ECOS
Ecologists Educators and Schools: Partners in GK-12 Education

ECOS Inquiry

1. Contributor's Name: Jen Marangelo, Brooke McBride, Alison Perkins

2. Name of Inquiry: Assessing the Effects of Insects

3. Goals and Objectives:

a. Inquiry Questions:
Where do insects go in the winter?
Do biocontrol insects have an impact on seed production in knapweed?

b. Ecological Theme(s):
Over wintering strategies of insects
Effectiveness of biocontrol on knapweed seed production
Data collection and interpreting data

c. General Goal:
Review how to identify an animal as an insect and how they develop
Understand that if an insect lives here in the summer and does not migrate, it lives with us in the winter
Understand the importance of collecting data to answer scientific question
Interpret data, understand some of the challenges of drawing conclusions, start thinking about all the issues to consider when evaluating the process of scientific inquiry
Students will draw conclusions from the data

d. Specific Objectives:
Students will learn different strategies of over wintering insects
Students will see over wintering larvae
Students will learn about the intended effects of biocontrol
Students will collect data and draw conclusions

e. Grade Level: 3-6

f. Duration/Time Required:
- → **Prep time – collect** knapweed, make copies
- → **Implementing Exercise during Class** –50 minutes
- → **Assessment** –10 minutes

4. Ecological and Science Context:

a. Background (for Teachers):

This inquiry uses the knapweed plant and should be done in the late fall, winter, or early spring when you can find larvae in the seed heads.

<u>What is an insect?</u>

Insects are a class of organisms in the kingdom Animalia and the phylum Arthropoda. All arthropods (which include insects, spiders, millipedes, centipedes and crustaceans) have an exoskeleton, a segmented body and jointed limbs. All insects have **3 body parts** (head, thorax and abdomen) and **3 pairs of legs**. The head of an insect has one pair of antennae (sensory organ), compound eyes, up to three simple eyes and mouthparts. The thorax is the point of attachment for all 6 legs and the wings, if present.

The Insect Life Cycle

The word metamorphosis means a change in form and is an appropriate word to describe how an insect develops. Some insects change a great deal as they grow from an immature insect into an adult. There are 2 general types of metamorphosis – complete and simple.

