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WEB CONSTRUCTION PATTERNS OF TWO ORB-WEAVING SPIDERS IN AGRO-ECOSYSTEM

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ABSTRACT

Web-building orb-weaving spiders are key generalist predators that regulate insect populations and adapt their behaviours to environmental conditions. This study investigates the web-building behaviour, architecture, and ecological role of Eriovixia excelsa in citrus plantations of Morshi and Zygiella indica in coffee plantations of Chikhaldara, Maharashtra, India. Web characteristics, including radii, sticky spirals, mesh width, hub asymmetry, capture area, and prey composition, were recorded directly in the field. E. excelsa constructed new webs daily in shaded areas between trees, with webs averaging 135–153 cm above ground and a construction time of 34.28 ± 0.25 min. Webs were symmetric (hub asymmetry index 0.10 ± 0.003), with an average mesh width of 2.48 ± 0.05 mm and capture area of 284.08 ± 6.25 cm². Z. indica repaired and reconstructed webs sequentially, including hub and spiral restoration, with total construction time of 41.58 ± 0.41 min and hub reconstruction taking 28.91 ± 1.26 min. Webs were 130–142 cm above ground, slightly asymmetric (hub asymmetry 0.34 ± 0.009), with mesh width 2.34 ± 0.03 mm and capture area 339.43 ± 9.3 cm². Prey captured by both species was dominated by Diptera, followed by Homoptera, Hymenoptera, and Coleoptera. Comparative analysis shows that E. excelsa favors routine hub-centered web construction, while Z. indica emphasizes repair and sequential assembly. These findings highlight the adaptive significance of web architecture and behavioral strategies.

KEYWORDS: *Orb-Weaving Spiders, Web Architecture, Prey Capture, Eriovixia Excelsa, Zygiella Indica, Behavioral Ecology.*

INTRODUCTION

Web-building spiders provide excellent models for studying behaviour in ecological contexts. Their webs not only facilitate prey capture but also influence various traits of spiders, including defence, reproduction, and habitat utilization. By regulating insect populations, spiders strongly affect ecosystem dynamics and serve as natural controllers of potential pests (Blackledge & Wenzel, 2001; Blackledge et al., 2003). Spider webs, while often regarded primarily as tools for foraging, are better conceptualized as structural modifications of the immediate environment that allow spiders to interact with both prey and predators.

Orb-weaving spiders, in particular, exhibit remarkable flexibility in web design. They can modify web architecture, including size, shape, and mesh density, in response to environmental cues, prey availability, and predation pressure (Edmunds & Edmunds, 1986; Higgins, 1990; Heiling & Herberstein, 2000). Web construction in orb-weavers follows three distinct phases: the creation of the frame and radii, weaving of an auxiliary spiral, and formation of the sticky or capture spiral (Foelix, 2011). Variation in web structure directly influences prey type, number, and capture efficiency (Miyashita & Shinkai, 1995). Studies on *Zygiella x-notata* have shown that the presence of potential prey affects web-building behaviour, with observable modifications in structure and placement (Pasquet et al., 1994; Toscan et al., 2012).

This study focuses on the orb-weaving spider *Zygella indica* Tikader & Bal, 1980, a species characterized by a diagnostic spiral-free sector in the upper part of its orb web (Levi, 1974). *Zygiella indica* is commonly found in the coffee-growing region of Chikhaldara, Maharashtra, India. Investigating the web biology and ecological role of this species can provide insights into the behavioural adaptations that optimize prey capture and survival. Similarly, studies on *Eriovixia excelsa* (Simon, 1906), a common orb-weaving spider in the citrus plantations of Morshi, Maharashtra, contribute to understanding species-specific web construction strategies in different agro-ecosystems.

Spiders belong to the order Araneae, a diverse group within the class Arachnida. With over 50,000 described species globally, they occupy nearly all terrestrial habitats, including tropical forests, deserts, caves, and human dwellings. They are distinguished by two main body segments—the cephalothorax and abdomen—eight legs, and chelicerae equipped with venomous fangs. As generalist predators, spiders play a vital ecological role by regulating insect populations and maintaining ecosystem balance (Blackledge & Gillespie, 2004).

