Predator–Prey Interactions

Predator–prey interactions have been among the most intensively studied areas of aquatic biology during the past several decades. Investigations have focused particularly on theories of “optimal foraging,” which seeks to describe predator behavior [e.g., Charnov (1976), Werner and Hall (1974), and Pyke (1984)], and “predator mediated community structure” (Hrbacek, 1962; Brooks and Dodson, 1965; Hall et al., 1976; Zaret, 1980; Werner and Gilliam, 1984; Sih et al., 1985; Kerfoot and Sih, 1987; Lampert and Sommer, 1997), which interprets community structure in relation to predatory activities. Many of these hypotheses still are speculative, although supporting evidence for some is growing. These concepts form a useful basis for the study of predator–prey relationships. The literature on this subject is extremely large; a few summary articles relative to limnology are cited in this exercise.

In evaluating predator–prey interactions, both the predators and prey have physiological and behavioral characteristics that must be considered. Major predator characteristics that can be evaluated include: (1) visual, mechanical, or chemical detection of prey; (2) how much energy is required during searching for and attacking prey; and (3) energy and time expended in handling, and total or partial consumption of prey. Evaluation of the ways in which prey respond to predation requires considerations of: (1) behavior and energy expended in escape responses, often by refuge in space and/or time; and (2) means by which prey adapt and coexist with predators. The latter coexistence can be accomplished by camouflage, differences in size, release of repulsive chemical compounds, frightening displays, evasive movements, morphological structures that impede or prevent consumption, and aggregation in large groups.

Predators and prey respond continuously to each other’s adaptations, which results in constant, although slow, coevolution and changing interactions. The extent of interactive couplings can be evaluated by exposing prey to predators under controlled experimental conditions [e.g., Thompson (1978) and Werner (1974)] or by the introduction of new predators or prey into established ecosystems [e.g., Langeland (1981) and Morgan et al. (1978)]. The latter approach should not be done without considerable forethought and understanding of ecosystem properties. The former experimental approach will be used in this exercise to gain insight into some basic predator–prey interactions.

OPTION 1

Procedures

The objective of this exercise is to compare the feeding characteristics of two predators, a common fish (bluegill, *Lepomis macrochirus*) and a dragonfly nymph
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(Corduliid odonate, *Tetragoneuria* spp.) under different conditions of light and prey densities. The prey will be *Daphnia magna*, a relatively large zooplanktonic cladoceran.

**Effects of Light on Predator Success**

**Procedures**

1. Place one bluegill and one odonate into separate containers filled with equal volumes of water at room temperature. Allow the organisms to acclimate for 15 min without disturbance (such as loud noise or startling moves), particularly around the fish. These predators have been starved and should feed readily.

2. Select 30 *Daphnia* of similar size from the available culture. Carefully add 15 *Daphnia*, one at a time with a wide-bore pipet, to each container and observe the feeding for 3 min. Remove the predators and count the prey remaining in each container. Record the number of prey consumed by each predator. Place each fed predator in a designated repository to avoid accidental reuse in subsequent experiments.

3. Repeat steps 1 and 2 above, but place the containers into total darkness immediately after adding the prey to each. Speed is essential when adding prey and placing the containers into darkness and when removing the predators after the 3-min feeding period.

4. Determine instantaneous prey mortality rates (*M*) for prey under different conditions, where:

   \[ M = \frac{(\ln N_0 - \ln N_f)}{t} \]

   and \( N_0 \) = initial prey density, \( N_f \) = final density of live prey, and \( t \) = time units (Dodson, 1975). The units of *M* are prey mortality per predator per time, usually a day.

**Questions**

1. Based on your observations and pooled class data on the feeding in light, compare predation by the fish and by the odonate.
   a. How does each predator detect prey?
   b. How does the prey organism detect the predator? What defenses do the prey appear to have?
   c. What predation strategy (searching or ambushing) is employed by each predator?
   d. What energy considerations are associated with each strategy?
   e. How are the prey consumed by each predator, and how does this affect feeding?
   f. What additional information would be useful in making a more complete evaluation of the effects of light on these predators?
   g. What environmental (habitat) factors favor each predator?
   h. What sources of error are possible in these experiments? How would they affect the results?

2. Why should exotic predators or prey not be introduced into natural ecosystems without “considerable forethought”?