

Silken Secrets: Revealing Spider Webs with Electron Microscopy

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Location of Project: Nanoscale and Microscale Research Centre, University of Nottingham.

Lay Summary

The green meshweaver is a relatively understudied spider that weaves a web on the surface of a single leaf. It produces a variety of silk types, such as strong structural silk, and incredibly fine silk used to capture prey. This project aimed to categorise the types of silk created, and to investigate whether silk spun in captivity differed from silk spun in the wild. To do so, wild webs were removed, the area marked and recollected after 48 hours. The same spider was given 48 hours to weave a new web on a leaf stored in a Petri dish, and the wild and captive webs were compared using electron microscopes. The types of silk appeared not to differ between captive and wild webs, although captive spiders most often chose to weave their webs between the edge of the Petri dish and the edge of the leaf rather than on the surface of the leaf. This was not seen in wild spiders which suggests a behavioural effect of captivity. A variety of silk types were also identified, including major and minor ampullate silk which are used for structural support, and cribellate silk which is the fine silk used for prey capture.

Photograph



Report

The aim of this project was to investigate whether silk produced by the green meshweaver (*Nigma walckenaeri*) (Figure 1) differed when woven in captivity vs the wild. The family this species falls within is relatively understudied meaning this project is an opportunity to learn more about its silk production.

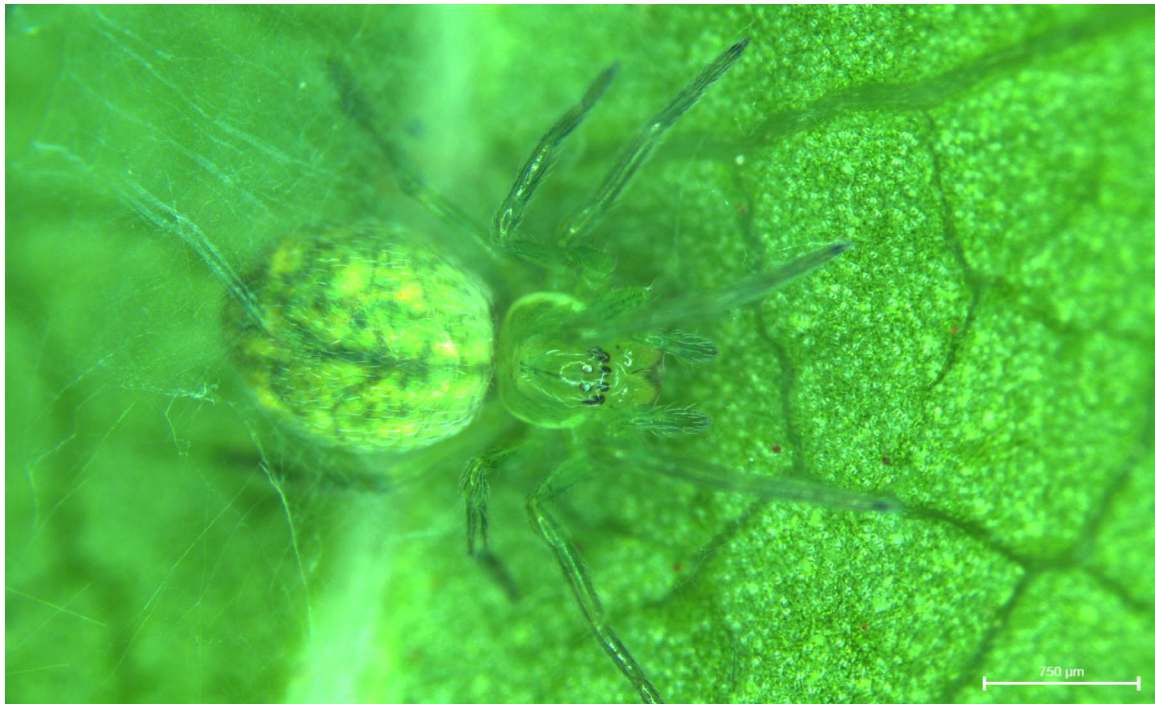


Figure 1. A female *Nigma walckenaeri* taken using a Leica M205FA optical microscope.

