Research Notes

Morphometric and spatial analysis of web-building behaviour in two spider taxa

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Abstract

Web architecture in orb-weaving spiders reflects a complex interaction between behavioural, environmental, and evolutionary factors. This study investigates the morphometric and spatial variation in web-building behaviour of two sympatric orb-weaving spiders, *Argiope pulchella* and *Eriovixia laglaizei*, inhabiting the cultivated landscapes of Bhoothakulam Grama Panchayath, Kollam District, Kerala, India. Newly built orb webs were systematically sampled using quadrat-based field surveys during a 16-month period from September 2020 to January 2022. Morphometric parameters, such as web diameter, height from the ground, angle, and number of radiating lines, were measured and analysed. Results revealed distinct differences in morphometric and spatial distribution within each species and between the two species. The contrasting architecture and behavioural plasticity reflect adaptive responses to ecological factors such as prey availability, environmental conditions, and predation risk. These findings highlight how subtle variations in web geometry serve as behavioural and ecological strategies enabling coexistence and resource partitioning among sympatric orb-weaving spiders.

Keywords: Argiope, behavioural ecology, Eriovixia, intraspecific variation, orb-weaving spiders, stabilimentum, web architecture.

Introduction

Spiders are an interesting group of primitive animals that are cosmopolitan in distribution, except in polar regions and the ocean.[1] *Argyroneta aquatica* is the only known spider species that spends its entire life underwater.[2] The majority of spider species construct webs as part of their natural behaviour. It is estimated that the total global spider population has the capacity to consume 400 to 800 million tons of insect prey annually.[3] There are five basic types of spider webs, *viz*., the cob or tangle web, sheet web, wobbly web, funnel web, and orb web; each is unique to a distinct species of spider. Spiders generally produce two different types of silk, dragline silk and capture silk. [4] The former forms the radial threads from the outer edges of the web to the centre, while the latter absorbs the momentum when prey collides with the web. Orb-weaving spiders demonstrate remarkable stereotyped behaviour in web construction, which typically proceeds through three sequential phases: establishing the frame and radii, weaving the auxiliary spiral, and finally constructing the sticky capture spiral.[4] During the capture-spiral, the spider's legs regulate spacing between turns, ensuring the regularity that characterises orb-web architecture.[5,6]

Despite this regularity, orb webs also show considerable variation between and within individuals. Factors such as humidity, temperature, and availability of attachment sites, as well as intrinsic traits like body size and energetic condition, can influence web size and structure.[7–10] A distinctive feature in some species, particularly those of the genus *Argiope*, is the stabilimentum, a conspicuous silk band woven into the web's centre. Its proposed functions include prey attraction, predator deterrence, and camouflage for the spider.[11] Another characteristic of some orb-weaving spiders is that they typically dismantle and rebuild their webs daily. This strategy not only conserves silk but also enables efficient relocation of foraging sites in response to shifting prey availability.[12] The balance between stereotyped construction rules and behavioural plasticity underscores the adaptability of orb-weaving spiders to both intrinsic and environmental pressures. The present study investigates the intraspecific variation in web construction across two sympatric orb-weaving spider species.

Materials and Methods

Study Site

The study was conducted in Bhoothakulam Grama Panchayath (Figure 1), Kollam District, Kerala, from September 2020 to January 2022. The area is well connected to the nearby towns of Kollam, Paravoor, and Varkala. The presence of numerous canals and water bodies contributes to the high fertility of the soil, supporting the extensive cultivation of major crops, including paddy, coconut, and banana. Fruit-bearing trees, such as jackfruit and mango, are also common, along with tuber crops like cassava (also known as tapioca). For the present study, two types of sites were selected: household premises with diverse shrub and tree vegetation, and agricultural plots cultivating banana and coconut.

