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Editorial: Function and diversity of arachnid silk structures

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Editorial on the Research Topic
Function and diversity of arachnid silk structures

Silk has independently evolved multiple times among arthropods, but only spiders and spider mites use silk throughout all stages and aspects of their lives (Craig, 1997; Blackledge et al., 2011; Saito and Sato, 2024). Among the diverse uses of silk, the construction of prey-capture webs by spiders is perhaps the most iconic. Yet, silk is also produced and used by other arachnid groups, notably mites and pseudoscorpions, to construct diverse structures in a wide array of contexts. In general, arachnid silk use includes the construction of retreats, nests, and egg sacs; immobilizing prey; producing ballooning threads for aerial dispersal; bridging habitat obstacles during relocation; and using silk threads as signal and safety lines (Foelix, 2011; Saito and Sato, 2024). Such functional diversity of silk use has enabled arachnids to thrive in a broad range of environments, from dry terrestrial habitats to aquatic ecosystems. The evolutionary versatility of silk likely contributed to the ecological and taxonomic diversification of arachnids themselves.

Today, arachnid silk structures are powerful and popular models in behavioral, ecological, and evolutionary research fields where inquiry into their evolutionary and functional complexity continues to flourish (Mariano-Martins et al., 2020; Blamires et al., 2023; Wijerathna et al., 2025). The goal of this Research Topic is to showcase recent and significant advances in our understanding of the remarkable diversity of arachnid silk structures. The variety of functions and the behavioral plasticity of their engineers provides insights into their evolutionary success story: from spiders, the largest group of true predators, to mites, encompassing two diverse groups of immense ecological diversity, and pseudoscorpions, tiny and often overlooked soil predators.

Through this Research Topic of original research papers and reviews, we offer a snapshot of the most dynamic areas of current research on arachnid silks and highlight open questions. We hope this compilation will not only inform but also inspire the current and future generations of arachnologists to address these knowledge gaps and chart new directions for future investigation.

In a review article titled "*The function of web decorations in orb web spiders*," Walter delves into the various hypotheses surrounding conspicuous silk structures, known as "web decorations" or "stabilimenta" that certain orb-weaving spiders incorporate into their webs (Herberstein and Tso, 2011). He examines hypotheses suggesting that decoration-functions range from attracting prey through visual signals, offering protection from predators, to providing mechanical reinforcement to the web. By synthesizing findings from numerous studies spanning decades of research, Walter does not only highlight the complexity of decoration function as well as the experimental and conceptual shortcomings of past studies, but also offers a new hypothesis that predicts web decorations evolved from ancestral silken retreats as specialized, predator-protective structures.

In their original research article titled "*Ultrastructure of silk threads of the water spider Argyroneta aquatica (Clerck, 1757) (Araneae, Cybeidae) in comparison with that of some mites*," Shatrov and Soldatenko examine the silk threads produced by the water spider, *Argyroneta aquatica*, the only spider species known to live almost entirely under water (Seymour and Hetz, 2011), utilizing light, electron, and atomic force microscopy. The authors identify five types of silk threads in *A. aquatica* and compare these with silk-like secretions from certain mite species: they find that some silk types are similar to those of water mites, while others to those of terrestrial tetranychid mites. This comparative analysis offers insights into the evolutionary adaptations of silk production in aquatic environments and broadens our understanding of silk diversity among arachnids.

In their original research article titled "*Diversification of spider silk properties in an adaptive radiation of Hawaiian orb-weaving spiders*," Alicea-Serrano et al. investigate the webs of *Tetragnatha* spiders on Hawaii. Closely related species on the same island often exhibit markedly different web architectures, and these designs converge with those of more distantly related species on other islands (Blackledge and Gillespie, 2004). The authors explore whether such ecological divergence is also reflected in the mechanical properties of silk. Although interspecific variation in silk properties is relatively modest, this study provides the first evidence that ecological specialization can lead to diversification of silk properties over short evolutionary timescales. These findings contribute to our understanding of how ecological adaptation influences the evolution of functional biomaterials in arachnids.

Finally, in their original research article titled "*Come rain or shine: Effects of external conditions on the properties of linyphiid silk*," Wharton et al. investigate the physical properties of silk produced by a comparatively little explored group, the family Linyphiidae. These spiders are amongst the most specious and abundant spiders in the northern hemisphere (World Spider Catalog, 2025) and renowned for their long-distance aerial dispersal using silken "sails" (Bell et al., 2005). The authors investigate how environmental factors—humidity, temperature, and exposure to ultraviolet (UV) light—affect the physical structure and properties of silk. Their findings indicate that increased humidity and UV light exposure, but not temperature fluctuations, lead to decreased tensile strength. This research highlights the complex interplay between silks and their ecological environment, underscoring the high adaptability of linyphiid spiders to diverse environments.

In conclusion, this Research Topic highlights the remarkable diversity and evolutionary significance of silk across arachnid lineages. From behavioral intricacies to biomechanical properties, arachnid silks offer a research window into adaptation, innovation, and ecological success. We hope this Research Topic inspires both deepened inquiry and fresh perspectives. There is still much to uncover—across taxa, environments, and disciplines. We invite the current and future generations of scientists to contribute their curiosity, technical expertise, and interdisciplinary vision to arachnid silk research.

Author contributions

MG: Writing – original draft, Writing – review & editing, Conceptualization, Supervision. DR: Writing – review & editing, Conceptualization. AW: Conceptualization, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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