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Joseph J. Fontaine
U.S. Geological Survey

Karie L. Decker
University of Arizona

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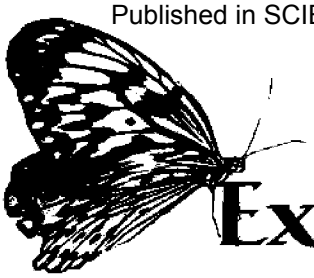

Exploring Predation and Animal Coloration through Outdoor Activity

Joseph J. Fontaine and Karie L. Decker

Abstract. Although children often characterize animals by the animals' color or pattern, the children seldom understand the evolutionary and ecological factors that favor particular colors. In this article, we describe two activities that help students understand the distinct evolutionary strategies of warning coloration and camouflage. Because both of these strategies effectively allow prey animals to avoid predation, they can help explain considerable variation in animal coloration.

Keywords: adaptation, camouflage, mimicry, predation, warning coloration

If you ask students to describe their favorite animal, one of the first details they bring up is color. Animals exhibit a vast array of color combinations, from bright oranges and reds to cryptic browns and greens. These colors often relate to important details about how animals mate, where they live, and how they escape predation. Although most students are aware of animals' color variation, few can explain why an animal is a particular color. For students to understand the causes and effects of the natural variation they see, they must begin by understanding its underlying forces.

One major force underlying animal coloration is predation. Most students understand this concept. They know that some animals eat other animals, and they understand that becoming another animal's meal is something to be avoided. This lesson asks students to consider how animals use color as a defense against predators. Students will learn how natural selection, through predation, can lead animals to develop either highly cryptic colors (camouflage) or extremely obvious ones (warning colorations). During this lesson, students will explore the roles of predator and prey to discover how camouflage and warning coloration can both be appropriate evolutionary solutions to predation. Students will learn that an animal's ability to hide depends on its color, the colors around it, and its size. They will also learn how some animals avoid predation by mimicking dangerous animals.

These investigations are appropriate for nearly any grade level but may be most appealing to students in grades K–6. The inquiry addresses National Science Education Standards A (Science as Inquiry) and C (Life Sciences) (National Research Council 1996). By participating in these active inquiries, students will learn to formulate observations about the effectiveness of warning coloration, mimicry, and camouflage in protecting prey from predators. Ultimately, students will use this information to assess how well each of these responses helps animals avoid predation and identify the conditions under which each response is most effective. Successful completion of this lesson requires two one-hour class periods, one for each inquiry. Although the inquiries are related, each may be completed without the other. Both inquiries require minimal materials (Appendix A).

Inquiry 1: Pipe Cleaner Animal Safari

Teacher Preparation

1. Create a data sheet that includes all the information that the students are expected to collect (Figure 1). For younger students, you may wish to use colored ink to match each pipe cleaner color category.

JOSEPH J. FONTAINE *is a senior research specialist with the U. S. Geological Survey (USGS) Sonoran Desert Research Station, School of Natural Resources, University of Arizona.*

KARIE L. DECKER *is a graduate student and National Science Foundation GK–12 Fellow with the Arizona Cooperative Fish and Wildlife Research Unit, School of Natural Resources, University of Arizona.*

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Pipe Cleaner Animal	Distance From Trail	Pipe Cleaner Color(s)	Background Color(s)
1	Near Medium Far	BL BR GR WH RE	
2	Near Medium Far	BL BR GR WH RE	
3	Near Medium Far	BL BR GR WH RE	

FIGURE 1. Sample data sheet for Pipe Cleaner Safari. Younger students may need a list of possible background colors to circle.

2. Construct 20–40 pipe cleaner animals. To construct the animals, twist together 2–6 pipe cleaners. Be sure to make both single-colored and multicolored animals with both bright and cryptic colors. Students can participate in constructing the animals, but not in dispersing them.
3. Disperse the pipe cleaner animals along a trail or sidewalk. Make sure to place some to match their background and some to stand out. Vary the animals' distance from the trail, from 1–20 m away, and vary their location relative to the ground, from ground-level to tree branches. Keep track of the total number of animals along the trail and their locations.

