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“One Bug, Two Bug, Good Bug, Bad Bug”

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Online M.S. Degree Project

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I. Introduction

Integrated Pest Management (IPM) is a holistic strategy for the management of pest species. It is a framework that relies on scientifically informed decisions to identify and remediate a pest problem in a way that minimizes harm to the environment, human health, and the economy (Dara, 2019). The term pest is broadly defined not just as a nuisance, but as any organism that has detrimental effects to a resource or public health and that exists at a population level that exceeds a threshold of economic damage. This encompasses invertebrates (such as insects, nematodes, and mites), vertebrates, plant pathogens, diseases, and weeds (Fernandez-Cornejo & Jans, 1999). IPM relies on a coordinated use of multiple tactics to promote a suppression rather than elimination of the pest. These tactics include cultural, mechanical, biological, and chemical controls (Dara, 2019).

The concept of IPM is fundamental to the study of entomology as insect pests represent a large portion of the pest problems facing agriculture systems, horticulture, and public health. Just in agriculture, it is estimated that invasive insects cost the global economy $70 billion in losses each year (FAO, 2019). It is no surprise that insects comprise a large portion of the overall pest problem as they are the largest group of animals on the planet, accounting for 80 percent of all currently known species of animals. Due to the insect's great ability to adapt to generally every known habitat, many estimates put the diversity of insects on a range of potentially 2-30 million species (Smithsonian, n.d.).

The way humans interact with insects is complex and varies based on socio-cultural influences. Many experiences with insects are shaped by fear, a condition referred to as entomophobia. A predisposition that shapes the way humans interact with many animals is the attribution of human traits to non-human animals, known as anthropomorphism (Lemelin et al., 2017). In the case of insects, these perceptions equate to negative associations of insects since most insects do not share human attributes, which can reinforce the feedback loop of fear, leading to entomophobia. This mindset likens most insects to pest status, though in truth only 1 percent of all insect species are pests (NPIC, 2020). In reality, humans depend on insects to provide ecological services estimated at $57 billion a year just in the United States. Insects provide essential functions including pollination of food crops, decomposition and recycling of waste, and maintenance of food webs (Losey & Vaughan, 2006).

Beneficial insects far outweigh harmful pest insects in numbers, but not in the understanding of the public. The education of what constitutes a pest is essential to changing the negative associations of insects. Not only do the IPM concepts make informed decisions of what constitutes a pest, IPM relies on context to make decisions on the tactics to remediate the pest. Therefore, teaching the concept of IPM can shift public perception of insects from negative to positive through education of sustainable pest management. The logical age group to begin this education is elementary aged students, who learn best by real-world, hands-on examples and lack understanding of abstract concepts. The consensus of early educators is that science activities that contain "guided inquiry" allow students to explore inferential thinking, while promoting scientific learning and capturing interest of the student (Matthews et al., 1997). Teaching IPM to elementary aged students allows students to make decisions on whether an insect is a pest, and to think critically on why this is or is not true. This knowledge will change the negative associations with pests, insects, and the field of entomology.

II. Overview

The IPM Lesson Plan is a five-day course meant to be taught sequentially throughout a school week. The course materials are catered to a third-grade education level but are also appropriate for fourth and fifth grade. The first day begins with a pre-test and an introduction of IPM concepts. The subsequent days cover each of the control methods of IPM with interactive activities: cultural, mechanical, biological, and chemical. The instructions are formatted in paragraph form rather than step-by-step instructions in order to facilitate the guided inquiry process. On the last day after chemical control is covered, the lesson plan ends with an activity where students combine their knowledge of control methods to design a full IPM initiative. Teachers also have the option to provide a post-test to gauge understanding of concepts. All supplemental materials, activities, and the pre/post tests are available in the Appendix Section. The IPM Lesson Plan caters to the Next Generation Science Standards 3-LS4 Biological Evolution: Unity and Diversity. Students who demonstrate understanding can:

3-LS4-3	Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
3-LS4-4	Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

Figure 1: Next Generation Science Standards. Source: nextgenscience.org

III. The Lesson Plans

Day 1- Introduction to IPM

Estimated Time Frame: 1-2 hours

Learning Objectives:

- Define Integrated Pest Management and how it operates based on identification and thresholds.
- Determine what constitutes a pest and the subjectivity of this term.

