SCIENTIFIC INQUIRY ACTIVITIES WITH MADAGASCAR HISSING ROACHES: AN EFFECTIVE WAY TO ENRICH YOUR ARTHROPOD EDUCATION PROGRAM

Ron Wagler
Assoc. Professor of Science Education, Dept. of Teacher Ed., University of Texas at El Paso
500 West University Avenue, Education Building 601, El Paso, TX 79968, USA

Amy Wagler
Assoc. Professor of Statistics, Dept. of Mathematical Sciences., University of Texas at El Paso
500 West University Avenue, Bell Hall 311, El Paso, TX 79968, USA

INTRODUCTION

Madagascar hissing roaches are amazing insects that can enrich arthropod education programs. However, finding fun and effective activities using these roaches can be difficult. This presentation will provide an overview of a series of published peer-reviewed articles that explain Madagascar hissing roach husbandry and scientific inquiry activities utilizing these remarkable arthropods. The six Madagascar hissing roach articles presented were written by Dr. Ron Wagler, Dr. Amy Wagler and Dr. Christine Moseley (See Figure 1).

Figure 1: Madagascar Hissing Roach Articles Presented

Wagler, A., & Wagler, R. (2014). The Dark Side of the Tube: A Science and Statistics Integration Activity Using Madagascar Hissing Cockroaches. *The Science Teacher, 81(5),* 25-30. Available at: http://static.nsta.org/files/tst1405_25.pdf Manuscript acceptance rate: 30%. Monthly Readership: +25,000, Pass-along readership: 75,000, Special Issue: Math-Science Connections, Article Companion Introduction Video: https://www.youtube.com/watch?v=7_rZznmua-Y

Wagler, A., & Wagler, R. (2014). Randomizing roaches: Exploring the "bugs" of randomization in experimental design. *Teaching Statistics*, *36* (1), 13-20. http://onlinelibrary.wiley.com/doi/10.1111/test.12029/abstract Manuscript acceptance rate: 34%

Wagler, R. (2011). Look at that! Using Madagascar hissing cockroaches to develop and enhance the scientific inquiry skill of observation in middle school students. *Science Scope*, *35* (4), 36-47. Manuscript acceptance rate: 30%. Monthly Readership: +18,000, Pass-along readership: 45,000

Wagler, R. (2010). Home sweet home: How to build a Madagascar hissing cockroach habitat out of recycled materials. *Science Scope, 33* (8), 34-39. Manuscript acceptance rate: 30%. Monthly Monthly Readership: +18,000, Pass-along readership: 45,000

Wagler, R. (2009). Chow down! Using Madagascar hissing cockroaches to explore basic nutrition concepts. *Science Scope, 32* (7), 12-18. Available at: http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/4/ss09_032_07_12 Manuscript acceptance rate: 30%. Monthly Readership: +18,000, Pass-along readership: 45,000

Wagler, R., & Moseley, C. (2005). Cockroaches in the classroom: Incorporating the Madagascar hissing cockroach into your science curriculum. *Science Scope, 28*(6), 34-37. Manuscript acceptance rate: 30%. Monthly Readership: +18,000, Pass-along readership: 45,000

A GENERAL OVERVIEW OF THE MADAGASCAR HISSING ROACH CURRICULUM ARTICLES PRESENTED

Article 1

Wagler, A., & Wagler, R. (2014). The Dark Side of the Tube: A Science and Statistics Integration Activity Using Madagascar Hissing Cockroaches. *The Science Teacher, 81(5),* 25-30.

Every high school graduate should be able to use data analysis and statistical reasoning to draw conclusions about the world. Two core statistical concepts for students to understand are the role of variability in measures and evaluating the effect of a variable. In the activity presented in this article, students investigate a scientific question that leads them to distinguish between natural and induced variability. The distinction leads students to making conclusions about which stimulus is most effective at drawing Madagascar hissing cockroaches (MHCs) out of the dark.

