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Structural and Mechanical Variations of Major Ampullate Silk Spun by Malaysian Nephila pilipes Spider

Abstract

Major ampullate (MA) silk is a natural biomaterial, spun by spiders with exceptional mechanical characteristics. Most researchers who studied MA silk structure were primarily interested in the properties of a dragline thread that protrudes from the spider's spigot when being chased by its predator. Apart from the dragline, the MA silk fibers may also be found in three pivot threads of the orb web known as the mooring, framework, and radial. However, it is currently uncertain whether the MA silk in these threads has properties similar to the dragline thread. Thus, this work attempted to compare the properties of MA silk fiber in the mooring, framework, radial, as well as the dragline threads. The MA silk fibers in mooring thread were found to exhibit significant quantity of MA fibers (12 ± 5.0 fibers per thread), thickness diameter (11.7 ± 0.6 μm), and supercontraction effect (high swelling ratio of 18.6), with an outstanding combination of strength (4464 MPa) and toughness (875 MJ/m3), outperforming the dragline thread. Positive correlation was found between the diameter of MA fibers and supercontraction effect and between the number of MA fibers and tensile strength. These findings might be modeled as a fundamental guide in silk spinning for future synthetic MA silk fiber development with extraordinary mechanical performance.

Keywords

Dragline thread; Framework thread; Mooring thread; Radial thread; Spider silk