UNIT 4. PREDATORS VS. PREY: EVOLUTIONARY ARMS RACES

SOURCES

required: Chapter 4 in Krebs & Davies (1993)
remedial: "Hunting" in Halliday 1994; "Hunting & Escaping" in the Trials of Life video series
supplement: Chapter 7 in Blumstein, D.T. and Fernandez-Juricic, E. "A Primer of Conservation Behavior"

PARTS OF THIS LECTURE OUTLINE

1. Adaptation or story-telling?
2. How can an arms race begin?
3. How do arms races end?

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1. ADAPTATION OR STORY-TELLING? *(Table 4.1 in Krebs & Davies 1993:77)*

1.1. Importance of testing hypotheses about co-evolution *(Krebs & Davies 1993:77-79)*

1.1.1. predator adaptations, e.g. learning abilities of blue jays
1.1.2. prey counter-adaptation, e.g. cryptic forewings & bright hind wings
1.1.3. hypotheses re. wings of Catocala moths (Fig. 4.2)
  1.1.3.1. cryptic fore wings => decrease detection by predator
  1.1.3.2. bright hind wings => increase startle effect on predator

1.2. Cryptic fore-wings *(Pietrewicz and Kamil 1981 cited in Krebs & Davies 1993:79-82)*

1.2.1. slide-shows for jays in aviary (Fig. 4.3)
1.2.2. correct response=> jay rewarded with a mealworm
  1.2.2.1. moth slide => jay pecks slide
  1.2.2.2. no moth on slide => jay pecks slide-advance key
1.2.3. incorrect response=> delay in presentation of next slide
1.2.4. results: two working hypotheses were accepted
  1.2.4.1. jays made more errors when moths matched background
  1.2.4.2. jays learned search image: same cryptic moths=> fewer errors

1.3. Bright hind-wings *(Tinbergen 1974: Fig. 4.5; Schlenoff 1985 cited in Krebs & Davies 1993:83-84)*

1.3.1. great tits more frightened by image of eye than symbol "+"
1.3.2. blue jays responded to moth-models with bright hind wings
  1.3.2.1. trained on grey hind wings=> startled by bright hind wings
  1.3.2.2. trained on bright hind wings=> not startled by grey hind wings
1.3.3. results: two working hypotheses were accepted
  1.3.3.1. birds show a startle response to bright eye stimulus (innate?)
  1.3.3.2. birds habituated to bright, do not respond to grey hind wings

1.4. Co-evolution: driven by predator searching activity *(Table 4.1 in Krebs & Davies 1993:77, 88-90)*

1.4.1. predator adaptations
  1.4.1.1. improved visual acuity (sensory morphology)
  1.4.1.2. learn search image (cognitive: food item)
  1.4.1.3. learn where to search for abundant prey (cognitive: food patch)
1.4.2. prey counter-adaptations
  1.4.2.1. crypsis (morphology)
  1.4.2.2. polymorphism (genetic variation; multiple adaptive peaks)
  1.4.2.3. avoid aggregations (behavior: dispersal)

1.5. Take-home message: Adaptationist story-telling

1.5.1. Myth: explanatory story that cannot be tested
1.5.2. Science: hypotheses that can be tested (function & evolution)
1.5.3. Example: co-evolution of bird learning abilities & moth wing color

TIP: To learn more about the fallacy of "adaptationist storytelling", google it, or search for "Adaptationism" on Wikipedia.

Part 1	**Study Questions for Chat & Quiz 4 "Adaptationist Storytelling"**
1.1	Describe two hypotheses about the function of an anti-predator adaptation of an insect, which is explained by coevolution of predator and prey? (TIP: e.g. fore and hind wings of Catacola moth)
1.2	How was an hypothesis about the function of crypsis tested for a species of your choice? (TIP: e.g. Catacola moth)
1.3	How was an hypothesis about the anti-predator function of bright coloration tested in a species of your choice? (TIP: e.g. Catacola moth)
1.4	Describe the co-evolutionary steps in which a predator's foraging behavior "set the stage" for counter-adaptation of its prey? (TIP: e.g. birds and insects)
1.5	What distinguishes myth from science in explanations of why there appears to be such a nice match between adaptations of prey and their predators?

