

Opportunistic mating in *Nephila pilipes* Spiders: Avoiding cannibalism, ensuring success

Shaifali Ojha*, Vipul Keerti Sharma

Department of Zoology, Govt. Holkar (Model, Autonomous) Science College, Indore, Madhya Pradesh, India

Corresponding Author: Shaifali Ojha

Abstract

The giant wood spiders or Golden silk orb-weavers are among the largest spiders with extreme sexual dimorphism with females being much larger than males. Males are at high risk as sexual cannibalism is prevalent especially during mating. In response, males go through elaborate courtship displays that cost them energy & potential life. Competition among males adds more complexity to the mating. The study investigates alternative mating tactics in a web-building spider (*Nephila pilipes*) used by males to maximize their chance of mating with females when they are feeding while avoiding predation risk & ensuring reproductive success.

To study opportunistic mating in spiders, we monitored females of the spider *Nephila pilipes* during feeding stage. Male behaviour was recorded when approaching & copulating with female. The event was photographed in an attempt to illustrate this adaptive strategy. Also the timing in observation of males & females were recorded to evaluate predation risk & opportunities for mating success.

In the current study we observed *Nephila pilipes* males court females while they were busy in feeding, minimizing the chances of being cannibalised. It enabled males to evade, & effectively mate without competition as far as predation is concerned. These mating strategies under sexual conflict are adaptation of males to minimise female aggression & intermale competition. In *Nephila pilipes* females sometimes mate during their feeding stage when the risk of cannibalism is at its lowest, & the study provided evidence of such behaviour. Such behaviour left the male protected from predation while ensuring reproductive success without interference from rival males. These results illuminate an example of male adaptation to high-risk mating environments during reproductive activities such as moulting or feeding in females.

Keywords: Cannibalism, courtship, mating strategies, opportunistic mating, sexual dimorphism

Introduction

The giant golden orb-weaver spider, *Nephila pilipes* is a large spider distinguished by pronounced sexual dimorphism. The female is large & is dark brown to black with bright orange, yellow, or white patterns on its opisthosoma & leg joints (Fig 1). The body is 8-10 cm long & it can be up to 28-30 cm in diameter when the legs are extended. Males of *Nephila* show the most extreme sexual dimorphism with their relative diminutiveness to conspecific females (Selden *et al.*, 2011) ^[15] & measure from 5–6 mm in length, & are typically a muted brown or grey. The huge size & banana-like yellow stripes against the body's rich background colour make the female spider & out in the background (Sawarkar & Sawarka 2023).



Fig 1: Female *Nephila pilipes*

Giant webs are built by genera of *Nephilid* spiders in aerial, arboricolous, or intermediate forms (Kunter *et al.*, 2018) which are attached to tree trunks, thick vegetation or other firm substrate. The highly efficient & specialized aerial trap in the form of planner & vertical orb web is constructed by the female giant wood spider. These webs are meant to trap bigger insects including butterfly, moths etc. The web may be inhabited by a number of organisms, such as other kleptoparasites spiders such as *Argyroides* species (Fig 2), & conspecific males ((Bhagade & Zanwar, 2016) ^[1]. On the web of the female, one can frequently find two to three males called "waiting males". Cues like vibration on web makes the female active & respond to the situations. ((Robinson & Robinson, 1973) ^[12].

In species where females are known to engage in sexual cannibalism, males have adapted a range of strategies -both behavioural & physical-to lessen the risk of cannibalism (Elgar 1992; Linda *et al.*, 2019) ^[3, 10]. In spiders, for instance, these are such as presenting nuptial gifts to the female (Toft & Albo 2016) ^[17] & Remote copulation (i.e., genital mutilation & plugging; Li *et al.*, 2012) ^[8], & opportunistic mating (Robinson & Robinson 1980 ^[11]; Fromhage & Schneider 2005).

Opportunistic mating is a well-known strategy to counter female sexual cannibalism in many animals (Foellmer & Fairbairn 2003; Neumann & Schneider 2019) ^[4, 10]. Opportunistic mating, by which a male mates with a female when she is disturbed or when she is feeding or undertaking moulting, is one of such kinds of strategies, & widely occurs in many animals, especially in spiders. (Ma *et al.*, 2021). Copulation attempts by males are often made when the

female is preoccupied with consuming her prey ((Fromhage & Schneider, 2004)^[5]. Using this tactic, there is an increase in the chances of successful copulation whilst reducing the chances of cannibalism.