Instructions and Activity:

Have students complete the pre-test before any instruction begins (available in Appendix). Next, ask students to think of 10 different insects and write them down. After this is completed, have students share what insects they wrote and have them decide whether this is a "good bug" or a "bad bug" and write them on the board into the two categories. Discuss with the students why they categorized each insect the way that they did. For each insect, ask the students to provide an example of a habitat where they would encounter this insect, and then ask if they would be a pest in a different habitat (for example: if they were found in a home, at a farm, in a greenhouse, in a school, etc. A cockroach could be a pest in your home but what if you saw one under a log outside your house?).

Explain to the students that what makes an insect a "pest" largely depends on where the insect is found and cannot be based upon the emotions associated with the insect. A pest is considered a pest if it is causing enough damage that it needs to be managed, and this is called a threshold. If the threshold is reached, the way we find a solution to manage the pest is based upon IPM. Go over with the students what IPM stands for, how a pest must be identified before any decisions are made, and how to survey for a pest (by collecting samples, setting up traps, scouting fields, etc.). From the earlier examples the students provided about a pest in a specific habitat, ask them to brainstorm how they would go about surveying for this pest and what a possible threshold would be (Ask: how many pests are too many pests? Is this pest causing damage or causing a farmer to lose money?)

Day 2- Cultural Control

Estimated Time Frame: 1-2 hours

Learning Objectives:

- Define the cultural control method of IPM.
- Deduce situations where cultural control would be appropriate.
- Devise methods of cultural control using specific entomological examples.

Background Info:

Cultural controls are any measures that prevent pest infestations. This includes preventative measures that will avoid damage from taking place, like sanitation practices, or adopting modifications that will reduce damage from pests. In agriculture, practices including row spacing to reduce plant density, modifying irrigation and fertilizer schedules, destroying crop residue, and removing and cleaning infected materials and equipment (Dara, 2019). In residential situations, this includes practices that remove attractants for pests and improving sanitation so that pests cannot establish in a household (Swier, 2016).

Instructions:

First, review concepts from Day 1 with students. This will be the segue into learning about the different controls within IPM. Explain cultural control and its place within the realm of IPM. To strengthen understanding of cultural control, students will interact with a real-world example of ants in a pest situation through the "Ants in my Pants" activity.

Activity:

Ask students if they have ever had ants in their kitchen at home. Ants are common household pests and can be controlled easily with cultural control. Ask students why they think ants appear the most in the kitchen rather than other areas of their house. Once students arrive to the answer that ants are attracted to food, ask what they think are ant's favorite food, record answers on the "Ants in my Pants" worksheet or on the board. Next, watch the video https://youtu.be/hBBBrGIW5k8 so students can see how ants are attracted to all kinds of different food items. Ants forage for food and bring back food to feed the whole colony. Now that students are familiar with the concept of how ants are attracted to food, ask students how they would remedy this ant problem in their house. Students should answer that they can remove the food items and ants will no longer have anything to forage on, and they will leave to forage somewhere else where food is readily available. Cleaning the kitchen and not leaving food out for pests to have access to is a method of cultural control.

Day 3- Mechanical Control

Time Frame: 1-2 hours

Learning Objectives:

- Define mechanical control and common methods of this control type.
- Justify the use of mechanical control in situations where it is appropriate.
- Learn about specific insect pests and how mechanical control improved the pest problem.

Background Info:

Mechanical controls are approaches that excludes the pest from an area or from causing damage. This includes methods of creating barriers and deterrents, setting traps, and physically removing pests (Dara, 2019). Some of the more familiar means of mechanical control include screens on windows and doors to prevent pests from entering residential spaces and sticky ribbon traps that are placed in areas that have high populations of flying insects.

