THE AMAZING ECOLOGY OF TERRESTRIAL ISOPODS

Third-grade students investigate roly-polies to learn about ecosystems.

By Christopher Dobson and Dan Postema

Ecology is the study of how organisms interact with their environment, and the best place to see these interactions is outside in natural habitats. Pillbugs (roly-polies) provide an excellent opportunity for students to learn ecological concepts through inquiry. Because of their fascinating behaviors, pillbugs are ideal organisms to introduce students to ecological thinking. Most children have discovered and played with these familiar and engaging creatures at some point in their lives. They are harmless and easy to find and care for. Bringing them into the classroom allows for repeated scientific observation and even simple investigations. We have guided explorations of pillbugs with third graders in summer science camps, as well as in fourth- and fifth-grade classrooms in a number of local schools. This article is based on these collective experiences. To get to know our organism a little better, see "Pillbug Profile."

Ecology Is Interactions

Ecology examines how organisms *interact* with their environment, including other organisms. This includes interactions with nonliving factors such as light, moisture, and temperature, or interactions with other organisms like competition or predation. Interactions can occur within

Pillbug Profile

Like other invertebrates (animals without backbones), pillbugs are ectothermic, meaning their body temperature varies with the environment. They have an exoskeleton (skeleton on the outside of their bodies) that must be molted several times as they grow. They have one prominent pair of antennae and a second smaller pair that is less noticeable. They have seven pairs of jointed legs protruding from seven thoracic body segments, located in front of six smaller abdominal segments. Students use a magnifying lens to make observations after carefully sticking a loop of masking tape to the back of a pillbug. This is not harmful to the pillbug and holds it still so students can examine its underside. See "Pill Bug Biology" (Raham 1986) for labeled diagrams of anatomy and relevant background information on pill bugs for teachers. For students, a list of trade books with readability levels beginning in the lower elementary grades is included under Resources.

Pillbugs are crustaceans and thus are related to aquatic species such as shrimp and crayfish, a fact that definitely surprises students (and many adults)! Many students think that pillbugs are insects, but we remind them that insects have three pairs of walking legs, not seven. Spiders have four pairs, and centipedes and millipedes both have many more. Technically speaking, pillbugs are *terrestrial isopods*, the only group of crustaceans to successfully make the move onto land. As crustaceans, they possess gill-like structures and require conditions that provide a certain level of humidity for these respiratory organs to work. Pillbugs can roll up into a ball or "pill" shape (see Figure 1). The family name of these species is *Armadillididae*, reflecting their armadillo-like appearance. Rolling up is not only a response to predators but can also help reduce water loss. One last feature students like to hear about is the pillbug's brood pouch (*marsupium*) on its underside. This structure provides shelter for juveniles after hatching. We ask students what other animals carry their babies in a pouch, and they usually say "kangaroo."

Sowbugs are another terrestrial isopod commonly mistaken for pillbugs. They cannot roll up into a ball and are visibly distinguished from pillbugs by their more flattened body shape and small tail-like appendages protruding from their rear ends (see Figure 1). We tell students to look for their "tails." Since they cannot roll up, they just run when disturbed. This makes it easy to distinguish pillbugs from sowbugs ("rollers" vs. "runners"). Recognizing pillbugs and sowbugs as distinct types of organisms allows students to know when they have more than one species. This can facilitate some interesting investigations of behavioral differences or interactions between the two species. London's Natural History Museum has a student-friendly key for identifying common terrestrial isopods (see Internet Resources). The British have several names for them, including woodlice, potato bugs, slaters, and chucky pigs!

FIGURE 1.

Pillbug vs. sowbug.

