A novel marine silk

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The marine silk shrimp *Crassicorophium bonellii* is able to spin underwater gossamer threads that sticky and salt-water resistant. This marine silk provides us with a novel example of Nature's way of engineering a highly functional material from an unexpected pre-condition. Thus the shrimp's silk also provides a novel example of a fibre secreting system that has independently evolved key components of a tried-and-tested production pathway found also in other arthropods.

In the past, extensive studies have investigated silks derived from terrestrial arthropods, such as the mulberry silkworm *Bombyx mori* and orb-web spiders, *Nephila clavipes* and *Araneus diadematus* (Aranaemorphae). Aquatic silks are known mainly from aquatic insect larvae such as caddis flies and one freshwater spider *Argyroneta aquatica*. Marine silks have not been closely investigated before.

Silks are by definition pulled fibrillar extrusions i.e. 'filaments that are spun at the point of delivery from feed-stocks, which can differ widely in detail but are all protein based'. Glues or cements on the other hand are by amorphous exudates that not, like all silk filaments, internally processed mechanically and/or biochemically.

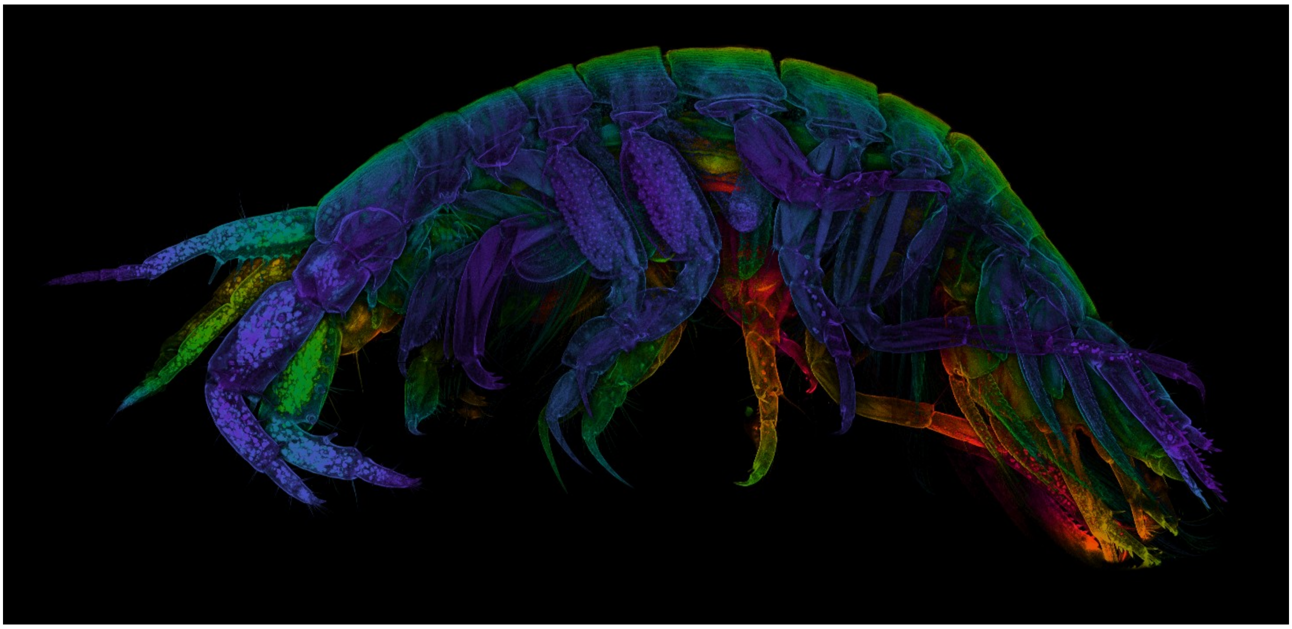
As a marine amphipod crustacean, the silk shrimp *Crassicorophium bonellii* is an amphipod crustacean that is distantly related to the sessile barnacles, which are well known for their extraordinarily hard marine 'cement' glues.

The silk shrimp has specialist secretory legs that allow it to spin a sticky, fibrous secretion, which is used to bind together the walls of its shelter consisting of collected sand grains, algal fragments or even faecal pellets. The silk filaments are pulled out when a leg moves away from the suface, not unlike the silks of spiders who pull their silk from abdominal spigots by moving away.

Intriguingly, the amphipod's silk fibre processing system seems to combine the barnacle's adhesive glue-cement exudate production glands with the internal extrusion spinning duct characteristic for spiders. Thus the silk shrimp successfully combines the stickiness of the barnacle cement with the fibrous morphology of spider-like silk threads.

Studying such a hybrid system has given the Oxford team new insights into the basic requirements for a silk spinning device. The comparison of independently evolved silk gland processing systems suggests certain generic underlying processing principles for a silk. These are reflected specifically in similar processing systems such as the raw silk producing glandular portion where silk molecules are synthesised and stored as a viscous liquid followed by a middle portion where the components are brought together and, finally, the extrusion portion where the fibre is formed.

Thus the comparative analysis between silk shrimps, barnacles and certain spider silks is beginning to suggest which key protein building blocks are required to make a fine marine silk, which make for an exceptional marine cement and which help to create a superb aerial silk. Assembly into adhesives or structural fibres with adhesive properties requires a fine balance of chemical and geometrical interactions. What the team observed when studying barnacle cement, shrimp silk and modern spider silks is a shift of this fine balance from a plain chemical interaction in the barnacle cement to more and more complex geometrical interactions in the shrimp silk and eventually in the spider silks. Being able to fully interpret the details of such molecular interactions in natural animal glues and fibres will get us a long way towards creating bio-inspired derivatives with comparable properties.



'Lateral view of the amphipod *Crassicorophium bonnellii* showing its spinning legs in the centre.' This is a depth coloured maximum projection of a confocal image stack'. K.Kronenberger & D. Johnston.