NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Living in a Gangsta's Paradise:
Mafia-Like Behavior in the Bird World

by
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Part I – Introduction

The brown-headed cowbird *(Molothrus ater)* is a medium-sized passerine (i.e., a bit smaller than a cardinal or robin) that is a member of the blackbird family. This species is sexually dimorphic, so males and females look different from one another (Figure 1). They have a widespread distribution ranging across much of North America.

What is possibly the most interesting aspect of cowbird life is their breeding habits. Most birds build a nest for their eggs and either one or both parents provide care for the offspring until they are capable of leaving the nest. However, in the case of the cowbird, neither males nor females build a nest or provide care for their offspring. Instead, female cowbirds produce huge number of eggs (dozens per year) and deposit them individually into other bird species' nests in the hope that the other species will raise their young. Cowbirds are known to lay their eggs in roughly 220 other bird species' nests, but individual female cowbirds tend to specialize on the nests of a specific bird species (Alderson et al., 1999).

Even though the cowbird egg can look drastically different from the host's eggs (Figure 2), some birds accept the egg and incubate it. Cowbird eggs require a short incubation period (10–11 days), so the cowbird egg typically hatches first in the nest (Briskie & Sealy, 1990) and are then fed by the host parents. In many cases, the cowbird nestling quickly becomes larger than the host nestlings and can therefore outcompete them for food.

Figure 1. Brown-headed cowbird *(Molothrus ater).* Adult male (left) and female (right). *Credit:* © Jean Landry | Dreamstime.com, ID 171201923; © Gregory Johnston | Dreamstime.com, ID 391477391.

The brown-headed cowbird is not the only bird species that reproduces in this manner. There are approximately 100 different species of birds that exhibit similar breeding behavior (Stevens, 2013).

The European cuckoo *(Cuculus canorus)*, for example, has also evolved this reproductive strategy, however, there are some notable differences between the cuckoo and the brown-headed cowbird. Similar to the cowbird, a cuckoo egg in a host nest will typically hatch first (Davies, 2000), but while the cowbird nestling does not disturb the other eggs in the nest, cuckoo nestlings will frequently push the other eggs out of the nest within a few hours of hatching (Wyllie, 1981). One other interesting difference is that cowbird eggs are generally not removed from the nest by host parents, whereas many bird species reject cuckoo eggs by either removing the egg from their nest or abandoning the nest entirely (Langmore et al., 2005).

Figure 2. Five eastern phoebe eggs *(Sayornis phoebe)* with a speckled brown-headed cowbird egg *(Molothrus ater)*. *Credit:* Galawebdesign, Wikimedia Commons, CC BY 3.0.

If European bird species have evolved the ability to recognize and reject a cuckoo egg in their nests, why have so many North American bird species not done the same for cowbird eggs?

Questions

1. Take a moment to think about why one species of bird might accept the egg of a different species in their nest. Are there any physical or behavioral constraints you can think of that would limit the ability of a bird to reject a cowbird egg? For example, maybe some bird species are unable to visually discriminate between their eggs and the cowbird eggs. List as many possible constraints as you can think of.

2. Now, choose one of the constraints you listed in Question 1 and imagine that the host species has evolved the ability to overcome that constraint. How might a cowbird respond to this new host behavior? List several possibilities. For example, if host birds can now visually identify the difference between their own eggs and the cowbird egg they could remove cowbird eggs from their nests. In response, cowbirds might evolve eggs that look more similar to host eggs.

Natural selection favors traits, including behaviors, that increase an individual's fitness. However, each behavior that an individual expresses has fitness costs and fitness benefits, and selection favors individuals whose behaviors produce the highest benefits compared to costs. Over generations, those individuals exhibiting behaviors with the highest net fitness become more common in a population.

3. Focusing now on fitness, what are possible fitness benefits to a host bird for accepting a cowbird egg in its nest? List any hypothesized benefits below.

4. What are possible fitness costs a host bird may experience from rejecting (removing) a cowbird egg? List any hypothesized costs below.

Part II – Interspecific Interactions

Interspecific interactions (interactions between members of different species) can range from simple to complex. In some situations, the costs and benefits of an interaction are obvious and their role in natural selection for each species is clear. For example, in predator-prey interactions, the benefit to the predator is gaining food or energy from the prey and a short-term survival gain, while the cost to the other species of being preyed upon is a loss of resources or energy or even death. However, not all species interactions are this clear regarding the potential costs and benefits to each of the interacting species. In the following activity, you will explore the relationship between the brown-headed cowbird and the prothonotary warbler. As you read through the background, think about what types of interactions are occurring and see if you can identify any costs or benefits of interacting with each other, or any constraints or limits to the behaviors they exhibit.

The prothonotary warbler *(Protonotaria citrea)* is a small warbler (smaller than the brown-headed cowbird) that is native to the eastern United States. It typically nests in tree cavities near water. Males are bright golden yellow with blue-gray wings and tail, and females are similar but slightly paler in color (Figure 3). During the breeding season (April to July), females lay 3–7 eggs in a nest that they construct. After 12–14 days of incubation, the nestlings hatch and are fed by both parents for the next 10–11 days before they leave the nest. The warblers repeat this process a couple of times per breeding season, attempting to raise one to three nests full of nestlings per year.

