Adventures with Arthropods

ECO-FRIENDLY LESSONS FOR MIDDLE SCHOOL

RON WAGLER

NSTA press
National Science Teachers Association

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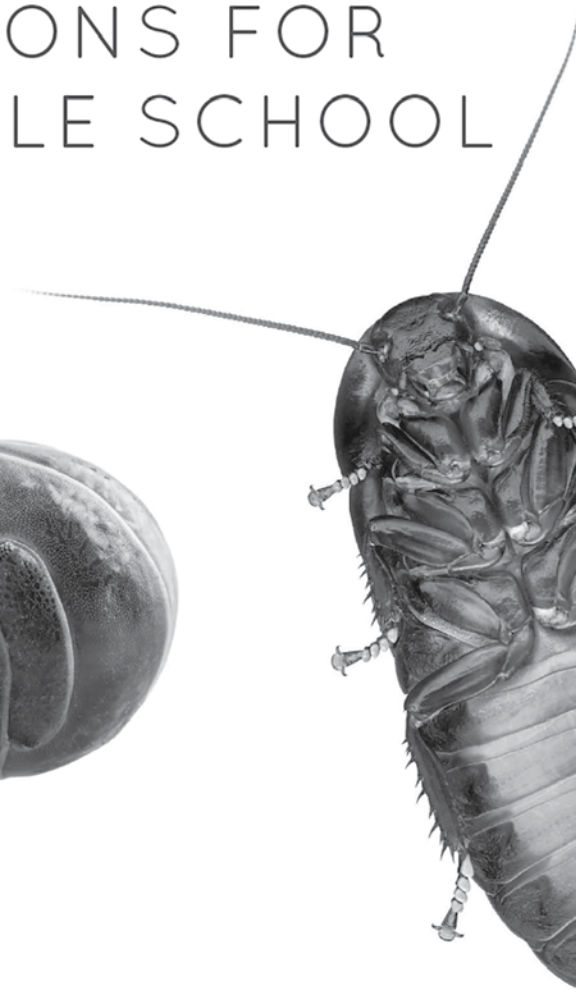

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Arlington, Virginia

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www.nsta.org/store
For customer service inquiries, please call 800-277-5300.

21 20 19 18 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Names: Wagler, Ron, 1967- author.
Title: Adventures with arthropods : eco-friendly lessons for middle school / Ron Wagler.
Description: Arlington, Virginia : NSTA Press, [2017]
Identifiers: LCCN 2017031734 | ISBN 9781681403052 (print)
Subjects: LCSH: Arthropoda--Study and teaching (Middle school) | Arthropod pests--Study and teaching (Middle school)
Classification: LCC QL434.4 .W34 2017 | DDC 595.076--dc23 LC record available at https://lccn.loc.gov/2017031734
e-ISBN: 978-1-68140-306-9

Some of the information in this book first appeared in NSTA journal articles and has been used with permission. Ron Wagler was the author of those articles.

Contents

About the Author

Ron Wagler is an associate professor of science education at the University of Texas at El Paso and the founder and director of the Living Arthropod and Environmental Education Laboratory. His laboratory is the only laboratory in the world dedicated to research related to arthropod education. The research behind this book was conducted in Ron's laboratory and then field tested in many different educational settings to verify its accuracy and effectiveness. Ron has been recognized nationally and internationally for his research in the field of arthropod education and has authored or coauthored more than 60 national and international peer-reviewed and professional publications. Ron pioneered most of the foundational research in the area of arthropod education and is considered one of the foremost experts in his field. He has received more than $1.2 million in research grant funds and has been a principal investigator or coprincipal investigator on many grant proposals. He has presented his arthropod education research and been a keynote speaker, expert panelist, roundtable speaker, and guest speaker at national and international conferences. Ron has more than 25 years of experience teaching biology, science education, and environmental education to students from the preK to doctoral levels. He participates in service to his department, college, and university; the national and international science education and environmental education communities; and his local community. Ron's research, teaching, and service activities have won corporate, conference, university, state, and national awards and have been highlighted in many media outlets, including *National Geographic*. You can follow Ron's ongoing adventures with arthropods on his Living Arthropod and Environmental Education Laboratory Facebook page at *www.facebook.com/LivingArthropodEducationLaboratory.*

Ron would like to thank Amy Wagler, PhD, who suggested that the main title of this book should be *Adventures With Arthropods.*