Instructions:

Begin the lesson by asking students if they can remember a time where they had an annoying fly buzz around their face and it just wouldn't leave them alone. They could swat it away, but it would always come back until it got so aggravating that it eventually got squished. The act of squishing a pest is, in fact, mechanical control. Explain the definition of mechanical control. This type of control can be done on a small scale, like controlling individual pests, or it can be done on a much larger scale, using specialized equipment like vacuums. Have students watch https://www.youtube.com/watch?v=jonm1iOsN3A and ask why this is a mechanical control. Next, ask students to think of things around their house that keep insects out. They should think of things like windows, doors, and the screens that cover these. Ask what would happen if we did not have these put up around our houses.

Activity:

Students will have the option to create either a trap or a physical structure that will serve as a barrier to a pest out of Legos or other classroom materials (regular blocks, pipe cleaners, clay, and other art materials would all suffice). First, begin by having students build a house fly out of the Legos (if students need inspiration, a quick google search of "lego insects" will show a plethora of examples). Next, they will build their own means of mechanical control out of the Legos, and the students can become as creative as they would like as long as the method falls under mechanical control. Have students show their Lego creation and ask them to explain how it controls the pest.

Day 4- Biological Control

Estimated Time Frame: 1-2 hours

Learning Objectives:

- Define biological control and differentiate how this method differs in its method than other means of control within IPM.
- Understand the risks associated with biological control, and the positive outcomes that have occurred.
- Learn about insect pests that are controlled through biological control.

Background Info:

Biological control is the use of biological agents to control pest species. These include existing and introduced enemies of pests and practices that conserve and increase the presence of natural enemies. The natural enemies of many insect pests include other insects themselves, as well as other arthropods, invertebrates, and pathogens. Many biological control agents are parasitoids, an insect that requires a living host to lay its eggs upon (Shelton, n.d.).

Releasing biological control agents into the environment comes with an inherent risk that must be carefully weighed before the release. No matter how well the organism is studied, how it will perform in natural conditions will never be certain. Therefore, the biological control agent must show specificity to the pest it is supposed to control. Many biological controls have been released and have turned into pests themselves. However, many biological controls exist originally within habitats and function through natural predator/prey relationships. Efforts to encourage and conserve these existing relationships within the food web are also a part of biological control, and this can include preserving habitats of the biological control and planting supplemental food sources for the biological control, such as flowers (Shelton, n.d.).

Instructions:

Ask students to picture in their heads the most notorious, bad guy, plant eating pest they can think of. Ask students if they thought of this:

Photo Credits: Joaquim Alves Gaspar, Wikimedia Commons

Looks pretty cute right? Maybe to us, but not to this plant:

Photo Credits: SD Frank, NC State Extension

Aphids are a widespread pest. Luckily, there are a number of predators that will feast on aphids and lay eggs within their bodies. Show students the videos https://www.youtube.com/watch?v=BtwdU8IE0zw, https://www.youtube.com/watch?v=ZptyWNJF4QY, and https://www.youtube.com/watch?v=6qOPboQqXBQ. Ask students who is the biological control and who is the pest in each video. Next, ask students what would happen if all these biological controls where together on one plant? What if there we were to put praying mantises on a plant with aphids and the lady bugs? Do you think the praying mantis would still only eat the aphids or would they eat the ladybug instead (which one would be a bigger meal to the praying mantis?)? A good predator doesn't always make a good biological control. If praying mantises were released in a garden, the result might be the praying mantises eating insects that aren't pests.

Activity:

Students will complete the garden food web activity entitled "Pest Fest." Students will follow the clues to match the predator or parasitoid with the pest.

Day 5- Chemical Control and IPM Wrap-up

Background Info:

Chemical control involves the use of synthetic, botanical, and microbial pesticides that are applied to control pests. They are categorized into groups based on modes of action (the ways in which the pesticide targets the pest) and the categories all have varying degrees of human and environmental hazards (Fernandez-Cornejo & Jans, 1999). The use of chemical pesticides should be carefully considered, especially if other methods of control are already in use. However, chemical control has a valid place within IPM and is an effective means of control when applied according to the pesticide label.