The Dark Side of the Tube

Amy Wagler and Ron Wagler

A science and statistics integration activity using charismatic cockroaches

Every high school graduate should be able to use data analysis and statistical reasoning to draw conclusions about the world. Two core statistical concepts for students to understand are the role of variability in measures and evaluating the effect of a variable (Franklin et al. 2007). In this activity, students investigate a scientific question that leads them to distinguish between natural and induced variability. The distinction leads students to making conclusions about which stimulus is most effective at drawing Madagascar hissing cockroaches (MHCs) out of the dark.

The Madagascar hissing cockroach: Overview

The beautiful and charismatic Madagascar hissing cockroach (*Gromphadorhina portentosa*) is a large nocturnal insect (photo, next page) indigenous to the island of Madagascar that most students find exciting and enjoyable to work with. MHCs are slow moving, cannot bite or fly, and are easy to handle (see sidebar, p. 29). They do not transmit disease to humans and do not infest human habitations. Both males and females can produce a loud hissing sound when disturbed. MHCs have a complex social hierarchy. Male MHCs fight other males to establish and defend territories within their colony to attract females for mating. These territories, once established, consist of one dominant male, a few females, and many nymphs.

Summer 2014 25

The Madagascar hissing cockroach activity

Science content

High school science students are often unable to statistically analyze the data that result from class experiments. This activity allows students to better emulate scientific practices by performing the same statistical analysis a scientist would perform in the laboratory, while requiring very little knowledge about data analysis. Students performing statistical analysis engage in two essential scientific practices identified in the *Next Generation Science Standards* (NGSS Lead States 2013): Analyzing and Interpreting Data and Using Mathematics and Computational Thinking. This activity also teaches the students about the behavioral characteristics of a large living arthropod and may stimulate curiosity about the arthropods that live in their regional environment. Finally, this activity may increase students' curiosity about other statistically based scientific studies they might design in the future.

Statistics content

To analyze and visualize the data collected, students will produce a means plot and compute an analysis of variance (ANOVA) model. The plot displays the means of each group with error bars based on the observed natural variability. The use of means plots and ANOVA models is common in scientific studies where one variable is changed or manipulated. The analysis allows an investigator to decide whether the differences in means are due to this manipulated variable or just to chance. The means plots allow a visual examination of the data while the ANOVA model provides a numerical description of how different the means of each group are. (For more on means plots and ANOVA models, see "Resources.") The statistics learning objectives of this activity align to the *NGSS* scientific practices of Analyzing and Interpreting Data and Using Mathematics and Computational Thinking (NGSS Lead States 2013) and the *Common Core State Standards, Mathematics* to "Reason abstractly and quantitatively" (MP.2) (NGAC and CCSSO 2010).

Setup and data collection

This activity involves making a plastic tube with a darkened end and a transparent end. Students will explore ways to draw the MHCs from the dark end to the light end. Begin the activity by placing students into groups of five and then

FIGURE 1

Materials needed (per group)

- 5 adult female MHCs*
- 2 clean, clear, two-liter plastic beverage bottles
- Scissors, black garbage bag, centimeter ruler
- 2 inch-wide clear tape (for taping bottles and black garbage bag)
- Stimulus (food, heating pads, fluorescent lights)
- Black permanent marker (low or no VOCs)
- Computer with internet connection
- Eye protection, vinyl gloves

*Withhold food from the MHCs for 48 hours before the investigation. Always provide water.

Adult male Madagascar hissing cockroaches have large protruding bumps on the plate behind their heads.

Article 2

Wagler, A., & Wagler, R. (2014). Randomizing roaches: Exploring the "bugs" of randomization in experimental design. *Teaching Statistics, 36* (1), 13-20.

Understanding the roles of random selection and random assignment in experimental design is a central learning objective in most introductory statistics courses. This article describes an activity, appropriate for a high school or introductory statistics course, designed to teach the concepts, values and pitfalls of random selection and assignment using the not-easily-forgotten Madagascar hissing cockroach. Evidence is summarized demonstrating conceptual gains for students performing the Randomizing Roaches activity, and follow-up activities are suggested.