Background

This inquiry aims to teach students how animal coloration and background color work together to camouflage animals. Before taking the students on safari, introduce the term *camouflage* (see Appendix B). Start by asking students what they think *camouflage* means. Most students have heard this term, but they may think of camouflage as clothing and not recognize its role in nature. To help students progress, ask whether they think animals can be camouflaged. Then ask them to think of an example of a camouflaged animal. After students have made their suggestions, show the class pictures of a few examples. A picture of a stick insect or a hen mallard can help clarify the concept of natural camouflage and at the same time show students that, no matter what their color, animals are camouflaged only if they match their background. A great example is a polar bear. On the pack ice of winter, the polar bear's white coat provides excellent camouflage. On the green tundra of summer, however, it is visible for miles. Background matching is so important that some animals even change color with their background. Students may know that chameleons and squid can change colors as they move through their environment, and ptarmigan change from brown in summer to white in winter. By the end of the discussion, students should understand that the colors around an animal are as important in determining whether it is seen as the color of the animal itself.

Procedure

After introducing the concept of camouflage, organize students into pairs and explain the activity. Working in pairs, students will have the opportunity to walk down the safari trail with the goal of observing as many pipe cleaner animals as possible. Before they begin, ask the students to predict which colors will be the easiest or hardest to find and at what distance they will find the most animals. Then give each pair of students a data sheet (Figure 1). Have them walk the trail and record the colors of each animal, its distance from the trail, and its background color. Students must follow a few rules on the safari walk. First, the students will have a limited amount of time to search for the animals (10–15 min). The students can also only move forward along the trail. Students should therefore not walk too fast, or they will reach the end with spare time that they could have used in their search. They should not walk too slowly, or they will not finish searching the whole trail. Finally, students must stay on the trail and cannot leave it to look for animals. To ensure that students remain observant and do not show each other the animals, make the safari a friendly competition.

Once students have completed the safari, have them compile their observations and answer a few simple questions about the exercise (Appendix C). By looking at their observations, students will recognize that some colors are easier to see, partly because those colors do not match their backgrounds. Students will also discover that animals closer to the trail—regardless of how well they are camouflaged—are easier to see than those farther away. Although most students may find this conclusion obvious, they may not understand why. To help them understand, put a pencil near one student's nose. Ask the student whether or not the pencil is easy to see and why. The student will likely answer that it is easy to see because it is so big. Then put the pencil in a new location across the classroom. Ask the same student whether it is now more difficult to see the pencil and why. Of course, the pencil appears much smaller and is more difficult to see from across the classroom. Although the pencil's size never changes, it appears smaller when you move it farther away from the viewer. Most students will agree that small objects are difficult to see. Last, to ensure that students understand how camouflage works, challenge them to draw a camouflaged animal in the environment where it is best camouflaged.

Inquiry 2: Monarch Madness

Teacher Preparation

Cut 30–40 foot-long sections of orange flagging tape. The actual number of sections will depend on the class size.

Background

This inquiry aims to teach students how poisonous animals use bright, showy colors to warn predators that they are dangerous and how nonpoisonous animals sometimes mimic these color patterns. As in Inquiry 1, you may wish to introduce some key concepts (see Appendix B) and pictures before you begin. Show pictures of a monarch butterfly, a coral snake, and a poison arrow frog to the class. Make sure the pictures include the animal's environment so that students can see how conspicuous the animals are against their background. Tell the students that all of these animals are poisonous. Ask the students why they think these animals look so bright. If the students have recently done the pipe cleaner safari, they might suggest camouflage. Make it clear to the students that these brightly colored animals do not match their background and therefore are not camouflaged. To help students understand why the animals in the pictures are so showy, introduce the term *warning coloration*. Although some students may know this term, they may not know how warning coloration works to deter predators.

