Habitats of Urban Moths: Engaging Elementary School Students in the Scientific Process

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Abstract
Inquiry-driven teaching methods allow students to take on an active role in their own education. Through this framework, students are able to cultivate an understanding of scientific concepts and their connections while experimenting in the classroom. Our project centered around teaching students about habitats of urban moths, which are abundant in most environments. Based on the students’ hypotheses on where moths might be, homemade moth traps were placed either in a local nature preserve or in the school playground over the course of two nights. Overall, 27 moths were captured. Students then learned how to pin moth specimens and assessed what they could infer from how many moths were captured in each of the collection areas. This project created an environment for students to approach Next Generation Science Standards performance expectations about the diversity of life and how organisms interact with their environments.

Key Words: inquiry-based learning; place-based learning; elementary education; moth ecology.

Introduction
Inquiry-driven science teaching has recently increased in popularity as a way to combine learning with experimentation (Pedaste et al., 2015). With an inquiry-driven framework, students are encouraged to actively participate in the scientific process and take ownership of their learning by gaining knowledge through their work (Pedaste et al., 2012). Typically, students work through self-directed experiments to understand how variables are connected (Wilhelm & Beishuizen, 2003). Rather than rote memorization, students are encouraged to learn about scientific ideas as they apply to the experiment in real time. This hands-on experience has been shown to help improve understanding and retention of scientific concepts (Minner et al., 2009). Additionally, students are able to develop their critical thinking and analytical skills by working to make connections on their own (Madhuri et al., 2012).

Community- or place-based learning emphasizes using the area that students live in as a primary resource for education. Rooting education locally is thought to help students develop stronger ties to their community, enhance their appreciation for nature, and invoke a commitment to serve their community as a contributing member (Sobel, 2004). In subject areas like biology and environmental science, one place-based learning option is studying local plants and animals. This can help students connect with nature in their local community while they learn broader scientific concepts like nutrient cycling, species diversity, or how anthropogenic activity impacts the environment (Vander Ark et al., 2020).

Insects, such as moths, are abundant in both urban and rural settings, making them an ideal taxonomic group for instructors who want to teach students about local biodiversity. Over the course of their life cycle, moths demonstrate a variety of ecological interactions. As caterpillars, moths are voracious herbivores. As adults, moths feed on nectar and act as pollinators. At all life stages, moths are food to birds, bats, and other predators (Bates et al., 2014). Because they are attracted to lights at night, there are no restrictions on collecting nonendangered moths for research and educational purposes. Additionally, their attraction to lights at night makes trapping moths relatively easy and low cost (White et al., 2016).

These features make moths good candidates for teaching science in elementary school classrooms. For example, Next Generation Science Standards (NGSS) performance expectation 2-LS2-2 calls for students to understand reciprocal ecological relationships such as those between plants and their pollinators. There are many examples of moth-plant relationships in which they depend on each other for reproduction and survival. One example is the well-studied relationship between yucca plants (Yucca sp.) and the yucca moths (family Prodoxidae) that pollinate them. Adult yucca moths use flowers for nectar and pollen, and while doing so they move pollen from plant to plant, helping yucca plants produce seeds (Pellmyr, 2003).

The NGSS also calls for students to make observations of plants and animals to compare the diversity of life in different habitats (PE 2-LS4-1). There are many factors that influence moth diversity in different habitats, a few of which are light at night, plants for caterpillars, nectar for adults, presence of potential mates, and presence of predators (Dulieu et al., 2007; Summerville & Crist, 2008; White, 2018). While these factors are well...
known, there is no general rule for what determines where moths prefer to be at night.

In this project, we asked students in a second grade public elementary school classroom in a suburban town (population 26,065) of central Michigan to help us determine what habitat features may influence moth location at night. Students developed their own ideas, and we helped them construct low-cost traps and conduct moth trapping. We worked together to facilitate student projects over the course of four weeks late in the school year, from mid-May through early June in 2019. This project was reviewed by our university's Institutional Review Board and approved (IRB # STUDY00002563).