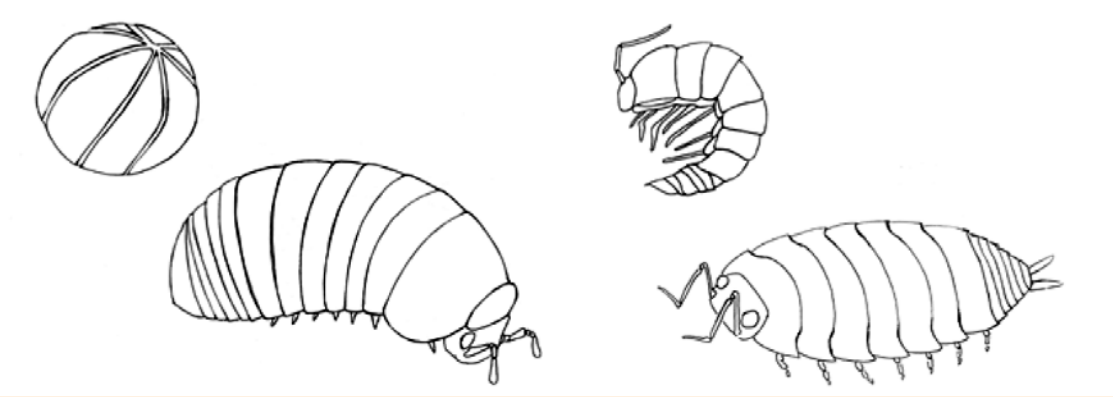

FIGURE 2.

Huddling behavior.

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a species or between different species. For example, pillbugs may compete among themselves for limited food or compete for the same food with another species, such as sowbugs or millipedes. Pillbugs are also subject to predation by a number of different species, including spiders, scorpions, frogs, salamanders, lizards, shrews, moles, birds, centipedes, and beetles.

Organisms have physical and behavioral traits that help them survive and reproduce in nature. For example, pillbugs are often found under rocks and woody debris, choosing habitats that provide the low light and higher moisture conditions they require. They are nocturnal and come out to forage at night. Another pillbug behavior is aggregation, or huddling close together (see Figure 2). They do this when the temperature drops or as a response to water loss. They can also burrow down into the soil to avoid dry air or extremes in temperature. These behaviors have allowed terrestrial isopods to be successful on land.

Organisms can also be described by their functional roles in an ecosystem, such as producer, consumer, or decomposer. Pillbugs and other terrestrial isopods are *detritivores*, eating dead organic material (mostly plants), as well as the bacteria and fungi growing on it. They play an initial role in nutrient cycling, breaking down organic matter for bacteria and fungi to finish decomposing. Students can see evidence of this if pillbugs are kept in the classroom. We have them look for the appearance of tiny fecal pellets (pillbug poop) over time; they look a lot like donut sprinkles. Another tidbit students find intriguing is that pillbugs eat their own feces, a behavior called *coprophagy*.

Student Observations

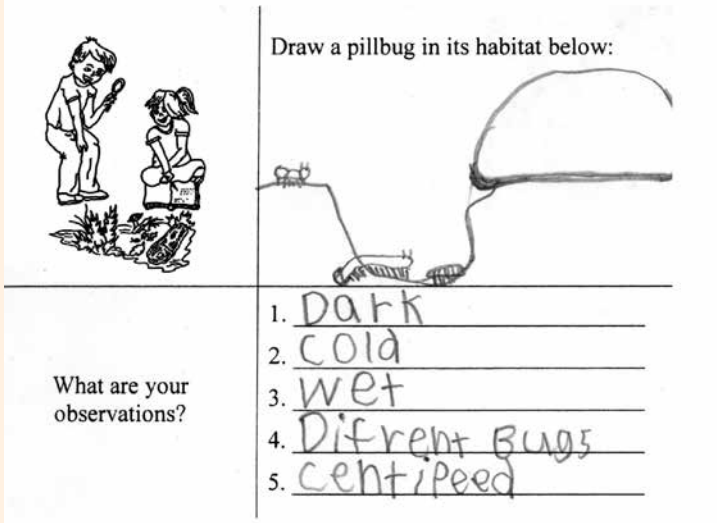
After reviewing basic information about pillbugs and ecology, we begin our investigations of pillbugs by exploring outside the classroom (see NSTA Connection for outdoor safety tips). Pillbugs are almost everywhere, and most school yards contain several populations. Fortunately, they are harmless, so safety is not an issue; they do not bite, sting, or spread disease. We caution students, however, that humans

can unintentionally harm them. Students use popsicle sticks to move leaves and debris when searching for and observing pillbugs and plastic spoons to pick them up. We carefully lift rocks and other objects for students that pillbugs may be under, watching out for less harmless species.