Chapter 3

Lessons Using Captive-Bred Madagascar Hissing Cockroaches

This chapter provides beginning-, intermediate-, and advanced-level lessons with Madagascar hissing cockroaches (MHCs) that will develop and nurture the scientific-inquiry skill of observation in middle school students. Many students' first experiences with formal science occur in an early elementary classroom, with science lessons that are largely focused on observation. Some middle school (grades 6–8) teachers erroneously believe that observation lessons are only appropriate in grades K–5, and that their sole purpose is to prepare those young students to conduct scientific-inquiry lessons in middle school that involve one variable change (NRC 1996). Because of this, in some middle school science classrooms, observation lessons are given a backseat to experiments involving variable manipulation; however, this is at odds with the *National Science Education Standards* (*NSES*) for grades 6–8, which uses the terms *observe, observed, observation, observations,* and *observational* more than 30 times (NRC 1996, pp. 142–171).

NRC (1996) also say that it is important that the science education experiences of students parallel the experiences of scientists (p. 214), and that

> *The instructional activities of a scientific inquiry should involve students in establishing and refining the methods, materials, and data they will collect. As students conduct investigations and make observations, they should consider questions such as "What data will answer the question?" and "What are the best observations or measurements to make?" (p. 144)*

All images are courtesy of the author unless otherwise noted. Full-color versions are available at *www.nsta.org/arthropods*.

Chapter 3

Observation is an essential component of science and an essential skill many scientists use throughout their career, and thus is a skill that must continue to be developed and nurtured in middle school students if they are to fully participate and succeed in science. Middle school students can develop and enhance their observation skills through participating in teacher-guided scientific-inquiry (NRC 1996) lessons in which they observe animals that tend to act in known, predictable ways. MHCs (*Gromphadorhina portentosa*) are one such animal.

Table 3.1 shows how Chapter 3 lessons support the *Next Generation Science Standards* (*NGSS*), the Nature of Science, and the *Common Core State Standards* (*CCSS*).

Table 3.1. Chapter 3 Lesson Support of Learning Standards

Lesson	Standards Supported
3.1. MHC Basic Behaviors 3.2. MHC Anatomy 3.3. MHC Eating 3.4. MHC Grooming 3.5. MHC Response to Temperature Change 3.6. MHC Pile-On Behavior 3.7. MHC Response to Lighting Levels	***NGSS*** **Nature of Science Connection** Scientific Knowledge Assumes an Order and Consistency in Natural Systems • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
3.8. MHC Male Agonistic Behavior for Floor Space 3.9. MHC Male Agonistic Behaviors for Raised Space 3.10. MHC Behaviors in Defended Territories	***NGSS*** **Performance Expectation** ***MS-LS1-4.*** Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively. **Science and Engineering Practice** ***Engaging in Argument From Evidence:*** Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **Disciplinary Core Idea** *LS1.B: Growth and Development of Organisms* • Animals engage in characteristic behaviors that increase the odds of reproduction.

Table 3.1 (*continued*)

Lesson	Standards Supported
3.8. MHC Male Agonistic Behaviors for Floor Space 3.9. MHC Male Agonistic Behaviors for Raised Space 3.10. MHC Behaviors in Defended Territories *(continued)*	***NGSS*** *(continued)* **Nature of Science Connection** Scientific Knowledge Assumes an Order and Consistency in Natural Systems • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. ***CCSS*** ***CCSS.ELA-LITERACY.WHST.6-8.1:*** Write arguments focused on discipline-specific content.

Source: NGSS Lead States 2013 and NGAC and CCSSO 2010.

Introduction and Setup for the MHC-Observation Lessons

Materials and Preparation

To prepare for the lessons in Chapter 3, gather the following tools and materials. The required amounts of the materials depend on the size and number of your student groups, which varies depending on class size.

For the class

- Transparent containers with secure lids
- Small nails or similar devices for puncturing the lids of the containers
- Foods MHCs will eat (e.g., dry dog food, celery, carrot, tomato, squash, grape, red leaf lettuce, romaine lettuce, banana, banana peel, sliced orange and apple, pea pods, sliced potato, and sweet potato skin)
- Small paintbrushes
- Small bag of baking flour
- Thermometers
- Heating pads
- Large bowls of ice
- 2-liter soda bottles
- Rolls of adhesive tape (2 in. wide, clear)
- Scissors
- Pieces of heavy fabric (for blocking light)
- Safety glasses or goggles (for when cutting or puncturing)

- Metallic silver paint pens or bottles of nail polish (not colored paint pens)
- Wood blocks (10 cm [4 in.] × 5 cm [2 in.] × 1 cm [0.4 in.])