Objectives

The overall goal of this project was to design and implement an inquiry-based science unit where students could explore the moth diversity in their local community. We engaged students in the scientific process as they surveyed moths in local habitats, constructed moth traps and handled moth specimens.

Methods & Results

Our project was implemented in a second grade elementary school classroom in Michigan over the course of four weeks from the second week of May to the first week of June. The teaching team consisted of two faculty members and one graduate student member of Michigan State University Department of Entomology, one faculty member and one graduate student member of the Michigan State University department of Teacher Education, and two undergraduate students from the Lyman Briggs College at Michigan State University. During the course of the project, the teaching team spent an average of 45 minutes with the class of 19 students twice a week. The project was broken into four parts model the cycle of scientific inquiry: observe and learn about moths, ask questions and create hypotheses, design and implement an experiment, and interpret results and ask more questions.

Part 1—Observe & Learn

The first step was to survey students on what they already knew about moths. Prior to any instruction, students were asked to draw, using pencil and paper, what they thought a moth looked like. They were given 10 minutes to complete their drawing, and any questions they asked were answered with simple encouragement (“just do your best”) in order to reduce the risk of influencing the students’ drawings in any way. This activity was repeated at the end of the project to gain a sense of how students’ ideas about moths changed over the course of the lesson series (Figure 1).

Further, students were asked to share verbally what they know about moths. To facilitate this with second grade students, the class was broken into groups of three or four students with a teaching team member assigned to each group. Students shared their thoughts while the teaching team member acted as the scribe. Next, one member of the teaching team stood at the front of the classroom and called on groups to share ideas and wrote answers on the board as students offered them. A few examples shared by students were, “they are a bit like butterflies but do different things,” “they are furry on the bottom and scaly on the top,” “they follow the moon to see where they are going at night,” and “when moth wings are wet, flying is difficult.” Each idea shared was treated the same, and no misconceptions were commented on.

Figure 1. (A) An assortment of examples of students’ moth drawings at the start of the four-week project. (B) Examples of students’ drawings after finishing the four-week unit.
After hearing students’ thoughts, we gave a short, image-based presentation on moths that focused on three key messages that we wanted students to retain and understand: moths help flowers make seeds (shown with imagery of moths pollinating flowers); moths are food for birds, bats, frogs, and other animals (shown with imagery of these animals eating moths); and some moths harm the environment (shown with imagery of herbivory damage in crops and forests). Though the intent of the project was primarily for students to learn through action, we incorporated this step as an opportunity to show imagery of a diversity of moths and habitats that otherwise might not be found during moth collection around their school.

Next, we allowed students to observe moths in display cases brought in from Michigan State University. During this time, we asked students about their observations on what moths look like, what makes them different from other insects, and what distinguishes the different types of moths on display. Similar to their initial share-outs, this was facilitated by splitting the class into groups of three or four students per teaching team member. The teaching team member wrote down the students’ ideas and ensured each student got an opportunity to share their thoughts. These activities were incorporated as opportunities for students to note the diversity of moths that occupy many habitats (NGSS 2-LS4-1).

**Part 2—Question & Hypothesize**

Once students had some general information on moths, they were asked a mixture of open-ended and guiding questions to facilitate hypothesis formation. For example, “what would you like to learn about moths?” or more leading, “how do you think we collected these moths?” During this discussion we also asked students to imagine how we might answer some of their questions. For example, if we were wondering about where moths live, we could go out and attempt to collect moths from different areas where we thought they might be found. Focusing on the concept that moths occupy many habitats, we took the students out on a walk around the grounds of their school, asking them to make predictions on where they thought moths might be found and why. This was an opportunity to use some of the knowledge they had learned during Phase 1—moths visit flowers, moths need to avoid predators, and moths eat leaves. While walking the grounds in groups of three or four students per teaching team member, students staked with flags areas where they predicted moths would be found.