Another noted behaviour is to breed with immature females (Biaggio *et al.*, 2016; Waner *et al.*, 2018^[2, 18]; Sentensk A *et al.*, 2020) prior to them reaching sexual maturity. In some *Nephila* species, the males guard the penultimate-instar females & copulate immediately after emergence as adults to monopolize matings before other males arrive. This strategy works well in species where several males traditionally combat for one female. The male usually waits on the opposite side of the female, on the center of the web. Unless the female catches a piece of prey, males rarely leave this area ((Schneider & Fromhage, 2010)^[14].



Fig 2: Kleptoparasite spider *Argyrodes elevates*



Fig 3: Sexual dimorphism in *Nephila pilipes* *Nephila pilipes*

It has been hypothesized that male only have the opportunity to mate with non-virgin females during the times when the female is eating as non-virgin females are less receptive than virgins. In the current study, however, the male exhibited opportunistic sexual behaviour by copulating with a female under similar conditions during foraging.

Materials & methods

The present work was carried out in Kajligarh, Indore in the State of Madhya Pradesh, India (22.719568N, 75.857727 E). The city supports dry deciduous & Sal forests, having a rich flora & fauna. The Sal Forest is an ideal habitat for the Giant wood spiders, both in terms of food & shelter. A Nikon camera with lens 125x optical zoom is used to record

the present work. The phenomenon was recorded from about 1.00 to 3.00 PM in the forest.

Observation

Fig 4 showed a female *Nephila* spider was preoccupied in feeding on her prey on the web. The female appeared to be busy in wrapping its prey. Two males were present in the vicinity. The dominant male slowly approached the female while the other male was seen to move apart from the female. The female showed only very feeble & slow movements when the dominant male approached to her. It seems that feeding is the priority for the female, perhaps because it's a more immediate energy & even while she is copulating. This multitasking might indicate that foraging is an important task that is intolerant to interruptions.

The male, exhibit opportunistic behaviour & try to mate with the female when she is in stationary position. Initially the dominant male kept his distance from the other male & positioned himself on the far side of the female's web. The dominant male moved slowly & deliberately toward the female's web from anterior side, avoiding abrupt movements that could alert the female. Also, the male was able to determine the position of the rival male & the activity of the female by using the vibrations of the web.



Fig 4: Female feeding on the prey

Following a short mating by inserting the pedipalp in the female's genital orifice (Fig 5), the male quickly moved away on the web. This behaviour reduced the chance of being cannibalized by the female & attacked by the rival male. The act was repeated after one hour with no rival male.



Fig 5: Male copulating with female

Result & discussion

The dominant male *Nephila* spider successfully copulated while the female was feeding, demonstrating an opportunistic & planned mating technique. The male assessed the female's activity & the presence of a larger competing male by closely observing web vibrations. The risk of cannibalism was reduced by his cautious anterior side approach & quick escape after copulation. Interestingly, the female preferred food above mating & remained mostly unresponsive.

These results highlight the adaptive tactics used by male *Nephila* spiders in competitive mating conditions. The ability of the smaller male to take advantage of the female's distraction emphasizes how important timing & stealth are to maximizing reproductive success. The female's behaviour on foraging further indicates that energy gain is a major driving force of mating behaviour. By highlighting the delicate balance between reproduction & predation danger, this study advances our understanding of sexual selection & survival trade-offs in arachnids.

Conclusion

In this study of the Giant Wood Spider *Nephila pilipes*, the male took advantage of the feeble state of the female, who was feeding. The male also had an added advantage of an inactive rival male. The male also benefited from his own proximity to the moulting female at that time, drastically reducing chances of any competition from other males, & avoiding the process of a long & complex courtship which would otherwise involve expenditure of many resources-energy, time & secretion of silk. The male was able to copulate with the female when she was engaged in feeding on the prey. Thus, such opportunistic behaviour of the male won for it the dual benefit of survival & ensuring his own paternity & continuation of his own genes through his sperm for propagation of the species.