For each student

- Nonlatex gloves
- MHC Behavior Data Collection Chart
- MHC Behavior Data Collection Chart for Lessons 3.8–3.10
- Adult Male MHC Agonistic Behaviors Associated With Lessons 3.8–3.10

All observation lessons in this chapter can be performed by having students observe the MHCs in multiple observation stations in different parts of the classroom, made with transparent plastic containers with secure lids (see Figure 3.1). To make these observation station containers, make small holes no larger than 1.5 mm (1/16 in.) in diameter in the transparent plastic containers using a small nail or other similar device. Beginning, intermediate, and advanced observation lessons will progressively familiarize students with MHC behavior. The lessons should be performed in sequential order to develop and challenge students' understanding of the scientific skill of observation. However, depending on your students' observational skill level, you may choose to skip the beginning-level lessons or the intermediate-level lessons.

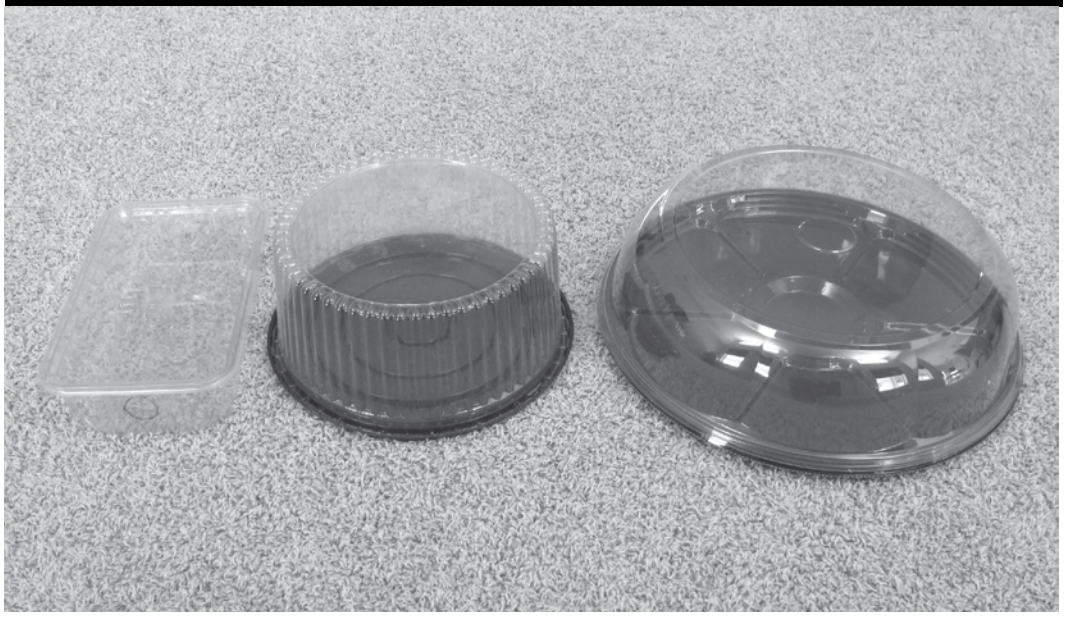
Beginning- and Intermediate-Level MHC-Observation Lessons

Demonstrate how to pick up an MHC. Gently pick up one MHC and let it crawl freely from one hand to the other or from your hand to a student's hand. Let the students know that MHCs have spikes on their legs and they might feel the spikes on their hands if they restrict the roach's movement with their hands. Often people who are unaware of the spikes are startled by that sensation and think the roach has bitten them; however, this is not so, as MHCs cannot bite. This experience can be avoided by informing the students about the spikes and encouraging them to not restrict the roach's movement with their hands.

Provide laboratory nonlatex gloves to students who are uneasy touching the MHCs directly. Inform all students that wearing the nonlatex gloves is optional when handling MHCs, but that they should always wash their hands with soap and water when they are finished holding MHCs or any other animal. If some students still fear picking up or touching the MHCs, remind them that MHCs are slow-moving, flightless, and cannot bite, but never force a student to pick up an MHC if he or she does not want to. One or two students can be designated as caregivers, and this role can rotate among students.