2. HOW CAN AN ARMS RACE BEGIN? (initial steps in co-evolution)

2.1. crypsis- camouflage *(Erichsen et al. 1980 cited in Krebs & Davies 1993:84-86)*
- 2.1.1. hypothesis re. wasted time due to empty "hits"
  - 2.1.1.1. if increase in search time is a cost to predator
  - 2.1.1.2. then those prey that are harder to detect will have higher fitness
- 2.1.2. experiment: great tits choose prey in straws from conveyer (Fig. 4.6)
  - 2.1.2.1. predictions based on mathematical equations (risk aversion)
  - 2.1.2.2. many empty straws, few cryptic large prey=> birds chose small prey
  - 2.1.2.3. few empty straws, many cryptic prey=> birds chose large cryptic prey
- 2.1.3. interpretation: only if crypsis increases search time will it be adaptive

TIP: If math is not "your thing", skip over the equations in this section, and focus on the word descriptions. For students who are talented in math and engineering, the equations may be easier to understand than the word.

2.2. **conspicuous warning coloration** *(Gittleman and Harvey 1980; Fig. 4.8 cited in Krebs & Davies 1993:86-88)*
- 2.2.1. hypothesis re. wasted time due to startle response
  - 2.2.1.1. if increase in handling time is a cost to predator
  - 2.2.1.2. then bad-tasting prey with warning coloration will have higher fitness
- 2.2.2. experiment: chicks chose colored bread crumbs on colored background
- 2.2.3. prediction: choose bright crumbs until chicks learn they are bitter o observation: as expected (Fig. 4.8)
- 2.2.4. interpretation: predators learn to avoid conspicuous bad-tasting prey

2.3. **trade-off between conspicuousness and crypsis**- guppy fish *(Endler 1983 cited in Krebs & Davies 1993:90-91)*
- 2.3.1. bright colors for mating (females choose males)
  - 2.3.1.1. diet related (red, orange, yellow)
  - 2.3.1.2. heritable structures (iridescent blue and bronze scales)
  - 2.3.1.3. neuro-endocrine behavior (black spots; melanin; size change)
- 2.3.2. dull colors for avoiding predation (crypsis)
  - 2.3.2.1. streams with predators=> fewer spots on guppies
  - 2.3.2.2. shrimp predators (red-blind)=> guppies still had red spots

2.4. **Experimental tests of hypothesis** *(Endler 1980 cited in Krebs & Davies 1993:91; Fig. 4.9)*
- 2.4.1. field: moved dull guppies from predator to non-predator stream
  - 2.4.1.1. result- proportion of guppies with spots increased in 2 yrs
- 2.4.2. lab: two tanks of fish observed for 20 months
  - 2.4.2.1. no predators=> increased proportion of spotted guppies
  - 2.4.2.2. predators=> decreased proportion of spotted guppies

2.5. Take-home message: initial steps in co-evolution
- 2.5.1. crypsis vs. conspicuousness
- 2.5.2. e.g. tits & worms in straws, chicks & crumbs, dull & bright guppies

Part 2	**Study Questions for Chat & Quiz 4 "How do Arms Races begin?"**
2.1	How was an hypothesis about initial steps in the evolution of a cryptic trait used as a basis for testing a model of foraging behavior for a species of your choice? (TIP: e.g. lab study of cryptic prey)
2.2	For "warning coloration", explain how an hypothesis about function was used to design and test a model about mechanisms of foraging behavior? (TIP: experimental manipulation of prey color and reward)
2.3	What is an example of heritable polymorphism in a population, related to an anti-predator adaption? (TIP: e.g. guppies)
2.4	How did Endler test the functional trade-offs between crypsis and warning coloration by examining polymorphism in a species? (TIP: Fig. 4.9 in KD'93)
2.5	How do predator/prey "arms races" get started?