To address this aim, 52 webs on *Laurustinus viburnum* leaves were removed while attempting to leave the spider undisturbed. *N. walckenaeri* individuals were then given 48 hours to weave a new web in the wild to ensure the web was of a known age. After 48 hours, 12 leaves that possessed both a new web and a spider were collected, and each spider was transferred to a new *L. viburnum* leaf of similar size. The spiders were stored in captivity in a Petri dish containing damp tissue paper for 48 hours to weave another web. Three spiders wove a web on a leaf while in captivity, and these were examined alongside their corresponding wild web. Specimens were imaged using a Leica M205FA optical microscope, a FEI Quanta 650 environmental scanning electron microscope (ESEM), and a JEOL 7000F field emission gun scanning electron microscope (FEG-SEM). This allowed for imaging of the overall web structure, as well as the individual silk fibres that made it up. The latter were measured using ImageJ. One additional *N. walckenaeri* individual was also examined using a SEM to image the spinnerets, cribellum and calamistra of this species.

Based on the data collected, it appears the main difference between captive and wild *N. walckenaeri* lies in the behaviour during web weaving. The spiders demonstrated behavioural differences when in captivity, with most individuals choosing to weave a web at the edge of the Petri dish rather than on the leaf itself. However, the silk produced appears to be consistent between wild-woven webs and the captive-woven webs when woven on a leaf. This project identified a variety of possible silk types that *N. walckenaeri* appears to produce; including major ampullate silk (MAP) used for structural support (Figure 2a), minor ampullate silk (mAP) (Figure 2b), and cribellar silk used for prey capture (Figure 2e). The latter is made by the cribellum (Figure 2c) and is hackled by the calamistra (Figure 2d) present on both hind legs. This creates fine silk masses with an average diameter of 61.9 μm . Individual cribellar silk fibres have an average diameter of 0.03 μm . These fibres are potentially formed from piriform silk, although future work on this species is needed to

concretely determine this. Imaging has also highlighted other types of silk, such as twisted fibres, fibres with repeated beading, and fibres forming large bundles.

