

# ELECTRONIC APPENDIX

This is the Electronic Appendix to the article

Flower choice copying in bumblebees

by

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Electronic appendices are refereed with the text; however, no attempt is made to impose a uniform editorial style on the electronic appendices.

## Online Supplementary Material

### Darwin's field notes

Darwin described his observations of bumblebees cutting holes at the base of flowers of the kidney bean plant and feeding from the nectar (nectar robbing). He then observed honeybees feeding from the holes cut by the bumblebees. Darwin wrote:

I think the hive bees [honey bees] either saw the humble bees [bumblebees] cutting the holes and understood what they were doing and immediately profited by their labour; or that they merely imitated the humblebees after they cut the holes and when sucking at them. Yet I feel sure that if anyone who had not known the previous history had seen every single hive-bee, without a moment's hesitation flying with the utmost celerity and precision from the underside of one flower to another, and then rapidly sucking the nectar, he would have declared that it was a beautiful case of instinct.

*(Romanes, 1884)*

### Material and Methods

#### a) Colours

During colour training and testing a 6 cm diameter circle of orange (HKS6n) or light green (HKS65n) coloured paper (Hostmann-Steinberg K+E Druckfarben, H. Schmincke & Co., Germany) surrounded each feeder hole, and the six circles were arranged against a dark green (HKS58n) coloured background. Note that the “green” flower models reflected in blue, green, yellow, and into orange wavelengths (figure 3). The two colors were chosen based on previous tests that showed that bees were able to distinguish both colors from one another and the background (Worden et al. 2005).

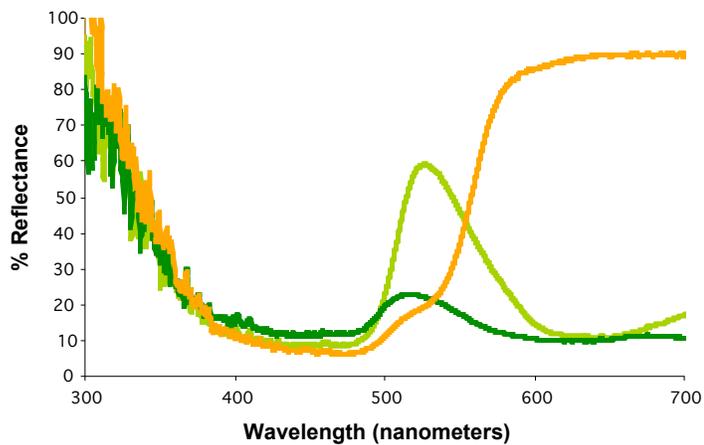


Figure 3. Reflectance spectra of coloured papers used for constructing background and flower models. Colours of lines represent flower colours (orange, light green) and dark green background

(b) Control for bee odours

Bumblebees mark flowers that they visit with scents, and other bees respond to these odours (Stout & Goulson 2002). These experiments were designed to detect visual copying exclusively. First, we changed flowers and wicks after removing live models from the arena so that scent marks from model bees were eliminated. In addition, the flower positions were randomized between model feeding and subject testing, so that any information left by models in the arena would no longer be accurate in directing bees towards rewards. Secondly, the experiment with artificial bees eliminated a potential for odour cues in the arena.

(c) Artificial bee models

Artificial bee models were made from hot glue injected into silicon molds (Smooth-On, Inc.) of dead bees, and were painted with acrylic paint (Golden Colors, Inc.) to closely match reflectance spectra of *B. impatiens* workers using an S2000 spectrophotometer (Ocean Optics, Inc.) with tungsten-halogen light source, referenced to a white Spectralon standard (see photo).

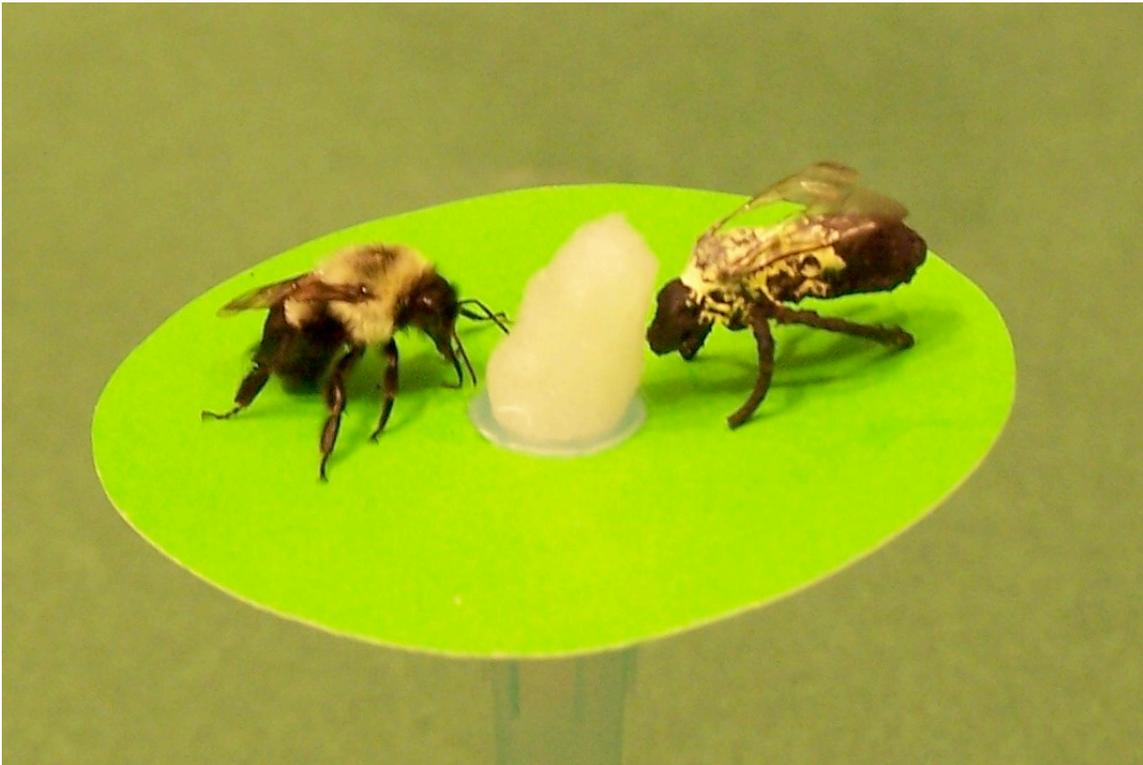


Photo caption: Live *Bombus impatiens* (left) with an artificially constructed model “bee” (right) on a green artificial flower.

Additional Reference

Stout, J. C. & Goulson, D. 2002 The influence of nectar secretion rates on the responses of bumblebees (*Bombus* spp.) to previously visited flowers. *Behav. Ecol. Soc.* **52**, 239-246.