Original Article

Randomizing Roaches: Exploring the 'Bugs' of Randomization in Experimental Design

Amy Wagler and Ron Wagler
www.uwyo.edu
e-mail: awagler2@uwyo.edu
rwagler@uwyo.edu

Summary Understanding the roles of random selection and random assignment in experimental design is a central learning objective in most introductory statistics courses. This article describes an activity, appropriate for a high school or introductory statistics course, designed to teach the concepts, values and pitfalls of random selection and assignment using the not-easily-forgotten Madagascar hissing cockroach. Evidence is summarized demonstrating conceptual gains for students performing the Randomizing Roaches activity, and follow-up activities are suggested.

Keywords: Teaching; Experimental design; Hands-on activity; Introductory statistics; Cockroach.

INTRODUCTION

Understanding the roles of random selection and random assignment in experimental design is a central learning objective in most introductory statistics courses (Zieffler et al. 2008; Sawilowsky 2004; Schield 2004). However, due to conceptual and vocabulary difficulties, it is often challenging for students to understand the distinct roles of random selection and random assignment in research studies (Rubin et al. 1990; Enders et al. 2006; Kaplan et al. 2009).

This article describes an activity designed to teach the concepts, values and pitfalls of random selection and random assignment. This activity, appropriate for a high school or freshman/sophomore university level introductory statistics course, requires active participation of the students using living subjects for devising plans for random selection and random assignment. Additionally, this activity increases the likelihood that students will stay engaged and remember the lesson throughout the course as its focus is on the memorable, Madagascar hissing cockroach (MHC) (figure 1). The use of this subject (i.e. the MHC) has many practical advantages for teaching these concepts because of the following: (1) MHCs are communal animals and socialize or group in a manner similar to human populations; (2) MHCs may be easily studied in a very short period; (3) MHCs are harmless to humans; (4) MHCs are readily available at universities, zoos and nature centres and can often be borrowed and returned; and (5) students of any age tend to have a keen interest in MHCs and thereby may retain a more accurate memory of the activity. Moreover, any activity that employs 'fun' can change the classroom environment by fostering a classroom community, reducing anxiety and encouraging a more open learning atmosphere (Lasser and Roaf 2008).

Madagascar hissing cockroach

The Madagascar hissing cockroach (*Gromphadorhina portentosa*) is a large insect indigenous to the island of Madagascar. MHCs are slow moving, cannot bite or fly and are easy to handle. They do not transmit disease to humans and do not infest human habitations. Both male and female MHCs can produce a loud 'hissing' sound when disturbed. This vocalization is produced by the roach forcing air through a modified breathing hole on the side of its body. The weight of a MHC varies from approximately half a gram me at birth to approximately 24 g when an adult. The length can also vary with a fully developed adult roach being from 5 to 8 cm in length.

The MHCs are insects with a complex social hierarchy. Male MHCs fight other male MHCs to establish and defend territories within their colony to attract female MHCs for mating. These territories, once established, consist of one dominate male MHC, a few female MHCs and many nymphs. These territories or clusters produce different groups anywhere throughout the enclosure that have very different proportions

Adult Male Madagascar Hissing Cockroach

Photograph by Ron Wagler.

Fig. 1. Adult male Madagascar hissing cockroach

Madagascar Hissing Cockroach Enclosure

Fig. 2. Madagascar hissing cockroach enclosure

of adult, juvenile, female and male MHCs from the overall population. Clusters within the enclosure also occur around the food source, water source and in the vertical egg cartons that are present in the MHC's enclosure (figure 2). If you decide to set up your own colony of MHCs instead of borrowing them from a university, zoo or nature centre, there are helpful articles that can assist you in the Resources section (Wagler, R. 2005; Wagler, R. 2009; Wagler, R. 2010; Wagler, R. 2011). If you would prefer to not use MHCs for the activity, terrestrial isopods (i.e. sow bugs or pill bugs) may be substituted.

