IZZY PRAYING MANTIS

Dedicated to Reducing Pesticides

Unit 5 Section 1 Lesson 1: Butterflies, Mealworms, and Beetlemania

Focus Areas: Pest Control: Biological; Science, Art

Focus Skills: observing, identifying, classifying, conducting a scientific experiment

Objectives

- To determine the steps involved in complete and incomplete metamorphosis
- To recognize that biological controls (natural enemies) may be used to control targeted pests
- To understand that care must be taken when selecting a biological control to ensure that only the targeted pest will be attacked by the introduced species

Essential Questions

- How is complete metamorphosis different from incomplete metamorphosis?
- How can insects, rather than chemicals, be used to control invasive plant species?
- How do scientists determine that it is safe to introduce a new species into a different habitat?
- Have there been times when biological control methods have failed?

Essential Understandings

- There are three stages of incomplete metamorphosis (egg, nymph, and adult) and four stages of complete metamorphosis (egg, larva, pupa, and adult).
- Many plants have natural enemies that control their growth and population.
- Scientists conduct studies to make sure the introduced species (biological control agent) will attack only the targeted pest.

IPM
INTEGRATED PEST MANAGEMENT

University of Connecticut
College of Agriculture and Natural Resources
Cooperative Extension System

- Sometimes, when scientific studies haven't been conducted carefuly enough, natural controls attack not only the targeted pest, but non-target organisms as well.

Background

Galerucella calmariensis

This native European beetle was introduced to North America in 1992 as part of a long term program to control purple loosestrife (*Lythrum salicaria*), a non-native invasive plant infesting North American wetlands. The beetles were released in Maryland, Minnesota, New York, Oregon, Pennsylvania, Virginia, and Washington in the U.S. and also in Canada. Since 1992, releases have been made in the majority of states in the U.S. Colonization of these introduced populations by *Galerucella* beetles has been successful in beginning to control the vast stands of purple loosestrife along highways and other wetland areas.

Appearance

Galerucella beetles are light brown, usually with a black triangle or a broad, dark stripe on the thorax. The body has parallel sides, is 3 to 5 mm long and half as wide, and is punctuated with coarse dots of fine, dense hairs.

Habitat

Purple loosestrife is an invasive plant species found in wetlands over much of temperate North America. A key strategy to the *Galerucella* introduction program is to locate the releases so that the beetles will be able to easily colonize and spread. Currently, purple loosestrife exists throughout northeastern U.S. and southeastern Canada, the midwestern U.S., and in isolated locales in the western U.S. and southwestern Canada. Each purple loosestrife plant produces thousands of seeds every year.

Wind and water carry seeds and have spread this invasive plant over large areas.

Pests Attacked

It is critical to determine if a biological control agent might be attracted to native, noninvasive plant species. *Galerucella* beetles are considered to be host-specific to purple loosestrife. This means that they are attracted to purple loosestrife and not to any other plants. Before the beetles were introduced to North America, approximately 50 native plants and economically important species, including some close relatives of purple loosestrife, were tested for susceptibility to the beetles. Only the native winged loosestrife and swamp loosestrife were potential hosts, and under field conditions in Europe, it was determined that if given a choice, *Galerucella* beetles avoided the North American natives.

Life Cycle

Galerucella beetles go through complete metamorphosis. Adults emerge in spring from hibernation in leaf litter and feed on the new leaves and shoots of purple loosestrife. The egg-laying phase lasts approximately two months in the spring, and eggs are laid in clusters of 2 to 10 daily on plant leaves and stems. A female beetle can lay 300 to 400 eggs in her lifetime, and adults live 8 to 10 weeks. Larvae feed on bud, leaf, and stem tissue. Pupation takes place in the soil or ground cover near the plants. Development from egg to adult takes about 6 weeks, and there is usually one generation per year.