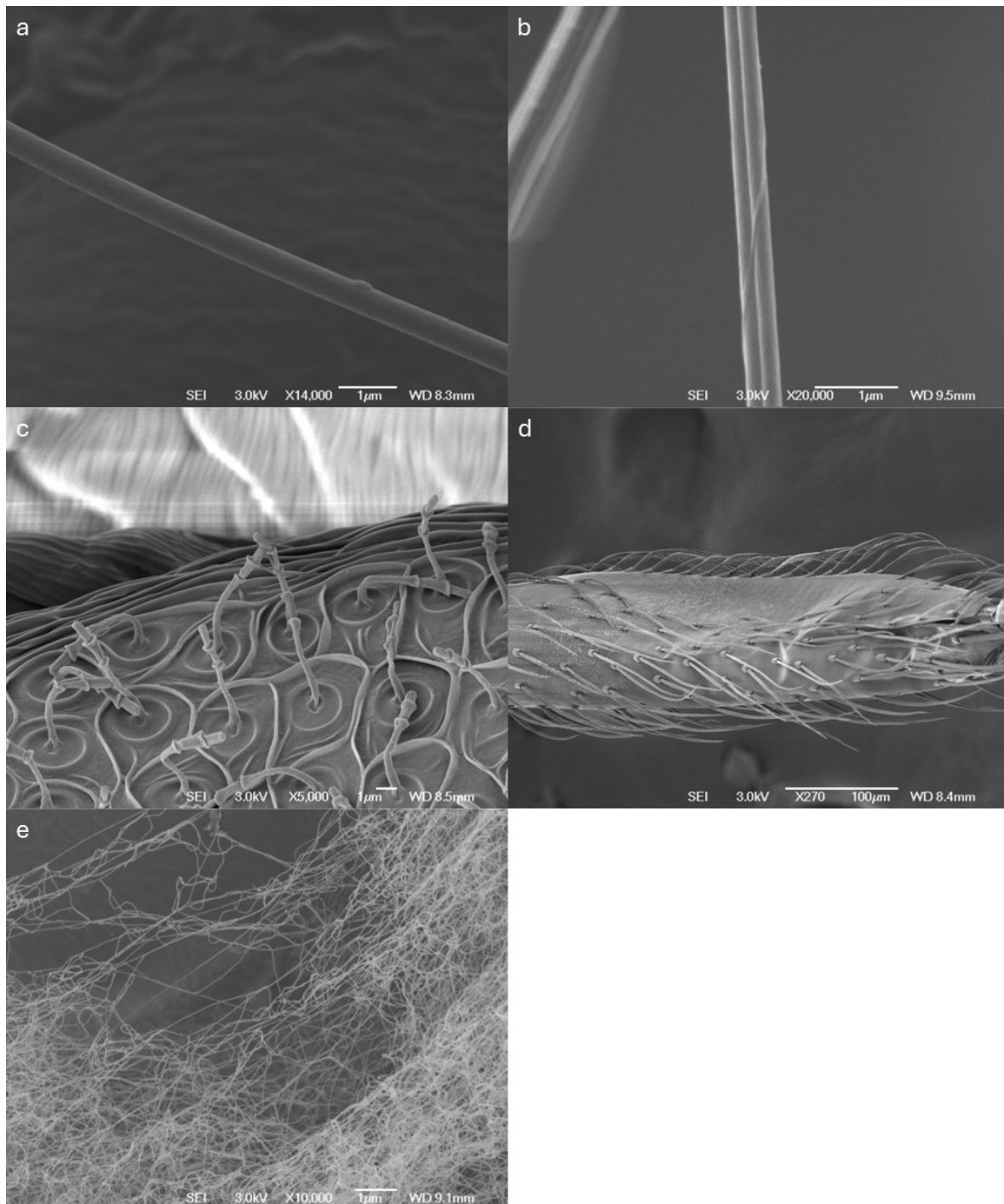


Figure 2a. *Nigma walckenaeri* major ampullate silk **b.** *Nigma walckenaeri* minor ampullate silk **c.** The cribellum of *Nigma walckenaeri* **d.** One calamistrum of *Nigma walckenaeri*. **e.** Cribellar silk. Imaged using a JEOL 7000F FEG-SEM.

Imaging of the spigots present on the cribellum (Figure 2c) and spinnerets (Figure 3) highlight 3 spigot types. One producing cribellar silk and 2 that, when compared to

Dolomedes tenebrosus spigots, appears as if it may produce MAP and piriform silk (Alfaro, Griswold and Miller, 2018).