Teaching the role of randomization

Derry et al. (2000) documented that students in beginning statistics courses demonstrate confusion about the roles of random selection and random assignment. Sawilowsky (2004) contends that students not only have difficulty comprehending the concept of random assignment but 'harbour considerable distrust' of the procedure (p. 221). There are examples of activity-based instruction for teaching the role of randomization in experimental designs (Labov and Firmage 1994; Schaeffer et al. 1996; Smart 1999; Enders et al. 2006). However, most of these activities employ computer simulation and lack a hands-on component. Hands-on activities can be a useful first step that builds the conceptual groundwork that may be deepened via computer simulation activities. For example, in a study concerned with developing conceptual knowledge of variability, Shaughnessy (2007, p. 982) found that students' conceptual knowledge increased with the use of hands-on activities.

Some examples of existing hands-on activities include the following. Enders et al. (2006) proposed a hands-on activity utilizing playing cards for teaching randomization in an effective and engaging method. 'Random Rectangles' and 'The Gettysburg Address' are both frequently used hands-on activities which focus on teaching the effect of random selection and the meaning of a representative sample. These are highly engaging and effectively teach the core concepts, but also utilize inanimate objects (i.e. rectangles and words) rather than living subjects. In contrast, the proposed activity, Randomizing Roaches, not only uses actual research subjects but also produces 'real data' that can be used throughout the rest of the semester.

THE ACTIVITY

Begin the activity by giving a very brief introduction about the MHCs where students are shown how to differentiate between adult and juvenile MHCs (adults are at least 5 cm in length), and adult female and male MHCs (male MHCs have protruding large bumps on the plate behind their head when sexually mature but male juvenile MHCs do not have these bumps) (figure 1). The task for this activity is to devise an experiment to assess whether age influences MHCs' preference for a high-protein or a high-carbohydrate snack. Each group will receive two clear containers with secure lids, a ¼ cup of dry dog food and a ¼ cup of high-carbohydrate cereal in cups. Each student should also have a timer (Table 1). Once the supplies are distributed to the students, the research question is displayed.

Article 3

Wagler, R. (2011). Look at that! Using Madagascar hissing cockroaches to develop and enhance the scientific inquiry skill of observation in middle school students. *Science Scope*, *35* (4), 36-47.

Middle school students can develop and enhance their observation skills by participating in teacher-guided scientific inquiry (NRC 1996) activities where they observe animals that tend to act in known, predictable ways. Madagascar hissing cockroaches (*Gromphadorhina portentosa*) are one such animal. This article presents beginning, intermediate, and advanced Madagascar hissing cockroach (MHC) activities that develop and nurture the scientific inquiry skill of observation in middle school students. The author concludes that once this skill has been developed and nurtured, students can be further challenged by conducting observational and experimental studies using statistics.

Article 4

Wagler, R. (2010). Home sweet home: How to build a Madagascar hissing cockroach habitat out of recycled materials. *Science Scope, 33* (8), 34-39.

Madagascar hissing cockroaches (MHC) are amazing insects that can be an integral part of an effective science learning and teaching environment. MHCs have a fascinating social structure. They make excellent pets, teach students how to properly care for animals, and their large size adds to their "wow" factor. These characteristics make them unique as classroom insects and add to their effectiveness in increasing your students' scientific knowledge. This article provides directions for building a free, eco-friendly, low-maintenance MHC home out of garbage.

Home Sweet Home

How to Build a Madagascar Hissing Cockroach Habitat Out of Recycled Materials

by Ron Wagler

There are approximately 4,000 known species of cockroaches on Earth. Even though cockroaches get a bad rap for being disease-carrying "bugs" that want to live in our homes, the truth is, less than 1% of the approximately 4,000 known species of cockroaches are associated with human habitations. You can help increase this number by building a free, eco-friendly, low-maintenance Madagascar hissing cockroach (MHC) home for your science classroom.

