Exploring Spidroin Phylogeny of Understudied Spiders

ABSTRACT

We used phylogenetic analysis to analyze the evolutionary relationships and mechanical properties of 2 spider silk fibroin proteins (spidroins) across non-*Araneidae* spider species with complementary research status and key characteristics.

(1) Major ampullate silk, *MaSp1* spidroin
(2) Pyriform silk, *PySp* spidroin

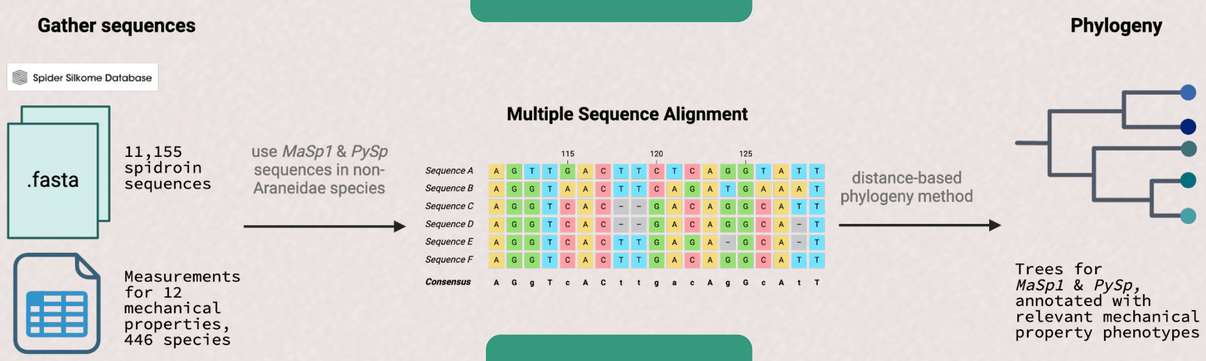
	(1) Major Ampullate Silk	(2) Pyriform Silk
Silk fibroin protein (spidroin)	*MaSp1*	*PySp*
Research status	Well-studied	Understudied
Key characteristics	High strength, toughness, elasticity	Adhesive with moderate toughness
Mechanical property phenotypes	Tensile strength, toughness, Young's modulus	Strain at break, water content, toughness
Applications	Structural applications e.g. textiles, high-performance materials	Biomaterials, coatings, adhesives

BACKGROUND

The Engineered Matters Lab (EML) at Genspace is a community biology lab team exploring the synthesis of spider silks. EML is focused on 2 types of silks: (1) Major ampullate silk, *MaSp1*, well-studied and highly regarded for its exceptional strength and toughness, making it ideal for structural applications, and (2) pyriform silk, *PySp*, less studied but holds promise for its adhesive properties and potential use in biomaterials and coatings.

While most efforts focus on orb-weaving (*Araneidae*) spiders, EML applies phylogenetic techniques to explore understudied spiders and their unique silk properties, leveraging data from the 2023 “1000 Spider Silkomes” study. With over $1.425 billion invested in the spidroin market, EML emphasizes the importance of broader spider research, including non-Araneidae species, to uncover evolutionary insights and novel applications beyond silk production.

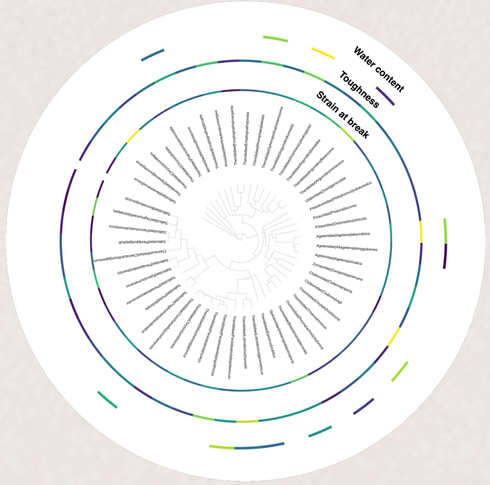
METHODS



RESULTS

Major ampullate silk, *MaSp1*

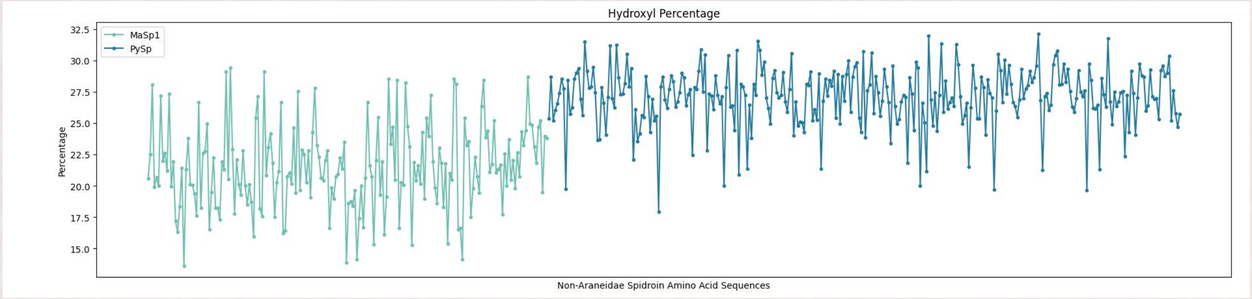
Pyriform silk, *PySp*



Annotated phylogenetic trees highlight promising species for further study:

Uloboridae octonoba varians,
Tetragnathidae leucauge dromedaria,
Theridiidae latrodectus geometricus,
Tetragnathidae leucauge tessellata

Agelenidae agelena labyrinthica,
Theridiidae argyrodes kumadai,
Theridiidae chrysso foliata,
Sparassidae heteropoda venatoria



DISCUSSION

- Performing phylogenetic analysis on *MaSp1* & *PySp* with annotations for mechanical property phenotypes relevant for the specific spidroins revealed distinct evolutionary patterns and high-performing species within both spidroins analyzed.
- In the *MaSp1* phylogeny, the top performers had consistently high measurements for all 3 mechanical properties (tensile strength, toughness, & Young's modulus). Additionally, these properties are clustered within clades, suggesting evolutionary pressures for structural strength.
- In the *PySp* phylogeny, the high measurements for the 3 mechanical properties (strain at break, toughness, & water content) are distributed more across distant clades, suggesting convergent evolution toward properties related to adhesiveness. This emphasizes functional diversity of *PySp*.
- Several species in the *Theridiidae* family were high performers in both the *MaSp1* & *PySp* phylogenies indicating a noteworthy starting point for species to study further.
- The average hydroxyl percentage of amino acid sequences in PySp was 27.2%, compared to 21.2% in MaSp1. This difference suggests that PySp spidroins may possess greater adhesive properties.

REFERENCES

1. Arakawa et al (2022). 1000 spider silkomes: Linking sequences to silk physical properties. Science Advances (Vol. 8, Issue 41. https://doi.org/10.1126/sciadv.abo6043.

2. Correa-Garhwal et al. (2019). Spidroins and Silk Fibers of Aquatic Spiders. In Scientific Reports (Vol. 9, Issue 1). https://doi.org/10.1038/s41598-019-49587-y.

3. Estimated $1.425B capital raised is based on publicly available funding data for Spiber ($910.9M), AmSilk ($42.3M) and Bolt Threads ($472.1M).

4. 360 Research Reports, 2022. Synthetic spider silk market 2022: Industry scenario, strategies, growth factors, and forecast to 2028. *Market Watch*.