Instructions:

Begin the lesson by asking students what the deadliest animal on the planet is. Students may provide answers such as snakes, sharks, or spiders. After the various guesses, inform them that the deadliest animal that kills more people ever year than any other animal, is an insect: the mosquito. This is due to the viruses and parasites that mosquitoes transmit. Mosquitoes must be controlled so that people don't get sick from these diseases. Ask students how they think mosquitoes can be controlled based on what they have learned so far. There are a number of ways mosquitoes can be controlled through an IPM approach, and the most successful program that aims to control mosquitoes does so using IPM. This approach employs chemical control for adult mosquitoes. Chemical control is the most effective way to control adult mosquitoes because they are flying through the air, and it is the fastest way to lessen the burden of disease in the case of an outbreak.

Activity:

Watch the video: https://www.youtube.com/watch?v=_30jPKzWdN0. Complete a full plan for the control of mosquitoes based on the principles of IPM. Have students first learn about the lifecycle of a mosquito and how this cycle must have water to complete.

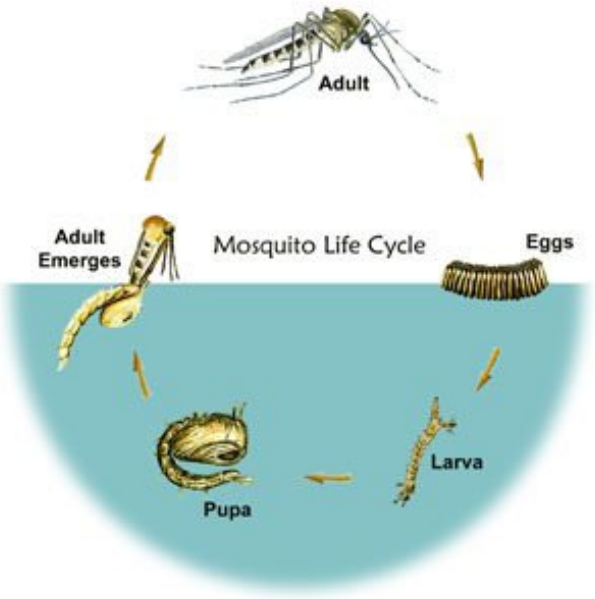

Photo Credits: EPA

Students may be familiar with the lifecycle of a butterfly already. The lifecycle of the mosquito is similar. They are both holometabolous meaning they go through a complete change in development. Draw student's particular attention to the aquatic larval and pupal stages of development. Mosquitoes larvae and pupae cannot survive without water in these stages. It is only after the adult mosquito emerges from the water that they become a pest and have the ability to blood feed on humans and other animals. Adult female mosquitoes need the

protein in a bloodmeal to make eggs. However, larvae filter feed and eat organic matter present in the water. Ask students if they think all mosquitoes feed on blood. The answer is no! Adult *Toxorhynchites* mosquitoes only feed on nectar from flowers but they are voracious predators as larvae. There are a number of different predators that feed on mosquito larvae, have students watch https://www.youtube.com/watch?v=agcPOi45_TQ to get some ideas. Ask students what types of predators might feed on the adult stage of mosquitoes (frogs, lizards, dragonflies, etc.). Have students fill out the "Mosquito IPM!" worksheet and provide as many answers as possible for each method of control. Lastly, if desired, have students complete the post-test.

IV. References

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V. Appendix

Name: _____ Date: _____

IPM PRE-TEST

Directions: Circle the answer for each question. It's ok if you don't know the answer, just do your best!

1. What does IPM stand for?

A. Insect Pet Museum

B. Integrated Pest Management

C. Impossible Predator Mission

D. Insect Pest Mastermind

2. What is a pest?

A. EVERY INSECT ON THE PLANET

B. Your little brother who steals your toys

C. An insect that is causing damage or is somewhere it shouldn't be

D. An insect that is scary

3. Circle all the Biological Controls:

A. Predators

B. Pollinators

C. Plant Eaters

D. Parasitoids

Name: _____ Date: _____

IPM POST-TEST

Directions: Write an answer for each question.

