**PREDATOR-PREY INTERACTIONS**

**Predation** refers to the interaction between two organisms, in which one (the prey) is killed and consumed by another (the predator). These interactions may occur between two organisms belonging to different species, or between two individuals of the same species. Dynamic models of predator-prey interactions have been developed, which show how the population sizes of both predator and prey species fluctuate over time. Past research has revealed that predation rates and patterns of population fluctuation vary considerably in frequency and intensity in response to a number of key factors. Primary among these factors are:

• Relative abundances of predators and prey

• Relative sizes of predators and prey

• Predator gender

• Prey physical/behavioral attributes (e.g., cryptic color, escape mechanisms)

• Energetic quality of prey

• Predator condition or gut fullness

• Predator experience

• Habitat heterogeneity

Last week we learned how competition for food can lower food intake and change preferences of an individual, potentially affecting other aspects of its life like survival, reproductive success, and the evolution of behavioral, life history, or morphological adaptations. The risk of predation can be a selective pressure on these traits as well. We saw that population size, life history traits including timing and quantity of reproduction, and morphological traits like tail shape, were affected by the presence of predators in guppy populations on campus. Today, we will look further into *non-consumptive effects of predator-prey dynamics* to discover how resource supply and predation pressure influence foraging decisions, such as the tradeoff between foraging and fleeing, and giving up density.

Consumers must decide how to allocate their time, energy, and attention when foraging to avoid predation. The way scientists expect consumers to navigate the tradeoff between eating and avoiding being eaten (among other things) is addressed in **optimal foraging theory** (OFT). Natural selection will favor foragers that maximize their food intake while allocating enough to their other needs. In this lab we will work with the tradeoff between foraging and fleeing predation. In the presence of predators, foragers face many **trade-offs** that relate to acquiring energy (i.e. feeding) while staying safe (see Lima and Dill 1990; Lima 1998 for reviews). These trade-offs may involve:

1. Splitting time between foraging and keeping an eye out for predators (vigilance)
2. Deciding to forage in dangerous but productive habitats versus safer but less productive ones (**resource supply** vs. predation risk)
3. How much food to remove from patches that vary in the risk of predation (**giving up density**, GUD)
4. When to cease foraging to flee an approaching predator (**flight-initiation distance**, FID)
5. How many individuals to forage with (group size)
6. Deciding how quickly to move, when to forage actively, and how long to forage (activity time and level)

Flight is a common reaction to the immediate threat of a predator. It involves deciding at what distance from the predator to initiate flight (FID), escape direction, and escape velocity. Because fleeing is costly in terms of both energetic expenditure and lost foraging or mating opportunities and fleeing too late can mean being killed, animals should not necessarily flee as soon as a predator is detected. Optimal foraging theory predicts there is an **optimal flight response** (Ydenberg and Dill 1986; Dill 1990). The cost of flight, the speed and angle of approach of the predator (loom rate), and distance to safety can influence escape responses (Ydenberg and Dill 1986; Dill 1990; Lima and Dill 1990; Bonenfant and Kramer 1994). OFT predicts that FIDs will be shorter (predators allowed to approach closer) when costs of flight are high, the loom rate is lower, and habitat characteristics favor easier escape (e.g., distance to cover is shorter). Often, the distance or time to safety is equivalent to the distance to a physical refuge, but in marine systems time to safety might be the amount of time it takes a prey animal to reach a critical velocity or find a good hiding place so they are inaccessible to a predator (Heithaus et al. 2002). Dill (1990) proposed that animals would maintain a consistent “margin of safety” by selecting a combination of escape velocity and FID. However, the margin of safety may increase as distance from cover increases since some species appear to flee well below their maximum speed. This choice of escape velocity would allow prey to respond to acceleration by the predator, and having such flexibility may be relatively more advantageous as distance from safety increases (Bonenfant and Kramer 1994).

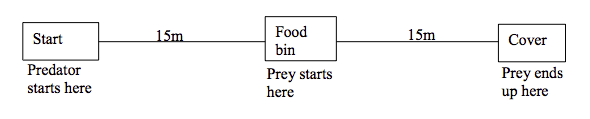
One way to test for the existence of food-risk tradeoffs besides changes in FID is to measure the giving up density (GUD) of foraging individuals. The GUD is the density of food remaining in a patch at the time an individual, or group of individuals, ceases foraging and abandons the patch (Brown 1988; 1992; 1999). OFT predicts that GUDs should be greater in habitats with higher predation risk than those with lower risk, since the marginal gain of continued foraging in a high-risk habitat does not outweigh the benefits of continued foraging at low food densities. However, the exact GUD in a patch will also be influenced by food availability in other patches, since time spent foraging represents lost foraging opportunities in other patches (Brown, 1988, 1992; 1999). This prediction has been supported in a number of species foraging on immobile prey such as granivorous rodents and squirrels (Brown 1988; 1992).

**Activity**

Students will break into groups of 3. One person will record data, and the others will play the parts of prey and predator. Each trial will start with the “predator” standing 15m from the “food” bin where the “prey” is foraging. The cover (refuge or hiding place) is 15m away from the Food bin and in line with the cover (Fig.1). The cover is a safe zone where the predator cannot attack the prey. The data collector will initiate the trial by yelling “Go!” and immediately the predator should start running toward the prey (maintain a constant speed for all trials) carrying a marker. The prey gathers food items one at a time for as long as possible and then flees to cover. At the moment the prey ceases foraging to flee, the predator drops the marker but continues pursuing his prey. The distance from the marker to the food bin where the prey started is the FID, and will be measured at the end of each trial. There are 3 possible outcomes of each trial: survive, starve, kill. If the prey reaches cover before being tagged by the predator, he has “survived”. If the prey did not obtain any food items, he “starved”, regardless of reaching cover or not. If the prey is tagged by the predator before reaching cover, he has been “killed”.

There are 2 treatments: high and low food resource. For the “high” treatment, there will be twice as many food items in the bin as for the “low” treatment. Each group of students will conduct each treatment 15 times. Record the data as shown in the data sheet below (Table 1). After every trial, replace the food before conducting the next trial.

Figure 1. Activity layout



**Materials (per group):**

Suitable outdoor and running clothes

One food bin with enough food for the “high resource” treatment

Data sheet with 15 trials for each of the two treatments

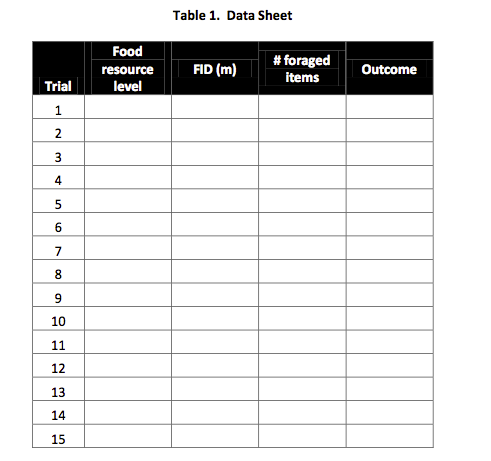
Flags to mark the start and cover areas

Transect tape to set up the activity and measure FID

**LITERATURE CITED**

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**Table 1. Data Sheet**

**Food re**