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Building evidence for conservation globally for 25 years
Spider diversity (Arachnida: Araneae) at Saurashtra University Campus, Rajkot, Gujarat during the monsoon

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Abstract: The present work deals with the diversity of spiders during the monsoon within the Saurashtra University Campus, Rajkot, Gujarat. A total of 38 species of spiders belonging to 32 genera and 14 families were recorded. Araneidae (25.81%) was found to be the most dominant family, with nine species from five genera. Guild structure analysis revealed seven feeding guilds, among all 31% most dominant feeding guilds represented by orb-web builders and stalkers, followed by ground runners (13%), irregular webs (10%), ambushers (7%), foliage hunters (6%), and space-web builders (2%). Ecological indices reveal high species richness (Margalef's d = 8.97) and diversity (Shannon Index H' = 3.526, Fisher alpha diversity α = 41.73). It concludes that the abundance of spider species at this study site was high and the evenness index was also high (e > 0, e = 0.8944). These findings suggest the absence of stress elements in the study area.

Keywords: Climate, evenness, feeding guilds, habitat, H' index, predatory status, Rajkot, species distribution, western India.

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INTRODUCTION

Spiders are ubiquitous predatory organisms in the animal kingdom (Riechert & Lockley 1984). They are abundant predators in many terrestrial ecosystems, with populations estimated to approach one million individuals per hectare in the wild (Bristowe 1971). They are primarily entomophagous, while few are involved in arachnophagy (Wise 1993). Many spider families contain species capable of capturing vertebrate prey, which are termed “habitual vertebrate-eaters” and “occasional vertebrate-eaters”; some larger spider species occasionally feed on small mice, birds and lizards (Nyffeler & Gibbons 2022). Spiders play a significant ecological role as exclusive predators and regulate insect populations (Wise 1993). Being ectothermic organisms, the food, feeding behaviors, metabolic rate and activity levels of spiders vary with temperature (Barghusen et al. 1997).

Currently, 51,733 species of spiders, belonging to 4,355 genera and 136 families, are reported worldwide (World Spider Catalog 2023). Their diversity in India is represented by 1,968 species in 498 genera and 62 families (Caleb & Sankaran 2023) and in Gujarat with 533 species under 190 genera and 41 families (Singh et al. 2023).

The present work intends to study the diversity and predatory functional group of spider species, during the monsoon and add information to the database of spider species on the Saurashtra University Campus, Rajkot.

Study area

Saurashtra University Campus (SUC) is situated in Rajkot City (22.291˚N, 70.743˚E, 140 m), in central Gujarat, State in western India (Figure 1). Biogeographically, the area falls within the biotic province 4B — Gujarat Rajputana — of the 4 - semi-arid zone (Rodgers & Panwar 1988). The climate of Rajkot is tropical semi-arid with three distinct seasons each year: monsoon, winter and summer. The annual rainfall is erratic in its occurrence, duration, and intensity. The annual rainfall was high (1,187.5 mm) during 2021; the average temperature varies between 21.73 °C and 34.62 °C, and the average annual humidity ranges from 59.0–93.8 % (morning) and 16.5–83.9 % (evening). The area spans 1.456 km² (360 acres) with hilly terrain (Figure 1B).

The SUC has centrally congregated concrete buildings, many parking sites where human activities are more common, habitat structures, and vegetation layers including many small to large water catchment areas, large ponds, check dam, a landscape with flat and hilly rocky terrain covering herbs and grassland patches, a large sports complex, wasteland on the periphery, vegetative implant areas like Dhanvantri Aaushadhi Udayan, forest lands, and a large botanical garden with a newly developed Miyawaki dense garden, which comprises a floristic diversity of 71 species in 62 genera belonging to 32 families (Lagariya & Kaneria 2021).

METHODS

The present work was conducted from August to October 2021 at SUC, Rajkot, comprising 31 visits conducted randomly in morning and evening sessions. On average, two hours were spent during each visit using techniques such as beating vegetation, aerial handpicking from buildings, vegetation and the ground surface handpicking technique during active visual searching.

Preservation and identification

The captured spiders were stored in plastic bottles with small holes for aeration. In the laboratory, only voucher specimens were transferred to 70% alcohol for later identification and kept in specimen tubes with labeling and the remaining live specimens after microscopic examination were freed into the wild. Detailed species identification was carried out under a stereo-zoom dissecting binocular microscope (Stemi 305 Zeiss ISH500) up to the generic and species levels. Microscopic photographs of the spider were captured using a Canon Power Shot A2300 HD Digital Camera and a Tucsen Camera (ISH500) mounted on the stereomicroscope.