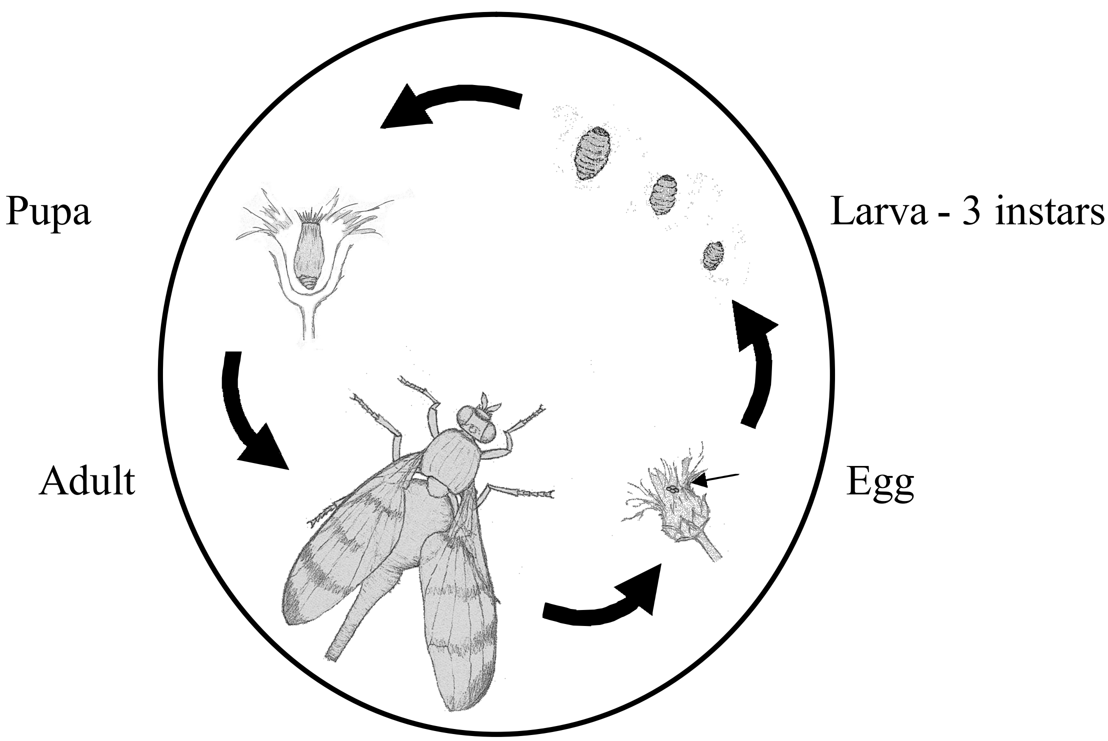
Complete Metamorphosis

Insects with complete metamorphosis (also called holometabolous insects) go through four stages: egg, larva, pupa and adult. These four stages are very different from one another - the animal looks and behaves different, may eat different types of food and usually lives in different places.

Adult females usually lay eggs near the food the larvae will need to eat. After the eggs hatch, the main job of larvae is to eat and grow. Due to its rigid exoskeleton, as a larva grows it must shed or molt the exoskeleton. Each time the larva does this we call the different stages instars. Different species go through different numbers of instars.

When it is time for the larva to become an adult it goes into the pupa stage, which sometimes involves forming a protective case. On the outside it appears that pupae don't really do anything because they aren't eating or moving. They are actually very active as the larva transforms into an adult. After pupation, adults emerge to mate and lay eggs.

This is the life cycle for a fly (*Urophora* species):



This type of fly lays its eggs in the seed heads of knapweed. When the egg hatches the larva will develop and feed inside the seed head. This fly larva will go through 3 instars before becoming a pupa. After pupation, the adult will emerge from the seed head to mate and lay eggs.

Many different groups of insects go through complete metamorphosis including butterflies, moths, flies, beetles, ants, bees and wasps.

Simple Metamorphosis

Insects with simple metamorphosis go through 3 stages: egg, larva (sometimes called nymphs or naiads) and adult. The wings on these insects develop on the outside of the body. If the adult insect has wings small wing pads can be seen on immature insects.

There are three types of simple metamorphosis: ametabolous, paurometabolous and hemimetabolous.

Ametabolous (meaning "no" metamorphosis) is the type of metamorphosis that primitive insects go through. Immature springtails, diplurans, proturans, bristletails and silverfish look like small versions of the adults but are not sexually mature.

Paurometabolous insects (meaning "gradual" metamorphosis) include insects whose larvae and adults live in the same habitat, eat the same food and generally look alike except the adults have full wings. Larvae have small wing pads that get larger each time the insect molts. Some common insect groups with this type of metamorphosis include grasshoppers, crickets, true bugs and cockroaches.

Insects with **hemimetabolous** metamorphosis (meaning "incomplete" metamorphosis) are those whose larvae, sometimes called naiads, are aquatic and adults are terrestrial. The larvae have small wing pads and may look very different from the adults. Examples include dragonflies, mayflies and stoneflies.

Where do insects go in the winter?

Many people think that insects die in the winter. If an insect lives here during the summer, and does not migrate, it lives here in the winter too. It may not be the adult that spends the winter with us, it may the egg, larva or pupa.

Insects are cold blooded which generally means that their bodies are the same temperature as the environment. In winter, or other harsh conditions like drought or extreme heat, insects must respond to the weather behaviorally and/or physically.

Behaviorally

In winter, insects move to locations where the surrounding temperatures are warmer. Some insects like monarch butterflies and painted lady butterflies migrate long distances. Other insects move down into the ground below the freezing line or to other protected places. Most of these insects enter a resting stage, called diapause (see below). Some communal species, like honeybees, are able to regulate the temperature inside their hives through activity that generates heat.

Physically

Insects are often able to survive extreme weather conditions by entering a resting stage called diapause, which is similar to hibernation in vertebrates. Diapause can occur at any life stage but is most common at the egg and pupa stage. Other insects are able to lower their bodies' freezing point with a chemical similar to antifreeze.

Knapweed/biocontrol background

Knapweed is a non-native plant and its natural enemies that normally keep the plant populations in check do not live here. As a result, knapweed out competes native plants in a wide range of habitats. One of the many methods used to control knapweed is biocontrol. Biocontrol is the use of natural enemies to control an organism. In this case, 13 types of insects have been introduced to reduce the distribution of knapweed. It is thought that using several species that cause different stressors to the plant will have a greater impact than any species used alone.

