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Construction and use of orb webs by jumping spiders (Araneae: Salticidae: Plexippina: *Vailimia* sp. indet.) in southwest India

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Abstract. A jumping spider (*Valimia* sp. indet.) from southwestern India constructs planar orb webs that serve as nocturnal retreats. These webs are not inhabited during the daytime. Their construction, involving the attachment of silk lines radiating from a hub or platform that is occupied by the spider at night, resembles the early stages of web construction by araneids, oxyopids and sparassids. Unlike most salticids these spiders moult while suspended from their dragline, as do araneids. Predation on brachyceran flies near the orb web is also documented.

Keywords. Araneidae, Goa, India, Karnataka, Kerala, moulting, Oxyopidae, Sparassidae, Telamonia dimidiata

Until recently the genus *Vailimia* Kammerer 2006 included only four little-known species from southeastern Asia, but recently two *Vailimia* species have been described from India (Table 1; Figure 1; Basumatary et al. 2020). Nicky Bay has posted photographs of male and female spiders from Singapore, including one inhabiting a web, that appear to represent a *Vailimia* species (as cf. *Anarrhotus* sp., Bay 2015). Atul Vartak has also posted photographs of a spider from the Kali Tiger Reserve in Karnataka that may also be a *Vailimia* (as *Anarrhotus* sp., Vartak 2019).

Table 1. Known species of *Vailimia* Kammerer 2006. This is a plexippine genus (Maddison 2015). The specific locality of the type species for this genus, *V. masinei*, is not known.

species	known sex	localities	other references
<i>Vailimia ajmerensis</i> Caleb & Jangid 2020 (in Basumatary, Caleb & Das 2020)	đ	Ajmer (26.50747°N, 74.68112°E), Rajasthan; Keoladeo National Park, Rajasthan	Kaur et al. 2014; Caleb 2019
<i>Vailimia bakoensis</i> Prószyński & Deeleman-Reinhold 2013	ď	Bako National Park, Sarawak, Malaysia	
<i>Vailimia jharbari</i> Basumatary, Caleb & Das 2020	♂♀(♀shown on orb web)	Jharbari Forest Range, Kokrajhar, Assam, India	
<i>Vailimia jianyuae</i> Prószyński & Deeleman-Reinhold 2013	ď	Bako National Park, Sarawak, Malaysia	Prószyński 2017
<i>Vailimia longitibia</i> Guo, Zhang & Zhu 2011	ď	Hainan Island, China	
<i>Vailimia masinei</i> (Peckham & Peckham 1907)	ď	Borneo	Prószyński 1984; Prószyński & Deeleman-Reinhold 2013



Figure 1. Known distribution of *Vailimia* species in south and southeast Asia. Populations observed in the present study are identified here as *Vailimia* sp. (7; see Figure 2 for detail).

The retreats or shelters constructed by salticid spiders are diverse, ranging from a simple layer of silk fibers on the underside of a leaf in *Asemonea* (Abhijith A. P. C. & Hill 2018) to the irregular cob webs of *Portia* (Jackson 1982; Ahmed et al. 2015), silk platforms suspended beneath or between leaves by *Hyllus* (Ahmed & Satam 2015) and *Telamonia* (Ahmed et al. 2019), and the more elaborate tubular shelters with multiple entrances of *Myrmarachne* (Hurni-Cranston & Hill 2018) and many marpissoid genera (Jackson 1979; Hill & Edwards 2013, fig. 33:4; Hill 2014, 2018).

Here we report the construction of an orb web as a nocturnal shelter by small plexippine salticids that we have identified as *Vailimia* sp. indet., in southwestern India (Figures 2-20). We have tentatively identified these as members of a single species, but they might represent more than one species. The orb-webs constructed by these spiders appear to be occupied primarily during the night. Both juveniles and adults have been observed in these orb-webs. During the day they may hunt from a nearby stem or other location not far from their orb-web.



Figure 2. Localities where salticids (*Vailimia* sp. indet.) have been observed in their orb webs. These sites (1-7) span a distance of about 900 km along the southwestern coast of India, in Goa, Karnataka and Kerala.



Figure 3. Adult male *Vailimia* sp. indet. Photographed at the Kaje vrukshalaya farm in Mangaluru, Karnataka by Abhijith A. P. C. Note the four long, erect setae across the top of the eye region.