Voucher specimens were deposited at the museum of the Department of Biosciences, Saurashtra University, Rajkot, Gujarat, with registration numbers from SUBZ1 to SUBZ62. Shannon diversity — (H’), evenness — (eH/S), Margalef’s species richness (d) and Fisher
alpha diversity (α) were computed using PAST software (Hammer et al. 2001) and their interpretations followed Magurran (2004).

RESULTS AND DISCUSSION

Out of the 62 spider specimens collected, a total of 38 species classified under 32 genera and 14 families were recorded during the monsoon at Saurashtra University Campus (Table 1). This represents 22.58% of the total 62 families reported from India (Caleb & Sankaran 2023). The family Araneidae exhibited the
Table 1. Checklist of spiders of Saurashtra University Campus areas.

<table>
<thead>
<tr>
<th>Common name / Feeding guild</th>
<th>Registration no.</th>
<th>Scientific name</th>
<th>No. of specimens, sex &amp; stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>True-orb weavers /Orb-web builders</td>
<td>Family: Araneidae Clerck, 1757</td>
<td>1. <em>Argiope anasuja</em> Thorell, 1887</td>
<td>1♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. <em>Argiope</em> sp. 1</td>
<td>1♂</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. <em>Argiope</em> sp. 2</td>
<td>1♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. <em>Eriovixia excelsa</em> (Simon, 1889)</td>
<td>1♀, 1♂</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. <em>Eriovixia</em> sp.</td>
<td>1♀, 1♂</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. <em>Guzyziella</em> sp.</td>
<td>1♀</td>
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<td></td>
<td></td>
<td>7. <em>Neoscona theisi</em> (Walckenaer, 1841)</td>
<td>1♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. <em>Neoscona</em> sp.</td>
<td>2♀, 1♂, 1♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. <em>Poltys</em> sp.</td>
<td>2♀</td>
</tr>
<tr>
<td>Sac spider/Foliage hunters</td>
<td>Family: Clubionidae Simon, 1878</td>
<td>1. <em>Clubiona</em> sp.</td>
<td>1♀</td>
</tr>
<tr>
<td>Ground sac spiders/ Ground runners</td>
<td>Family: Corinnidae Karsch, 1880</td>
<td>1. <em>Castianeria</em> sp.</td>
<td>1♀</td>
</tr>
<tr>
<td>Ground spider/ Ground runners</td>
<td>Family: Gnaphosidae Banks, 1892</td>
<td>1. <em>Eilica tikaderi</em> Platnick, 1976</td>
<td>1♀</td>
</tr>
<tr>
<td>Two tailed spiders/ Foliage hunters</td>
<td>Family: Hersiliidae Thorell, 1869</td>
<td>1. <em>Hersilia savignyi</em> Lucas, 1836</td>
<td>1♀, 1♂</td>
</tr>
<tr>
<td>Wolf spiders/Ground runners</td>
<td>Family: Lycosidae Sundevall, 1833</td>
<td>1. <em>Evippa shivaji Tikader &amp; Malhotra</em></td>
<td>1♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. <em>Hippasa</em> sp.</td>
<td>1♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. <em>Wadicosa fidelis</em> (O. Pickard-Cambridge, 1872)</td>
<td>1♀, 1♂</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. <em>Wadicosa</em> sp.</td>
<td>2♀</td>
</tr>
<tr>
<td>Lynx spiders/ stalkers</td>
<td>Family: Oxyopidae Thorell, 1869</td>
<td>1. <em>Oxyopes bharatae Gajbe,</em> 1999</td>
<td>2♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. <em>Oxyopes hindostanicus</em> Pocock, 1901</td>
<td>3♀</td>
</tr>
<tr>
<td>Daddy long-leg spiders/irregular webs</td>
<td>Family: Pholcidae C. L. Koch, 1850</td>
<td>1. <em>Artema atlanta</em> Walckenaer, 1837</td>
<td>1♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. <em>Crossopriza lyoni</em> Blackwall, 1867</td>
<td>3♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. <em>Pholcus phalangioides</em> Fuesslin, 1775</td>
<td>1♀, 1♂</td>
</tr>
<tr>
<td>Nursery web Spiders/ambushers</td>
<td>Family: Pisauridae Simon, 1890</td>
<td>1. <em>Perenethis</em> sp.</td>
<td>1♀</td>
</tr>
<tr>
<td>Jumping spiders/ Stalkers</td>
<td>Family: Salticidae Blackwall, 1841</td>
<td>1. <em>Hasanus</em> sp.</td>
<td>1♀, 1♂</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. <em>Hylius semicupreus</em> (Simon, 1885)</td>
<td>1♀, 1♂</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. <em>Langosa</em> sp.</td>
<td>1♀</td>
</tr>
<tr>
<td>Jumping spiders/ Stalkers</td>
<td>Family: Salticidae Blackwall, 1841</td>
<td>1. <em>Menemurus</em> sp.</td>
<td>1♀, 1♂, 1♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. <em>Magnus</em> sp.</td>
<td>1♀</td>
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<tr>
<td></td>
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<td>3. <em>Phintelloides undulatus</em> (Caleb &amp; Karthikeyani, 2015)</td>
<td>1♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. <em>Plexippus paykulli</em> (Audouin, 1826)</td>
<td>1♀, 2♂</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. <em>Thyne imperialis</em> (Rossi, 1846)</td>
<td>1♀</td>
</tr>
<tr>
<td>Huntsman spiders/ Foliage hunters</td>
<td>Family: Sparassidae Bertkau, 1872</td>
<td>1. <em>Olios obesulus</em> (Pocock, 1901)</td>
<td>1♀</td>
</tr>
</tbody>
</table>
### Spider diversity at Saurashtra University Campus