References

1. Bhagade A, Zanwar P. Study of opportunistic sexual behaviour of male in giant wood spider *Nephila pilipes*. International Journal of Plant, Animal & Environmental Sciences,2016;6(3):1–4.
2. Biaggio MD, S&omirsky I, Lubin Y, Harari AR, &rade MCB. Copulation with immature females increases male fitness in cannibalistic widow spiders. Biology Letters,2016;12(9):20160516. doi:10.1098/rsbl.2016.0516.
3. Elgar MA. Sexual cannibalism in spiders & other invertebrates. In Oxford University Press eBooks, 1992, 128–155. doi:10.1093/oso/9780198546504.003.0007.
4. Foellmer MW, Fairbairn DJ. Spontaneous male death during copulation in an orb-weaving spider. Proceedings of the Royal Society B Biological Sciences,2003;270(suppl_2). doi:10.1098/rsbl.2003.0042.
5. Fromhage L, Schneider JM. Safer sex with feeding females: sexual conflict in a cannibalistic spider. Behavioral Ecology,2004;16(2):377–382. doi:10.1093/beheco/ari011.
6. Hernández L, Molina J, Aisenberg A. Shape of male palpal hook affects female sexual cannibalism in *Leucauge mariana* (Araneae: Tetragnathidae). Journal of Arachnology,2019;47(2):280. doi:10.1636/joa-s-18-058.
7. Kuntner M, Hamilton CA, Cheng R, Gregorič M, Lupše N, Lokovšek T, *et al.* Golden orbweavers ignore biological rules: phylogenomic & comparative analyses unravel a complex evolution of sexual size dimorphism. Systematic Biology,2018;68(4):555–572. doi:10.1093/sysbio/syy082.
8. Li D, Oh J, Kralj-Fišer S, Kuntner M. Remote copulation: male adaptation to female cannibalism. Biology Letters,2012;8(4):512–515. doi:10.1098/rsbl.2011.1202.
9. Ma Y, Hua Z, Mao A, Li D, Zhang S. Male opportunistic mating increases with intensity of female sexual cannibalism in 3 web-building spiders. Current Zoology,2021;68(1):113–119. doi:10.1093/cz/zoab090.
10. Neumann R, Schneider JM. Males sacrifice their legs to pacify aggressive females in a sexually cannibalistic spider. Animal Behaviour,2019;159:59–67. doi:10.1016/j.anbehav.2019.11.003.
11. Robinson MH, Robinson B. Comparative studies of the courtship & mating behavior of tropical Araneid spiders. The University of Chicago Journal,1980:36.
12. Robinson MH, Robinson B. Ecology & behavior of the giant wood spider *Nephila maculata* (Fabricius) in New Guinea. Smithsonian Contributions to Zoology,1973;149:1–76. doi:10.5479/si.00810282.149.
13. Sawarkar AS, Sawarkar SB. Orb web features of Giant Wood Spider *Nephila pilipes*. Research Journey,2019;110:145–149.
14. Schneider J, Fromhage L. Monogynous mating strategies in spiders. In Springer eBooks, 2010, 441–464. doi:10.1007/978-3-642-02624-9_15.
15. Selden PA, Shih C, Ren D. A golden orb-weaver spider (Araneae: Nephilidae: *Nephila*) from the Middle Jurassic of China. Biology Letters,2011;7(5):775–778. doi:10.1098/rsbl.2011.0228.
16. Sentenská L, Uhl G, Lubin Y. Alternative mating tactics in a cannibalistic widow spider: do males prefer the safer option? Animal Behaviour,2019;160:53–59. doi:10.1016/j.anbehav.2019.11.021.
17. Toft S, Albo MJ. The shield effect: nuptial gifts protect males against pre-copulatory sexual cannibalism. Biology Letters,2016;12(5):20151082. doi:10.1098/rsbl.2015.1082.
18. Waner S, Motro U, Lubin Y, Harari AR. Male mate choice in a sexually cannibalistic widow spider. Animal Behaviour,2018;137:189–196. doi:10.1016/j.anbehav.2018.01.016.