Madagascar hissing cockroaches (MHC) are amazing insects that can be an integral part of an effective science learning and teaching environment. MHCs have a fascinating social structure. They make excellent pets, teach students how to properly care for animals, and their large size adds to their "wow" factor. These characteristics make them unique as classroom insects and add to their effectiveness in increasing your students' scientific knowledge.

Two of the biggest barriers for teachers who want to set up an MHC colony in their classroom are the initial cost of the MHC home and the long-term care involved in maintaining the insects. Store-bought terrariums and equipment can be purchased, but they are often beyond the budget of most teachers, require more maintenance, are unimaginative in their construction, and limit student viewing of the complex social interactions of MHCs.

This article provides directions for building a free, eco-friendly, low-maintenance MHC home out of garbage. Millions of tons of garbage are thrown away and incinerated or buried in landfills each year in the United States. This garbage has adverse effects on the environment. The sample MHC home and all of its features can be made of this same garbage (see Figure 1). This is a winning combination for you, your students, the MHCs, the environment, and organisms that exist in the environment.

FIGURE 1 Sample materials

Items destined for a landfill that can be used to construct a MHC home and its features. Items include plastic containers, plastic beverage bottles, egg flats, toilet paper rolls, and an old discarded shirt. Larger containers may also be used. The tape, rubber bands, and scissors are used to construct the home.

FIGURE 2 Hallways

Two hallways are made of different types of beverage bottles with their bottoms cut off and new openings taped together. Soda bottles (top example) with this spout diameter are too small for large adult MHCs to fit through. Beverage bottles with larger spout diameters (bottom example) are big enough for large adult MHCs to fit through and freely move from room to room. Your choice of bottles will determine which rooms the MHCs can move to.

FIGURE 3 Home construction accessories

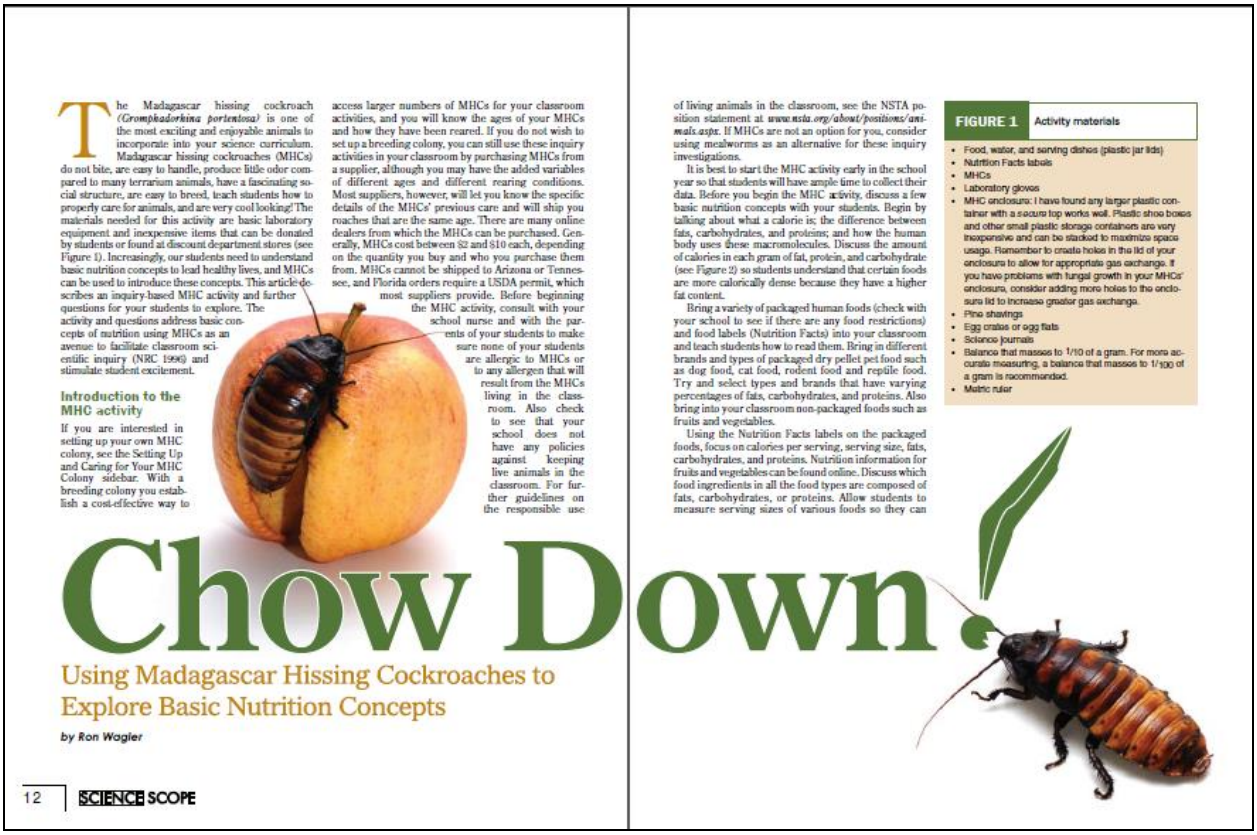
From left to right: a soda bottle cap and spout, a soda bottle collar, a soda bottle cap, and a roach-lock connector (a soda bottle cap with the top cut off).