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<table>
<thead>
<tr>
<th>Common name / Feeding guild</th>
<th>Registration no.</th>
<th>Scientific name</th>
<th>No. of specimens, sex &amp; stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comb-footed/ Space web builders</td>
<td>Family: Theridiidae Sundevall, 1833</td>
<td>33. <em>Latrodectus geometricus</em> C. L. Koch, 1841</td>
<td>1♀, 1♂</td>
</tr>
<tr>
<td>Crab spiders/ Ambushers</td>
<td>Family: Thomisidae Sundevall, 1833</td>
<td>SUBIOZ57</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUBIOZ58</td>
<td>35. <em>Thomisus</em> sp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUBIOZ59</td>
<td>36. <em>Tmarus kotigeharus</em> Tikader, 1963</td>
</tr>
<tr>
<td>Feather legged lace weaver/ Orb-web builders</td>
<td>Family: Uloboridae Thorell, 1869</td>
<td>SUBIOZ60</td>
<td>37. <em>Miagrammopes</em> sp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUBIOZ61</td>
<td>38. <em>Uloborus</em> sp.</td>
</tr>
</tbody>
</table>

SA—Sub adult | J—Juvenile | Y—Young | VY—Very young | SUBIOZ—Saurashtra University, Museum of Department of Biosciences, Zoology.

**Figure 2. Familial percentages of individuals and species of spider during monsoon.**
maximum representative with 16 individuals (25.81%), comprising nine species from five genera, followed by the family Salticidae with 14 individuals (22.58%), comprising eight species from eight genera (Table 1, Figure 2).

The relative abundance analysis of the age and sex status of the collected spiders revealed that females (73%) were almost three times as many as males (27%). The proportion of the potential group (adults) to non-potential individuals was almost one and a half (1.5P:1NP). Age and sexual maturity of spiders may provide a broad range of mate choice decisions for males, as males of a sexually cannibalistic spider chemically assess relative female quality and mate with adaptive females (Cory & Schneider 2020).

Seven feeding guild structures (Uetz et al. 1999), including orb-web builders (31%), stalkers (31%), ground runners (13%), irregular webs (10%), ambushers (6%), foliage hunters (6%) and space-web builders (3%) were recorded. Among these, the most dominant were orb-web builders (19 individuals from 11 species) and stalkers (19 individuals from 10 species). Among orb-web builders, araneids were dominant with nine species compared to Uloboridae (two species), while stalkers (31%) were primarily from the families Oxyopidae and Salticidae. Ground runners (13%) included members from the families Corinnidae, Gnaphosidae and Lycosidae, while irregular webs (10%) included pholcids. Ambushers (6%) included Pisauridae and Thomisidae. Foliage hunters (6%) included clubionids, hersiliids and sparassids and only 3% were space web builders (theridiids) (Table 1, Figure 3).

Among the 38 spider species, 21 were habitat-specific and were found in the Miyawaki forest in the botanical garden and Nandanvan forest areas. Species such as Poltys sp., Clubiona sp., Evippa shivajii Tikader & Malhotra, 1980, Hippasa sp., Hyllus semicupreus (Simon, 1885), Mogrus sp., Thyene imperialis (Rossi, 1846), Olios obesulus (Pocock, 1901), Thomisus sp., Tmarus kotigeharus Tikader, 1963, and Miagrammopes sp. were among those found. Another 17 species, including Guizygiella sp., Castianeria sp., Eilica tikaderi Platnick, 1976, Perenethis sp., Langona sp., Phintelloides undulatus (Caleb & Karthikeyani, 2015), Monaeses sp., and Uloborus sp. were found near buildings, parking lots and ground surface areas. Latrodectus geometricus C.L.Koch, 1841, was found to be more common at parking spots along the corners of iron pole joints.