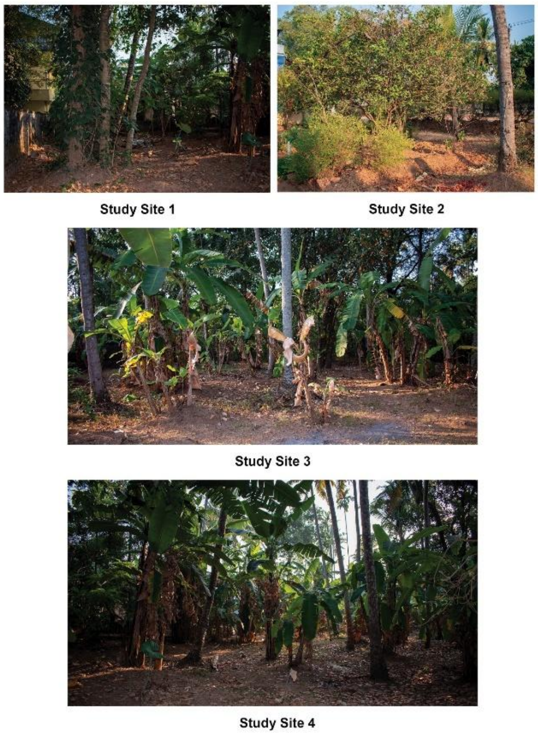

Figure 1: Sites where the study was conducted (sites 1 and 2 are household premises; sites 3 and 4 are agricultural plots)

Species selection

The orb webs of two spider species, namely *Argiope pulchella* and *Eriovixia laglaizei,* were selected for the present study. Each study site was surveyed for one hour in the morning and evening to locate orb webs.

Species identification

The two spider species, *Argiope pulchella* and *Eriovixia laglaizei,* were identified with the help of morphological keys and identification guides[13–15] and were further confirmed with the help of experts.

Sampling method

The quadrat method was followed for searching spider webs. For the study, quadrats measuring 5 × 5 m were identified to ensure uniform coverage and accurate representation of the habitat. Only fresh and undamaged webs were selected. A diagrammatic sketch of each web was drawn on drawing paper, and photographs were taken using a Nikon D5600 digital SLR camera.

Measurement of web parameters

The angle of each web from the ground was measured using a protractor. Height and diameter of the webs were measured using a measuring tape. The radiating lines of each web were manually counted from the ground, as well as with the aid of photographs.

Observations and Results

Orb webs of several species were observed during the study. However, only two species, *Argiope pulchella* (Figures 2A-F) and *Eriovixia laglaizei* (Figures 3A-F), were selected for detailed studies. A total of 60 webs of *Argiope pulchella* and 65 webs of *Eriovixia laglaizei* were recorded, of which 50 webs from each species were considered for comparative analysis and detailed observations. Pencil drawings illustrating the web pattern and typical web structure of the *Eriovixia laglaizei* are presented in Figures 4 and 5.

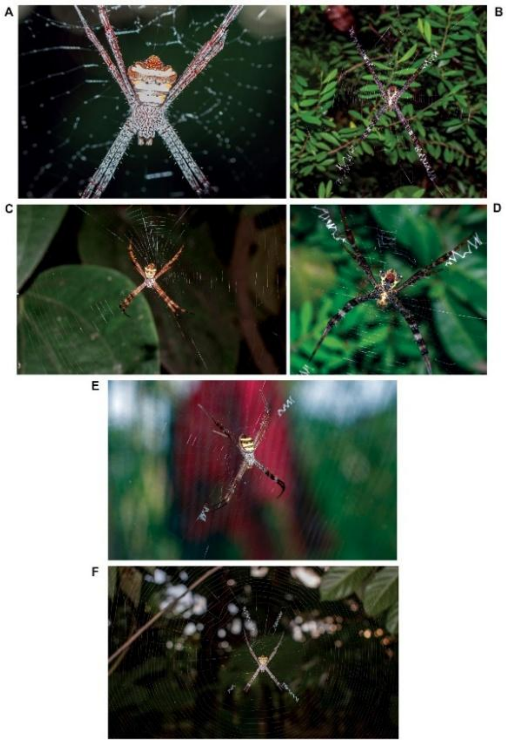

Figure 2A-F: Images of *Argiope pulchella* from different locations with and without a stabilimentum in the web