Figure 4. Adult female *Vailimia* sp. indet. occupying the center of her orb web, at Sanoor, Dakshinakannada, Karnataka. **4,6**, Detail of (3,5) respectively. The dorsal carapace of this spider may have lost its setae (*rubbed*). Photographs by Mr. Jithesh Pai, used with permission.



Figure 5. Adult female *Vailimia* sp. indet. at Sanoor, Dakshinakannada, Karnataka. Note the presence of four setae acroos the rear of the eye region, as seen in the adult male (Figure 3). Photographs by Mr. Jithesh Pai, used with permission.



Figure 6. Adult female plexippine *Telamonia dimidiata* (Simon 1899) feeding on an immature *Vailimia* sp. indet. Photographed at the Kaje vrukshalaya farm in Mangaluru, Karnataka by Aniruddha Sharma S., used with permission.



Figure 7. *Vailimia* sp. indet. on stem near its web at Manimoole farm, Vittal, Dakshinakannada, Karnataka. **1,** Note the row of vertical setae across the top of the carapace. **5,** Detail of (4). This may be a penultimate female of the species shown in Figures 4-5. This spider, observed from 29 MAY to 7 JUN 2020, is also shown in Figures 8-11. Photographs by Sanath Ramesh.



Figure 8. *Vailimia* sp. indet. feeding on a captured brachyceran fly, on or near its web at Manimoole farm, Vittal, Dakshinakannada, Karnataka. **1-3**, Three views of feeding spider. After heavy rains this web was damaged and this spider moved on. **4**, Same spider in a different web, feeding on a different brachyceran fly. This spider occupied three different webs in succession, from 29 MAY to 7 JUN 2020. Photographs by Sanath Ramesh.

Although these *Vailimia* have been observed feeding on or near their webs (Figure 8), we have no evidence that the orb-web or silk lines laid down by these spiders contribute significantly to the capture of prey. The vibration of silk strands may alert a *Vailimia* to the presence of nearby prey (Figure 9), or to the movement of an approaching predator. The interaction of one *Vailimia* with a much larger scarab beetle (Figure 10) is of interest as it demonstrates that, in addition to recognition of dangerous predators (Figure 6) and suitable prey, these spiders also recognize that some categories of insect are harmless.



Figure 9. Selected sequential frames from a 30fps video of *Vailimia* sp. resting on a stem near its web at night. This spider jumped at an alate ant that became partly entangled in its web, then briefly bit it (3, arrow) before rejecting it and pushing it away. Photographed at Manimoole farm, Vittal, Dakshinakannada, Karnataka by Sanath Ramesh, 5 JUN 2020.



Figure 10 (continued on next page). Selected sequential frames from a 30fps video of *Vailimia* sp. resting on a stem near its web in the evening. **1-3**, The *Vailimia* turned to follow the movements of a black scarab beetle below its position. Photographed at Manimoole farm, Vittal, Dakshinakannada, Karnataka by Sanath Ramesh 5, JUN 2020.



Figure 10 (continued from previous page). Selected sequential frames from a 30fps video of *Vailimia* sp. resting on a stem near its web in the evening. **1-11**, The *Vailimia* turned to follow the movements the scarab beetle as it moved on the stem behind its position. **12-25**, As the scarab moved back down the stem, the Vailimia pushed it away several times with legs I (15, 17, arrows), they stayed away from it by moving down the stem.



Figure 11. *Vailimia* sp. indet. resting on a stem near its web at Manimoole farm, Vittal, Dakshinakannada, Karnataka. The spider occupied a down-stem position and did not attack the brachyceran fly shown here (upper right). **2,** Detail of inset from (1), showing contact of its claws with silk lines (radii) of its web (arrows). Photographs by Sanath Ramesh.

