



A unique role-playing game examining plant-insect interactions for elementary and middle school students

The following active-participation, role-playing game provides students the opportunity to experientially investigate the dynamic interactions between insect herbivory and the allocation of plant defenses. While initially designed as part of a 50-minute “Hands-On” presentation for the Ingham County School District’s annual “An Invitation to Sample Success: A Math / Science Conference for Girls in Grade Six” (Ingham County, Michigan), where it has been presented numerous times, the game has also been enjoyed by several middle-school science clubs. In 1999, it received the Entomology Educational Project Award from the Board Certified Entomologists of Mid-America (North Central Branch of the Entomological Society of America).

This plant-insect interaction simulation introduces primary school students to some of the ecological mechanisms involved in regulating plant-insect interactions, and highlights some of the evolutionary pressures driving the process of co-evolution. In this simulation, students take either the role of an “Insect Larva Specialist,” racing to develop from neonate to pre-pupa, or the role of a plant “Root-Hair,” acquiring resources used to either “grow” more leaves or “defend” existing leaves. The plant-insect interaction simulation demonstrates: (1) the selective pressures on herbivorous insects to forage, grow and pupate as quickly as possible; (2) the selective pressures on plants to allocate resources to growth and/or defense; and (3) the ecological interface of these two groups. Insect Larvae Specialists forage “forest patches” for leaves of their preferred host plant and gather as many leaves as needed to pupate; however, they can only gather leaves that have not been chemically defended. The first Insect Larva Specialist to pupate is the winner among the insect-participants, and play ends. At this point, the Root-Hairs team with the most leaves left in their forest patch (which they have been gathering and losing to the insects over the course of the game) wins for the plant-participants.

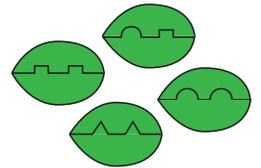
Materials and Room Set-Up:

Materials:

- 1 roll masking/colored tape - used to delineate game play areas (“molting arena”, “root-activity zone”, and “soil pack zone”)
- 2-3 hula hoops (taped to the floor) used to delineate each forest patch
- 25 “soil packs” - brown paper lunch bags with a hole punched in the top and loose string closure (so that they can be picked up by dowel rod)



- 300 “leaves” – Simple leaf shapes cut from paper, each having a template drawn on one side (30 each of 10 different templates), and a 2.5 inch strip of hook side of a hook and loop closure (e.g., Velcro®) stuck on the opposite side to receive chemical defenses. To make the templates, a combination of two shapes should be used, either two of the same shapes or a combination of two different shapes (squares, circles, triangles and pentagons)



- 150 “carbon sources” – paper squares with loop side of a hook and loop closure (shorter than hook side on leaf) on one side



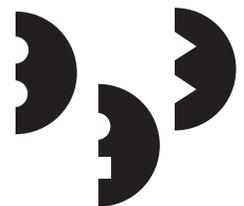
- 150 “water droplets” – paper droplets with loop side of a hook and loop closure (shorter than hook side on leaf) on one side



- 6 “root hair helpers” - dowel rods (approximately 3 feet long by ½ inch diameter)

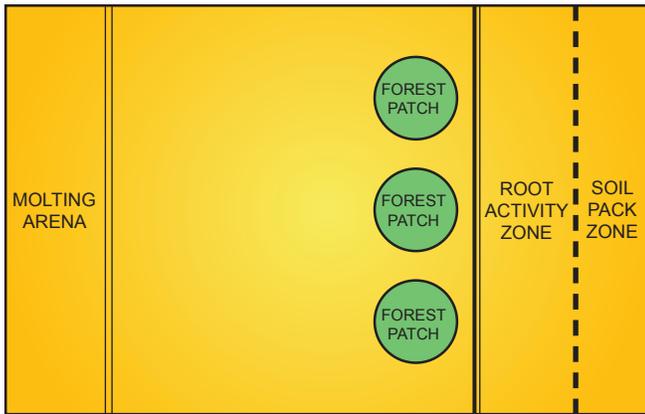


- 10 “taste buds” - leaf templates for the Insect Larvae Specialists to hold, matching patterns drawn on the leaf shapes



- One set of instar indication stickers for each larva – sets of 4 small stickers with the letters “P”-“U”-“P”-“A” on them (the game is designed to have up to 12 larvae per round)





Room Set-Up:

This engaging role-playing game is intended for 6-18 students with two supervising adults. A standard classroom, with desks moved and 15-30 minutes of preparation time prior to student arrival, has worked well on previous occasions. The room will be divided into four activity zones: a molting arena; forest patches; root-activity zone; and soil pack zone. Distances between zones will depend on the space available; however, the distance between the molting arena and forest patches should be maximized, with forest patches evenly-spaced and equidistant from molting arena; forest patches are located between the molting arena and root activity zone, and the root activity zone should be touching the forest patches and 2-3 feet from the soil pack zone.