Adult beetles are very mobile and successful in seeking out new stands of purple loosestrife. Most searching for a host plant occurs after hibernation when plant growth is resuming in spring, and again following the emergence of new beetles in July and August when plant growth has peaked. Once an area of purple loosestrife has been located, migration

slows, and the beetles remain in that location. The overwintered adults die by late June, soon after the reproduction phase has been completed.

Impacts

In Europe, there are several insects that act together with *Galerucella* beetles to control purple loosestrife. As a result, only small, scattered stands of the plant exist. The current control program in the United States includes the introduction of the *Galerucella* beetles as well as two other insects: a weevil that feeds on purple loosestrife roots and a flower-eating weevil that is also specific to purple loosestrife. It is predicted that when these insects become established, North American purple loosestrife may be reduced by 90% over approximately 90% of its present range.

Early indications are that *Galerucella* beetles are very susceptible to pesticides; exposure should be strictly avoided. Places where purple loosestrife is evenly distributed and that are free of standing water most of the year are optimal for introducing the beetles. The establishment of a colony of *Galerucella* beetles may take 7 to 10 years, and the selected site (1 to 10 acres is adequate) needs to be safe from land development. No insecticides should be used while the colony of beetles is becoming established.

Vocabulary

camouflage	to conceal or disguise, usually by blending in with the surroundings
complete metamorphosis	a four-stage insect development from egg to larva to pupa to adult
conclusion	an answer reached on the basis of evidence

Unit 5 Section 1 Lesson 1: Butterflies, Mealworms, and Beetlemania

environment	the physical, chemical, and biological factors surrounding an organism
food chain	the way food (energy) is passed from one organism to another in a community
generation	the entire body of individuals born and living at about the same time
habitat	the place or environment where a plant or animal naturally lives and that provides it with food, water, shelter, and space
incomplete metamorphosis	a three-stage insect development from egg to nymph to adult
infestation	an invasion or spreading in large numbers that may be troublesome
insecticide	a chemical substance used for killing insects
larva	immature insects that are wingless and often worm-like. They will eventually enter a pupal stage and then transform into adults that have a completely different appearance from any previous life stage.
leaf litter	the layer of dead leaves and plant parts covering the top layer of soil
metamorphosis	the change of an insect or other animal from one form to another as it matures
nymph	the immature stage of an insect that undergoes simple, or incomplete, metamorphosis

Unit 5 Section 1 Lesson 1: Butterflies, Mealworms, and Beetlemania

pesticide a chemical used for killing pests such as insects or fungi

prediction something foretold on the basis of observation, experience, or scientific reason

pupa the resting or inactive stage of an insect that undergoes complete metamorphosis

Logistics

Time: **Introduction**: Life Changes - Metamorphosis: 30 minutes
Involvement: 7 to 14 days with daily observations
Follow Up: 8 to 12 weeks with daily observations

Group Size: 5 to 30

Space: an area with comfortable seating

Follow Up: local wetland habitat selected with the University of Connecticut Purple Loosestrife Biological Control Program Coordinator, Donna Ellis

Time of Year (Follow Up):

Winter - introduction to Beetle Farmer Program; obtain supplies to rear beetles

Spring - rear beetles for release in early summer

Materials

Handout 1 "Metamorphosis Match-Up" *
Handout 2 "Mealworm Magic" *
Handout 3 "Butterfly Metamorphosis Magic" *
Supplement 1 "Complete Metamorphosis Chart" *
Supplement 2 "Incomplete Metamorphosis Chart" *
Complete and Incomplete Metamorphosis Picture Card Set *

magnifying lenses
Video/DVD
butterfly kits and meal worm kits (order from Carolina
Biological (www.carolina.com),
Delta Science (www.delta-ed.com), or
Nature Watch (www.nature-watch.com)
Assessment for a Scientific Drawing *

* single copy provided

Preparation

1. Make copies of Handout 1, "Metamorphosis Match-Up," Handout 2, "Mealworm Magic," and Handout 3, "Butterfly Metamorphosis Magic," one for each child.
2. Follow the directions on the kits for setting up the caterpillar and mealworm pupae.
3. When all caterpillars have formed pupae, set up the butterfly container by following the directions in the kit.
4. If all of the mealworms in the containers have pupated, add some mealworms from the refrigerated box so that children can compare the two life stages.

