what might be a dangerous environment? One trick which is often very effective is its ability to dive down into the water and hide in the aquatic vegetation. This may be one of the reasons why it is more numerous on Pevensey Levels waterways, where there is a good growth of *Stratiotes aloides*, and at Redgrave/Lopham, where there are *Potamogeton* species. Does its very close relative *D. fimbriatus* also have this ability? I have never seen it referred to in the *Dolomedes* literature but perhaps a reader can provide more information. The preferred habitat of *D. fimbriatus* would suggest that to escape predators by diving is not necessary because water is frequently not present or else too shallow to make the escape effective. I hope other *Dolomedes*-watchers will contribute to this discussion.

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Intentional Pollen Feeding in the Spider *Araneus diadematus* Clerck, 1757

by Claudia Ludy

Spiders are almost invariably described as carnivorous. However, there are a few reports that spiders also ingest plant-derived nutrients such as nectar (Taylor & Foster, 1996; Jackson *et al.*, 2001) and pollen (Smith & Mommsen, 1984). While hunting spiders probably actively forage pollen in times of prey scarcity (Vogelei & Greissl, 1989), orb-weaving spiders are believed to consume pollen accidentally by 'recycling' their webs (Smith & Mommsen, 1984). This unintentional pollen feeding of orb-web spiders was shown by Smith & Mommsen (1984) indirectly by demonstrating that spiders with a supply of pollen survive longer than starved spiders. Until now, there has been no direct proof of deliberate pollen uptake in orb-weaving spiders. In this study, intentional pollen feeding in juvenile and adult garden spiders (*Araneus diadematus* Clerck, 1757) was directly proven by visual observation, and verified by a molecular biological method.

Pollen consumption by an adult garden spider was observed in the field. The spider was maintained in the laboratory under standardised conditions (temperature 20 °C, 10 h/10 h light/dark regime) for several weeks. It built its orb-web in a wooden frame (30 x 30 cm), and was exposed at a height of 80 cm for seven hours on a field margin covered with flowering plants. During field exposure, a pollen-carrying wild bee was caught in the spider web. The spider wrapped up the bee with silk, but the bee was eventually able to escape, leaving behind the spider's silk wrapping including a mass of pollen. Later on, the spider took the silk-wrapped pollen to the hub, and after a few minutes, fluid appeared on the cluster, and the pollen mass changed colour (Fig. 1).

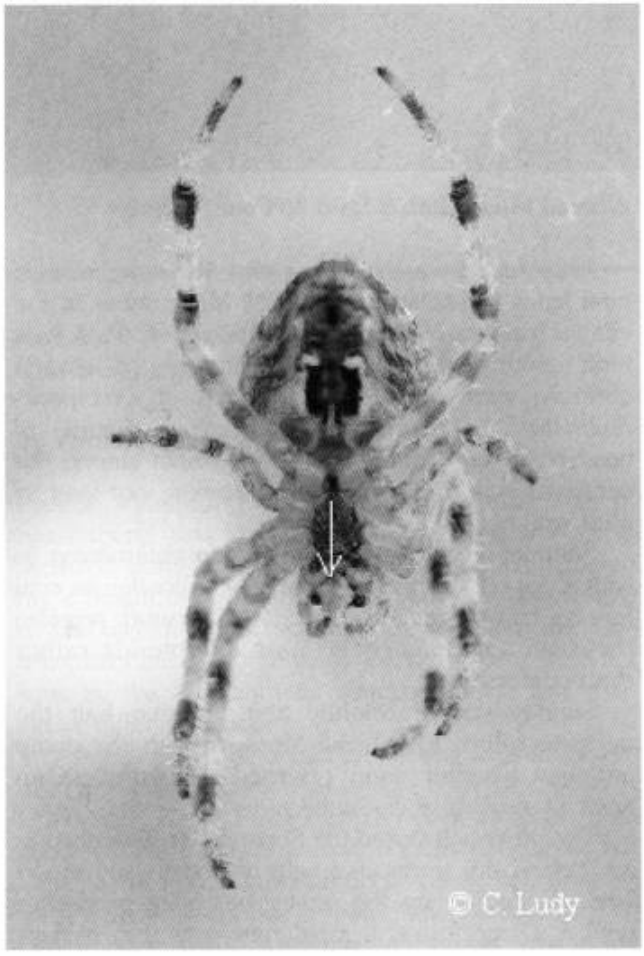

Figure 1. Pollen-eating adult female of *Araneus diadematus* (ventral view) in the field. Fluid on the pollen mass and a change of colour of the pollen (white arrow) indicated extraintestinal digestion.