Before play begins, the forest patches are each stocked with an equivalent number (20-25) of undefended leaves, and the remainder of the leaves, carbon squares and water droplets are distributed randomly throughout the 25 soil packs, which are then distributed throughout the soil pack zone.

The Roles, the Rules and Play:

Root-Hairs: The objective of these participants is to have the forest patch with the most leaves in it when the game is over. Root-Hairs can accomplish this by chemically-defending their leaves so that they are inedible to the foraging Insect Larvae Specialists and by “growing” new leaves. Each forest patch is assigned two Root-Hairs, so there are 2-3 forest patches depending on the number of students participating (2 forest patches for 6-10 students; 3 forest patches for 11-18 students). Each Root-Hair is given a dowel rod. They can move freely in the root-activity zone directly behind the forest patches. Reaching with their dowel rods, they collect soil packs from the soil pack zone. They then sift through the contents of the soil packs, which will contain additional leaves, as well as carbon sources and water droplets. Attaching both a carbon source and a water droplet to the surface of a leaf will chemically defend the leaf so that the Insect Larvae Specialists cannot collect it. Once the game is over, the “Forest-Manager” (one of the adult supervisors) will count the leaves remaining in each forest patch.

Insect Larvae Specialists: The objective of these participants is to collect enough edible leaves to pupate first. If there are 6-10 students, all but 4 will be Insect Larvae Specialists. If there are 11-18 students, all but 6 will be Insect Larvae Specialists. At the onset of the game, larvae will rush to the forest patches and will forage through the patches, looking for leaves that match their leaf template and are not chemically defended by the Root-Hairs. If they are specialists on that type of leaf and the leaf is not chemically defended, then the Insect Larva Specialist can collect that leaf. After collecting five leaves, the Insect Larva Specialist heads back to the molting arena, presenting their leaves to the “Molt-Instructor” (the second adult supervisor) for verification. The

Insect Larva Specialist then molts by counting aloud to 20 (“one metamorphosis, two metamorphosis, three metamorphosis...”). Once the larva reaches 20, he or she is given an instar indication sticker, and may re-enter play.

Molt-Instructor: An adult supervisor fills this role. The Molt-Instructor collects all Insect Larvae Specialists in the molting arena, assigns them leaf templates, lines them up and shouts: “Hatch!” starting the game. The Molt-Instructor waits in the molting arena; when an Insect Larva Specialist arrives with five collected leaves, the Molt-Instructor verifies that the pattern on the leaves matches the leaf template held by the Insect Larva Specialist and makes sure that the Insect Larva Specialist remains in the molting arena while counting before re-entering play. The Molt-Instructor also assigns molt-indication stickers (in order): “P”; “U”; “P”; “A”. When the first Insect Larva Specialist has collected enough leaves and gone through enough molts to spell “PUPA”, then the Molt-Instructor calls: “We have a PUPA!”

Forest-Manager: An adult supervisor fills this role. This adult oversees the activity in the root-activity zone, verifying that Root-Hairs serving forest patches stay within the root-activity zone, and overseeing the number of leaves in the forest patches. If Insect Larvae Specialists are faster than Root-Hairs, it is possible to defoliate the forest patches. When this happens, Insect Larvae Specialists will often wait near the edge of the forest patch to collect new leaves as soon as they’re added by the Root-Hairs. Although an important ecological lesson, it can really slow down progress during play. If this happens, it is the role of the Forest-Manager to gather leaves from the Molt-Instructor and randomly distribute them through the 2-3 forest patches as well as in the soil packs.

Post-Play and Strategies:

In the course of this game, the participants should attain a better idea of how insects and plants interact with one another, how insects forage for food, and some of the kinds of defenses that plants have against too much insect feeding. The students should understand what it means to be a specialist feeder. A variation of the game can be played in which some of the insects are generalists (those insects with a leaf template that has two different shapes on it can eat leaves containing any of those two shapes), so that students can better understand the differences between specialists and generalists. Another variation that may be played involves limiting one or both of the nutrients needed to chemically defend leaves – this mimics drought or other stresses that can cause forest patches to become rapidly defoliated by insect herbivores. One strategy that the Molt-Instructor and Forest-Manager should consider adopting is the practice of allowing some “cheating” on the part of the Insect Larvae Specialists in the game. In the beginning of the game, the supervisors should give the illusion of making sure that the students are playing by the rules, but as play commences, they should be less vigilant against cheating. Later in play, as competition for leaves increases, Insect Larvae Specialists will cheat either by removing defenses from leaves in the forest patch, or by turning in leaves that do not match their leaf template. Although neither one of these strategies exactly mimics the process of evolution (since it occurs within the lifespan of a single insect), it can open up a discussion of evolutionary adaptations, such as the ability to detoxify chemical compounds, as well as the ability to make host plant shifts.

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