Once students are somewhat familiar with the MHCs, they can perform the beginning- and intermediate-level MHC-observation lessons given in Table 3.2 (p. 18). The more complex interactions in Lessons 3.8–3.10 (Table 3.4, p. 23) take what students have learned in Lessons 3.1–3.7 and challenge students further. For all of this chapter's lessons, smaller numbers of MHCs may be used. The lessons can be conducted in a dimly lit room or a dark room with

Figure 3.1. Examples of MHC Observation Station Containers



Examples of transparent, disposable plastic food packaging that can be repurposed as MHC observation stations. For the safety of students and the MHCs, do not use containers that previously contained chemicals.

a red light (MHCs prefer darkness) but this is not essential. If you have access to a camera, you can also record the MHC behaviors for later review. Students should be aware that quick movements, loud sounds, and vibrations can inhibit the MHCs' behaviors.

All observation lessons should be performed in small groups. Encourage students to quietly discuss the MHCs' behavior with the rest of their group during the observations. This allows students to use feedback from their peers to collectively and cooperatively come to conclusions about the behaviors. Feedback of this nature assists students if they need clarification about the MHC behaviors, helps them develop essential social skills, and conveys the value of working together to solve a problem (NRC 1996). Some MHC behaviors will be apparent to students, whereas others will not. If, after some time, students are having trouble seeing specific behaviors, use leading questions to direct them to the behavior you want them to observe. If at all possible, do not tell students what the MHCs will do—that would eliminate the excitement of discovery learning. The student observations associated with Lessons 3.1–3.7 can be performed immediately after setup. When a lesson is finished, the MHCs can be returned to their permanent classroom enclosure.

Table 3.2. Beginning- and Intermediate-Level MHC-Observation Lessons

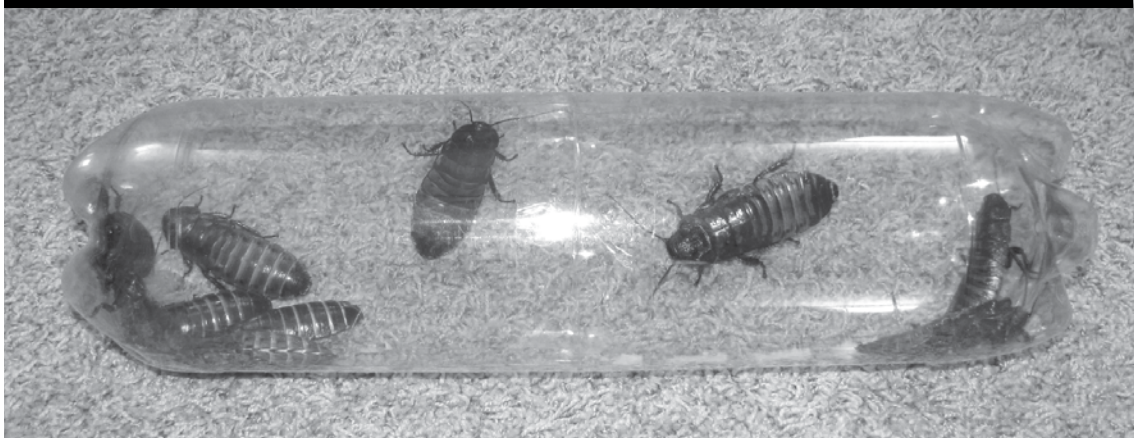
Lesson	Setup	MHC Behavior or Characteristic
3.1. MHC Basic Behaviors	Place five adult MHCs in a transparent container with a secure lid.	Have students observe the MHCs walk, move their antennae, use their antennae to touch each other and the enclosure, climb, use their mouth parts to touch each other and the enclosure, walk on the top of one another, hiss, and lie flat against the floor.
3.2. MHC Anatomy	Place five adult MHCs in a transparent container with a secure lid.	Have students observe the MHCs' color, exoskeleton top and bottom, two antennae, six jointed legs, three body parts (head, thorax, and abdomen), leg spikes, padded feet, and mouth parts, as well as the differences between adult males and adult females.†
3.3. MHC Eating	Place five adult MHCs in a transparent container with a secure lid, and then place in the container a variety of foods that MHCs are known to eat in captivity. These include dry dog food, celery, carrot, tomato, squash, grape, red leaf lettuce, romaine lettuce, banana, banana peel, sliced orange and apple, pea pods, sliced potato, and sweet potato skin. ***Safety note:** Remind students that they should never eat food used in science lab lessons!*	Have students observe the MHCs eating some foods and not eating other foods. MHCs will eat all foods listed in the setup column; however, most MHCs prefer some foods over others.
3.4. MHC Grooming	Using a small, dry paintbrush, lightly dust baking flour onto the antennae and legs of five adult MHCs. Place them in the transparent container with a secure lid. When the lesson is completed, rinse the flour off the MHCs with lukewarm water (Bobula Smith and Valentine 1985).	Have students observe the MHCs grooming (i.e., cleaning) their antennae and legs (Bobula Smith and Valentine 1985).
3.5. MHC Response to Temperature Change	Set up two transparent containers (with secure lids), each with a thermometer and five adult MHCs. Place a heating pad beneath one container and let the temperature rise to 90°F. Place the other container in a large bowl of ice and let the temperature decrease to 60°F. ***Safety note:** Use caution when working with heating pad, and keep away from water—potential electrical shock hazard.*	Have students observe that the MHCs move less when the container is cold and more when the container is warm. MHCs are ectotherms. They increase their activity when their environment is warm, and decrease it when their environment is cold.