Outside, we have students take note of the conditions in locations where they find pillbugs and relate this back to their need for certain humidity levels (moist, cool, dark environments). We ask students to describe any differences in moisture, temperature, or light that they detect in a pillbug habitat (e.g., under a rock or small log) relative to the surrounding environment. Students often say things like, it's "wetter," or "a little cooler," or "a lot darker." We ask students how pillbugs are interacting with their environment. Specifically, we ask them why they think the pillbugs are choosing this particular habitat. They usually respond by saying something like, "The pillbugs need it to be cool and moist so they can breathe with their gills."

FIGURE 3.

A third-grade student's observations.



We ask students what else they notice. Are pillbugs isolated as individuals or are they huddled in groups? Are they the only species present? Pillbugs and sowbugs can be found together, along with other species, some of which may be predators. We ask students what interactions may be occurring in the presence of other species. Do they suspect competition? We remind them that all organisms are in competition with each other for limited resources, such as food, space, and so on. What about predation? Terms such as *predation* may be unfamiliar to students, although the concept of predator and prey is not. We make a point to introduce appropriate terminology, in this case emphasizing predation as an integral interaction of ecosystems.

Students draw the habitat and record their observations (see Figure 3), which we can use as a form of assessment (discussed later). In this figure, note that the student drew an uplifted rock and described conditions underneath it as "cold," "dark," and "wet"—good ecological observations. The student also indicated that, in addition to pillbugs, he saw "different bugs," including a "centipede," a potential predator. These observations, as well as the student responses above, show a developing understanding of pillbugs and their ecology, an initial insight into ecosystem function.

There are many YouTube videos (*www.youtube.com*) of pillbugs online. We show a few of these to engage students before going outside, or even afterward to generate ideas for further investigation. A playlist of videos that we recommend is posted on the NSTA YouTube page (see NSTA Connection), but we encourage you and your students to search for more. Students can also use digital cameras or phones to capture their own pillbug videos or pictures, and present them in a slide show to showcase their observations.

