

Fish as Prey “Anti-Predation Cycle”

- Predator-prey “arms race” results in prey evolving strategies to deter each stage in the predation cycle
- In prey, selection strongly favors strategies that disrupt the predation cycle as early as possible (i.e. don't be seen and you can't be eaten)



The “Anti-Predation” Cycle

- Avoid detection
- Evade pursuit
- Prevent and deflect attacks
- Discourage capture
- Discourage handling



Predation Cycle-5 parts

- Searching
- Pursuing
- Attacking
- Capturing
- Handling

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Avoid Detection

- **Camouflage**

- **Protective resemblance:**
(Make yourself look like your background)

- Body growths
 - Background matching coloration
 - Reduced movement
 - e.g. leafy seadragons mimic seaweed
 - e.g. flatfish change color and pattern



Avoid Detection



- **Camouflage - Disruptive coloration**

- Body covered regions contrasting colors (or vertical bars or spots)
 - **Breaks up outline of fish** - less recognizable as potential food item
 - e.g. angelfish (left), jackknife fish (right)

Avoid Detection

As an alternative to camouflage, prey may be conspicuous, but use **mimicry** to resemble something inedible!

- E.g. look like plant material, or mimic a toxic fish

Below: (a) tasty prey fangblenny w/ color pattern that mimics (b), a juvenile bluestreak cleaner wrasse that is left alone by most predators.

Shown in (c) and (d) are fangblennies that lack mimetic coloration.



Avoid Detection

- Invisibility
- **Countershading**
 - “Unique to aquatic systems” (raptors??)
 - Pattern on fish opposite to patterns of light in water
 - Dark on top, light on bottom
 - View from top - fish blends into dark water background
 - View from bottom - blends into light background of sky
 - Works for all viewing angles
 - **Reverse countershading** used by males during breeding season



Avoid Detection

- **Invisibility: silvery sides**

- Open water species
- Covered in small “mirrors”
- Laterally compressed to be as vertical as possible (deviations from vertical make the fish visible – hence silvery flashes!)



Avoid Detection

- **Detect your predator before it detects you!**

- Swim in a shoal or school (more eyes on the look-out!)
- Spend time under objects that cast a shadow
 - Being in shadow allows a fish to see predators in the open, well before the predator sees them (think about driving through a forest)
 - But... predators use the same strategy!



Avoid Detection

- **Invisibility: Transparency**

- Surface dwelling species
- e.g. glass fish
- Larvae and juvenile fish
- Clear muscles and bones
- Brain, eye, gonads can't be clear
 - Covered by silver film (function unknown)



Avoid Detection

- **Swim with others**

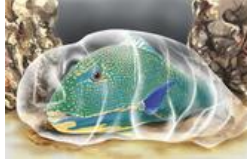
- Lower probability of detection for an individual in a school than an individual on its own
- Different species form **monospecific groups**
 - Predators target different individuals
- Prey can act as a group aggressively towards predator (= **mobbing behavior**; also seen in birds)
- **Predator inspection**
 - Single fish go out and evaluate predator (i.e. somebody drew the short straw)



Avoid Detection

- **Beyond visual detection**

- In general, little known
- Sound is more important to conceal in terrestrial habitats (easier to hear in water, but harder to locate source of sound)
- Electric insulation to avoid detection by electrolocation...??
- **Mucous cocoons** of resting parrotfishes (excreted from gills) *may* prevent the release of body chemicals that could reveal their presence to predators.... (?)



Evade Pursuit

- **Strategies to discourage predator**

- Spines
- Toxic skin/internal organs
- Make use of **aposematic** (=warning) coloration or behavior:
 - Bright, conspicuous coloration and/or slow escape response
 - Signal to predator that they are dangerous
 - e.g. surgeonfish, lionfish



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Evade Pursuit

- **Move to shelter**

- Complex habitats
 - Bottom sediments
 - Macrophytes
 - Corals
 - Any spaces prey can get into that predator cannot follow



Evade Pursuit

- **Move to shelter** - Complex habitats
 - E.g. garden eels, zooplanktivores, razorfish



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Evade Pursuit

- **Open water escape!**
 - Outrun, out-maneuver, or “fly”
 - Most prey can’t outrun predators - are smaller
 - Prey may be able to out-maneuver
 - Flyingfish “fly” (i.e. jump and glide) out of the water
 - Can double their speed (up to 70 km/h & 8m out of water)!
 - Many prey species jump out of water, do not glide like flyingfish



Prevent and Deflect Attack

- **Prevent** with last-second evasive move
- **Deflect** with structural defenses (i.e. spines, etc.)



Prevent and Deflect Attack

- **Foraging in groups** helps prevent attack
- **Dilution effect** = the probability of an individual being eaten decreases with larger group size



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Prevent and Deflect Attack

- **Prevention of attack by group foragers**
 - **Confusion effect:** Predators become confused by so many prey (some specific prey behaviors encourage this)
 - Predators switch targets too often to catch many prey
 - Prey fish choose to enter larger schools when given the choice



Discourage Capture

- Take advantage of **gape limitation**
- Static or dynamic adaptations associated with body size/shape
 - Prey may be difficult to handle or hard to eat
 - Elongate spines or fins or very deep body
 - Blow up (e.g. pufferfish) or erect spines (e.g. bluegill)



Discourage Capture

- **Alarm chemicals** (Ostariophysii)
 - Produced when the skin is broken; other fish may respond by schooling more densely, leaving area, etc. (response varies by species). Alarm chemicals may also attract larger predatory fishes that scare off the target predator
- **Visual alarm signals** (fin movements, head bobbing—again, used to communicate with others)
- **Auditory signals**
- Evolution of signals requires a benefit to individual
 - Kin selection
 - Attraction of larger predator

Discourage Handling

- Rabbitfishes - forward directed spines, so they can't go in backward or forward
- Mucus excretion
 - Distasteful (e.g. toadfish) or may make mechanical handling difficult (e.g. hagfish)
- Tough dermis
- Releasable scales



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Foraging vs. Threat of Predation

- **Tradeoff:** the more a fish forages, the more food it will acquire, but also more likely to be eaten



- Many fish species change foraging behavior or switch habitats when predators are present
- Fish constantly conducting **cost-benefit analyses**
 - Willing take more risks if rewards are greater
 - Another way to think of optimal foraging theory (i.e. increase benefit and minimize cost)

Trophic Cascades (more later)

- Indirect interaction

- **Density mediated**

- Pisciivores effect zooplankton by eating zooplanktivores

- **Behaviorally mediated**

- Pisciivores effect zooplankton by causing zooplanktivores to change their foraging behavior

