How to know without having been there? — Investigating communication channels in the nectar collecting system of a honeybee colony

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Honeybees collect nectar from flowering plants in the environment to accommodate their energetic demands. In a honeybee colony a temporal caste, "foragers", is collecting nectar. These foragers bring their harvest into the colony, where they unload their nectar loads to one or more specialised "storer bees", another temporal caste in the colony, responsible for the next step of nectar processing. Natural selection has shaped the foraging-related processes of honeybees, like the communication between foragers via dances, in a way that a colony can react to changing environmental conditions in an adaptive way. To investigate this complex dynamic social system and the information and nectar channels we developed a multi-agent model of the nectar flow inside and outside of a honeybee colony. This model allows us to investigate the nectar collection process and nectar processing pathways on the colony level, as well as from the point of view of a single bee during the foraging trip and during the nectar proceeding inside the colony. The simulation includes near-natural environmental factors, like scattered nectar sources with variable distances between flowers and a near-natural model of the honeybee metabolism. The inside of the colony (the so called "dance floor") was simulated as two one-dimensional transfer zones for foragers and storers, what enabled us to simulate the unloading-procedure in a highly abstract and defined manner. Our model predicts that a cohort of foragers, collecting nectar from a single nectar source, is able to detect changes in quality (e.g., the nectar flow) in other food sources they have never visited, by analysing side-effects of the nectar processing system of the colony: We identified two novel pathways of forager-to-forager communication by analysing the results predicted by our model. Foragers can gain information about changes in the nectar flow in the environment via two ways: Firstly, foragers can detect changes in their mean waiting time for unloadings, which are performed by the storer bees. Secondly, the foragers can detect changes in the number of experienced multiple unloadings after returning from a foraging trip. The amount and quality of information available to the single forager about the environmental situation is increased, what enables the forager to modulate its individual decisions. The sum of this modulated forager decisions can lead to an optimisation of the foraging behaviour in an unsteady environment. This way, two distinct groups of foragers, that forage on different nectar sources and that never communicated directly, can share information via a third cohort of worker bees. We show that the communication channels within this noisy social network allow the colony to perform collective information processing. Simulation runs with fluctuations in the environmental nectar flow revealed, that the honeybee foraging system is even more adaptive (by exploiting the before mentioned communication channels) than was previously thought.