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BOOK REVIEW

Spider silks: a possible key to evolution of spiders

Spiderwebs and Silk: Tracing Evolution from Molecules to Genes to Phenotypes
CL Craig
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Reviewed by J Nagaraju

'Spiders are defined by their silks', says Catherine Craig in her book, 'Spiderwebs and Silk'. Spiders, unlike the lepidopteran insects produce silk for their entire lifetime. For spiders, spinning silk is a foraging behavior to trap their prey on the intricate webs and hence silk is an indispensable survival strategy.

In this book, Craig, who has an extensive experience in the topic looks at spider silks from an evolutionary perspective as is evident from the subtitle of the book – 'Tracing evolution from molecules to genes to phenotypes'. She gives a fascinating and vivid account of evolution of spider silks and correlates it with the evolution and evolutionary success of spiders. Interestingly, she draws attention to the co-occurrence of the spider silk evolution with spider speciation in the evolutionary history of spiders. The two important evolutionary events in spiders – the divergence of the advanced spiders (Araneomorphae) from the primitive spiders (Mygalomorphae) and the divergence of modern orb weavers (Araneoidea) from the primitive orb weavers (Deinopoidea) coincide with the evolution of two types of silk-producing glands, the major ampullate gland (MA) and the flagelliform gland (Flag). This suggests a link between silk protein evolution and spider evolution. She has given a fascinating account on how studying spider silk proteins can give us insight into the evolution of spiders. The description tempts me to rephrase Theodosius Dobzhansky's statement in the context of spider evolution: Nothing in (spider) biology makes sense except in light of (spider silk) evolution.

Wherever possible and relevant, the author has given a comparative account of spider silks with the silks secreted by the lepidopterans, especially the domesticated silkworm *Bombyx mori*, the most well-studied lepidopteran model. She has compared the amino-acid composition, genetic organization, mechanical properties, energy requirements, etc and has tried to address the question of 'What makes spider silk unique?'. With a series of factual details supported by experimental evidence she has addressed this issue quite successfully.

In the first two chapters, the author gives an elegant analysis of the amino-acid composition and genetic organization of different types of silks across the spider group from the silks produced by the primitive spiders to the silks produced by the recently evolved spider species. Interestingly, all the silk proteins, including those of spiders show the predominance of the three amino acids: alanine, glycine and serine, the composition of which, of course, varies with the silk type. The variability lies in the sequence, length and number of these repeats. Silk proteins are 'hotspots' for evolution due to their repetitive amino acid and nucleotide sequences, but still the functional and molecular constraints maintain a fine balance between evolution and conservation.

Spider silk is known for its unique properties like high tensile strength, elasticity, toughness, etc. In the third chapter, the author focuses on the structural information based on nuclear magnetic resonance (NMR) and X-ray diffraction data of different types of silks and correlates it with the functional properties. Many experiments highlighted in this chapter suggest that spiders attract specific types of prey through evolutionary manipulation of silk colors and patterns. Thus, silks with properties best suited for the spider's survival got selected in evolution. The author concludes that the functional requirement acts as an important selective factor in the evolution of spider silks. This fact is best corroborated in a recent report on *Galleria mellonella* (Greater wax moth) fibroin heavy chain silk protein that resembles in mechanical properties the spider silks rather than the *B. mori* (mulberry silk) and the *Antheraea pernyi* (tussah or tasar silk) silks. The environment of beenests in which *G. mellonella* larvae reside probably played a decisive role in the evolution of their silks.

In chapters 4–6, the author has demonstrated with a series of elegant field and laboratory experiments, the role of the insect (spider's prey) in the evolution of spider silks. With the help of experimental data, she has narrated the role of insect's visual capacities, learning ability and behavior on the evolutionary pattern of the spider webs.

Like all good things, making silk also comes with a heavy price for the organism. In chapter 7, the author considers the ATP requirements of different silk types. Despite the process's high ATP requirements, spiders have evolved ways of efficient cost management, for example, the Araneoids consume and recycle their own silk.

Last but not the least, in the eighth chapter the author dwells upon the striking absence of 'Eusociality' among spiders. Eusocial behavior epitomized by honeybees has evolved as a means of energy conservation. Since spiders are involved in a metabolically expensive activity of silk production throughout their life, it is even more surprising that spiders lack eusocial behavior. The author hypothesizes that the absence of juvenile hormone (JH) could be the reason. JH is a key hormone in development, and triggers an extended growth period that leads to differences in phenotypes in a genetically homogeneous population – the first step towards eusociality. JH is known to have an antagonistic effect on silk production in silkworms. I agree with the author that the absence of JH in spiders may be a trade off to accomplish the lifetime requirement of silk production. Thus, silk production must have come at a cost to developmental diversity in spiders. However, this is just a hypothesis and the author emphasizes the need for future research in this area.

The book is a well-written, informative spider silk monograph. It gives an interesting account of evolution of spider silk proteins and its correlation to various factors like biochemical properties, gene organization, development, physiology and the responses of the prey. The book is recommended to evolutionary biologists, biotechnologists, arachnologists and to all those who have an interest in the wonders of nature. Spider silk has been referred to as 'Bio-Steel' due to its extreme tensile strength and finds immense applications in industry in the making of bulletproof vests, materials for space stations, medical sutures etc. The book will stimulate further research efforts in artificial silk synthesis. The author drives home the point that evolution of silk is a complex process encompassing many parameters.

However, the book has some drawbacks. Chapters 3 and 4 are too lengthy; this makes the nonspecialist reader lose interest and the main point seems to be lost among the vast amount of detailed information given. Also, because of its technical details, the book may discourage an otherwise interested audience. Limited availability of published DNA and protein sequences of spider silk proteins makes the evolutionary study less accurate and a precise study should await more information to come in future. Nevertheless, the book will serve as an important source of information on all aspects of spider silk proteins. The slow pace of information on silk protein added to the annals of literature is unlikely to render the book outdated, at least in the near future.

J Nagaraju
Laboratory of Molecular Genetics, Centre for DNA Fingerprinting and Diagnostics, ECIL Road, Hyderabad 50 0076, India
E-mail: jnagaraju@cdfd.org.in