A hallmark of spiders is their ability to produce silk from specialized spinneret glands, which they use to construct webs, retreats, egg sacs, and dispersal threads. Webs are multifunctional: they enable prey capture, reduce energy expenditure compared to active hunting, provide protection against predators, and serve as a medium of communication through vibrations transmitted along silk threads. Orb webs, in particular, exemplify an adaptive strategy, with variations in size, shape, and placement optimizing prey interception while minimizing exposure to threats (Wise, 1993; Sebastian & Peter, 2009).

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Modern studies integrate biomechanics, materials science, and molecular biology to explain silk's exceptional strength, elasticity, and adhesion. Humidity and environmental factors modulate the adhesive properties of capture threads, enhancing prey capture efficiency (Opell & Stellwagen, 2019). Evolutionary analyses suggest that orb-web architectures have undergone multiple gains and losses, reflecting the interplay of silk genetics, spinning behaviours, and ecological pressures (Bond et al., 2014).

Taken together, the study of spider web construction provides a unique window into behavioural ecology, material science, and evolutionary biology. By examining species such as *Zygiella indica* and *Eriovixia excelsa*, researchers can better understand how spiders adapt their webs to maximize prey capture, minimize predation risk, and respond to environmental variation.

MATERIALS AND METHODS

Study Area

The present study was carried out on *Eriovixia excelsa* and *Zygiella indica* in two distinct agricultural regions of Amravati district, Maharashtra, India. The research on *Eriovixia excelsa* was conducted in citrus orchards of Morshi Tahsil (21.3392° N, 78.0131° E), an area well-known for orange cultivation. Daily temperatures in the citrus fields ranged from 28 ± 4 °C at night to 35 ± 4 °C during the day. In contrast, the study on *Zygiella indica* was carried out in coffee plantations at Chikhaldara, situated in the Satpura hill ranges at an altitude of 1118 m (21°20′–21°21′ N, 77°0′–77°22′ E), a prominent coffee-growing region of Maharashtra, with daily temperatures ranging from 18 ± 4 °C at night to 27 ± 4 °C during the day.

Characteristics of the Web

Web characteristics of both *Zygiella indica* and *Eriovixia excelsa* were measured directly in the field. Observations were carried out in the evening. Only webs of adult specimens were considered for the study. Prior to recording measurements, each web was sprayed with corn-starch using a sprayer to enhance visibility, and the web dimensions were measured.

Field Parameters

Web characteristics were identified based on araneoid web literature (Blackledge and Gillespie, 2002; Kuntner et al., 2008a, 2008b; Gregoric et al., 2010). The parameters measured from the collected spiders included primary radii, number of vertical sticky spirals, number of horizontal sticky spirals, non-circulating sticky spirals above and below the hub, web width (cm), and web height (cm). Body length (mm) of the spiders was also recorded in the field. The time required for completing the web was noted, and the height of the web from the ground was measured from the ground to the first vertical non-circulating sticky spiral below the hub. Prey items captured in the webs were collected and identified up to the order level.

RESULTS AND DISCUSSION

Orb-weaving spiders are generally considered generalist sit-and-wait predators (Foelix, 1996; Foelix, 2011). In our study, we documented the web-building behavior and ecology of Eriovixia excelsa in citrus plantations of Morshi and *Zygiella indica* in coffee plantations of Chikhaldara.

Web Construction and Behavior

Eriovixia excelsa was observed resting on the hub during evening hours and was active primarily at night, building a new web each day in shaded areas of the plantation. Webs were typically placed in openings between trees. Web construction took 34.28 ± 0.25 min on average, and the webs were positioned 135–153 cm above ground. Some webs showed signs of damage and subsequent repair. When disturbed, spiders either ran away from the hub or jumped off the web. Prey capture behavior was immediate, with spiders biting and wrapping prey such as Diptera, Homoptera, Hymenoptera, and Coleoptera. The capture behavior aligns with observations by Eberhard (1982), who noted that attack followed by wrapping is an evolutionarily advanced predatory strategy.