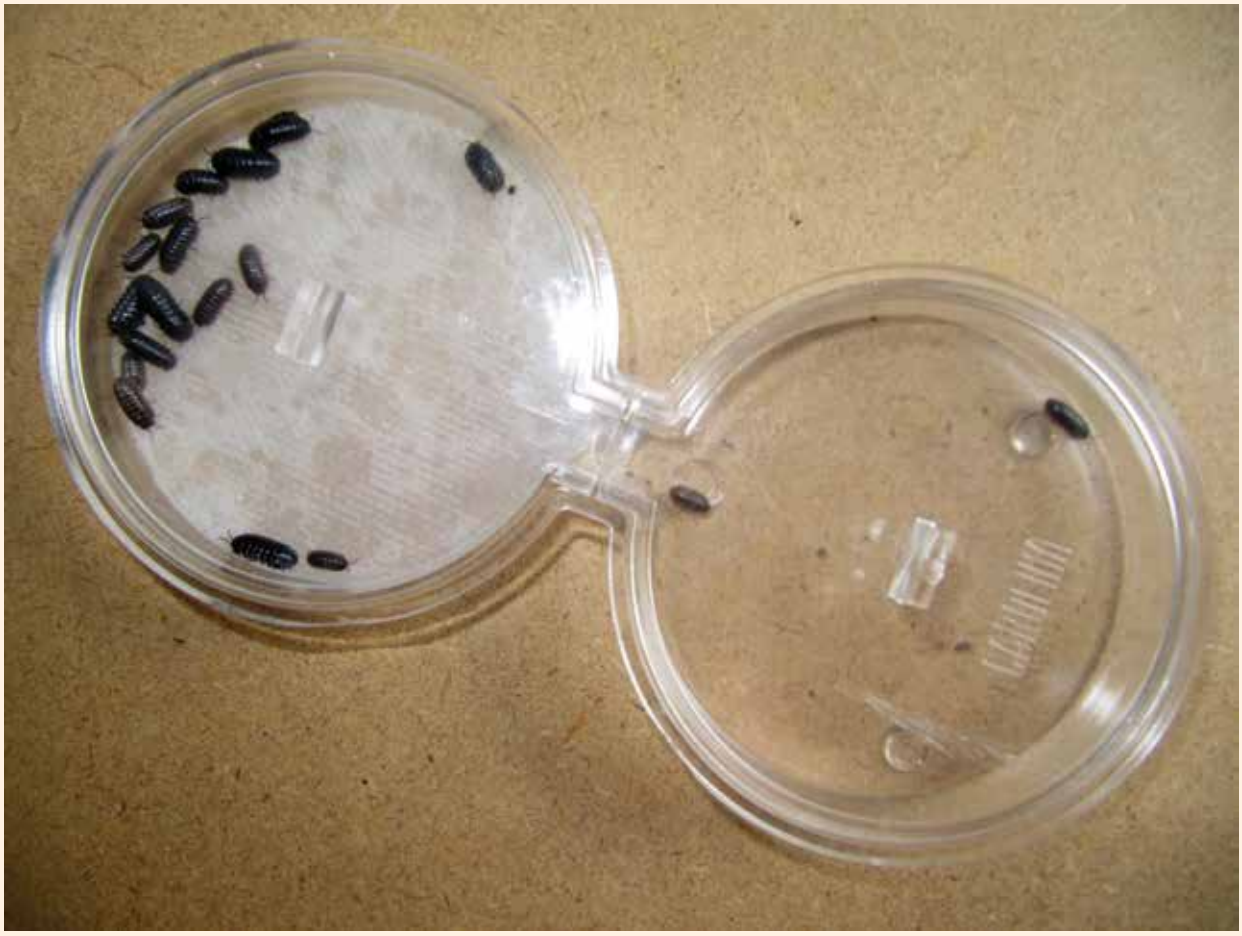
Investigate Further

To get serious about pillbugs, we take them back to the classroom and start our own colonies (see "Making a Pillbug Habitat" on p. 65). We also purchased choice chambers from Carolina Biological (see Internet Resources). These allow for investigations in which pillbugs can roam freely and "choose" between two different conditions (one of our recommended videos shows the use of choice chambers). You can also construct your own choice chambers simply by putting pillbugs in any container with two different conditions, separated by enough space for a "choice" to be made.

The use of choice chambers has allowed us to investigate "cause and effect" relationships with pillbugs (e.g., moisture). Students ask the question, "Do pillbugs prefer a moist or dry environment?" To answer this question, we have students place a cut-to-fit, moistened paper towel in one side of a choice chamber. Then students add 10 pillbugs, equally distributing them between chambers, and observe which side they find more suitable. We have students wait 10–15 minutes to allow pillbugs to explore both chambers and settle on a preference.

FIGURE 4.

Pillbugs in a choice chamber.



Then students simply count the number of pillbugs on each side to conclude they prefer a moist environment (see Figure 4). Another question students ask is, "Do pillbugs prefer a light or dark environment?" To answer this question, students cover the outside of one chamber in paper towels, creating a dark environment. Then students shine a desk lamp on the chambers to encourage shelter-seeking. Students add an equal number of pill bugs to both chambers and wait 10–15 minutes to conclude that they prefer a dark environment. Based on their observations of pillbugs outside in natural habitats, students easily predict that they will prefer moist, dark conditions in choice chambers, and are delighted when these predictions come true.

Another investigation we have easily conducted without choice chambers explores the "group behavior" of pillbugs. We tell students that some animals form groups and have specific social interactions that benefit each member of the group. Pillbugs huddling together in low humidity levels, or cold temperatures, are examples of this (see Figure 2). We have students place about 10 pillbugs in a sandwich-size Tupperware container, although any thin-walled plastic container will do. Students place the container with pillbugs in another larger tub of ice water, allowing it to float on top of the water. Within 15 minutes or so students are excited to see pillbugs demonstrating the group behavior of huddling. We make sure to relate this behavior to ecology and ecosystems, specifically pointing out that an organism's interactions with the environment include interactions with other organisms.

Additional pillbug observations become possible by raising your own colonies because they require time to occur. Students can see the molting, fecal pellets, and juve-

FIGURE 5.