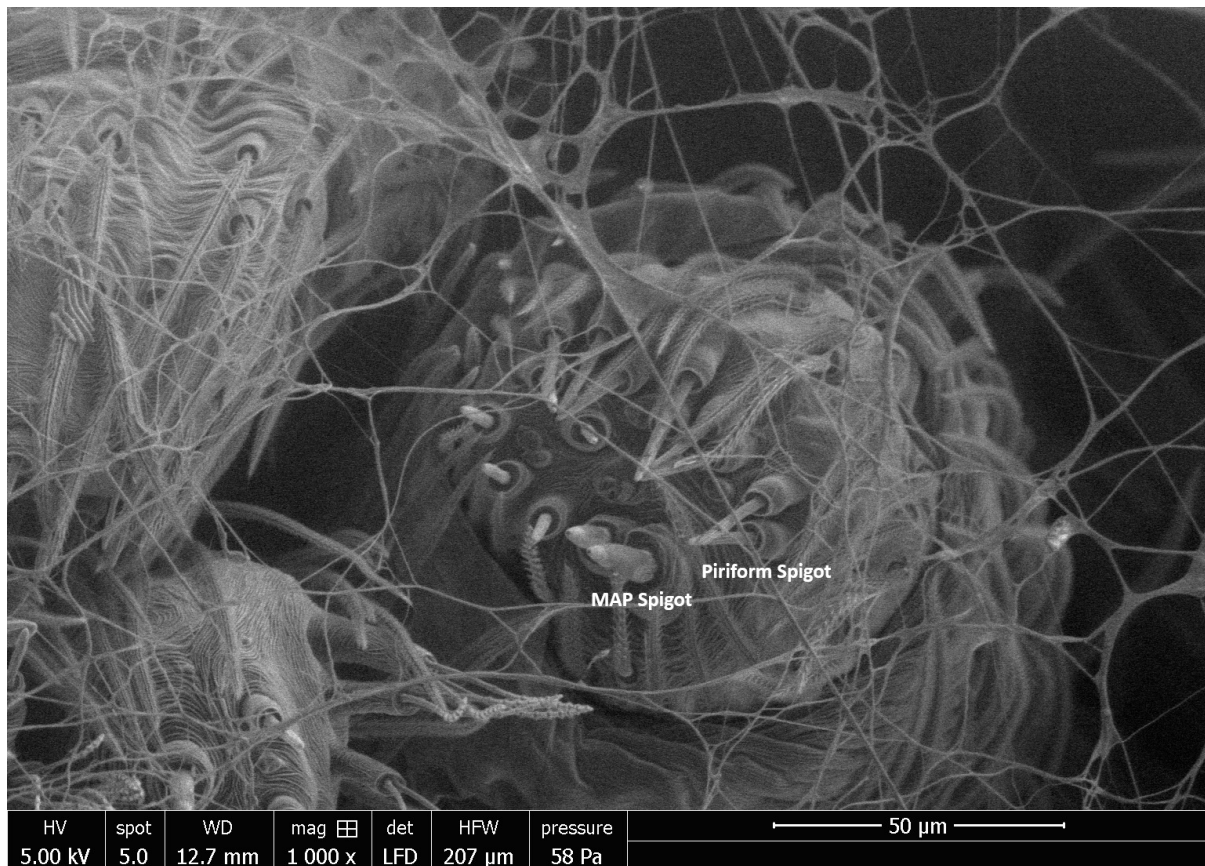


Figure 3. An image of a *Nigma walckenaeri* spinneret showing both major ampullate silk (MAP) spigots and piriform spigots. Taken on a FEI Quanta 650 ESEM.

I greatly enjoyed this project for many reasons. Firstly, the project was an excellent opportunity to learn what a research environment is like. Secondly, it taught me a lot about a variety of methods of electron microscopy - a subject I find fascinating but have not had much experience with prior to the project. Finally, the project allowed me to work with spiders, which are a personal favourite of mine. This was especially exciting as there is limited literature on this species which really highlighted the benefits of the research. I also developed a variety of microscopy-based skills throughout this experience, such as how to coat specimens with metal before using the FEG-SEM for the highest resolution imaging.

I am currently exploring future career options, but I would be interested in work focused on animals and/or conservation, whether that be research based or otherwise. I am also considering a PhD which was part of my reasoning for applying for this project as it gave me an opportunity to experience research firsthand. I have always been fascinated by spiders and working with them throughout this project has been very enjoyable, so I will be keeping an eye out for any further opportunity to do so in the future. The variety of microscopy I was able to get involved in was also very interesting. I would like to take part in more in the

future, as this project deepened my understanding of how useful electron microscopy can be in research.

References

Alfaro, R.E., Griswold, C.E., Miller, K.B. (2018) 'Comparative Spigot Ontogeny Across the Spider Tree of Life.', *PeerJ*. doi: <https://doi.org/10.7717/peerj.4233>