Figure 3. Adult male (left) and female (right) prothonotary warbler. *Credit:* Dominic Sherony, Wikimedia Commons, CC BY-SA 2.0.

The prothonotary warbler will also nest in artificial cavities such as human-made nest boxes. Adding human-made nest boxes to prothonotary warbler habitat allows researchers to more easily monitor egg laying and hatching success, and monitor the bird's behavior. The nests of the prothonotary warbler are common hosts of brown-headed cowbird eggs, with research suggesting that cowbirds show a preference for this particular species' nest (Peer & Liang, 2025). In 2003, a pair of ecologists (Jeffrey Hoover and Scott Robinson) monitoring prothonotary warbler nest boxes for breeding behavior noticed some odd things:

- warbler nests without cowbird eggs have higher rates of nest destruction than those with cowbird eggs, and
- warbler nests where cowbird eggs appear, then disappear, have high failure rates.

To summarize the interactions between these two species, the cowbird leaves its egg in the warbler nest. Warbler parents then raise the cowbird nestling along with their own. Warbler nests without cowbird eggs are frequently destroyed, and nests that had a cowbird egg but the cowbird egg disappeared are more likely to fail (Hoover & Robinson, 2007).

Questions

Answer Questions 1 and 2 individually, and then come together in your group to answer Question 3.

1. Which type of species interaction do you think could be occurring between cowbirds and prothonotary warblers? Do you think this relationship is an antagonistic interaction, competition, or mutualism? Generate a hypothesis that could explain their relationship.

2. How could you distinguish between the species interactions you chose in Question 1 and the other types of species' interactions listed in the question? What would you need to know or measure?

3. Share and discuss your answers to Questions 1 and 2. Then choose one hypothesis and design an experiment to test this hypothesis. In thinking about how to test your hypothesis, consider the following:
   - the benefits of observational vs. manipulative experiments,
   - the variables you would need to measure to estimate the costs or benefits of interacting, and
   - how to ensure that your experiment is feasible (for example, if you wanted to record and watch videos of the nests, keep in mind that you would need to monitor a large sample of nests 24 hours a day for multiple months to produce robust results).

Part III – Retaliatory Behavior

Read the paper "Retaliatory mafia behavior by a parasitic cowbird favors host acceptance of parasitic eggs" by Hoover and Robinson (2007) and answer the following questions.

Questions

1. Do you think the research these authors performed is experimental or observational? Explain your rationale.

2. This paper states that cowbirds are "brood parasites." In your own words, define the term "brood parasite."

3. The authors claim that cowbirds use "mafia-like" retaliatory behavior.
   a. How do the authors define this behavior?
   b. What is the goal of this mafia behavior?
   c. From an ultimate perspective, why would an individual cowbird perform this behavior?

4. The authors claim that cowbirds exhibit "farming" behavior with their hosts.
   a. How do the authors define this behavior?
   b. What is the goal of this farming behavior?
   c. From an ultimate perspective, why would an individual cowbird perform this behavior?
   d. How is "farming" behavior different from "mafia-like" behavior?

5. Why do the authors classify the interaction between cowbirds and their hosts as an antagonistic interaction? Do you agree? Why or why not?

6. Provide a proximate explanation and an ultimate explanation of how mafia-like behavior of cowbirds can slow the evolution of egg rejection behavior in hosts like the prothonotary warbler.

7. Not all North American bird species accept cowbird eggs in their nest. For example, the American robin *(Turdus migratorius)* will remove virtually 100% of cowbird eggs that appear in their nests (Briskie et al., 1992). What do you think it would take for the prothonotary warbler to overcome the costs associated with the farming and mafia-like behaviors of cowbirds and become a cowbird egg rejecter (e.g., behaviorally, evolutionarily, etc.)? Provide and explain at least three ideas.

8. One strategy for dealing with parasites is tolerance, the ability of a host to limit negative fitness consequences of a parasite. The evolution of tolerance as a viable host strategy is more likely when there is some aspect of coevolution between a parasite and their host. Imagine a scenario in which prothonotary warblers evolved the ability to tolerate cowbird parasitism. Describe:
   a. A trait that could have evolved in the warblers to allow them to tolerate the cowbirds nestlings in their nest.
   b. A trait that could have evolved in the cowbirds to allow them to be better tolerated.

Part IV – Data Analysis

Thus far, this case study has focused on the interactions between the brown-headed cowbird and prothonotary warblers. However, cowbirds are known to lay their eggs in approximately 220 other bird species' nests (Alderson et al., 1999). Do cowbirds interact with other host species in the same retaliatory way?

For example, in another study, researchers monitored the breeding success of dark-eyed juncos *(Junco hyemalis carolinensis)* for nests that: 1) naturally did not contain cowbird eggs, 2) naturally contained cowbird eggs, and 3) naturally had a cowbird egg that was removed by the researchers (Turner et al., 2022a). These scientists have made their original data set publicly available (Turner et al., 2022b). You can use these data to explore and test for an impact of cowbirds on the breeding success of another common bird species. Your instructor will provide more details on how to analyze these data.

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