Pillbug habitat without lid.

niles described earlier. After they leave the brood pouch, juveniles are tiny and almost white, so students must look closely (one of our recommended videos shows pillbug juveniles). Putting a small frog in with a colony overnight allows students to see predation, or at least evidence of it (disappearing pillbugs). Students have even found evidence of pillbugs eating a deceased member of their own species (the half-eaten body of a deceased pillbug in a colony of only pillbugs)—that's cannibalism! This and the eating of their own feces may be disturbing to some students, but are not likely to be witnessed directly by them. Any discussion of these topics can be framed in the context of the ecological role of pillbugs in decomposition and the cycling of matter.

Assessing Learning

We assess students in various ways throughout their investigations, but in particular we focus on whether students' observations and questions are improving over time, reflecting a growing knowledge of pillbugs and ecological interactions. For example, a student who notices a millipede near some pillbugs and wonders if it is competing for the same food source is demonstrating that they have learned: (1) to distinguish between pillbugs and millipedes; (2) that millipedes are also detritivores; and (3) that competition is one type of ecological interaction.

Making a Pillbug Habitat

A rectangular plastic tub (14 × 8 × 4 5/8 in.) with an opaque lid (see Figure 5) makes a good habitat after we poke holes in the lid for air. The teacher should do this using a hammer and small nail. Keep the tub in a cool location out of direct sunlight. Line the bottom of the tub with sand on one side and soil on the other. Moisture is key, so keep a folded-up moist paper towel on the sand side, since mold will not grow as well there. Re-wet the paper towel once a day, and saturate it before leaving them over the weekend. Place pieces of bark, woodchips, leaf litter, and other items on the soil side to simulate a natural environment. A few carrot shavings and small pieces of lettuce can feed a small colony of about 30 pillbugs for a week or more. Place the carrot and lettuce on the sand to reduce fungal growth. You can also order pillbugs, sowbugs, and culture kits online from Carolina Biological Supply Company (see Internet Resources) if you prefer. Or, just collect individuals for a day of investigation to be returned after school unharmed.

In evaluating their investigation skills, we observe if students' abilities to design investigations become more sophisticated with practice. As they gain experience conducting investigations, students become better at making "fair tests." They learn the importance of controlling all variables except for the one of interest (e.g., moisture or light level). We also assess student drawings of pillbugs to see if they show accurate ecological interactions. For example, a student recording observations (see Figure 3) might identify a millipede as a potential competitor or a spider as a potential predator. This reflects an important aspect of our assessment. We want students to build an understanding of ecology as organisms interacting with their environment, including other organisms. We monitor student observations, questions, and comments to see evidence of this developing understanding over time. Finally, throughout our investigations with students, we look to see that students are engaging in argument from evidence, gauging their development in this critical science practice. For example, when students make a claim, do they reference data they have collected or specific observations they have made. See Cox-Peteresen and Olson (2001), Ross (1995), and Burnett (1992) for additional ideas on assessment, including a pill bug symposium in which students present their findings like scientists.

Conclusion

Through simple investigations, students can explore interactions of pillbugs with the physical characteristics of their environment, such as light and moisture (cause and effect). They also can see how pillbugs use particular behaviors, such as huddling, to cope with changes in these conditions (social interactions and group behavior). Students learn how pillbug's specific requirements result in particular behaviors and habitats. Pillbugs are an engaging and accessible model, so go outside and get your students thinking like ecologists as they investigate the amazing interactions of pillbugs with the environment. ■

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Internet Resources

Carolina Biological Supply Company
www.carolina.com

London's Natural History Museum: Common Terrestrial Isopods Identification Key
www.nhm.ac.uk/nature-online/life/other-invertebrates/walking-with-woodlice/identification

Connecting to the Standards

Standard 3-LS2 Ecosystems: Interactions, Energy, and Dynamics

Performance Expectation:
3LS2-1 Construct an argument that some animals form groups that help members survive.

Science and Engineering Practice:
Engaging in Argument From Evidence

Disciplinary Core Idea:
LS2.D: Social Interactions and Group Behavior

Crosscutting Concept:
Cause and Effect

NGSS Table: 3-LS2 Ecosystems: Interactions, Energy, and Dynamics
www.nextgenscience.org/31s2-ecosystems-interactions-energy-dynamics

NSTA Connection

Visit *www.nsta.org/SC1403* for outdoor safety tips and *www.youtube.com/user/NatSciTeachAssoc* to access a playlist of pillbug videos.