Each orb-web is comprised of a platform of silk laid down at the hub of a series of silk lines (radii) radiating from this hub in a largely vertical plane (Figures 12-19). At night these salticids rest on this platform. Construction of the hub and associated radii resembles the early stages of construction of an orb-web by an araneid spider (Vollrath 1986; Zschokke & Fritz 1995, 2000; Zschokke 1996), corresponding to the proto-hub and proto-radii of the araneid, with successive radii formed by walking along a detour from the hub to position and attach each radius in turn (Figure 19). There are limited ways to efficiently build a structure of this kind and the similarity of this salticid orb web, which appears to play little role if any in predation, to the orb web of araneid spiders may simply reflect convergence on a common geometric solution. Whereas an araneid may need to leave its web to find shelter from a predator, these salticids apparently benefit from the fact that they are more likely to be safe from nocturnal predators when suspended on these webs. Like araneids, they may also be able to detect the presence of nearby arthropods that might be dangerous, or that might serve as prey, through vibrations transmitted to the hub by the radii.



Figure 12. *Vailimia* sp. indet. resting on its vertical platform between dry grass stems (straw) at Putturu, Dakshina-kannada District, Karnataka. **2-3**, Detailed views of this spider resting at the hub. Initially this spider was facing down, but after it was disturbed it jumped away, still connected to the hub by its dragline. Photographed by Abhijith A. P. C.



Figure 13. *Vailimia* sp. indet.) resting on its vertical platform at Vittal, Karnataka. **2,** Enhanced contrast version of (1) revealing extent of the vertical platform at the hub and several associated radii. **3,** Detail from (1). Photograph by Sanath Ramesh.



Figure 14 (continued on next page). *Vailimia* sp. indet. resting on its vertical platform at night (1), and views of the empty platform on the next day (2-4), when the spider could not be found in the vicinity. A small packet that might represent the remains of insect can be seen near the spider, attached to the hub, but there was no sign that the web, not sticky or adhesive, played a role in prey capture. This spider jumped and moved to nearby branches when the web was disturbed. Photographed in Kasaragod, Kerala by Prasantha Krishna.



Figure 14 (continued from previous page). *Vailimia* sp. indet. resting on its vertical platform at night (1), and views of the empty platform on the next day (2-4), when the spider could not be found in the vicinity. **3-4,** Enhanced contrast images based on (2), showing details of the densely woven platform at the hub and associated radii.



Figure 15. *Vailimia* sp. indet. resting on their vertical platforms at night. **1-3**, Spider resting on its platform at night. **2**, Detailed view of this spider from (1). **3**, Enhanced contrast image based on (1), showing layout of the hub and radii. **4**, Detailed anterior view of salticid shown in Figure 4. Photographed in Kasaragod, Kerala by Prasantha Krishna.



Figure 16. *Vailimia* sp. indet. resting at the hub of its nocturnal retreat in Sirsi, Uttarakannada District, Karanataka. Radii constructed on a plant of about 1.3 m in height spanned about 10 cm. Silk comprising this retreat was not sticky. When disturbed the spider took a long jump to a nearby branch, but returned to the hub in about an hour. On the next morning this spider left the retreat, apparently to search for prey on the same plant (Figure 17:1-4), but as confirmed by a local boy it returned to the same retreat that night. **2, 8,** Enhanced contrast views of (1) and (7). Photographs by Abhijith A. P. C.



Figure 17. Empty retreat (1-2) and close-up views of the salticids (*Vailimia* sp. indet.) that occupied these retreats. **1-2**, Empty retreat on the morning after it was occupied by one of these spiders (Figure 13). **3-4**, Detail of the spider shown in Figure 13 at night after it was disturbed and jumped away from its retreat. Photographs (1-4) by Abhijith A. P. C. in Sirsi, Uttarakannada District, Karnataka. **5**, Detailed view of spider that appeared to be hunting away from its web during the daytime. Photographed in Kasaragod, Kerala by Prasantha Krishna.



Figure 18. Salticid (*Vailimia* sp. indet.) with retreat. **1-2**, Spider resting on its hub platform at night. **3**, Detail of (1). **4**, Empty hub on the next day. This retreat was constructed on a tree at a height of ~1.6-2 m above the ground and was only occupied at night. Photographed in Kasaragod, Kerala by Prasantha Krishna.



