Behavioral Ecology of Vertebrates

Unit 4. Predators & Prey

Module 2 Habitat

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Learning, Discovering and Sharing Knowledge

Last unit we talked about foraging, next unit we will talk about competitors, this unit is on coevolution of predators and prey. If you recall, when we looked at foraging, we noted that sometimes foraging decisions are constrained by the presence of predators. Let's look more at anti-predator adaptations.

Learning Objectives (Davies et al. 2012:81)

Coevolution of predators & their prey:

1. **Coevolution**: behavior of predator edits the gene pool of the prey and vice versa.
2. **Steps in predator evolution**: instinctive startle response, learn to detect new prey, learn search image,
3. **Counter adaptation of prey**: mimicry, camouflage, startle predator

Predators edit prey genotypes and vice versa

1. COEVOLUTIONARY "ARMS RACE"

If predators pick the most obvious prey, why are some so brightly colored like this tropical treefrog? | We will focus first on the concept of "co-evolution" because that will be key to the concepts coming up in the following units. Here we talk about the shifting proportions of genotypes in the gene pools of two species that do not exchange genes (predator and prey). In the next unit, we will be applying this same concept to shifting proportions of genotypes influencing competition for resources within the same population of one species.

1.1 Coevolution (Davies et al. 2012:84, Fig. 4.1)

Memorize this figure, because it is the key concept in a nutshell.

Co-evolution: Predator & mimic prey (Davies et al. 2012:100-103)

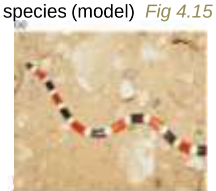
Mullerian: convergence of two harmful species ("mutual mimics") *Fig 4.14*

Metapopulation of 1 species
Pop 1 Pop 2 Pop 3

Sp .A
Sp.B
Sp.X
Sp.Y

gene 1 gene 2 gene 3
Genetic polymorphism

Batesian: convergence of harmless (mimic) and harmful species (model) *Fig 4.15*



Model: coral snake

Mimic: king snake

Credits: C. Wilcox (edited by J. Packard)

You are familiar with examples of Mullerian and Batesian mimicry. Lets dialogue about how this concept of coevolution applies, in terms of predators editing the genotypes within one species. | Fig4.14 is confusing until you realize that each row is a different species. So the top row of millipedes shows genetic polymorphism within the species A: 3 genotypes, each fixed in an isolated population separated in a habitat fragment distant from all others.

PROMPTS FOR WEBINAR DIALOGUE:

Q1. How do the examples in Fig. 4.14 illustrate convergent evolution resulting in Mullerian mimicry by harmful species?

Q2. How about Fig. 4.15 and Batesian mimicry of a harmless mimic and harmful species?

Q3. Which species are the mimics and models in Mullerian mimicry?

Lets discuss the predator's behavior

- What is your hypothesis about the role of bird predators as a "selection pressure" in:
  - Batesian mimicry *(harmful model, harmless mimic)*
  - Mullerian mimicry *(two harmful species)*

- Let's look at this in more detail from the perspective of the gene pool of the prey

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Some examples:

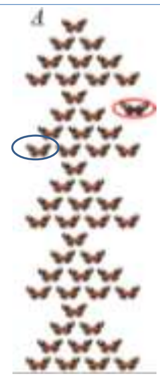
H1. In Batesian, birds edit out the "non-mimic" genotypes from the gene pool of the harmless mimic species

H2. In Mullerian, birds edit out the "non-mimetic" genotypes differently in each habitat where they find populations of both species.

H3. In Mullerian, the birds in one habitat fragment edit out the "non-mimetic" genotypes in species A as well as species B.

Coevolution: Predator's role (Davies et al. 2012:100)

- Mullerian: Two races of H. erato butterflies *(CR: Costa Rica, CO: Colombia)*
- **H1**: Predators choose non-mimics over mimics
- Experiment: painted wings in CR
  - Control- CR "mimic"
  - Treatment- CO "non-mimic"
- Result: more "mimics" survived than "non-mimics"
- Accept or reject H1?



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Lets focus on one example of how the editing role of predators was tested in Mullerian mimicry.