Note:
Feeding the butterflies. About 11 days after the first pupa forms, adult butterflies emerge. Follow the feeding directions.

Meal worms. Some mealworms may start to pupate 10 days after arrival. The pupae are thicker and shorter than mealworms and pointed on the end. They are a different color than mealworms and have no legs. Pupae sometimes move when touched.

Approximately 7 days after the pupae are formed, some adult beetles will emerge. This will continue to happen over the next few weeks (or

months, depending upon the temperature of the containers). Adults can be kept in the same containers and eat the same food as the mealworms.

Activity

Challenge: Raise healthy insects!
(Display for group viewing)

Part I
Introduction
Life Changes - Metamorphosis
Observing Metamorphic Stages of Two Insects

Paraphrase the following **Background** information:

Of the 1,500,000 species of creatures that live on the Earth, there are more kinds of insects than any other living thing. Scientists estimate there are 475 million different types and many that have yet to be discovered.

All insects go through distinct stages as they grow and develop. This process is known as metamorphosis.

I. Explain that there are two types of metamorphosis:

a. **Complete metamorphosis** occurs when insects hatch from eggs, but the larvae do not resemble the adults and typically eat different foods. They enter a pupal or resting stage where their entire body structure is rearranged. When they emerge weeks later from the cocoon, or pupal casing, they are fully formed adults.
   1. Insects that go through complete metamorphosis include: lacewings, ladybird beetles, butterflies, moths, flies, fleas, ants, bees, wasps, and beetles.
   2. Examine the Complete and Incomplete Metamorphosis Picture Card Set for examples.

b. **Incomplete metamorphosis** occurs when insects begin life as eggs and hatch into **nymphs** that typically resemble wingless adults. They eventually develop wings and organs to reproduce.
   1. Insects that go through incomplete metamorphosis include: springtails, silverfish, dragonflies, mayflies, termites, stoneflies, crickets, grasshoppers, mantids, earwigs, cockroaches, lice, true bugs, aphids, cicadas, and thrips.
   2. Examine the Complete and Incomplete Metamorphosis Picture Card Set for examples.

II. Have participants complete Handout 1, "Metamorphosis Match-Up."

Involvement

The children will:

- observe caterpillars and mealworms as they change from eggs to adults
- keep a record of these changes over time

Procedure

1. Over the next two weeks, have the children observe the mealworms and caterpillars using the hand lenses. Draw the insects.
2. Ask them, after the insects have entered the next stage of development (nymph for the mealworm and larva for the butterfly): How have the insects changed? (different color, shape, no legs, little movement)

3. Using Supplements 1 and 2 (metamorphosis charts), identify the differences between complete and incomplete metamorphosis.
4. Ask the children if they know what happens in the pupal stage when the butterfly is in the cocoon or chrysalis. (This is the resting stage some insects go through before they become adults.)

5. Ask them to compare human growth and development to that of insects. They could create a pictorial timeline to show their own growth and development.
6. Have the children identify or research the names of organisms that go through incomplete metamorphosis (insects) and complete metamorphosis (tadpoles).
7. When the insects hatch, have the children observe and draw them.
   - How are the adults different from the larval or pupal form? (wings, longer legs, antennae)
   - How are they the same? (segmented, 6 legs, similar color)
8. Have the children complete Handout 2, "Mealworm Magic" and Handout 3, "Butterfly Metamorphosis Magic" for reinforcement.

Follow Up

Real World Problem Solving

Children can become Beetle Farmers as they participate in an exciting authentic project through the University of Connecticut's Department of Plant Science. They can raise *Galerucella* beetles and actually release them in a designated area that is infested by purple loosestrife.