After marking their predictions in small groups, a teaching team member summarized students’ predictions and reasoning on the board back in the classroom (Table 1). Concurrently with the share-out, we asked students to form hypotheses on why they thought moths might be found in a certain location. Their reasoning was drawn from Phase 1 and knowledge they had from their own experiences with moths and other insects prior to beginning the project.

Following class discussion, the students settled on two locations they wanted to compare—a well-lit and highly populated area near their school playground and a forested nature preserve next to the school that is relatively dark at night and doesn’t experience much human activity.

**Part 3—Experiment**

Students worked in small groups of three or four students and one teaching team member to build their own moth traps. The materials needed to build a trap were a cylindrical stake, a two-liter bottle, a binder clip, a piece of cardstock or construction paper, an LED light (5 mm straw hat type), a coin cell battery (CR2477 battery, 3 volt), scissors, and duct tape (Figure 2). The teaching team pre-cut the two-liter bottles in half, a task that may be difficult for small hands. Once constructed, traps were deployed by the teaching team on two nonconsecutive nights in areas chosen by students during Part 2. The teaching team set out the traps because they needed to be set out at dawn and dusk, outside of school hours. This also meant the teaching team members were the only ones to touch the pesticide strip placed in the collection bucket of the trap. We used Hot Shot brand No Pest Strips (https://www.hotshot.com/products/general-insect-control/no-pest-strip.aspx) cut into small pieces, the active ingredient of which is dichlorvos (2,2-dichlorovinyl dimethyl phosphate).

Collected moths were brought back to the classroom where students were taught how to pin and spread moth specimens (Figure 3). Overall, 25 moths were collected in the forested nature preserve and 2 moth were collected near the school playground. To pin moths, students used Bioquip brand insect pins, small pieces of foam board to push their pins into, and strips of wax paper to hold moth wings into position. Students worked closely with members of the teaching team to ensure safety when using the sharp pins. It takes about 24 hours for a moth specimen to be fully dried and set in place after being pinned. Once students had pinned their moths, they were given moth identification guides to flip through and determine what moth species they had pinned (Beadle & Leckie, 2012; Handfield 2011). In place of book guides, it would also be possible to use online resources such as bugguide.net or discover-life.org.

Here we would like to address potential questions about the safety and ethics of insect collecting. Regarding safety, while the pesticide strips should not come into contact with eyes or mouths, placement in a well-ventilated area or outdoors allows vapors from the strips to disseminate safely (Hot Shot, 2016). The strips used inside the insect traps are efficient and kill moths rapidly upon their entrance into the trap. These pesticide strips were handled only by the teaching team members placing out the traps and were removed from the traps before they were brought into the classroom. Regarding ethics, we note that there is a long history of enthusiastic discourse around the ethics of insect collection for hobby, education, and research purposes (Trietsch & Dean, 2018; Drinkwater et al., 2019; Fischer & Larson, 2019). There is no single “right” answer to this question, and different readers, educators, and students may feel differently about this practice. It is not our goal with this paper to present the arguments for or against using insects in this manner.

**Table 1. Suggestions from students on where to place traps in order to capture moths.**

| Location             | Reasoning                                      |
|----------------------|------------------------------------------------|
| Well-lit areas       | Lights attract moths.                         |
| Forests              | They have flowers and trees.                  |
| Closets in homes     | Some moths like clothing.                     |
| Tree-covered areas   | There is no light.                            |
| Below a tree         | Moths eat leaves.                             |
| Near a flower        | Moths like flowers.                           |
| Open field           | No trees block flight. There are many flowers.|
| Nature reserve park  | There are lots of trees and few people.       |
Figure 2. Trap used to capture moths. Two-liter bottle (A) cut in half and top placed upside down to allow moths entry but prevent escape. Binder clip (B) holding a coin cell battery (C) to nodes of an LED light (D). Bamboo stake (E) taped onto the bottle and holding the binder clip. Paper, with opening cut (F), affixed to a stake with tape to knock moths into the bottle. Pesticide strip (G) placed in bottle to incapacitate moths as they enter. Example on the right of a student’s trap.