Table 3.2 (*continued*)

Lesson	Setup	MHC Behavior or Characteristic
3.6. MHC Pile-On Behavior	On a day when the humidity is particularly low, place 10 adult MHCs in a transparent, dry container with a secure lid. Do not put food or water in the container (Yoder and Grojean 1997).	Have students observe the MHCs piling on top of one another to reduce their water loss (Yoder and Grojean 1997).
3.7. MHC Response to Lighting Levels	Using a small nail or other similar device, make small holes, no larger than 1.5 mm (1/16 in.) in diameter, in two 2-liter bottles. Cut off the first 4 inches of the spout end of both bottles. Place 10 adult MHCs in one of the bottles and tape the cut edges of both bottles together so the bottles make a continuous tube. Lay the tube on its side and allow the MHCs to move so they occupy both sides and the middle of the tube (Figure 3.2). Then, place one end of the tube near a sunny window or other very bright light source. Lay a piece of thick fabric over the half of the tube farthest from the window or bright light source. ***Safety notes:** (1) Wear eye protection when making holes or cutting material. (2) Nail ends can be sharp and cut or puncture skin. Sharp hazard!*	Have students observe the MHCs moving away from the brightly lit end of the tube and into the dark end of the tube. When the MHCs have done this, turn the tube around so the MHCs are by the light again. Place the fabric as before, so half of the tube is dark. The MHCs will move to the dark side again. The students can do this as many times as they would like. As nocturnal animals, MHCs prefer dark environments.

†Adult MHCs are sexually dimorphic. This difference in appearance will be apparent. Adult male MHCs have two large, protruding bumps on the dorsal plate behind their head. Adult female MHCs also have protruding bumps (i.e., tubercles) in the same location, but they are smaller and smooth.

Figure 3.2. MHC Tube Made From Two 2-Liter Bottles and Used in Lesson 3.7



Chapter 3

Recording MHC Behavior in the Beginning- and Intermediate-Level Lessons

Figure 3.3 is a data collection chart for Lessons 3.1–3.7. For each lesson, students should record the behavior name and the number of times it was displayed by the adult MHC. (A good way to keep track of this is to make a tally mark each time the behavior occurs.) Students should also describe and draw the behavior. If students need more space than provided on the form for the description and drawing, they can use an additional piece of paper. The time each behavior occurred can also be added to the chart, if desired. The data your students observe and collect, whether in written or schematic form, can be reviewed to assess whether students understand the behaviors the MHCs have displayed. (See the "Assessing Student Observation and Understanding of MHC Behavior" section on p. 25.)

Advanced MHC-Observation Lessons

Once students have performed the beginning- and intermediate-level MHC-observation lessons and you are confident they have mastered them, they can move on to advanced-level Lessons 3.8–3.10. These three lessons focus on adult male MHC agonistic (aggressive and defensive) behaviors. MHCs are social insects with a fascinating social structure. One of the most amazing aspects of the MHC social structure is these agonistic behaviors displayed by males and the use of complex acoustic signals (their hissing) done by males and females. This MHC "language" is not well understood.