Challenge: Become a Beetle Farmer!
(Display for group viewing prior to lesson)

Integrated Pest Management (IPM) methods can be used to control invasive plants in backyards, in parks, and in natural landscapes. IPM technologies include the use of biological, mechanical, cultural, and chemical controls. Biological control, the use of natural enemies to reduce an invasive plant's population below a biological or economic threshold, is a sustainable, low-input method to control the invasive plant purple loosestrife.

Unit 5 Section 1 Lesson 1: Butterflies, Mealworms, and Beetlemania

The Beetle Farmer Program was initiated in Connecticut in 2004 to enhance educational outreach for biological control and to increase the distribution of the *Galerucella* beetles in the state. Raising beetles to control purple loosestrife through the Beetle Farmer Program is an exciting opportunity for community involvement for people of all ages, including K-12 teachers and children, conservation groups, Scouts, senior citizens, and families. If you know of a site invaded by purple loosestrife where biological control is desired, or if you would like to raise *Galerucella* beetles to release at a particular site, become a Beetle Farmer and start this successful program in your school or community.

To sign up for the Beetle Farmer Program, contact Donna Ellis at the University of Connecticut [phone: (860) 486-6448; email: donna.ellis@uconn.edu]. The primary vehicles used for communicating information are the University of Connecticut Beetle Farmer website (www.hort.uconn.edu/ipm) and the Beetle Farmer List Serve (an electronic mailing list). The website contains photographs and descriptive information about purple loosestrife and the *Galerucella* beetles, a PowerPoint presentation with step-by-step instructions on beetle farming, maps showing towns and counties where the beetles have been introduced, a rearing guide for the beetles, newspaper articles, program summaries, and much more. Beetle Farmers receive timely information about the program via the List Serve in an interactive format.

The Beetle Farmer Program has introduced more than **1 million** *Galerucella* beetles, also known as purple loosestrife biological control agents, into more than 90 wetlands in Connecticut since 1996. Hundreds of Beetle Farmers have participated, releasing the beneficial beetles into numerous wetlands across Connecticut where purple loosestrife control is needed.

What are the steps involved in Beetle Farming? Here is a timeline of Beetle Farmer activities:

February and March

February through March is a good time to acquaint yourself and your children with the statewide program, learning about the biology of both the *Galerucella* beetles and purple loosestrife, and the problems that invasive non-native plants create in natural areas. Teachers and children can attend a Beetle Farmer workshop that is usually held each year in March in several Connecticut locations.

You should also begin procuring supplies (see Beetle Farmer website for supply list), but the project does not require a large budget for the items needed. For example, used three-gallon containers and potting mix can be donated by local garden centers or homeowners. Sleeve cages made of bridal veil material or Noseeum netting that are used to cover the plants while the *Galerucella* beetles go through their life cycle can be purchased or sewn, if you are handy with a sewing machine.

April

You will need to dig purple loosestrife plants by the third week in April and put them in the containers so they will have time to grow before introducing the adult *Galerucella* beetles onto them. If you subscribe to the Beetle Farmer List Serve, you will receive announcements for "Dig Days" where we meet at wetlands to dig purple loosestrife plants for the project.

Space requirements for this project are minimal, depending on the final number of *Galerucella* beetles desired. If you want to grow one or two plants you can put each plant in a plastic dishpan half-filled with water. At the University of Connecticut, 24 potted purple loosestrife plants are grown in two small wading pools and only need a 5-foot x 10-foot area.

May

Once the plants have reached 18 inches in height, you will visit a field insectary to collect a starter colony of beetles to put on the caged plants. Field insectaries are wetlands where the *Galerucella* beetles have already been introduced, have become established, and are controlling purple loosestrife. You will receive announcements on the Beetle Farmer List Serve for "Beetle Collection Days" beginning in late May where we will meet to gather the beetles for your plants. Approximately 15 adult *Galerucella* beetles are introduced onto each potted purple loosestrife plant.