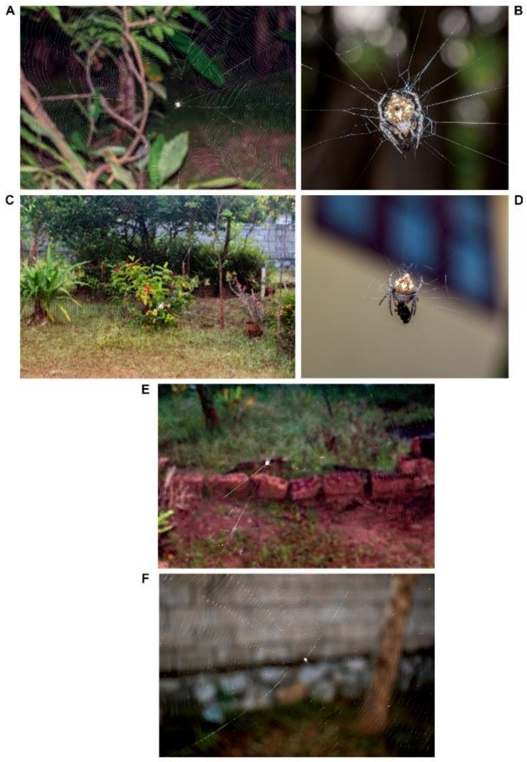

Figure 3A-F: Images of *Eriovixia laglaizei* from different locations

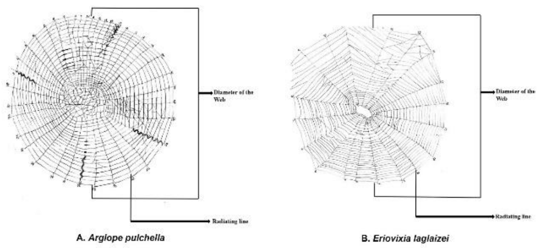

Figure 4A-B: Pencil drawings representing the web characteristics of the web of *Argiope pulchella* and *Eriovixia laglaizei*

Figure 5: A typical web pattern of *Eriovixia laglaizei* showing the important structural characteristics

Table 1: Quantitative analysis of web architecture in *Argiope pulchella*

No.	Radiating Lines	Diameter of the orb (cm)	Height from the ground (cm)	Angle (˚)
1	38	30	126	80
2	32	26	100	80
3	34	30	120	80
4	36	29	118	82
5	31	24	125	80
6	36	30	120	80
7	32	28	114	80
8	44	50	145	80
9	28	20	200	82
10	53	24	125	80
11	50	30	130	80
12	54	35	130	80
13	32	44	140	75
14	28	30	120	80
15	34	25	200	75
16	52	30	150	82
17	30	31	100	80
18	42	22	200	75
19	50	20	190	75
20	34	30	145	82
21	36	42	130	80
22	52	50	160	80
23	29	30	135	75
24	36	24	200	82
25	42	25	170	80
26	36	32	100	75
27	34	30	115	80
28	28	43	134	78
29	50	50	126	80
30	51	30	200	81
31	34	32	200	80
32	32	30	140	82
33	31	20	135	75
34	36	24	180	75
35	45	26	175	80
36	46	30	160	82
37	34	50	140	75
38	36	20	120	80
39	36	30	130	80
40	40	46	170	82
41	52	42	200	75
42	50	30	140	75
43	36	29	100	80
44	34	30	150	82
45	28	30	132	82
46	34	28	129	80
47	36	46	156	82
48	34	50	176	75
49	30	30	182	76
50	49	20	198	80

