The journey of pollen and the process of pollen dispersal

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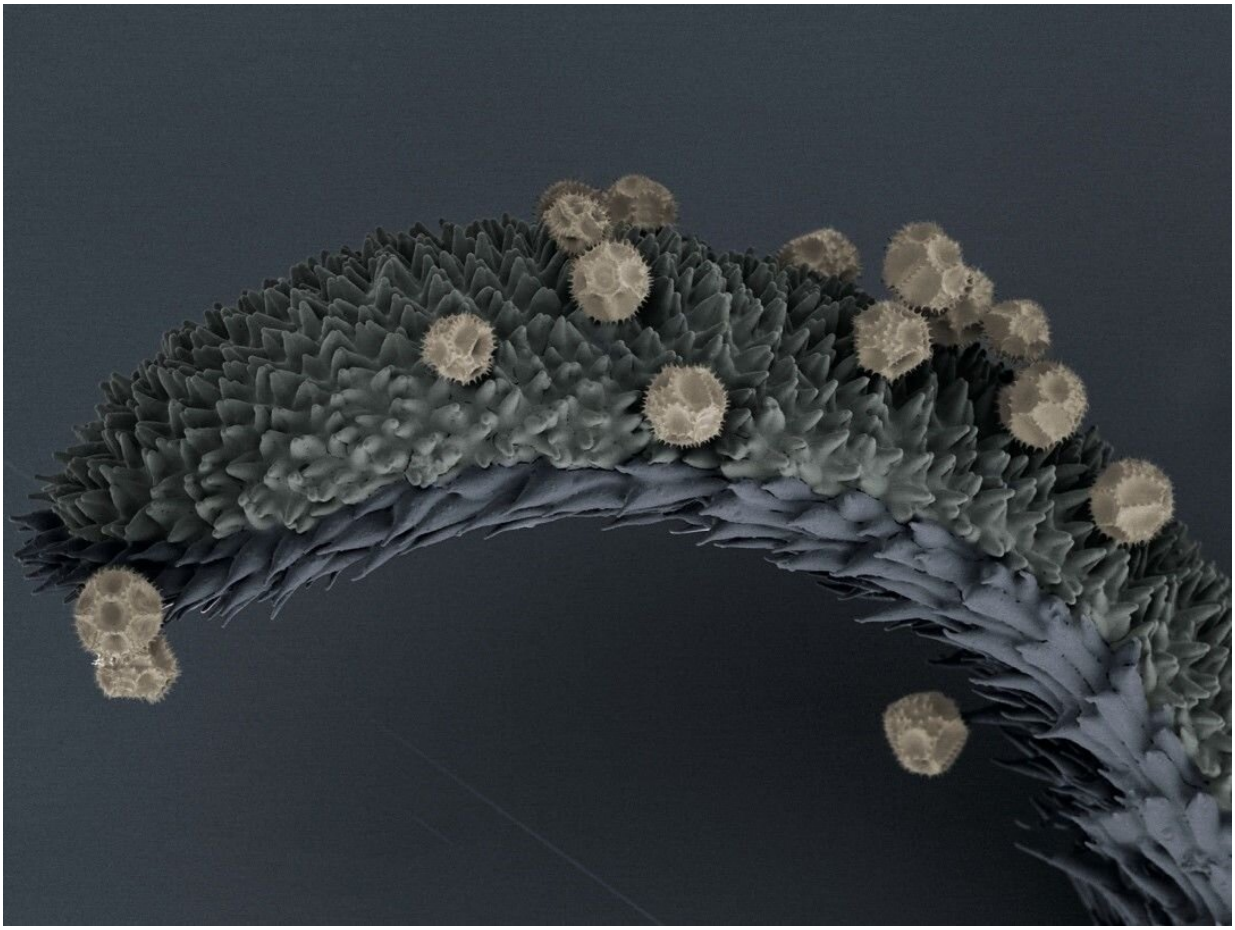

Colored cryo-SEM image of stigma of Hypochaeris radicata. It embraces the successful pollen that have completed their journey of pollination. Credit: Shuto Ito