Ask the students whether they know what happens when a bird eats a monarch butterfly. As caterpillars, monarchs sequester toxins from milkweed, which they concentrate and store in their bodies. If a bird eats a monarch, the bird will vomit. This unpleasant experience causes it to avoid eating monarchs in the future. How can birds learn to avoid monarchs after just one encounter? Ask the students to name a food they do not like. Did it take more than one serving to decide it tasted bad? Point out that students could eat this food by mistake sometimes if it does not stand out from other foods on their plate. This is why monarchs and many other poisonous creatures are bright orange or red. These bright colors make the butterflies stand out, unlike most prey animals. Predators quickly learn to identify and avoid these bright colors. Even predators that have only encountered one individual with warning coloration will likely avoid others with similar markings, poisonous or not. Mimicking a poisonous animal can therefore help nonpoisonous animals avoid predation as predators follow the old adage, "Better safe than sorry."

Mimicry occurs frequently in the natural world. Nearly every poisonous animal that displays warning coloration (often called the *model*) has a mimic. Some mimics are also poisonous and gain respect by looking like a more common poisonous animal, like a security guard whose badge looks similar to a police officer's. Other mimics are not poisonous and simply get by on their looks. The viceroy butterfly, for example, looks like its model, the monarch, but the viceroy has no toxins and is perfectly palatable for birds. Yet birds don't eat it, because it looks like a poisonous monarch. The viceroy's coloration protects it from predation, although it is not poisonous itself.

Procedure

Once students have a simple understanding of warning coloration and mimicry, introduce the activity. Monarch Madness is a game of tag. In this game, some of the students will be birds (i.e., predators), and the rest will be a mix of poisonous or nonpoisonous butterflies (i.e.,prey). To begin, select five to seven students to be birds. Assign the rest of the students to be butterflies. The butterflies' object is to migrate across a field without being eaten. If a predator tags and "eats" a butterfly, however, the butterfly must sit down. Privately tell some of the butterflies that they are poisonous. If a bird eats one of them, the butterfly must not only sit down but tell the predator to sit as well. Tell the birds that their objective is to eat (i.e., tag) as many butterflies as they can without getting "sick" and having to sit down.

Once everyone has a role, take the students into the schoolyard. Select an area about 30 yards long with two ends. Line the butterflies along one end and the predators in the middle. At this point, none of the butterflies have any warning coloration, so the predators will not know which ones to avoid because they are poisonous. Blow a whistle to have the butterflies start their migration. When all of the butterflies reach the other end or are sitting, blow the whistle again to stop the game. Have the students count the dead butterflies and the sick predators. After the students have tallied the outcome of the round, gather the butterflies at one end of the field and have all the predators return to the center. Reassign the butterflies as poisonous or not and repeat the migration. After several similar migrations, pause and ask the birds whether it is difficult to determine which butterflies are poisonous. Ask the butterflies whether there is any advantage to being poisonous or any disadvantage to being nonpoisonous.

Now give some butterflies a strip of orange flagging tape to carry. Explain to everyone that only the butterflies with the flagging are poisonous. Then restart the migration. After each round, have the students count and record the number of dead butterflies of each type and the number of sick predators. After a few rounds, ask the students the same series of questions. Students will realize that the addition of warning coloration has made the game safer for predators and for poisonous butterflies. The nonpoisonous butterflies however, may feel more vulnerable than before.

Redistribute the flagging. This time, give some butterflies flagging marked with permanent marker so that

it appears a little different from the plain flagging on close examination. Explain to the predators that there are now three types of butterflies: poisonous butterflies with plain flagging (models), nonpoisonous mimics with marked flagging, and palatable butterflies with no flagging. Restart the migrations, again stopping after each round to count. Stop the migration after a few more rounds and ask the same questions. Students will soon realize the advantage of mimicry. For the final set of rounds, give all the butterflies flagging, but make sure that most of them are mimics and only a few are models. Restart the migration.

