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Evolution & Behavior

High performance silks deployed by web building wolf spiders

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ABSTRACT

Wolf spiders that build webs produce silks that perform differently than those that do not build webs, supporting hypotheses that web building and silk performance co-evolved in spiders.

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Silk is a truly amazing fibre naturally produced by moths, caddisflies, some flies, ants, bees, and grasshoppers, as well as spiders. If you have seen a spider abseil from their web, you are familiar with dragline silk, one of several types of silk a spider produces. Spider dragline silk is considered nature's toughest material.

Spider dragline silk is one of few substances that combines both exceptional strength and elasticity, making it the toughest material it is. The properties of dragline silk are considered necessary for a spider web to absorb the impact of prey that fly or fall into it. Scientists therefore think that spider webs and the properties of dragline silk affect each other's evolution, by a process called co-evolution.

We all know that spiders build webs, but some spiders, while they produce silk, do not build webs. Among those who build webs, many different types of webs have evolved. For example, there are spiders that build aerial webs to catch fast flying prey, and these webs have the strongest and most extensible dragline silks. The fact that a web that needs the most strength and elasticity is built with the strongest, most extensible silk seems to confirm that the type of spider web and the dragline silk properties co-evolve.

Dragline silks are thought to be made up of two kinds of proteins, called major ampullate spidroin 1 (or MaSp1)-type and major ampullate spidroin 2 (MaSp2)-type. It is known that only web building spiders secrete silks containing both proteins. It, therefore, makes sense to predict that web building and silk proteins have also co-evolved. Indeed this is the conventional thinking, but there might be reasons why it is not necessarily the case.

Thus far, most of our knowledge on the link between web building spiders and their silks comes from examinations of web building and silk properties across a large diversity of spiders. These studies show that spiders that build webs use different silks, with different properties to the silk of spiders that do not build webs. However, some groups of spiders, such as wolf spiders (Family Lycosidae), are related to web-building species, but most species (albeit not all) do not build webs. What kind of silks do these wolf spiders produce? If web building and high performance silks are linked, then we might deduce that the few web building wolf spiders will make different silks than the non-web building ones.

To fully test our deduction we needed to find a mix of web building and non-web building wolf spiders from similar habitats at a single location. Luckily, we found this among the wolf spiders in Uruguay. We collected two species of web building wolf spiders and six species of non-web building wolf spiders from woodlands and grasslands in Uruguay. We then brought them to our laboratory in Rivera or Montevideo, and collected their dragline silk using a mechanical spool.

We then compared three properties of silk among the different wolf spiders: (1) their mechanical performance, (2) their amino acid composition, as these are used to predict the ratio of MaSp1-type and MaSp2-type proteins, and (3) how their silk proteins are arranged at the molecular level. First, we spooled silk onto cardboard frames to test the silk's mechanical performance with a Universal Testing Machine, a special machine that measures the force required to stretch the silk until it breaks. Second, we collected a bundle of silk onto a glass tube, and did an analysis of amino acid composition. Third, we collected silk onto steel cards that were specifically made for performing wide angle X-ray scattering analyses, an analysis that allows us to visualize how these proteins are arranged at the molecular level.

It was evident to us that the mechanical properties of silk, the composition of amino acids, and the molecular arrangement of the silk proteins differed between the web building and non-web building wolf spiders. We confirmed statistically that these differences were linked to whether the wolf spider species built webs or not.

Our results unequivocally showed that the mechanical properties of dragline silk and web building are functionally linked among wolf spiders. This gives support to a broader hypothesis that web building and silk high performance has co-evolved in spiders. We also think there are implications for understanding the loss of web building among certain spiders. Perhaps wolf spiders as a group have lost web building because the burden of producing high performing dragline silks was too much.

Because of the unique properties of spider dragline silk, scientists are always on the lookout for spiders that can help us to better understand how dragline silks are made and the functions they perform in nature. We think that by fully understanding the evolutionary process driving silk properties in different spiders we will be able to identify useful new models.