The orb webs of *Argiope pulchella* contained 28 to 54 radiating lines (Table 1). Among these, those with 36 radiating lines were the most frequently observed, representing 20% of all samples (Figure 6A). The web diameter ranged from 20 to 50 cm, with an average size of approximately 30 cm, accounting for 34% of the recorded measurements (Table 1 and Figure 6B). The webs were observed in both shaded areas and areas with adequate sunlight. A zig-zag decoration, known as a stabilimentum, characteristic of *Argiope pulchella*, was observed a few days after the web was constructed. The webs were typically located 100–200 cm above the ground (Table 1 and Figure 6C), although the height varied depending on the site's topography. The webs were oriented at an angle of 75° to 82° (Table 1 and Figure 6D). *Argiope pulchella* exhibited both diurnal and nocturnal activity, maintaining its web structure despite minor environmental or other disturbances.

The webs of *Eriovixia laglaizei* had 17 to 26 radiating lines (Table 2), with 20 lines being the most common in 26% of the samples (Figure 7A). The web diameter ranged from 32 cm to 116 cm, with an average web size of 34 cm, comprising 30% (Table 2 and Figure 7B).

The webs were commonly observed during the early morning hours, when the environment was slightly cold and humid. These were observed at heights ranging from 88 cm to 210 cm above the ground (Table 2 and Figure 7C) and placed at an angle of 87° to 90° (Table 2 and Figure 7D). *Eriovixia laglaizei* constructed its webs in the late evening after sunset, and removed them after sunrise, probably as a response to the increase in atmospheric temperature, subsequently moving to concealed resting sites. *Eriovixia laglaizei* would rapidly remove its web and relocate to safer locations when disturbed.