The student observations associated with Lessons 3.8–3.10 can be performed immediately after the setup; however, it is highly possible (especially for Lessons 3.9 and 3.10) that periodic observations over a few days will be needed to ensure that students observe all of the behaviors the MHCs will display in these lessons (listed in Table 3.3, p. 22). See the "Recording MHC Behavior in Advanced-Level Lessons" section for how students should record their observation data and the "Assessing Student Observation and Understanding of MHC Behavior" section for guidance on teacher assessment of students' recorded observations (both sections on p. 25). All MHCs used in Lessons 3.8–3.10 should be individually marked with a different letter to identify them. (See the schematic diagram in Figure 3.4, p. 23.) The letter can be drawn on the thorax of the MHC using a silver paint pen or nail polish. (Colored paint pens will not work.) Drawing a letter on MHCs will not injure them. The three advanced-level observation lessons are described in Table 3.4 (p. 23). *Safety note:* Always wash hands with soap and water after completing these lessons.

Figure 3.3. MHC Behavior Data Collection Chart

Date: _____	Observation begin time: _____
Observer name: _____	Observation end time: _____

Observations of Adult MHC Behaviors and Characteristics

Behavior or Characteristic	If Behavior, How Many Times Performed?	Written Description*	Drawing*

*If you need more space, use a separate piece of paper.

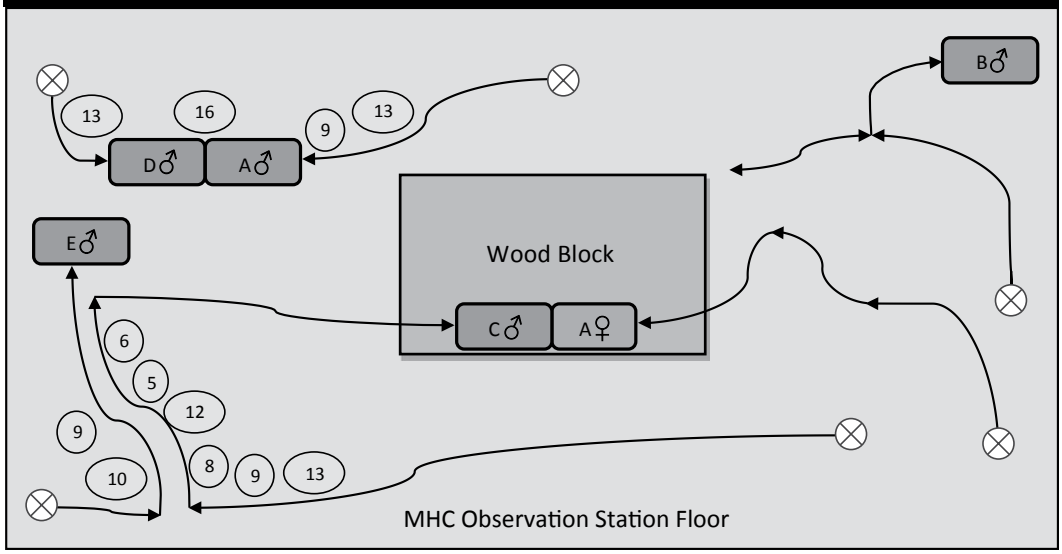
Table 3.3. Adult Male MHC Agonistic Behaviors Associated With Lessons 3.8–3.10

Agonistic Behavior Number	Adult Male MHC Agonistic Behavior
1	Sits on another adult male MHC.
2	Chases another adult male MHC.
3	Flips another adult male MHC.
4	Pushes another adult male MHC with its abdomen.
5	Uses its antennae like fencing swords on another adult male MHC.
6	Lunges at another adult male MHC.
7	Hits another adult male MHC with its abdomen.
8	Pushes its abdomen up in the air.
9	Hisses at other adult male MHCs.
10	Lays flat against the floor.
11	Moves away from another adult male MHC.
12	Shakes its abdomen back and forth.
13	Moves toward another adult male MHC.
14	Lifts the front of its body off of the floor.
15	Moves one side of its body toward the floor.
16	Lowers its dorsal plate so its "horns" (its tubercles) are exposed, and then runs forward and hits another adult male MHC with its horns.

Sources: Modified from Clark and Moore 1995 and Guerra and Mason 2005.

Note: Be assured that none of these behaviors injures the adult male MHCs in any way.

