The organization of foraging behaviour

Average-quality territories can have 3000 flowers, and residents must harvest nectar from all of them, every day, just to stay alive. But to gain enough fat in a week or two to fuel their flight to Mexico for the winter (about 40% of their body weight), they must not waste more energy than necessary to harvest energy. How do they accomplish all this, and in particular how "street smart" are they? Some of the studies this question generated blew our minds. Here's one example.

Glenn Sutherland and I used a combination of experimental enrichment of patches of flowers and detailed observation of behaviour to see how sensitively hummingbirds respond to variation in the profitability of different parts of their territories. Every morning for three summer seasons, we recorded where residents went in their territories, what they did when they got there, and how long they took to do it, accurate to a small part of a second. This included all probes of flowers, all aggressive interactions with other hummingbirds, and all bouts of flying and perching and averaged some 3000 hummingbird actions per 4-hour session.

The experiment unfolded in a 4-day cycle. We recorded behaviour every morning, beginning at first light. The first day was an unmanipulated control; we just recorded what the bird did without changing anything. Well after dark on the first and second nights, we added a precisely calibrated amount of nectar to each flower in one particular patch of flowers and then retired, then recorded again in the morning. We enriched no patches the third night, then recorded again the fourth morning.

These data showed us that territorial hummingbirds respond sensitively to the relative profitability of patches of flowers within their territories. Once they discover a bonanza, they specialize on it, statistically, until they've milked it down to the average quality of the other patches in the territory. Specializing on the bonanza releases foraging pressure on the other patches, allowing them to accumulate more nectar. Specializing yields more nectar for less flying time, and allows more perching time. Because residents usually detect intruders from the perch, this strategy also affords more efficient territory defense and faster fat gain than if they foraged equitably among patches as they had done before making the discovery.

Excitingly, the same data showed that hummingbirds' "spatial memory" of the spatial structure of their environments is very well developed, and allows them to survive and thrive in the rapidly changing economy of mountain meadows. Here's a dramatic example.

On Day 1 of the cycle, when territories were unmanipulated, residents first visited the patch that we would enrich that night after about 40 minutes of foraging, on average. When that patch was enriched on Day 2 but the bird didn't know about it yet, they got there after the same amount of foraging. But on Day 3, when the patch was enriched and it had also been enriched the day before, they got there much quicker than before, and sometimes immediately. The hummingbird remembered the bonanza at least overnight, then used that knowledge to guide its foraging the next day! The strongest evidence for spatial memory came on Day 4, when the patch was no better than others but it had been better the day before: the bird visited it immediately. For us, this "mistake" strongly reinforced the primacy of spatial memory. Hummingbirds were foraging by what we thought of as “spatially structured expectations” of profitability. You will see below that the “mistake” also inspired the “switch experiment” that we used in Glenn’s MSc study of hummingbird spatial memory.