Figure 19 (continued on next page). Sequential positions (1-34) occupied by a salticid (*Vailimia* sp. indet.) as it constructed its retreat in Kasaragod, Kerala, taken from a 59.94 fps video record produced by Prasantha Krishna. At top selected frames from this sequence are composited to show movement from the end of one radius down to the hub (1-15), then movement down and to the stem from the hub with a trailing dragline (15-19), attachment of the dragline to anchor a new radius (22, arrow), followed by return to the hub while climbing beneath the new radius (25-28). 20-24, Individual frames showing trailing dragline as it was extended from the hub (20), hold on that dragline with the claws of leg RIV (21), first movement onto the attached (arrow) dragline (23), and the beginning of a rapid climb back to the hub (24).

139.77s

3 3.70s	4 63.86s	5 74.37s	6 74.81s
7 74.96s	8 75.48s	9 76.41s	10 76.84s
11 80.41s	12 82.02s	13 93.54s	14 95.96s
62			

Figure 19 (continued from previous page). 3-14, 31-34, Two sets of sequential frames showing how this spider turned around the hub of its orb-web to deposit the silk that comprised its resting platform (only visible in 32). Extension of the spinnerets can be seen in some of these frames (6, 8, 10, 12). This construction activity resembles the early stages of construction of an araneid orb-web (*proto-hub* and *proto-radii*).

150.57s

153.35s

155.44s

Since the retreat of a salticid is usually, but not always (Abhijith & Hill 2019, *Telamonia dimidiata*), used as a moulting sac it is noteworthy that this *Vailimia* moults while hanging on its dragline in the manner of many wandering and web spiders (Figures 20-22; Pascoe 1980; Uhl et al. 2015). This moulting process does not appear to differ substantially from the process observed by a salticid protected by a thick molting sac (Figure 21:1), but suspension allows the spider to use gravity to continue to lower itself on the dragline as it separates from the exuvium. Although moulting has been associated with mating in some orb-weavers (Araneidae; Figure 22), we presently have no information on the courtship and mating of *Vailimia*. We also do not know what this spider does to protect its brood, but like most wandering and web spiders they may still produce a protective sac for this purpose.



Figure 20. Observations of *Vailimia* sp. indet. in Goa. **1-2**, Two views of spider resting on its silk platform. **3**, Spider after it has separated itself from the exuvium by descending on its dragline. The exuvium maintained its hold on the dragline with legs IV. **4-5**, Closer views from (3). **6**, Detail showing this spider extending and inflating its legs while suspended. All observations and photographs by Aditya Naik, used with permission.



Figure 21. Moulting by wandering spiders. **1**, Female *Phidippus putnami* (Peckham & Peckham 1883) (Salticidae). The thick moulting sac was opened to observe this spider. **2**, cf. *Carrhotus* Thorell 1891 (Salticidae) with exuvium in thin moulting sac. **3-4**, Two different *Epeus* Peckham & Peckham 1886 (Salticidae) with exuviae, in thin moulting sacs under leaves. **5**, *Heteropoda* Latreille 1804 (Sparassidae) moulting from dragline. **6**, *Olios milleti* (Pocock 1901) (Sparassidae) moulting from dragline. **7**, *Hamadruas* Deeleman-Reinhold 2009 (Oxyopidae) with exuvium beneath leaf. **8-11**, Sequence showing *Oxyopes shweta* Tikader 1970 (Oxyopidae) molting from dragline. Photo (1) by David E. Hill (South Carolina). Photos (2-11) by Abhijith A. P. C. (Karnataka).



Figure 22. Moulting by orb-weaver spiders (Araneidae). **1**, Female *Nephila* Leach 1815 moulting from dragline. **2**, Detail of (1) showing smaller male in mating position. The genus *Nephila* is sometimes placed in the Nephilidae. **3-4**, *Neoscona* Simon 1864 moulting from dragline. **5-6**, *Parawixia* F. O. Pickard-Cambridge 1904 moulting from dragline. **7-8**, Male *Argiope bruennichi* (Scopoli 1772) waiting for a moulting female (7) and then mating with that female (8) as she was hanging beneath her exuvium before her cuticle darkened or hardened. The condition of a newly-moulted female may reduce the vulnerability of the male to her attack (Uhl et al. 2015). Photos 1-2 by Vipin Baliga (Karnataka). Photos 3-6 by Abhijith A. P. C. (Karnataka). Photos 7-8 by Uhl et al. (2015), adapted and used under a <u>Creative Commons Attribution 4.0 International License</u>.

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