The MHC home will allow you to breed MHCs that can be used in your science classroom and will give students the opportunity to view the complex social behaviors of MHCs. It is best if the materials used to build the MHC home and all of its features are brought in by students and built in class. Even though this "trash ter-

Article 5

Wagler, R. (2009). Chow down! Using Madagascar hissing cockroaches to explore basic nutrition concepts. *Science Scope, 32* (7), 12-18.

The Madagascar hissing cockroach (*Gromphadorhina portentosa*) is one of the most exciting and enjoyable animals to incorporate into your science curriculum. Madagascar hissing cockroaches (MHCs) do not bite, are easy to handle, produce little odor compared to many terrarium animals, have a fascinating social structure, are easy to breed, teach students how to properly care for animals, and are very cool looking! This article describes an inquiry-based MHC activity and further questions for your students to explore. The activity and questions address basic concepts of nutrition.



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Introduction to the MHC activity

If you are interested in setting up your own MHC colony, see the Setting Up and Caring for Your MHC Colony sidebar. With a breeding colony you establish a cost-effective way to access larger numbers of MHCs for your classroom activities, and you will know the ages of your MHCs and how they have been reared. If you do not wish to set up a breeding colony, you can still use these inquiry activities in your classroom by purchasing MHCs from a supplier, although you may have the added variables of different ages and different rearing conditions. Most suppliers, however, will let you know the specific details of the MHCs' previous care and will ship you roaches that are the same age. There are many online dealers from which the MHCs can be purchased. Generally, MHCs cost between $2 and $10 each, depending on the quantity you buy and who you purchase them from. MHCs cannot be shipped to Arizona or Tennessee, and Florida orders require a USDA permit, which most suppliers provide. Before beginning the MHC activity, consult with your school nurse and with the parents of your students to make sure none of your students are allergic to MHCs or to any allergen that will result from the MHCs living in the classroom. Also check to see that your school does not have any policies against keeping live animals in the classroom. For further guidelines on the responsible use of living animals in the classroom, see the NSTA position statement at *www.nsta.org/about/positions/animals.aspx*. If MHCs are not an option for you, consider using mealworms as an alternative for these inquiry investigations.

It is best to start the MHC activity early in the school year so that students will have ample time to collect their data. Before you begin the MHC activity, discuss a few basic nutrition concepts with your students. Begin by talking about what a calorie is; the difference between fats, carbohydrates, and proteins; and how the human body uses these macromolecules. Discuss the amount of calories in each gram of fat, protein, and carbohydrate (see Figure 2) so students understand that certain foods are more calorically dense because they have a higher fat content.