For *Zygiella indica*, web also monitoring at evening. Unlike *E. excelsa* , *Z. indica* was often absent from the hub at first, returning to clean debris and repair damaged silk threads before constructing the web. Web construction followed a consistent sequence: first repairing old radii, then constructing new vertical radii, followed by spirals, non-circulating sticky spirals below and above the hub, and finally the vertical and horizontal sticky spirals in anticlockwise order. The total time for repairing and constructing the web was 41.58 ± 0.41 min, with hub reconstruction taking 28.91 ± 1.26 min.

Both species displayed vertical webs with slightly displaced hubs toward the top frame, consistent with observations in other araneids and Nephilids (Masters and Moffat, 1983; Kuntner et al., 2008). Females typically rested on the hub at night, while during the day they remained in retreats connected to the hub via signal lines, a behavior similar to other *Zygiella* and related genera (Gregoric et al., 2010).

Web Architecture and Prey Capture

The webs of *E. excelsa* were generally symmetric, with hub and web asymmetry indices of 0.10 ± 0.003 and 0.14 ± 0.003, respectively. The average mesh width was 2.48 ± 0.05 mm, and the capture area was 284.08 ± 6.25 cm^2. Prey captured were dominated by Diptera, followed by Homoptera, Hymenoptera, and Coleoptera. Variation in mesh width may influence prey size and retention, enabling spiders to optimize prey capture based on energetic needs (Blackledge and Zevenbergen, 2006).

For *Z. indica,* webs showed slightly higher asymmetry (0.34 ± 0.009), while the average mesh width was 2.34 ± 0.03 mm, and the web area was 339.43 ± 9.3 cm^2. Prey captured were primarily Diptera, followed by Homoptera, Coleoptera, and Hymenoptera. The web design and mesh size likely influence prey interception, consistent with findings from Herberstein and Elgar (1994) and Pavol and Grygláková (2005), indicating that larger web areas can increase prey capture efficiency.

Prey Handling and Feeding

Both spiders exhibited immediate prey handling behaviours. *E. excelsa* attacked prey upon contact and wrapped it in silk, demonstrating an efficient feeding strategy. *Z. indica* similarly captured and wrapped small flying insects, including moths, confirming that orb-web design and construction sequence are crucial for foraging success. These behaviours support earlier findings that prey capture and handling are strongly influenced by web architecture (Eberhard, 1967; Murakami, 1983).

Influence of Environmental Factors

Web placement and construction for both species appeared influenced by temperature, humidity, light, and microhabitat features. *E. excelsa* built webs in shaded areas of citrus plantations, while *Z. indica* constructed webs in coffee plantations between plants. Prey availability also affected web construction and repair behavior, as observed in previous studies on *Zygiella x-notata* (Pasquet et al., 1994).

Comparative Observations

While both species are orb-weaving generalist predators, differences were noted in their web-building strategies. *E. excelsa* consistently builds new webs daily at the same location and remains on the hub during construction, whereas *Z. indica* actively repairs damaged webs and constructs webs in a sequential, structured manner. The slightly larger capture area and mesh size of *Z. indica* webs may allow targeting of a broader prey spectrum. Hub and web asymmetry indices suggest that E. excelsa webs are more symmetric, whereas *Z. indica* shows slight upward hub displacement.

CONCLUSION

The present study highlights the behavioral ecology and web-building strategies of two orb-weaving spiders, *Eriovixia excelsa* and *Zygiella indica*, in their respective habitats. Both species are generalist sit-and-wait predators, relying on webs for prey capture, energy conservation, and protection. *E. excelsa* constructs new webs daily in shaded citrus plantations, exhibiting symmetric webs with moderate mesh width and a capture area suited for a variety of insect prey. In contrast, *Z. indica* in coffee plantations actively repairs and reconstructs webs following a structured sequence, with slightly larger capture areas and moderate asymmetry, allowing effective interception of diverse prey.

Web architecture, including mesh width, hub position, and overall asymmetry, strongly influences prey capture efficiency and handling behaviour in both species. Comparative observations reveal that while both spiders share common orb-weaving traits, they differ in web-building strategies: *E. excelsa* favours routine hub-centred construction, whereas *Z. indica* emphasizes repair and sequential web assembly.

Overall, these findings underscore the adaptive significance of web design and construction in orb-weaving spiders and demonstrate how behavioural strategies are shaped by ecological and environmental conditions, ultimately influencing foraging success and survival.

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