PROMPTS FOR WEBINAR CHAT:

Q1. Do you agree that this is the hypothesis tested by Benson (1972) and later by Mallet & Barton (1989)? Why or why not?
Q2. Based on this evidence, would you accept or reject hypothesis?
Q3. Was this experiment based on selection of phenotypes or genotypes?
Q4. Do you "buy" the argument that this result explains what happened to genotypes in the phylogenetic history of this population? Does this explain why the coloration of the CR race differs from the CO race of the same species?

Coevolution: Batesian Mimicry Davies et al. (2012:102)

Harmful model

Harmless mimic

- Predators behave as "editors"
  - Learn to avoid harmful models
  - Choose variants of the harmless mimic that look the LEAST like the harmful model
  - "Non-mimic" genotypes were edited out of the gene pool of the mimic species
- Q1. Why does the % "mimic" increase when the abundance of the model species is higher than mimics in a given habitat fragment?
- Q2. When would the % "mimic" genotype decrease in the gene pool of a harmless mimic species?
- Q3. Why would the % "mimic" genotype decrease when alternative harmless prey are available in the same habitat fragment?

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Examples of some responses:

Q1. The predators are reminded more frequently to avoid the mimic genotypes in the harmless species because they have encounters with the truly harmful model species
Q2. If there was a population decline of the truly harmful model species, then predators would receive fewer lessons convincing them to avoid the non-harmful "mimic" genotype in the harmless mimic species. The %"mimic" and %"non-mimic" would equilibrate without this persistent editing by the predators.
Q3. If there was an increase in alternative harmless prey in the habitat fragment, then predators would receive fewer lessons to avoid the harmful model. Same logic as Q2.

Coevolution: Apply to Mertensian mimicry

Lethal Texas coral snake (mimic)

Noxious Mexican milk snake (model)

- Occurs when a harmful species mimics harmless species
- Predator's first encounter with a mimic results in predator death
  - No option of learning to avoid prey
- Predator genotypes
  - *"avoid bright objects" (A)*
  - *"no avoidance" (NA)*
- Why would predators instinctively avoid bright objects without prior experience?

Credits: C. Wilcox (edited by J. Packard)

This example was not in Davies et al. (2012), but is very relevant to the evolution of the startle response to aposomatic (warning) coloration.

WEBINAR PROMPTS
Examples of answers:

A1. The instinctive startle response is coded in the genotype "A", which increased in % when "NA" genotypes got snakebite.
A2. The "A" genotype codes for a lack of habituation to strange, bright, novel colors.
A3. The "A" genotype codes for quick learning and persists due to individuals that had sublethal encounters with snakes.

1.4 Poll- lets see if you understand

Which of these topics that we just covered would you like to chat more about?

a) Coevolutionary “arms race”
b) Predator role as an “editor”
c) Mullerian mimicry (both harmful)
d) Batesian mimicry (harmless mimics harmful)
e) Mertensian mimic (harmful mimics harmless)

Lets dialogue more using the elearning discussion tool

Davies et al. 2012, Fig 4.4

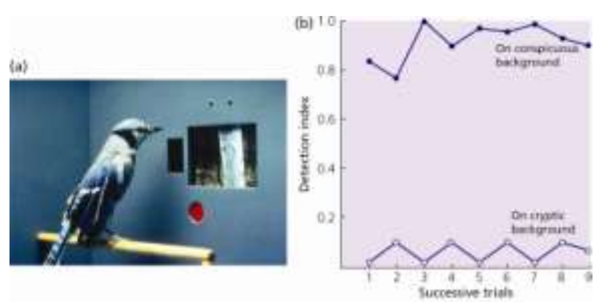
“Improvements” in detecting & handling prey

2. STEPS IN PREDATOR EVOLUTION

In the previous dialogue about the coevolutionary “arms race”, we have seen how inter-dependent are the strategies of the predators and their prey. Several hypotheses emerged about which traits of the predators function as “editors” , resulting in changes in % genotypes within prey. Now lets examine whether these are “story-telling”, as critiqued by Davies et al. (2012:86). Where is the evidence?

