DOI: 10.55278/IUOS6719

Diversity of silk production in insects

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Silk is one of the earliest natural fibres discovered by man. Silks are fibrous proteins containing highly repetitive sequences of amino acids stored in the animal as a liquid, and configure into fibres when sheared or spun at secretion (Craig, 1997). The cocoon silk of domesticated silkworm, *Bombyx mori* (Lepidoptera: Bombycidae) is prized over millennia for textiles, and most of our understanding about silk production is from this species. However, silk is known to occur in many arthropod classes, and a few molluscs and fishes also.

Fig 1: Spider silk

(Source: natural-japan.net)

Fig 2: Embioptera silk

(Source:https://smbasblog.com/2020/07/05/the-curious-webspinner-insect-knits-a-cozy-home-deep-look-video/)

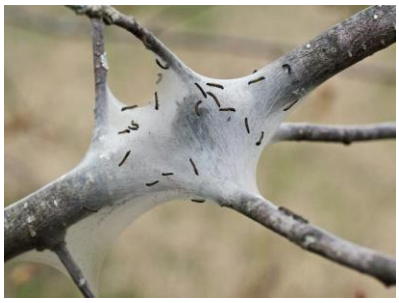

Fig 3: Insect silk

(Source:https://uwm.edu/field-station/the-wonders-of-webs-ii-insect-silk/)

Among the class Insecta, 16 out of 30 orders produce silk for a variety of purposes, which include reproduction, shelter, protection from predators, *etc.* (Walker *et al*., 2012). Study conducted by Gurr and Fletcher (2011) revealed that the silk produced by Australian endemic leafhopper, *Kahaono montana* Evans (Cicadellidae: Typhlocybinae) provided protection from the lacewing predator, *Mallada signata* (Schneider) (Neuroptera: Chrysopidae).

In insects, silk is produced and stored in dedicated glands. On the basis of location, Sehnal and Akai (1990) classified silk glands into labial glands, Malpighian silk glands and dermal glands. Labial gland accounts for most silks and is the prominent feature in caterpillar and pupal biology of Lepidoptera. Antlions,

mayflies and thrips produce silk from, their Malpighian glands whereas, some water beetles and lacewings synthesize silk from dermal glands.

Insect silks have high levels of amino acids like glycine, alanine and serine. The abundance of these amino acids is most likely due to their non-essential character and intermediate hydrophobicity. Insect silks are semi-crystalline materials whose structure differs from species to species in molecular organization. Hydrogen bonds within and between the structures contribute to the mechanical strength and stability of silk fibres. Accordingly, five different structures have been identified *viz.*, extended β-sheets, cross beta, α-helices, collagen helices and polyglycine-II (Rudall and Kenchington, 1971).

Fig. 7: Silk refuges produced by *K. montana* (Source: Gurr and Fletcher, 2011)

Sutherland *et al*. (2007) identified a silk gene, *DFibroin* from highly expressed mRNA extracted from the prothoracic basitarsus of male hilarine flies (Diptera: Empididae). The silk gene from the basitarsi cDNA library matched an approximately 220 kDa protein from the silk-producing basitarsus. The hilarine silk protein is high in glycine and asparagine, and adopts an extended β-sheet conformation.

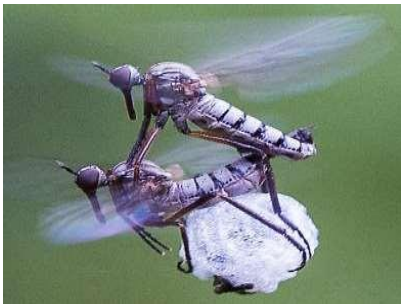

Fig 8: Silk produced by Hilarine fly (Source: https://bugguide.net/node/view/1049683/bgimage)

Insect silk possesses extraordinary mechanical properties in terms of strength, extensibility and stiffness. The obvious example of the use for silk is cloth, which also takes up the highest proportion of silk consumption. Scientists from Khan Koen University, Thailand, invented a silk bicycle using silk with resin at one third the cost of carbon-fiber or aluminium frame. The silk frame can take fives time the pressure and eight times the tension of an aluminium frame. As the silk frame has 30 times more elasticity, it also serves as a natural shock absorber. The versatility and sustainability of silk-based materials attract its use in food packaging, medicine, automobile industry, dietary and cosmetic supplements, optics, art, craft, *etc.* (Huang *et al.,* 2018).

Though the term ‘silk’ encompasses a wide range of distinct materials, it is

remarkable that certain features are common among silk production systems in insects. Today, insect silk has taken on new importance to society beyond fabric. Mechanically enhanced silk is expected to open up possibilities for numerous novel applications.

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MS Received 20 April 2022
MS Accepted 05 May 2022