3. HOW DO ARMS RACES END?

3.1. **brood parasites**: cuckoos (Europe) and cowbirds (America) *(Krebs & Davies 1993:93-96)*
- 3.1.1. similarities: both lay eggs in nests of host species
- 3.1.2. differences: hosts win over cuckoos; cowbirds win over hosts
  - 3.1.2.1. cuckoo chicks reject host eggs; cowbirds don't
  - 3.1.2.2. cuckoo eggs mimic host eggs; cowbird eggs don't
- 3.1.3. longer co-evolution of cuckoos/hosts than cowbirds/hosts

3.2. **evolutionary equilibrium**: no change=> stabilizing selection *(Krebs & Davies 1993:98-100)*
- 3.2.1. defenses of warbler hosts (insectivores) parasitized by cuckoo
  - 3.2.1.1. perceptual: identify model eggs different from their own
  - 3.2.1.2. behavioral: reject eggs laid early, at dawn, if cuckoo near
- 3.2.2. adaptations of cuckoo parasites (eat insects and warbler eggs)
  - 3.2.2.1. morphology: polymorphism in egg color matching host's eggs
  - 3.2.2.2. adult behavior: cuckoo waits until laying warbler leaves nest
  - 3.2.2.3. chick behavior: cuckoo dumps eggs of host out of nest

3.3. **continuing arms race**: snapshot of change=> end is only apparent *(Krebs & Davies 1993:96-97)*
- 3.3.1. cuckoos invaded a new area where magpie hosts do not have defenses
  - 3.3.1.1. at this time, cuckoos win over hosts
  - 3.3.1.2. predict change in proportion of host genotypes=> more picky
  - 3.3.1.3. later, cuckoos may return to areas where selection was relaxed
- 3.3.2. cowbirds invaded new areas due to agricultural expansion
  - 3.3.2.1. host species: "accepters" (e.g. black-cap vireos), "rejecters"
  - 3.3.2.2. "accept cost": (+) raise own nestlings with cowbird > (-) renest
  - 3.3.2.3. "reject strange egg": robins (2 criteria); gray catbirds (1 critera)

3.4. **Take-home message: end occurs only when conditions don't change** *(Krebs & Davies 1993:92-93)*
- 3.4.1. hypotheses: evolutionary equilibrium vs. snapshot of change
- 3.4.2. e.g. cuckoos (long-term adaptation); cowbirds (short-term change)

Part 3	**Study Questions for Chat & Quiz 4 "How do Arms Races End?"**
3.1	Compare similarities and differences in brood parasitism behavior, between two species of your choice? (TIP: e.g. cowbirds and cuckoos).
3.2	For two species where the parasite/host "arms race" has ended, what is the evidence of coevolution of behavioral traits? (TIP: cuckoo)
3.3	Compare two brood parasites, one that shows evidence of a continuing "arms race" and one where there appears to be evolutionary equilibrium? (TIP: e.g. cowbird and cuckoo)
3.4	How does co-evolution end...or does it?

4. SUMMARY

- 4.1. **Adaptationist story-telling** (myth if it cannot be tested)
  - 4.1.1. Science: hypotheses that can be tested (function & co-evolution)
  - 4.1.2. e.g.: co-evolution of bird learning-abilities and moth wing-color
- 4.2. **Initial steps in co-evolution:** beginning of arms race
  - 4.2.1. crypsis and conspicuousness
  - 4.2.2. e.g. tits & worms in straws, chicks & crumbs, dull & bright guppies
- 4.3. **End occurs only when conditions don't change**
  - 4.3.1. hypotheses: evolutionary equilibrium vs. snapshot of change
  - 4.3.2. e.g. cuckoos (long-term adaptation); cowbirds (short-term change)

Summary	Study Questions for Chat & Quiz 4 "Co-evolution of Predators & Prey"
4.1	What were 3 take-home messages re. coevolution of predator/prey (or parasite/host) behavior?
4.2	Why is predator/prey coevolution analogous to an "Arms Race"?