Wasp masters manipulate web-building zombie slave spiders

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Some wasps have unpleasant habits. Hijacking an unsuspecting insect or spider, parasitic wasps incapacitate their hapless victims by taking control of their nervous systems and turning them into zombies. Once the wasp has its victim in its clutches, it deposits its egg on or within the victim's body, ready for the next generation to develop.

Keizo Takasuka from Kobe University, Japan, explains that one particular wasp, *Reclinervellus nielseni*, turns its spider targets (*Cyclosa argenteoalba*) into drugged navvys whose final act is to construct a tough 'cocoon' web from the original orb web to protect the developing wasp pupa after the spider's death. According to Takasuka, *C. argenteoalba* produce several different styles of web over the course of their lives - 'orb' webs when hunting and 'resting' webs for protection when moulting - each produced by a specific set of behaviours. However, it wasn't clear

which of the spider's behavioural patterns and web-types the wasp was adapting to its own ends until Takasuka investigated how the wasp manipulated its spider host and web. He publishes his discovery that the wasp larvae masters force their zombie spider hosts to build a modified and reinforced resting web before steering them back to the centre of the web to construct a cocoon in *The Journal of Experimental Biology*.

To find out what the unsuspecting spider victims were forced to do by their zombie masters, Takasuka headed to shrines in two nearby cities (Tamba and Sasayama) from mid-April to mid-May ready to collect spiders complete with their webs and parasitic larvae. However, Takasuka recalls that keeping the spiders alive in the lab before their zombie state was triggered was quite a challenge. Some refused to build webs in captivity and he occasionally destroyed the delicate structures when he inadvertently snagged supporting frame threads attached to distant objects. However, after weeks of patiently nurturing the spiders, he was rewarded when 10 obediently constructed cocoon webs for their parasite masters.

Analysing the cocoon webs, Takasuka was struck by their similarity to the resting webs, complete with fluffy decorative structures. And when Takasuka analysed the spiders' behaviour as they constructed the cocoon webs over a 10 h period, he saw that the manipulated spiders always constructed the new web on the site of the old orb web, painstakingly removing the sticky spiral first, then reinforcing the radial and frame threads and then adding the fibrous web decorations. And, when the web was complete and the wasp larva done with its spider slave, the larva directed the spider to return to the hub of the web before murdering it.

So, the cocoon webs looked like resting webs, but were they true adaptions of the more conventional web? Takasuka and Kensuke Nakata photographed the webs in UV light and were impressed to see the fibrous decorations shining brightly, to deter other insects from

inadvertently blundering into the pupa's nursery. And when Tomoki Yasui, Toru Ishigami and Takasuka investigated the strength of the different types of silk that contribute to the web's structure, they were amazed to see that the cocoon web was significantly tougher than the orb and resting webs: the breaking force of the cocoon radius and frame silks was 2.7-40 times greater than for the orb and resting webs. However, the breaking stress of the silks was not increased significantly, leading Takasuka to suspect that instead of forcing the spiders to alter silk production, the wasp slave-masters were directing the spiders to lay down more fibres to strengthen the cocoon web, which is essentially a reinforced resting web.

Explaining that parasitized spiders transition into zombie web building even when the parasitic larva has been removed, Takasuka also suggests that resting web construction is triggered by the same hormones that control moulting and he suspects that the larva may inject a substance similar to a moulting hormone into the hapless spider during the later stages of its stay, ready to trigger cocoon web building when the larva is ready to pupate.

More information: Takasuka, K., Yasui, T., Ishigami, T., Nakata, K., Matsumoto, R., Ikeda K. and Maeto, K. (2015). Host manipulation by an ichneumonid spider ectoparasitoid that takes advantage of preprogrammed web-building behaviour for its cocoon protection. *J. Exp. Biol*. 218, 2326-2332

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