1. What is a pest?

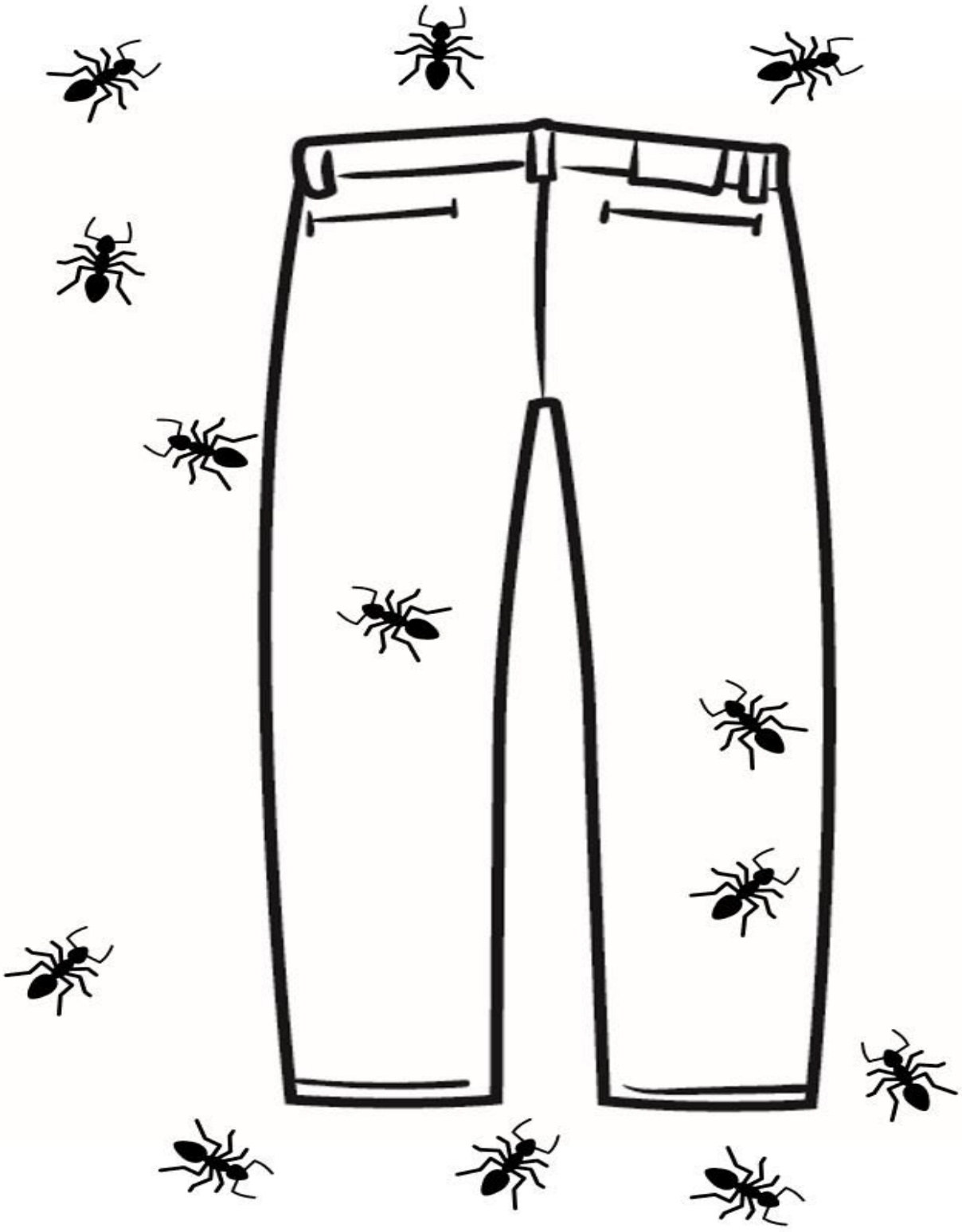
2. Why should you identify a pest before you decide what control methods to use?

3. What's the name of the IPM control method that uses sanitation, like cleaning up spilt food, to control pests?

4. What control method(s) would you use for a caterpillar eating the tomato plants in your garden?

5. Why do we use IPM to control pests?

ANTS IN MY PANTS!



PEST FEST

Directions: match the garden pest on the left side to the biological control on the right

Mosquito IPM!

How will you control mosquitoes?

Cultural Control

Mechanical Control

Biological Control

Chemical Control