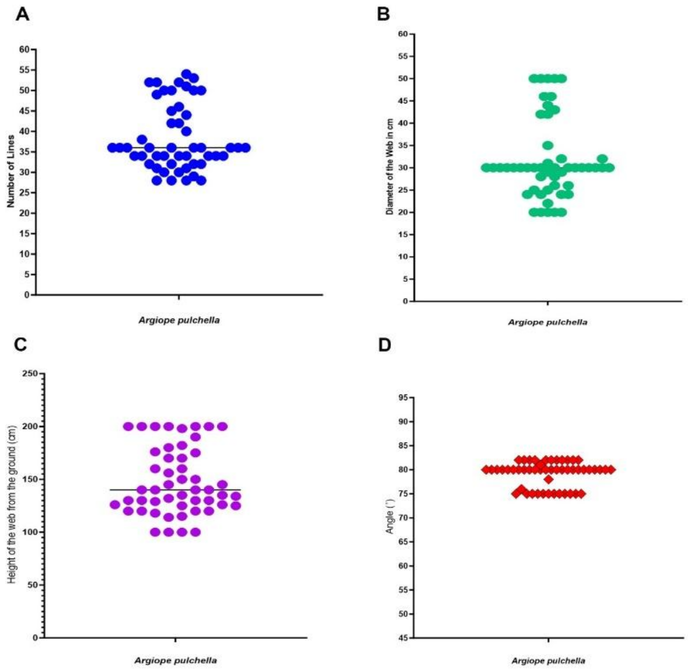

Figure 6A-D: Quantitative analysis of web architecture in *Argiope pulchella*

Table 2: Quantitative analysis of web architecture in *Eriovixia laglaizei*

No.	Radiating Lines	Diameter of the orb (cm)	Height from the ground (cm)	Angle (°)
1	19	32	147	90
2	22	36	152	90
3	21	34	154	90
4	20	32	149	90
5	23	34	156	90
6	23	34	155	90
7	19	35	150	90
8	24	116	88	90
9	25	115	210	90
10	20	100	110	90
11	26	50	150	90
12	19	92	155	90
13	20	44	145	90
14	17	90	130	90
15	22	68	156	90
16	24	70	143	90
17	19	33	156	90
18	17	34	142	88
19	26	32	94	90
20	20	115	89	87
21	20	34	90	90
22	25	40	100	90
23	18	85	118	90
24	19	34	200	90
25	23	39	119	90
26	20	114	183	88
27	19	34	200	90
28	20	32	88	90
29	17	34	210	90
30	25	114	187	90
31	26	115	157	90
32	20	34	163	90
33	20	36	194	90
34	17	32	89	90
35	18	34	96	90
36	20	116	163	90
37	24	114	119	90
38	19	34	137	89
39	20	34	156	90
40	25	34	201	90
41	24	32	210	90
42	17	116	153	90
43	19	114	182	90
44	20	112	193	88
45	19	34	175	90
46	17	32	89	90
47	20	36	192	90
48	26	34	200	90
49	24	116	89	90
50	25	36	88	90

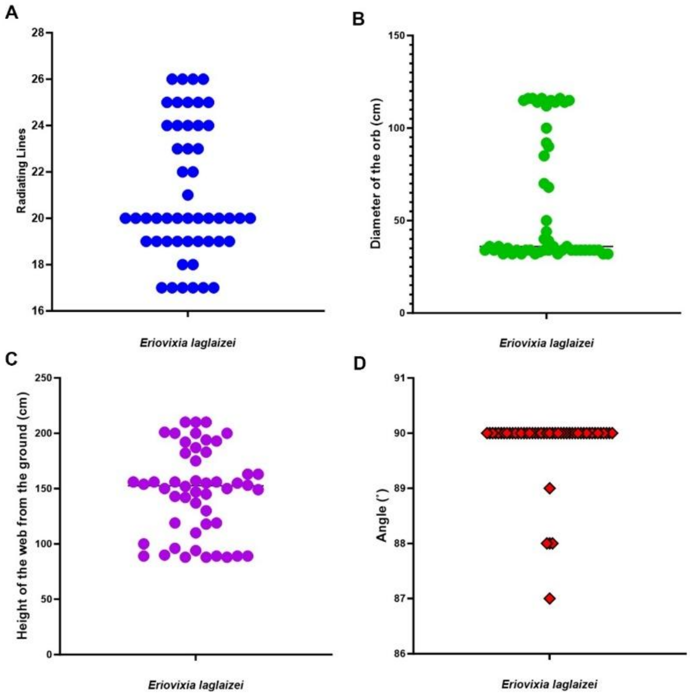

Figure 7A-D: Quantitative analysis of web architecture in *Eriovixia laglaizei*

Discussion

In the present study, vegetation-rich sites, including agricultural plots and household premises at Boothakulam (Kollam District) were surveyed for spider webs. The surveys were conducted during the early morning and evening hours. Although the orb webs of several spider species were recorded, only those of *Argiope pulchella* and *Eriovixia laglaizei* were selected for detailed study, as these two species are the most encountered and exhibit distinct contrasting web architectures. The two species also differ in body size and prey capture strategies. *Argiope pulchella* constructs large, strong, vertical orb webs with prominent stabilimenta (zigzag silk decorations), which are believed to aid in attracting prey and avoiding predators.[16] *Eriovixia laglaizei*, on the other hand, builds relatively smaller orb webs, usually without stabilimenta, and rests near the hub. These spiders are well camouflaged, often resembling dried leaves.[17] Such contrasting features make them ideal subjects for studying adaptive variations in web architecture.

Although 60 webs of *Argiope pulchella* and 65 webs of *Eriovixia laglaizei* were recorded during the surveys, only 50 webs of each species were examined in detail. Some *Argiope pulchella* webs were constructed at considerable heights, making detailed observation and photography difficult; such webs were therefore excluded from analysis. In the case of *Eriovixia laglaizei*, webs located at inaccessible sites or at great heights were not selected for study. Moreover, this species is highly sensitive to environmental disturbances, and any interference often results in the spider removing its own web. To avoid causing harm or disturbance to the spiders or their webs, such specimens were left unstudied. Analysis of the collected data revealed intraspecific variations in web characteristics of both species. Parameters such as the number of radiating lines, web size, orientation angle, and height from the ground showed slight variations among individuals within each species.