Figure 3. Diagram of how to pin a moth. Pinning board can be created by attaching pieces of foam board together with a groove in the center for the moth body to be pinned into.

Pilot studies conducted by our teaching team in a middle school classroom did not reveal student concerns about insect collection nor suggest that killing insects would be a barrier for student learning (Stroupe et al., 2018). If this is an area of concern or interest for an educator, we encourage them to provide an opportunity for students to discuss the ethics of insect collecting with their students prior to moth trapping and to consider alternative activities if concerns arise. In the case of the project that we present here, students did not voice concern about the moths we collected. This could be in part because their introduction to moths was through pinned specimens, or perhaps because of the nocturnal nature of most moths, students were not observing and personifying moths in the wild before collecting them.
Part 4—Interpret Results & Start Again!

To help visualize what we had collected, all the pinned moth specimens were organized onto a “Biodiversity Board” (Figure 4). Using this display, students were asked to interpret what they had learned about moths. This opened a discussion on moth habitat preferences, how they fit into local ecosystems, and our research projects often lead to more questions. Lastly, we resurveyed students by asking them to draw what they think of when they think of a moth. Again, they were given 10 minutes to work independently with no feedback from the teaching team. Both the pre- and post-unit drawings were scored for various markers consistent with features discussed during the unit that separated moths from other animals (Figure 5).

Discussion

In total, the students collected 25 moths from the forested nature preserve and 2 moths from the well-lit area near their school playground over the course of 2 nights. Our project took place in Michigan from the second week of May to the first week of June. In this research area, moths generally fly from the end of May through the end of August, meaning students were catching some of the first moths emerging for the season. This may have limited the number of moths available for collection. For other institutions in warmer or more mild climates, this project could be conducted during a broader range of days within the school year.

Visualizing the collection using a Biodiversity Board with all their moths sorted by catch location helped students connect the traps placed in the two study locations and the moths they now had in front of them. While discussing results, students were asked to recall their initial predictions that led them to choose those two locations and reflect on why the forested nature preserve might have caught more moths than the well-lit area. One student suggested, “because [the forested nature preserve] has more trees and leaves, that’s how moths can hide” noting our discussion on moths’ need to avoid predators.

There were consistent differences observed between the pre- and post-unit drawings created by students. Though not intended as a strict quantitative measure of students’ grasp of moth biology, a few interesting trends emerged when comparing drawings (Figure 5). For example, though students were given the same amount of time to work on their drawings before and after the project, the post-unit drawings often featured more structural detail such as the addition of antennae or a proboscis (moth tongue). In their post-unit drawings, 42% of students also added habitat features, such as trees and flowers, connecting back to the experiment the students had conducted on moth location within a habitat.

Figure 4. Students observing the Biodiversity Board with moths they have pinned and helped to identify.

Figure 5. Pre- and post-unit drawings from 19 students were scored for markers, based on features discussed during the unit, that make moths unique from other animals.
During our final discussion as a class, we asked students what they had learned about moths through this experiment. Some students remarked on the experience itself, noting that moths can be tricky to pin. One student pointed out that moths can sometimes be bad for the earth because they eat so many leaves. Students also reflected on the diversity of moths and how that varies between habitats, noting that there are many moth species in general and that there were many more types of moths found in the forested nature preserve than there were at their school playground. We believe these reflections are an indication that the project created opportunities for students to form ecology-focused connections like those denoted by the Next Generation Science Standards.

Lastly, this project was created with elementary-age children in mind but could certainly be implemented for older students as well. In our case the students had lots of help when it came to facilitating discussion, writing down their thoughts, and the trap construction components that required more dexterity. To adjust the project for older students we believe they could be given even more agency during these activities to encourage independent development throughout the project. Additionally, in this project the entire class worked together to explore a single hypothesis; at higher levels, students could work in teams or pairs to address their own hypotheses, and then they could report their findings to the class in either a written or oral format.

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