2.1 Detection

(Davies et al. 2012:87, Fig. 4.4)



Detection mechanisms in predators include both (a) sensory (visual acuity) and (b) cognitive (recognition neurons). This study showed jays are indeed better able to detect prey on a background where they are conspicuous compared to a cryptic background. Some species are better at detection than others, implying there is a heritable component to these mechanisms.

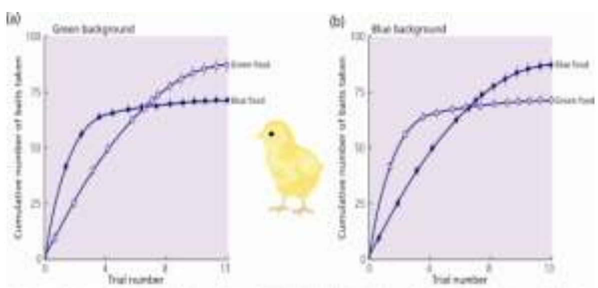
2.2 Startle response (Davies et al. 2012:90, Fig. 4.3)

- Jays trained to remove a cardboard model to get food; hindwings appear when pecked
- **H1**: startle-response is instinct
- Treatment: trained on cryptic; tested with cryptic/bright or bright/cryptic (control)
- Result: more startle response to cryptic/bright (natural)

Is the startle response learned, or does it have a heritable component? Is there a genotype coding for this instinct? |

In the treatment, there were two models. The Cryptic/bright model was like the moths in nature, the jay pecks at the cryptic forewings and bright hind-wings flipped open. The Bright/cryptic model was the reverse, the jay pecks at the bright forewings and cryptic hind wings emerged.

2.3 Search image (Davies et al. 2012:97, Fig. 4.13)



The concept of "search image" means that the individual has the ability to learn to switch from one type of prey to another type of prey.

This classic study showed even chicks can learn at an early age to (a) detect non-cryptic food items on a background of a different color and (b) choose cryptic food items that taste better.

2.5 Poll- lets see if you understand

Which example would you like to chat bout more?

a) Crypsis
b) Startle response
c) Session image

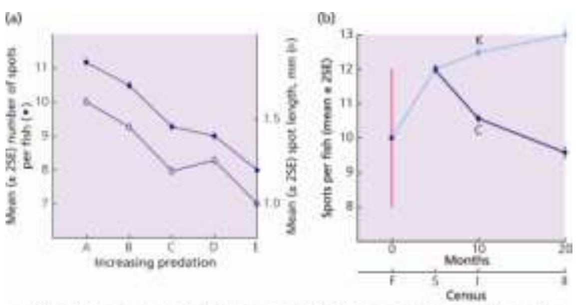
Lets dialogue more about this using the elearning discussion tool

Davies et al. 2012:93

Predators "edit" the gene pool of their prey

3. COUNTER ADAPTATION OF PREY

3.1 Crypsis (Davies et al. 2012:105, Fig. 4.17)



Changes in %"cryptic" vs %"non-cryptic" genotypes have been recorded in guppies in (a) field experiments and (b) artificial selection in the laboratory.

3.2 Warning coloration (Davies et al. 2012:95)

(a) (b)

There are many examples of species specific colorations where bright colors have evolved in species that have other antipredator adaptation such as toxins.

3.3 Host mimicry (Davies et al. 2012:113, Fig. 4.22)

Same principle applies to coevolution of brood parasites (prey) and their hosts (predator). The top row show genetic polymorphism (ABC) within one species, the Australasian cuckoo. Why? In distant populations separated in habitat fragments, cuckoos have different host species (DEF) in whose nests the cuckoos lay their eggs. The hosts kick out the "non-mimic" cuckoo fledglings. Amazing convergence in coloration of cuckoos that mimic their hosts!

3.4 Poll- lets see if you understand

Which example would you like to chat about more?

a) Cryptic counter-adaptation in prey
b) Warning coloration in well-defended prey
c) Host mimicry in Australian cuckoos

Lets dialogue more about this using the elearning discussion tool

Summary (Davies et al. 2012:113)

Coevolution of predators & their prey:

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