Figure 3.4. Simplified Schematic Diagram of the Movement and Interaction of Five Adult Male MHCs (A–E ♂) and One Adult Female MHC (A♀) from Lesson 3.10



The symbol ⊗ indicates where the MHC was initially placed into the observation station by the student. See Table 3.3 for the corresponding behaviors recorded by the numbered ovals.

Table 3.4. Advanced-Level MHC-Observation Lessons

Lesson	Setup	MHC Behavior or Characteristic
3.8. MHC Male Agonistic Behaviors for Floor Space	Place five adult male MHCs in a transparent container with a secure lid. Observe their behavior. ***Safety note:** Wash hands with soap and water after completing this lesson.*	Have students observe adult male MHCs use agonistic behaviors (see Table 3.3) to attempt to establish territory and defend it against the other four adult male MHCs. The territory each will defend in this lesson will be a part of the floor space of the container they are in. Adult male MHCs establish and defend territories to attract adult female MHCs for potential mating opportunities. The adult male that mates with a female (or females) attracted to his territory will pass his genes on to the next generation of MHCs. **Extend:** After students have performed the observation with five MHCs, you can further challenge their abilities by having them attempt to record the movement and interaction of 10 adult male MHCs and determine whether a change in the population density of adult male MHCs causes a difference in behavior (Clark and Moore 1994; Guerra and Mason 2005).

Table 3.4 (*continued*)

Lesson	Setup	MHC Behavior or Characteristic
3.9. MHC Male Agonistic Behaviors for Raised Space	Place five adult male MHCs and one wood block (10 cm [4 in.] × 5 cm [2 in.] × 1 cm [0.4 in.]) in a transparent container with a secure lid. If you do not have a wood block of these dimensions, wood blocks or rocks with similar dimensions can be used. ***Safety note: Wash hands with soap and water after completing this lesson.***	Have students observe adult male MHCs using agonistic behaviors (see Table 3.3, p. 22) to attempt to establish territory and defend it against the other four adult male MHCs. The territory in this lesson will be the wood block in the container they are in. Students should observe that one of the adult male MHCs will eventually win ownership of the wood block, sit on top of it, and defend it against the others (Clark and Moore 1994; Guerra and Mason 2005). This lesson is like Lesson 3.8, but with different territory for the adult male MHCs to attempt to establish and defend. In captivity, adult male MHCs will use platforms as territories to attract females for potential mating opportunities. The MHCs will display the same agonistic behaviors as observed in Lesson 3.8, except in this lesson, the territory the adult male MHCs will establish and defend will be a platform (the wood block). **Extend:** After students have performed the observation with five MHCs, you can further challenge their abilities by having them attempt to record the movement and interaction of 10 adult male MHCs and determine whether a change in the population density of adult male MHCs causes a difference in behavior.
3.10. MHC Behaviors in Defended Territories	Place five adult male MHCs, one adult female MHC, and one wood block (10 cm [4 in.] × 5 cm [2 in.] × 1 cm [0.4 in.]) in a transparent container with a secure lid. If you do not have a wood block of these dimensions, wood blocks or rocks with similar dimensions can be used. ***Safety note: Wash hands with soap and water after completing this lesson.***	Lesson 3.10 builds on Lesson 3.9. Have students observe that once an adult male MHC has established and defended a territory (e.g., a part of the floor space or a wood block), an adult female MHC will come to that territory and stay in it with the male that won that specific space **Extend:** Further lessons can be performed that manipulate the ratio of males to females and the number of blocks in the transparent container (Clark and Moore 1994; Guerra and Mason 2005).

Recording MHC Behavior in Advanced-Level Lessons

Figure 3.5 (p. 26) provides an MHC Behavior Data Collection Chart that can be used for Lessons 3.8–3.10. For these lessons, assign each student one MHC for observing and recording data. The 16 behavior numbers in Figure 3.5 correspond to the behaviors listed in Table 3.3 (p. 22). Students should make a tally mark on the chart each time the adult male MHC displays a given behavior. Students should also make note of any general observations and female behaviors. Ask students to draw on their data collection chart schematic diagrams of the MHC interactions they observe (see Figure 3.4, p. 23). For "General observations and notes about female behavior" and the "Schematic diagram of MHC movement and interaction," the time the behavior occurred also may be added.