The Shannon Weiner Index (H') in the current study was high (H’ = 3.526). A high H’ value would indicate an even distribution of species. It allows us to not only know the number of species but also the abundance of the community. Typical values of the Shannon-Weiner Index (H’) are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increase. It can be concluded that the abundance of spider species at this study site is high. The evenness index (e) was high (e >0, 0.8944). As the evenness index increases with a decrease in stress (Pielou 1966), this indicates that the study areas have very minimal to no stress elements.
Margalef’s species richness indicated a higher value ($d = 8.97$), and this minimizes the effect of sample size bias (Odum 1971). Species richness as a measure on its own takes no account of the number of individuals of each species present. It gives as much weight to those species that have very few individuals as compared to those that have many individuals (Magurran 2004). Fisher’s alpha diversity ($\alpha = 41.73$) is also significantly high. This may reflect comparatively less stress in their environment.

The feeding guild analysis represents 31% of orb-web weavers and stalkers. This may be due to flourishing vegetation layers during monsoon, including trees, shrubs, grasses and herbs landscapes that provide a healthy environment and shelters to other faunal invertebrate and vertebrate organisms; vegetation stratifications reveal ideal substrate for orb-web weaver spiders such as araneids and uloborids. The web-spinning activities are usually influenced by physiological factors, i.e., temperatures, humidity and rainfall (Barghusen et al. 1997). Stalkers, including salticids and oxyopids, feed on similar prey. Web-weavers are almost strictly insectivorous, while stalkers and wandering spiders exhibit a mixed strategy of insectivorous and araneophagic foraging patterns (Nyffeler 1999). The presence of diverse spider species (Table 1) indicates healthy surroundings, availability of food resources, habitat structures, prey occurrence and feeding activities during the study period at Saurashtra University Campus.

REFERENCES


Images 1 to 17 represent spiders of SUC.
1—Argiope anasuja ♀ dorsal | 2—Same, ventral | 3—Argiope sp.2 | 4—Eriovixia excelsa ♀ reddish brown dorsal | 5—Eriovixia excelsa ♀ yellowish white dorsal | 6—Eriovixia excelsa ♀ ventral | 7—Guizygiella sp. | 8—Neoscona theisi ♀ dorsal | 9—Same, ventral | 10—Poltys sp. ♀ | 11—Clubiona sp. ♀ | 12—Casteineria sp. ♀ | 13—Elica tikaderi ♀ | 14—Hersilia savignyi ♀ dorsal dark brown | 15—Hersilia savignyi ♀ dorsal white brown | 16—Evippa shivajii ♀ dorsal and external epigyne in the inset | 17—Hippasa sp. ♀. © Jyoti Dave & Varsha Trivedi.
Images 18 to 33 represent spiders of SUC.
18—Wadicosia fidelis ♀ dorsal | 19—Same, ventral | 20—Wadicosia fidelis ♂ dorsal | 21—Same, ventral | 22—Oxyopus bhartee ♀ with eggs | 23—Oxyopus hindustanicus ♀ with eggs | 24—Aretema atlanta ♀ with eggs | 25—Crossopriza lyoni ♀ | 26—Pholcus phalangioides ♀ lateral | 27—Pholcus phalangioides ♂ ventral | 28—Perenethis sp. | 29—Hasarius sp. ♀ | 30—Hasarius sp. ♂ | 31—Hyllus semicupreus ♀ dorsal | 32—Hyllus semicupreus ♂ dorsal | 33—Langona sp. ♂.
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Images 34 to 49 represent spiders of SUC.
Images 50 to 64 represent spiders of SUC.

50—Monaeses sp. ♂ dorsal | 51—Same, ventral | 52—Same, carapace | 53—Same, caudal abdomen dorsal | 54—Same, ventral palp | 55—Thomisus sp. ♀ dorsal | 56—Same, ventral | 57—Tmarus kotigehrus ♀ dorsal | 58—Same, ventral | 59—Same, external epigyne | 60— Miagrammopes sp. ♀ dorsal | 61—Same, ventral | 62—Same, carapace | 63—Same, calamistrum on 4th leg | 64—Uloborus sp. ♀ with egg mass.

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