Bees Foraging for Food

Foraging animals have a basic problem to solve, when their food supply is in patches (acorns under trees, flowers growing in patches, worms in apples, etc). Food is easy to collect food when they first begin searching a new area. As the animal continues feeding, food becomes more difficult to find and it has to search longer and longer for each additional morsel. This suggests that the curve relating the time spent foraging in the patch and the amount of food found (or energy gain) starts off with a steep slope but then gradually levels off. Food is easy to find in another patch, but it takes time to find and travel to the next patch, and the animal gains no food while it is traveling.

The choice about how long to stop for a feeding is one of the basic decisions for an organism that is searching for resources among widely scattered patches. What is the optimal "giving up time" (when an organism should leave a patch that it is exploiting). When should the animal say enough is enough and move on to find the next patch? One crucial parameter that governs this decision is the travel time between patches. An animal gains no energy while traveling.

Other situations are quite similar. Guppies are a small tropic fish found in freshwater streams in Trinidad. The males court females and the female chooses whether or not to mate with male. The longer a male courts a female, the greater his chance is of mating with her. The males are polygynous (they may mate with many females) but they must spend time searching for each female. How do they decide when to abandon the courtship and try another female?

For our example, we will consider a bee foraging for pollen on flowers that are dispersed across a yard. It gathers pollen rapidly when it first arrives at a new plant, but then finds it more difficult to pick up additional pollen. At some point, the bee must decide when to leave for "greener pastures". Figure 1 illustrates the consequences of this choice.

Suppose it takes 5 seoncds to travel between flowers and the pollen collection function is

$$C(t)=\begin{cases} 0 \text{ if } t<5 \\ 30-30e^{-0.2(t-5)} \text{ if } t\geq 5. \end{cases}$$

Figure 1 illustrates the difference in total pollen accumulation in a 40 second period if the bee forages for 5 seconds before moving on and foraging for 15 seconds before moving on. Notice the total amount accumulated in a 40 second period is greater for 5 second foraging (about 76 μg) than for 15 second foraging (about 58 μg).

In this investigation, we want to determine the length of time that gives the largest total pollen accumulation in a fixed period of time.

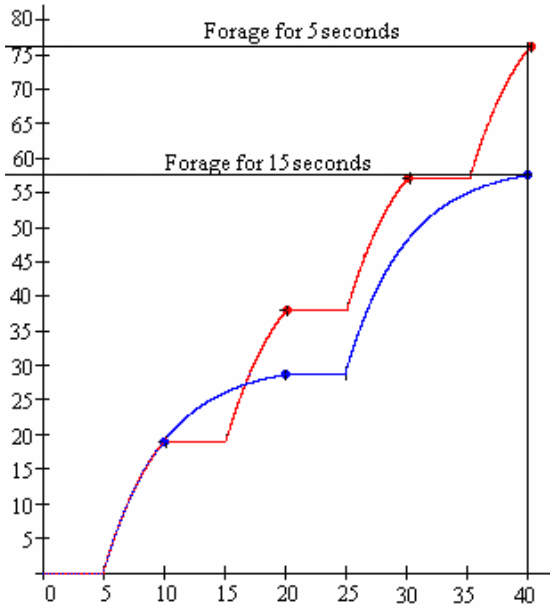

Figure 1: Comparing 5 and 15 second foraging times