Assessing Student Observation and Understanding of MHC Behavior

The rubric in Table 3.5 is a general assessment tool that can be used to assign an overall numeric value to the quality of the written and schematic behavioral data. This rubric can also be modified to meet the needs of additional MHC-observation lessons you and your students develop.

Table 3.5. Rubric for Assessing Students' Recorded Data for and Understanding of MHC Behavior

Observation Skill Level	Skills Demonstrated
Exemplary	• Maximal effort to observe, record, and communicate the MHC movement and interaction data • Maximal understanding of MHC behaviors and why they occur
Competent	• Moderate effort to observe, record, and communicate the MHC movement and interaction data • Moderate understanding of MHC behaviors and why they occur
Developing	• Minimal effort to observe, record, and communicate the MHC movement and interaction data • Minimal understanding of MHC behaviors and why they occur
Beginning	• Extremely minimal effort to observe, record, and communicate the MHC movement and interaction data
None	• No effort to observe, record, and communicate the MHC movement and interaction data

Figure 3.5. MHC Behavior Data Collection Chart for Lessons 3.8–3.10

Date: _____
Observer name: _____
MHC identification symbol: _____
Sex of MHC being observed: _____

Observation begin time: _____
Observation end time: _____

Agonistic behavior number	Number of times performed	General observations and female behavior notes*:
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

Schematic diagram of MHC movement and interaction*:

*If you need more space, use a separate piece of paper.

MHC Events Students May Also Observe

Some of the coolest events to observe with MHCs are birth, courtship and mating, and molting (shedding of the exoskeleton). Figure 3.6 is a photograph of a newly molted male MHC and Table 3.6 describes these three events. These events are also three of the most difficult behaviors to observe because of their infrequency; they are usually observed by the MHCs' main caregivers. When caregivers observe them occurring, they should inform the teacher so the rest of the class can observe the event.

Figure 3.6. Recently Molted Adult Male MHC

Table 3.6. MHC Birth, Courtship and Mating, and Molting

Event	Description
Birth	When an adult female MHC gives birth, small, white nymphs will crawl from the opening at the end of her abdomen. Do not disturb a female MHC while she is giving birth and for two days afterward.
Courtship and Mating	MHC courtship is initiated by either an adult male or adult female. The male and female MHCs touch each other with their antennae. The male extends his abdomen and the female drags her abdomen across his. The two MHCs join the openings at the ends of their abdomens. During courtship, male MHCs that do not hiss will not successfully mate. Do not disturb a pair of MHCs during courtship and mating (Clark and Moore 1995).
Molting	When an MHC molts, a slit will appear on its upper back and the MHC will slowly push its body out through that opening. A newly molted MHC is white (but has black eyes), but it will darken to its normal color over time. Do not disturb an MHC while molting and for two days afterward.

Chapter 3

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Index

Page numbers in **boldface** type refer to figures or tables.

Index

Adventures WITH Arthropods

ECO-FRIENDLY LESSONS FOR MIDDLE SCHOOL

Have your middle schoolers ever thought of Madagascar hissing cockroaches as highly social and charismatic? Or roly polys as cute and cuddly? Or tarantulas as bold and beautiful? If not, it's time to introduce them to the world of arthropods—the amazing bugs that make up more than 75% of Earth's animal species. This book is the resource you need to help students learn about the incredible phylum *Arthropoda,* whose life history, global biodiversity, and sheer numbers make it the most successful group of animals on Earth.

The target audience of *Adventures With Arthropods* is middle school teachers and their students. However, with slight modifications, the book can also be used in elementary schools, high schools, and even college classrooms and for formal and informal learning at zoos, museums, and nature centers. The book builds engagement through 26 lessons, many of which support the *Next Generation Science Standards*. The lessons teach about everything from anatomy, growth, and behavior to eating preferences and environmental needs of three arthropod groups. They also illustrate arthropods' many essential ecological services, without which global ecosystems would collapse.

Author Ron Wagler, PhD, is an associate professor at the University of Texas at El Paso and the founder and director of the Living Arthropod and Environmental Education Laboratory at the University of Texas at El Paso, the only laboratory in the world dedicated to research related to arthropod education. In this book, Wagler enthusiastically guides you on which arthropods are classroom safe, what's involved in the humane care of living arthropods, and how to choose arthropod species that don't require too much maintenance and will captivate both your students *and* you.

GRADES 6–8

NSTA press
National Science Teachers Association

PB435X
ISBN: 978-1-68140-305-2