Pollen-feeding in a juvenile *A. diadematus* (approximately 8 weeks old with a length of about 3 mm) was observed in the laboratory. The spider was kept in a wooden frame (10 x 10 cm), where it built its orb-web. The spider was fed with fruit flies (*Drosophila* sp.) and was kept under the conditions described above for several weeks. Maize pollen (*Zea mays*) was placed onto the orb-web with a small brush. The spider immediately reacted by pulling on the radial threads. Subsequently, it moved towards a pollen package, touched the pollen package with its pedipalps, and then carried the pollen to the hub. Following this the pollen package was held between the chelicerae, and became darker in colour and coated with liquid (Fig. 2).

The following laboratory experiment was carried out to prove pollen consumption directly: Juvenile garden spiders (*A. diadematus*) were kept under the above laboratory conditions, and were fed fruit flies.

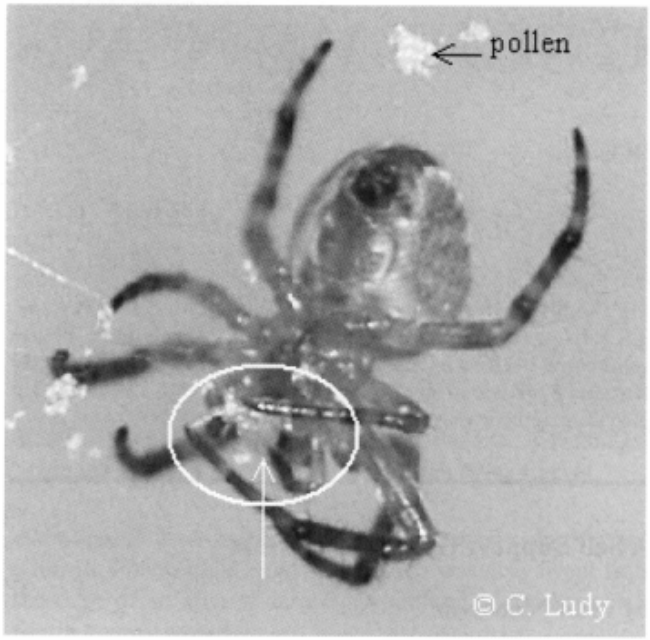

Figure 2. Maize pollen-eating juvenile *Araneus diadematus* (ventral view) in the laboratory holding and consuming a pollen mass (white circle and arrow). As compared with other pollen in the spider web (black arrow), fluid on the pollen package and a change of colour of the pollen indicates extraintestinal digestion.

The webs of 11 spiders were dusted with pollen of conventional maize (control), and to another 20 spider webs pollen of genetically modified Bt-maize was applied (variety 'Navares', event Bt176). The Bt-maize produces a protein of the entomopathogenic bacterium *Bacillus thuringiensis* (Cry1A(b) protein), which can be detected by an enzyme-linked immuno-sorbent assay (ELISA). After the spiders had recycled their webs, the spiders were collected and frozen at –18°C to prevent possible degradation of the Cry1A(b) protein, and stored for six months. Subsequently, the spiders were defrosted at 5°C, and washed with water in order to remove any pollen possibly adhering to the spider (additionally, spiders were checked for pollen under a binocular microscope). Then, the gastrointestinal system of the prosoma was dissected and picked in cyclohexylaminopropane sulfonic acid buffer (CAPS buffer: 50 mM, pH 10.5). The dissected tissue was analysed for Cry1A(b) content with a commercial ELISA kit (EnviroLogix QuantiPlate™ kit for Cry1Ab/Cry1Ac from Adgen®). In 13 of the 20 spiders (65%), whose webs were dusted with Bt-pollen, but in none of the 11 spiders of the control group, the Cry1A(b) toxin was detected.

The behavioural observations showed that both juvenile and adult garden spiders can ingest pollen directly. Possibly, spiders recognise pollen as food by touching the pollen with taste receptors on the pedipalps. Fluid on the pollen package and concomitant colour change of pollen was likely due to the application of digestive enzymes from the spider's midgut, indicating extraintestinal digestion. Further, the results of the ELISA with spiders whose webs were dusted with Bt-maize pollen, prove an uptake of pollen by the spider. The detection of the Cry1A(b) protein in the spider's gastrointestinal system proved to be an effective method to verify pollen consumption. Thus, feeding Bt-maize pollen and a subsequent analysis by ELISA is a possible method to detect pollen feeding in both various spider groups and other animals.

Figure 3. Web of an orb-weaving spider in a maize field during pollen shedding of maize containing thousands of pollen grains.

To my knowledge, this is the first published direct evidence that juvenile and adult orb-web spiders actively consume pollen. On the other hand, spiders sometimes refused offered pollen by dislodging the pollen actively out of their webs. This indicates that spiders sometimes regard pollen as a useless web load, perhaps affecting capture efficiency of the web. Spiders consuming pollen in this study were fed only with *Drosophila* flies, which are of poor nutritional value for spiders (Bilde & Toft, 2000), and perhaps therefore some spiders took the chance to utilise the extra protein portion of the pollen. As orb-webs can contain immense amounts of pollen in the field (Fig. 3), pollen-feeding may have a substantial significance for juvenile spiders.

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