After completing these last rounds, ask the students what they have learned about how warning coloration and mimicry work (Appendix D). When is it is easiest for the predators to forage safely? When is it most difficult? When did the different types of butterflies feel safest or most vulnerable? Are the relative numbers of unmarked, mimic, and model butterflies important? Soon students will begin to understand that warning coloration and mimicry have advantages, but they also have limits. Predators likely ate similar numbers of poisonous butterflies in the first and last rounds, for example, even though the butterflies in the last rounds had warning coloration. This should teach students that models lose the advantage of warning coloration when there are too many mimics. When models are less common than their mimics in natural systems, predators encounter more palatable mimics than poisonous models. Instead of learning to avoid brightly colored animals, predators learn that they are a good source of food.

Assessing What Students Learn

Through these investigations, students can demonstrate a number of scientific skills (e.g. mathematics, attention to detail, and creativity) that educators can assess either formally or informally. Teachers can evaluate each student's understanding of the content of these inquiries by asking the student to answer simple questions about animal coloration (Appendix C). Ultimately, teachers can assess their students' depth of understanding by asking them to integrate all the information that they have gathered in these two inquiries to make predictions about the conditions that favor camouflage versus those that favor warning coloration and to report their thoughts to their classmates.

Conclusion

Animals display a wide variety of color patterns. The question of why has fascinated both scientists and students from Aristotle (2004) to Darwin (2007) to researchers today. By using inquiry to examine the influence of predation on animal coloration, students begin to develop a concrete understanding of how one of Earth's major ecological factors has shaped such obvious attributes of plants and animals. This foundation enables students to better understand the world around them and helps prepare them to face future challenges in learning about the natural world's fundamental processes.

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Appendix A
List of Materials

Pipe Cleaner Safari
- 50–100 pipe cleaners of various colors
- Pencils
- Clipboards
- Data sheets

Monarch Madness
- Roll of orange flagging tape
- Permanent marker

Appendix B
Vocabulary

Adaptation	an anatomical structure, physiological process, or behavioral trait of an organism that increases the long-term survival and/or reproductive success of the organism.
Camouflage	also called cryptic coloration, the coloring of an animal to match its background, making it difficult to detect by potential predators or prey
Warning Coloration	also called aposematic coloration, the bright coloration of animals with effective physical or chemical defenses that acts to warn potential predators
Mimicry	one species has a superficial resemblance to another unrelated species, often to deceive other species
Batesian Mimicry	a form of mimicry in which a species that is palatable looks like a different species that is poisonous or otherwise harmful
Müllerian Mimicry	a form of mimicry in which two species, both of which are poisonous or otherwise harmful, look like each other

Sources, N. A. Campbell and J. B. Reece. 2005. *Biology*. San Francisco, CA: Pearson Education.
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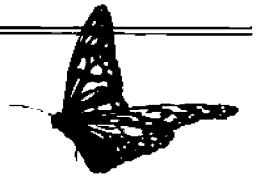
Appendix C
Pipe Cleaner Safari Discussion Questions

1. What color did you find the most often? Which did you find least often? Why?
2. Was it easier or harder to find multicolored animals? Why?
3. On which background colors did you find the most and least animals? Why?
4. Did you find more animals that matched their background or were different?
5. At what distance was it easiest to find animals? At what distance was it hardest? Why?
6. How do you think the most and least common animal colors found would be different in different seasons (e.g., winter, spring, summer, fall) or different environments (e.g., desert, rainforest, beach, grassland)? Why?
7. Many animals can only see in black and white. If you could only see in black and white, do you think it would have been harder to find the animals? What colors might you have found the most and least often? Why?
8. Do you think you could find more animals if you tried again? Why?

Appendix D
Monarch Madness Discussion Questions



1. When was it most difficult to be a predator? When was it easiest? Why?
2. When was it most dangerous to be a poisonous butterfly? When was it least difficult? Why?
3. When was it most dangerous to be a nonpoisonous butterfly? When was it least dangerous? Why?
4. When was it most dangerous to be a mimic? When was it least dangerous? Why?
5. What happens if there are more mimics than poisonous butterflies?
6. Do you think warning coloration is good for predators, prey, or both? Why?
7. How similar do you think a mimic has to look to a poisonous animal to gain protection from predation? Do you think the mimics are safer the more they look like poisonous animals?
8. In what other ways could prey warn its predators if the predators could only see in black and white?