Bring a variety of packaged human foods (check with your school to see if there are any food restrictions) and food labels (Nutrition Facts) into your classroom and teach students how to read them. Bring in different brands and types of packaged dry pellet pet food such as dog food, cat food, rodent food and reptile food. Try and select types and brands that have varying percentages of fats, carbohydrates, and proteins. Also bring into your classroom non-packaged foods such as fruits and vegetables.

Using the Nutrition Facts labels on the packaged foods, focus on calories per serving, serving size, fats, carbohydrates, and proteins. Nutrition information for fruits and vegetables can be found online. Discuss which food ingredients in all the food types are composed of fats, carbohydrates, or proteins. Allow students to measure serving sizes of various foods so they can

FIGURE 1 Activity materials

- Food, water, and serving dishes (plastic jar lids)
- Nutrition Facts labels
- MHCs
- Laboratory gloves
- MHC enclosure: I have found any larger plastic container with a *secure* top works well. Plastic shoe boxes and other small plastic storage containers are very inexpensive and can be stacked to maximize space usage. Remember to create holes in the lid of your enclosure to allow for appropriate gas exchange. If you have problems with fungal growth in your MHCs' enclosure, consider adding more holes to the enclosure lid to increase greater gas exchange.
- Pine shavings
- Egg crates or egg flats
- Science journals
- Balance that masses to 1/10 of a gram. For more accurate measuring, a balance that masses to 1/100 of a gram is recommended.
- Metric ruler

Chow Down!

Using Madagascar Hissing Cockroaches to Explore Basic Nutrition Concepts

by Ron Wagler

Article 6

Wagler, R., & Moseley, C. (2005). Cockroaches in the classroom: Incorporating the Madagascar hissing cockroach into your science curriculum. *Science Scope*, *28*(6), 34-37.

The Madagascar hissing cockroach (MHC) provides an excellent avenue to introduce students to the joys of inquiry-centered learning. MHC's are relatively tame, produce little odor, do not bite, and are easy to handle and breed. Because of these characteristics, they are ideal for classroom activities, science projects, and as pets. They also help reduce fears and misunderstandings about insects. This article describes the basic biology of the MHC, how to set up and care for a classroom colony, and a list of suggested inquiry-centered classroom activities that teachers and their students will find both educational and fun!

BIOLOGY

COCKROACHES IN THE CLASSROOM

by Ron Wagler and Christine Moseley

The Madagascar hissing cockroach (MHC) provides an excellent avenue to introduce students to the joys of inquiry-centered learning. MHCs are relatively tame, produce little odor, do not bite, and are easy to handle and breed. Because of these characteristics, they are ideal for classroom activities, science projects, and as pets. They also help reduce fears and misunderstandings about insects. This article describes the basic biology of the MHC, how to set up and care for a classroom colony, and a list of suggested inquiry-centered classroom activities that you and your students will find both educational and fun!

Ron Wagler is a graduate student in environmental science at Oklahoma State University in Stillwater, Oklahoma. Christine Moseley is an associate professor at the University of Texas at San Antonio in San Antonio, Texas.

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BIOLOGY

Setting up and caring for your colony

The first step in setting up your colony is acquiring the MHCs. Local pet stores will usually have the roaches in stock or be willing to order them for you. There are also many online dealers, including Carolina Biological Supply Company, from which the roaches can be purchased. Generally the roaches cost about $2–$4 per roach from local pet stores and about $8.25 per roach from biological supply companies. Be aware that MHCs cannot be shipped to Arizona, California, Florida, or Tennessee. If the roaches are not an option for you, consider using mealworms or butterfly larvae as alternatives for these inquiry investigations.

It is best to start your breeding colony with at least four males and four females, but if cost is an issue two males and two females may be purchased as starting stock. Many of the activities that are suggested will require more than eight roaches. By having a breeding colony you can establish a cost effective way to have access to larger numbers of roaches for your classroom activities. Students could be encouraged to work on research through local zoo personnel, local pet store owners, or nearby college entomology clubs to set up the classroom colony.

