The role of pollen as a reward for learning in bees

Submitted by **Elizabeth Nicholls** to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Psychology

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature: ……..

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Abstract

In contrast to the wealth of knowledge concerning sucrose-rewarded learning mechanisms, the question of what bees learn when they collect pollen from flowers has been little addressed. Pollen-rewarded learning is of interest not only in furthering our understanding of associative conditioning pathways in the insect brain, it may also shed light on the role that cognitive processes may have played in shaping the early evolutionary relationship between plants and their pollinators, given that pollen is thought to have been the ancestral reward for flower visitors. Thus the central aim of this thesis was to demonstrate the conditions under which pollen may reinforce learning of floral features in two model species, the honeybee (*Apis mellifera*) and bumblebee (*Bombus terrestris*). Having developed a number of paradigms for the study of pollen-rewarded learning, here I ask what bees might learn during pollen collection, both in terms of the sensory characteristics of pollen itself and additional cues paired with this reward. Freely flying bees were shown to be sensitive to differences in the type of pollen offered for collection and were able to associate the presence of a coloured stimulus with both the availability and quality of the pollen reward. The sensory pathways involved in the evaluation of pollen were also investigated. When bees were restrained, in order to more tightly control exposure to the reward, pollen was not found to support learning in an olfactory conditioning task. Furthermore, when delivered in solution with sucrose, pollen was found to inhibit learning relative to bees rewarded with sucrose alone. It seems that pollen contains compounds which are perceived as distasteful by bees and that through the contamination of nectar, pollen may influence bees foraging decisions via differential learning and recognition of floral cues.

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