For allergy sufferers, the pollination period is a tough time, whereas for plants it is the opportunity to reproduce: in addition to the wind, insects, in particular, carry pollen from one flower to another to pollinate them. During this transport, the pollen must repeatedly attach to and detach from different surfaces. To date, the underlying adhesive mechanisms have hardly been studied so far. Now, scientists from the Zoological Institute at Kiel University have discovered that the mechanisms are far more complex than previously assumed. They differ depending on the duration of the contact and the microstructure of the surfaces. In their study presented in the current issue of the *Journal of the Royal Society Interface*, they found a unique pollen gripping mechanism on the receptive female part of plants for the first time. The results could provide important knowledge for the transport of medicinal substances, and also—in light of the alarming decline in insect populations—for the development of alternative strategies in agriculture and food production.

Pollen: an all-round adhesive talent

Itchy nose, red eyes, constant sneezing—materials scientist Shuto Ito suffered from a severe pollen allergy. To learn more about the process of pollen dispersal he left his hometown in Japan to study the adhesive properties of pollen under Professor Stanislav Gorb at Kiel University. Bionics researcher Gorb and his working group "Functional Morphology and Biomechanics" investigate the special abilities of plants and animals, and how these can be imitated artificially.

"If pollen is transported by insects from flower to flower, it encounters three different types of surfaces to which it must attach itself and then detach again. We want to find out which adhesive mechanisms enable this," explained Gorb. Doctoral researcher Ito investigates these mechanisms using as a model species Hypochaeris radicata, also known as common cat's-ear (or false dandelion). This species within the family of the composite plants blooms from spring to late autumn in the entire

northern hemisphere. As with many other plants, the pollen on their yellow flowers is covered with an oily substance known as pollenkitt. "Until now, scientists believed that pollenkitt has a central adhesive function. But we have found out that under certain conditions it behaves in exactly the opposite way. We must consider the adhesive mechanisms in a much more differentiated manner," Ito summarised the findings thus far. Accordingly, pollen adhesion is influenced by a complex interplay of the age of the pollen, the humidity and the respective surfaces for adhesion.

Examining the starting and ending points of the pollen's journey

In their current study, the scientists concentrated on the two parts of the plant, which are most important for the pollination. They represent the starting and ending points of the pollination: on the style of a flower, the pollen grain is presented before it is rubbed off by an insect. On the upper end of the style, the incoming pollen grains land on the stigma.

With an atomic force microscope, the scientists measured how strongly the pollen adhered to both the style and the stigma in Hypochaeris radicata. They discovered that both parts of the plant have very distinct adhesive properties, which change during the course of the pollination. Thus, the pollen adhesion on the stigma increases, while that on the style is rather restrained. The adhesion force of fresh pollen on the stigmatic surfaces exhibited a dramatic increase over the contact time of 180 seconds by a factor of 11.9, while the adhesion force of fresh pollen on the stylar surfaces yielded an increase only by a factor of 2.7.

Optimal adjustment during the course of evolution

"We assume that during the course of evolution, the two parts of the

plant have developed different functions, in order to optimize the pollination process," explained Ito. If the adhesion increased on the style as the starting point of pollination, then the pollen grains could not be detached. In contrast, the stigma has increased its adhesive properties and keeps hold of pollen grains once they come into contact with it. "The newly found pollen gripping mechanism on the stigma is likely to assure the reproduction of plants by anchoring pollen on the stigma until fertilization occurs" Ito continued.

The scientists suggest that the different properties of the two parts of the plant are due to their different surface structures and the presence or absence of secreted liquid on the surface, which can be seen at the resolution of an electron microscope. They examined shock frozen samples of the plants with a Cryo scanning electron microscope. In this condition, the samples retain their original structure, and even fluids such as the secreted liquid on the stigma can be observed in high-resolution images.

New insights into coating processes and transporting medicinal substances possible

"If we can discover the mechanisms by which such interactions of microparticles and surfaces could be controlled, we could potentially draw conclusions for coating and printing processes, the transport of medicinal substances, or the treatment of respiratory diseases," suspects Gorb. And maybe one day special filters for pollen allergy sufferers.

More information: Shuto Ito et al, Attachment-based mechanisms underlying capture and release of pollen grains, *Journal of The Royal Society Interface* (2019). DOI: 10.1098/rsif.2019.0269

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