Once your roaches have arrived they will need a place to live. Since your colony will, more than likely, be in a classroom for the students to observe and enjoy, it is best to use a 10- to 20-gallon glass aquarium. An aquarium, aquarium lid, pine shavings (substrate), and heating pad can be purchased at a pet store or at a local department store. The total cost should be between $35 and $60. (At my local megastore I found the following prices: 10-gallon aquarium—$10; lid—$7; 1,500 cubic inches of pine shavings—$2; and heating pad—$15.) MHCs have padded feet, which enable them to climb many surfaces, so it is important to have a well-sealed lip on your aquarium or to place a 2.5-cm wide layer of petroleum jelly around the top edge of the aquarium. This barrier will prevent any roaches, adults or nymphs, from escaping.

When working with my colonies, I have found a 2.5-cm layer of pine shavings makes for an ideal substrate for the bottom of the aquarium, but it is not essential. Other substrates such as gravel or bark may also be used. Cedar chips should never be used as a substrate as they contain turpines that may inhibit nymph development. If a substrate is used it should be replaced once every two months. Paper towel rolls and half an egg carton may also be placed into the aquarium, as this will provide cover for your roaches and the developing nymphs. Larger rocks and branches may also be used (Darmo and Ludwig 1995).

Proper temperature is also important for the well being of your MHCs. Because roaches are from a tropical to subtropical climate, they do well at a room temperature of 72°–76° F. Do not expose your roaches to temperatures lower than 65° F. During holidays when no one will be in the classroom, a heating pad may be used to regulate temperature, or a student could be assigned to take the aquarium home for the break. Because roaches are cold-blooded, they tend to act lethargic and will not breed when they are exposed to temperatures lower than 70° F (Darmo and Ludwig 1995). In contrast, we have found with our own colonies that when the MHCs are exposed to higher temperatures (80° F or higher) they tend to increase their activity levels and may breed. Temperature is important if you would like a breeding colony versus a few roaches in an aquarium for your students to observe. One way to achieve an ideal breeding temperature (80°–85° F) is to use a heating mat or heating pad. Basic models cost $15–$40, but more expensive models ($60–$100) with more features can also be purchased. These heating elements are used with reptiles and can be purchased at most pet stores. Placing the heating pad at one end of the aquarium will create multiple temperature zones for your roaches (Mulder and Doss 1996).

Madagascar hissing cockroach

MHCs are large (5–10 cm in length), wingless, nocturnal cockroaches that are only native to Madagascar, a tropical to subtropical island off of the east coast of Africa. Male and female MHCs are easy to identify when adults. Male roaches have two large protruding bumps (tubercles) on their dorsal plate (prothorax) behind the head. Females also have tubercles in the same location but they are reduced and smooth (Mulder and Doss 1996). Males and females are both equipped with a modified breathing hole (second abdominal spiracle) on the side of their body. When air is forced out of these holes a hissing sound is produced. The roaches usually produce this hissing sound when they are fighting, mating, or are bothered (Mulder and Doss 1996).

A social hierarchy is seen when the roaches live in colonies. Males, which only fight other males, establish and defend their territories. These territories may be a rock or any other type of similar structure. The male will only leave those territories for food or water (Mulder and Doss 1996). Typically one adult male and several adult females and assortment of nymphs will be seen in these territories. During mating the male will hiss and posture to attract the female. Gestation is between 60 to 70 days and a female will give birth to 20 to 40 young (nymphs) over a one to two day period. MHCs are atypical compared to other roach species in that they produce eggs, which hatch in the female's body. After the nymph is born, which is white upon birth, it will undergo six molts (shed its exoskeleton) before reaching full development in 5 to 10 months (Darmo and Ludwig 1995).

March 2005 SCIENCE SCOPE 35