Eriovixia laglaizei were smaller in size than *Argiope pulchella*, yet they construct comparatively larger webs. Previous studies have explained that hungry spiders tend to construct larger webs to capture bigger prey, and that the web size is not necessarily correlated with the size of the spider.[18] *Eriovixia laglaizei* was usually found resting somewhere in the middle part or hub of the web during the early morning hours. The spider removes its web at dawn and constructs a new one at night, a routine that is repeated almost every day. This behaviour likely serves to avoid predators and unfavourable environmental conditions, such as high temperature and humidity, as well as disturbances from other animals and human activities.

Eriovixia laglaizei removes its web when disturbed and relocates to a safer place. During web construction, it releases fine silk threads from its spinnerets, which may drift on air currents until these are attached to a suitable anchor point, forming the foundation for the orb web. The completed web consists of radial spokes and sticky spiral threads coated with glue droplets, creating an efficient trap that utilises minimal silk while offering a large capture area. However, these webs are brittle, weaken quickly, and are often rebuilt daily. Before rebuilding, the spider consumes its old web to recycle valuable silk proteins, which are energetically expensive to synthesise.[19,20] This recycling process helps conserve energy and eases relocation when prey availability decreases.[21] In contrast, *Argiope pulchella* maintains its webs throughout the day and is less affected by minor disturbances.

The spiders construct their webs in an orderly manner, and species-specific manner, with only slight variations observed among individuals of the same species. Webs of *Eriovixia laglaizei* are typically positioned at greater heights compared to those of *Argiope pulchella*, which are generally found closer to the ground. *Eriovixia laglaizei* constructs its webs both in open areas and confined spaces, whereas *Argiope pulchella* predominantly prefers confined habitats. Webs of *Eriovixia laglaizei* are oriented at an angle of 87-90^0, while those of *Argiope pulchella* are inclined at a 75–82^0. The height and inclination of the webs may change depending on the topography of the place and the abundance of prey. Spiders face a major challenge in their web–building behaviour: how to maximise prey capture while minimizing energetic expenditure.[22] Web construction is inherently expensive, requiring significant metabolic input for silk production, considerable time, and exposure to predation risk.[17-24] Web damage can impose substantial fitness costs due to reduced prey capture and the additional energy required for repairing the web.[21,25,26] Web damage may result from a variety of factors, including the impact of prey, collisions with larger non–prey animals, wind, rain, and falling debris.[17,19,22] To avoid potential risks, spiders construct their webs at varying heights and orientations. *Argiope pulchella* and *Eriovixia laglaizei* exhibit distinct differences in the height and orientation of their webs, both intraspecifically and interspecifically.

Argiope pulchella belongs to the family Araneidae, and it is a downward-facing spider known to build the classical vertical orb webs. Araneids are generally known as "sit and wait" foragers owing to their specialised hunting strategy in which they remain at the central portion of the web, known as a hub, from where they usually attack their prey.[27] The web of *Argiope* *pulchella* is a complex structure, and its construction involves several steps. Prior to constructing its web, the spider explores the available substrate. After weaving the primary rays and the framework, a draft hub is created, marking the convergence of the primary rays. It then constructs the secondary rays to complete the frame, followed by the tertiary rays. Starting from the hub, the spider constructs a provisional spiral comprising dry (non-sticky) threads, extending outwards with progressively increasing spacing. Finally, it returns from the periphery towards the hub, weaving a sticky spiral thread which is neither regular nor tight. The spider thus produces a web of intricate architecture.[28,29]