If the purple loosestrife plants are healthy and an average of 15 adult beetles is introduced onto each plant, it is estimated that approximately 1,500 new beetles (offspring) will be produced per plant. If 24 purple loosestrife plants are grown, 36,000 new generation beetles will be produced.

June

We encourage all Beetle Farmers to release their new generation beetles in local wetlands so that the site can be visited each season to monitor the progress of the beneficial insects in controlling purple loosestrife. Connecticut has Federal and State permits that allow the introduction of the beetles. A consent form needs to be signed by the property owner or person responsible for each new wetland site to allow the beetles to be released.

One suggestion to assist you in locating a release site is to contact your local Inland Wetlands or Conservation Commission to find areas where purple loosestrife is growing and control of this invasive plant is desired. We also have hundreds of Connecticut field records available for your use

that depict where purple loosestrife has been documented in the state. Land trusts and property owners are other good sources of information to use in locating a suitable release site.

Any type of wetland with a minimum of one-tenth to one-quarter acre of purple loosestrife can be used as a release site. Wetland habitats may include wet meadows, marshes, and edges of ponds and lakes. Over the years we have found that the beetles, which overwinter underground as adults, will survive best at a site that undergoes some seasonal flooding in the spring, but these insects do not do well at a site with prolonged seasonal flooding.

July

The beetles need a $4^{1/2}$ to 6 week period to complete their life cycle on the sleeve-caged plants. Once the new generation beetles begin to emerge from the soil in the containers, you will observe them crawling on the inside of the cages. At this point, simply transport the containers of purple loosestrife to the release site and remove the sleeve cages. Most of the releases will occur in the first part of July, after school has finished for the year. You can arrange to meet with your children at the release site, or in some situations the containerized plants can be transported to the release site before the end of the school year.

Biological control is a patient process, with large wetlands requiring an average of 7 years to significantly reduce purple loosestrife populations. The results will be very rewarding, however, as you witness the gradual return of native wetland flora and the wildlife that it supports.

Assessment

Use the Assessment for a Scientific Drawing to assess understanding of the concepts.

Follow Through

Site Monitoring for *Galerucella* Beetles
Cornell University has developed a national protocol to monitor the effects of the *Galerucella* beetles in wetlands. Visit the website to learn more about monitoring a site:
www.invasiveplants.net/monitoring/pl_Protocol.pdf

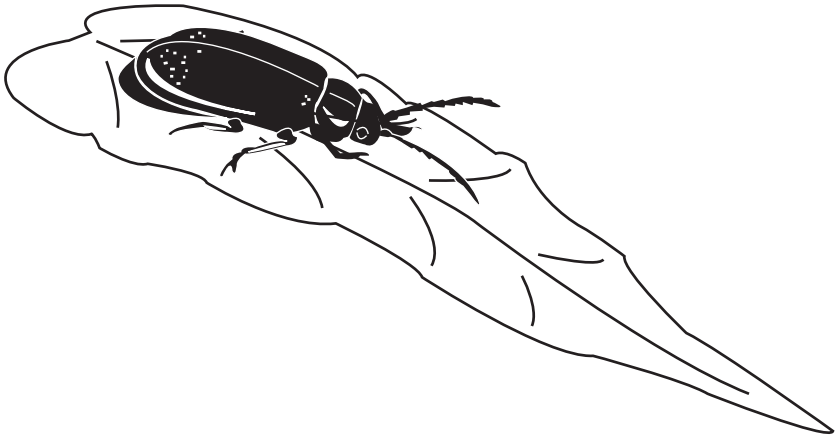
Monitoring forms are available from the Cornell University website to count populations of *Galerucella* eggs, larvae, and adult beetles, to measure effects of *Galerucella* feeding damage to purple loosestrife, and to study wetland plants at release sites:
www.invasiveplants.net/invasiveplants/monitoring/purpleforms.pdf

Suggested Resources

Butterflies and Bees – Discovery School Learning Kit

Mealworms by Adrienne Mason

University of Connecticut Beetle Farmer Project
www.hort.uconn.edu/ipm



Notes