IS THE MOST STRETCHABLE COCOON SILK NANOCOMPOSITE BUNDLE THAT OF THE SPIDER META MENARDI?

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**Summary.** Spider silks display generally strong mechanical properties, even if differences between species and within the same species can be observed. While many different types of silks have been tested, the mechanical properties of bundles of silk taken from the cocoon of the cave spider Meta menardi have not yet been analyzed. Meta menardi has recently been chosen as the "European spider of the year 2012", from the European Society of Arachnology. Here we report a study where silk bundles were collected directly from several caves in the north-west of Italy. Field emission scanning electron microscope (FESEM) images showed that bundles are made up of a large number of threads, each of them with diameter of 6.03 ± 0.58 µm. The bundles were strained at the constant rate of 2 mm/min, using a tensile testing machine. The observed maximum stress, strain and toughness modulus, defined as the area under the stress-strain curve, are 0.64 GPa, 751 % and 130.7 MJ/m³, respectively. To the best of our knowledge such an observed huge elongation has never been reported for cocoon silk bundles and suggests a “blade of Arianna” mechanism, for preserving the connection with the eggs also under critical detachment conditions. The Weibull statistics was used to analyze the results from mechanical testing, and an average value of Weibull modulus (m) is deduced to be in the range of 1.5 - 1.8 with a Weibull scale parameter (σ₀) in the range of 0.33 - 0.41 GPa, showing a high coefficient of correlation (R² = 0.97).
1 INTRODUCTION

Spider silks often display strong mechanical properties [1] and have been studied extensively during the last five decades. Because of the complex structure of spider silk, large scale synthetic production still remains a challenge and can only be achieved through a controlled self-assembly of the macromolecular components with nanoscale precision [2].

To our knowledge, few studies have been conducted on bundles of egg sac (cocoon) silk. In the literature, the strain of spider cocoon silk is in the range from 19 % for *Araneus gemmoides* [3] to 29 % for *Argiope argentata* [4]; while the average stress is 1.1 GPa with a maximum stress of 2.3 GPa for *Araneus gemmoides* [3].

The cave spider *Meta menardi* has recently been chosen as the "European spider of the year 2012" from the European Society of Arachnology. Since no engineering studies of the cocoon of the cave spider *Meta menardi* yet exist and just few ones have been focused on egg sacs, we decided to conduct tensile tests on bundles of cocoon silk. We tested the bundle of threads which connect the cocoons of *Meta menardi* to the ceiling of the caves (Figure 1). To be able to see how the threads were stacked in each bundle, a Focused Ion Beam (FIB) was used to cut the bundle. Using the FESEM micrographies of the cross-section of the FIB-cut bundle, we were able to measure the real diameter and the exact number of single threads in each bundle. Thus, the stress-strain curves and the Weibull shape and scale parameters of the cocoon silk of *Meta menardi* are here determined.

![Figure 1: Egg sac of the spider Meta menardi (photo by F. Tomasinelli, 2006)](image)

REFERENCES


