New study uses video to show honey bees switch feeding mechanisms as resource conditions vary

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Within nature, the compatibility of animals' feeding mechanisms with their food sources determines the breadth of available resources and how

successfully the animals will feed. Those who feed on the nectar of flowers, such as honey bees (Apis mellifera), encounter a range of corolla depths and sugar concentrations. The nectar of flowers comprises the prime source of energy and water for honey bees, who are dominant pollinators throughout the world.

Regional climate conditions contribute to plants producing nectar in various volumes and concentrations, and evaporation and pollinator feeding frequently leaves the nectar reservoirs of flowers below capacity. Thus, honey bees' ability to feed "profitably" under naturally varying resource conditions is advantageous.

An international research team has studied the feeding mechanisms of honey bees and has reported on how these bees switch between using suction and lapping to derive maximum benefit from flowers of varied sizes and concentrations of sugar. The team's study, titled "Honey bees switch mechanisms to drink deep nectar efficiently," is published in *Proceedings of the National Academy of Sciences*(*PNAS*).

Prior research has studied suction and lapping feeding behaviors in honey bees, but this paper notes that earlier studies have included an "unnatural condition of virtually unlimited nectar supplies. Such large nectar pools are rare in the flowers they visit in the wild."

In this study, the team shows that during feeding, the distance between the honey bees' mouthparts and the nectar, as well as the concentration of sugar within the nectar, are determining factors in whether the bees procure it via suction or lapping.

The feeding mechanism of honey bees consists of a long, thin proboscis that includes a pair of labial palpi inside a pair of elongated galea (lobes). This structure serves as a feeding tube, and the bee's hairy glossa (tongue) is situated inside.

For this study, the researchers pre-starved honey bees, fed them sucrose solutions of 10%, 30%, and 50% w/w contained in capillary tubes, and used high-speed videography to record the bees' feeding behavior with each. Blue dye, which had no nutritional effect, was added to each solution for visual contrast, and the bees tolerated it well.

At the 10% w/w concentration, bees inserted their proboscides deep into the solution and extended their tongues beyond the proboscis tubes to suction the liquid until they could no longer reach the meniscus.

At 30% w/w—an approximate concentration commonly found in nature, according to the research—the bees began by quickly lapping the solution, slowing down as the liquid level receded, and gradually switched to suction until the liquid receded beyond their reach.

At 50% w/w, the bees lapped the solution, beginning rapidly and slowing as the liquid receded, and did not transition to suction at all. Notably, the bees showed a smaller decrease in lapping frequency at 50% w/w than during their transitions to suction at 30% w/w.

The researchers conclude that short-distance lapping helps honey bees most efficiently gather nectar to fill the maximum collection capacity of their tongues, but lapping at longer distances would be less efficient than suction due to more time needed for capillary filling. The decreased lapping frequency observed with the thickest of the tested nectars indicates an allowance for the capillary rise needed for maximum tongue-saturation capacity.

In summary, regardless of nectar depth, lapping is a better strategy for honey bees collecting nectars of high sugar concentrations, and suction is faster for those with lower concentrations of sugar.

The team also believes that the feeding mechanism switching behavior

may be a unique ability among this species. Noting a previous study published in *Soft Matter* in which bumble bees (Bombus terrestris) did not switch between feeding behaviors with nectars of varying viscosities, the team in this study also used a solution of 10% w/w with bumble bees to test whether this would change according to their distance from the liquid, but it did not; the bumble bees only exhibited lapping.

Furthermore, previous research with orchid bees (Euglossini) has shown that they mainly use their long proboscides to procure nectar via suction, but that they have exhibited both suction and lapping with small amounts (films) of nectar. However, there is currently no evidence to show that orchid bees make this switch based on corolla depth or nectar properties.

The research team included members from China's Sun Yat-Sen University School of Aeronautics and Astronautics and School of Advanced Manufacturing, The University of Washington Department of Biology and Burke Museum of Natural History and Culture in the U.S., South Africa's University of Pretoria Department of Zoology and Entomology; Belgium's Université libre de Bruxelles, Nonlinear Physical Chemistry Unit and Université de Mons, Laboratoire InFlux; and Kiel University's Department of Zoology in Germany.

More information: Jiangkun Wei et al, Honey bees switch mechanisms to drink deep nectar efficiently, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2305436120