followed by post monsoon (October to January); pre-monsoon (February to May) showed comparatively a lesser number (Fig. 5).

The maximum possible diversity is represented by H_{\max} which is calculated considering all total 38 species recorded during the study. The Shannon index for zone I, zone II and zone III calculated were 2.7256, 3.2675 and 2.3548 respectively. Greater diversity was noted in zone II. Values of Evenness index suggest that species are more evenly distributed (zone I - 0.7492, zone II - 0.8982 and zone III - 0.6473).

$H_{\max} = \ln(S) = \text{Maximum diversity possible} = 3.63758616$

Godrej mangroves form a fairly productive ecosystem; extremely rich in biodiversity. According to Buchholz and Ceylan (2013) and Pearce and Venier (2006), invertebrates due to their short life span, great abundance, sensitivity towards fluctuating environment and high diversity can be utilized as bio-indicators to study the characters of the habitat within which they found. Spider without being an exception, might have its contribution in

maintaining the health of an environment. Spiders are generalist predators (Wise, 1993), although insects found to form a major part of their diet, other arthropods are also happened to be preyed by them, while some species observed to be show cannibalistic behavior too (Foelix, 1996). Habitat heterogeneity supports sufficient alternative prey for them Maloney *et al.* (2013) stated that spiders can act as effective predators of certain insect pests in agricultural fields. Apart from above, during the survey, klepto-parasitic behaviour was observed in the family Theridiidae, where *Argyrodes* sp spotted in the web of *Argiope* sp and *Cyrtophora* sp (family-Araneidae) to steal the food captured and paralyzed by respective spider species (Plate 1: Image 2). Some feed on plant sap (Nyffeler *et al.*, 2016). It can be said that variation in spider population indirectly has consequences on overall food web of an ecosystem. Due to fairly high diversity, ease of collection and wide range distribution, spiders can be used as efficient bio-indicators (Pearce and Venier, 2006).

The statistical analysis worked out gives an idea about the overall diversity of Order Araneae at Godrej Mangroves, Vikhroli, Maharashtra. Zone I the dense mangroves represents inferior spider diversity ($H=2.7256$, $E=0.7492$). A dense mangrove comes under the coastal region where, vegetation is exposed to much salinity also the habitat is quite



Plate 1. Spider diversity at Godrej mangroves, Vikhroli, Mumbai, Maharashtra 1. *Rhene flavicomans*, 2. *Argyrodes* sp, 3. *Thomisus* sp, 4. *Leucauge decorata*, 5. *Tetragnatha* sp, 6. *Cyrtophora* sp, 7. *Eriovixia* sp, 8. *Argiope pulchella* 9. *Oxyopes shweta*, 10. *Nilus* sp, 11. *Olios* sp, 12. *Icius alboterminus*

marshy and wet therefore it may cause difficulty for spiders to survive as it's been observed that they need a bit dry place for web development as well as for their other activities like prey catching, mating, parental care, etc. In addition, as low insect abundance can also be attributed to fewer occurrences of spiders in the zone I. The moderate mangrove zone, which can act as a connecting link between coastal and terrestrial region; has combination of halophyte and other land vegetation; forming an ideal habitat for spider population. Godrej Zone-II has blend of true mangroves like *Rhizophora apiculata* (Red Mangrove), *Rhizophora mucronata* (Red Mangrove), *Avicennia marina marina* (Gray mangrove) as well as mangroves associates such as *Acanthus ilicifolius* (Sea Holly), *Salvadora persica*, *Derris trifoliata*, *Sesuvium portulacastrum* along with other vegetation which includes, *Thespesia populnea* and *Hibiscus tiliaceus*. The occurrence of greater diversity and evenness in zone II (H=3.2675, E=0.8982) might be due to varied heterogeneous habitat which can act as an ideal environment for other invertebrates including insects; so, as the prey population is comparatively high in Zone-II spider diversity has been found to be superior. As the vegetation structure moves further reaching zone III, it mainly comprises of grassland where the diversity of spiders is comparatively low (H=2.3548, E=0.6473). In case of grassland, web construction, protection from predators, prey capture, might be fairly challenging due to lack of suitable place to retreat, or the habitat is pretty much open thus possibly making them vulnerable to predators. Evenness indices of three zones revealed that composition and properties of mangrove flora affect the distribution and abundance of spiders (Rashid *et al.*, 2009).

The extensive leafy canopy provides great humidity (Sasekumar, 1974; Ross and Underwood, 1997) and shelter for spider retreat which otherwise would expose them to greater risk of desiccation. Godrej mangroves shows dominance of family Salticidae which can be attributed to their aggressive predatory approach, small size, various color-morphs; assisting them to easily camouflage within surrounding while stalking a prey. In addition, salticids have relatively

a good vision and are able to distinguish colours and thus can distinguish prey from a considerable distance (Sebastian and Peter, 2009) which help in unrestricted foraging strategies from canopy to the exposed ground when tide levels are low (Macnae, 1969). However, in terms of abundance, Araneidae positioned first which is also supported by Macintosh and Ashton (2002). Least diversity at Godrej Mangrove was represented by Uloboridae, Scytodidae, Hersiliidae and Sparassidae constituting one species under each genus. The reason might be due to lack of preferable food or these species might not be able to tolerate such harsh environment of mangroves of study area.

Seasonal study discovered a distinct pattern in the spider abundance (Fig. 1). It indicated that the species are considerably more during monsoon due to temperature, relative humidity and abundance of food (Ghafoor and Mohamood, 2011) and further it shows a decline. After monsoon insects reduce their activity and become dormant due to lack of favorable environment; this may create a pressure on spiders while searching for food causing decreased in diversity. Variation in habitat, its structure, vegetation composition, temperature, humidity and prey availability causes clear spatial patterns of spiders in the mangrove forests (Berry, 1963). Spiders have a very significant role to play in ecology by being exclusively predatory and thereby maintaining ecological equilibrium (Sebastian and Peter, 2009). In the view of above study, spiders found to be the one of the key-indicator group of mangrove ecosystem. Understanding the dynamics of mangrove ecosystem, is a need of time especially when, anthropogenic activities taking toll of this fragile ecosystem.

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