Compared to *Argiope pulchella*, *Eriovixia laglaizei* builds larger webs but with fewer radiating lines. It is noteworthy that as the number of radiating lines increases, the size of the cells in the web decreases, potentially leading to an increase in the web's strength. The webs constructed by *Eriovixia laglaizei* are therefore weaker than those of *Argiope pulchella*. It was observed that *Eriovixia laglaizei* swiftly removed its webs in response to environmental disturbances or human activity. As mentioned earlier, the structural strength of the web increases with the number of radiating arms, which could make rapid removal of the web somewhat difficult. This may explain the comparatively fewer radiating lines observed in the webs of *Eriovixia laglaizei*.[30,31]

In comparison, the webs of *Argiope pulchella* were more stable and structurally stronger. Consequently, they possessed a greater number of radiating arms. Additionally, to reinforce the web and deter predators, a decorative structure known as stabilimenta was added to its webs. Such structures were absent in the webs of *Eriovixia laglaizei*. In summary, *Argiope pulchella* constructed robust, well-organised orb webs characterised by dense radiating lines and a prominent stabilimentum, which enhanced both stability and visibility. Conversely, *Eriovixia laglaizei* constructed larger but more fragile webs with fewer radii and lacking a stabilimentum, reflecting a comparatively weaker structural design.

Eriovixia laglaizei are better prey catchers than *Argiope pulchella*, as it is often observed with prey entangled in its web during the morning hours. The various designs and structural features of spider silk webs have a significant influence on spider behaviour. Webs not only enable spiders to capture prey, but also provide them with an extensive perceptual field. The spider can detect objects that touch the web, pass nearby, or become trapped. Due to its high sensitivity, the spider can detect everything from rain and wind to a falling leaf or large prey. Webs are thus a true extension of the spider's sensory organs, providing enhanced control over its surroundings.[32] The arrival of prey is signalled to the spider through the transmission of vibrations across the silk network, both upon impact and during the subsequent struggle of the trapped prey.[19]

The webs of *Argiope pulchella* contain decorations called stabilimentum, which are absent in the webs of *Eriovixia laglaizei*. These decorations, formed a few days after the completion of the web, are made of silk, rich in protein, indicating a high metabolic investment by the spider. Although their exact function remains debated, several hypotheses suggest that stabilimenta serve multiple purposes, such as attracting prey, providing camouflage, functioning as a moulting platform, enhancing web stability, attracting mates, or warning potential predators.[11,33] Some studies have reported that webs decorated with stabilimenta capture or intercept more flying insects than undecorated ones.[34]

In *Argiope pulchella*, the stabilimentum typically appears as wide zigzag or discoid white silk bands near the hub of the web.[35] It may protect the spider from predators and facilitate prey capture by making the spider appear larger or concealing its exact position.[36] Studies indicate that well-fed spiders construct larger stabilimenta, while poorly fed ones produce smaller stabilimenta or none at all. Although the presence of stabilimenta can reduce prey capture rates by about 30%, it significantly decreases web destruction by birds (70% in undecorated webs versus 30% in decorated ones).[37] According to some studies, decorated webs capture more prey per unit area,[38], possibly by causing reflection of ultraviolet light. Despite these findings, the precise function of stabilimentum remains controversial.[39].

From the present comparative study, it appears that even within a species, spiders exhibit flexibility in their web-building behaviour to optimise prey capture under varying environmental conditions. Such behavioural plasticity may be crucial for their persistence in human-modified landscapes, where habitat structure and prey availability fluctuate considerably. As this is a pilot study, further research involving a larger number of species is required to validate and substantiate these preliminary findings.

Conclusion

The present study demonstrates that *Argiope pulchella* and *Eriovixia laglaizei* differ markedly in their web architecture, strength, and functional efficiency. *Argiope pulchella* builds compact, stable orb webs with stabilimenta that enhance visibility and prey capture, while *Eriovixia laglaizei* constructs larger but structurally weaker webs without such decorations. These variations directly influence each species' hunting strategy, prey detection ability, and response to environmental factors. Overall, the comparative analysis highlights how differences in web design contribute to the ecological roles and adaptive behaviours of these two orb-weaving spiders.

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Conflicts of interest:
There are no conflicts of interest

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