For this inquiry you will focus on the insects commonly found in the seed head during the late fall through early spring. You will find larva of flies and moths and evidence of beetles (large holes in the seed head), which developed in seed heads but have already emerged.

Some of the fly larva will be in galls – one species has a very hard gall and another species has a papery gall. Once you find the larva you can tell the difference between fly and moth larva by a defined head capsule and obvious legs. The flies do not have an obvious head or legs and will be very still while the moth larva have a head capsule, legs and will move quite a bit.

Type of Biocontrol	What will you see?	What does it do to knapweed?
Flies 4 species Knapweed banded gall fly *Urophora affinis* Knapweed seedhead fly *Urophora quadrifasciata* *Terellia virens* *Chaetorellia acrolophi*	The 2 *Urophora* larvae develop in a gall. One is thick and hard with a pointed tip. Getting in to this gall can take some effort. The other gall is light and papery. Fly larvae are creamy white and barrel shaped. They do not have a distinct head capsule or legs. The wide end of the larva with a dark spot is actually the anal plate.	All damage to the plant is due to feeding on the seeds or other tissues in the seed head. Two of the flies form a gall, which further drains nutrients from the plant.
Moth Spotted knapweed seedhead moth *Metzneria paucipuctella*	Creamy white with a distinct head capsule, legs and prolegs.	Larvae eat developing seeds. Each larva can destroy 8 seeds and decrease the viability of others.
Beetles Knapweed flower weevil *Larinus minutus* *Larinus obtusus* *Bangasternus fausti*	You will know a beetle developed in a seed head if you see large hole at the top. The adult emerged in Sept. or Oct. and is spending the winter in the ground at the base of the plant.	Larvae eat the seeds and pappus hairs. Adults eat leaves and may defoliate plant.

b. Background (to present to Students): See methods/procedure for students below.

5. Motivation and Incentive for Learning: Students get hands-on experience locating biological controls in knapweed. They get to collect data and make decisions using their results.

6. Vocabulary:

Abdomen – body region behind thorax, usually has 10 segments, can have appendages at the tip

Biocontrol – the use of natural enemies to control an organism
Diapause – a period of arrested development, can occur in response to harsh conditions such as cold weather, lack of food or dry conditions
Gall – abnormal growth of plant tissue stimulated by insect or pathogen attack
Larva – plural = larvae. Usually considered the immature stage (between egg and pupa) of an insect that goes through complete metamorphosis
Prolegs – fleshy abdominal legs
Pupa – plural = pupae. The stage of an insect between larva and adult for those that go through complete metamorphosis
Thorax – the body region behind the head that bears wings and legs; divided into three segments: prothorax, mesothorax and metathorax

7. Safety Information: n/a

8. Materials List (including any handouts or transparency masters):

- Life Cycle Diagram
- What is Inside a Knapweed Seed Head? Illustration
- Assessing the Effects of Insects Worksheet
- Knapweed plants (try to collect knapweed from a location students are familiar with – the schoolyard or a popular park)
- Something to dissect the knapweed plants on (dark paper works well but you can also use paper towels or paper plates)
- Magnifying glasses and/or microscopes (optional)

9. Methods/Procedure for students:

a. Pre-investigation work:

Prior to this inquiry, review what an insect is and the insect life cycle using the attached insect life cycle diagram. To lead into the inquiry, it is fun and helpful to lead students through the following points of discussion and reflection:

- What do you do to protect yourselves from winter weather? We will be discussing where *insects* go/what *insects* do in the winter. (Elaborate on your students' ideas based on the background information presented above). Insects don't just die in the winter. Any insect that lives here in the summer, and doesn't migrate, lives with us in the winter.

- We will have an opportunity to see some insects that spend the winter with us inside a plant. (Show them the knapweed and ask them if they know what it is and tell them where you got it). Two types of insects, flies and moths, might use this plant as their home during winter. (Briefly describe/review the life cycle of these insects. Adults fly around in spring and summer looking for a place to lay eggs. They lay their eggs in the seed head or flowers, the eggs hatch into larva after just a few days and it's the larva that spend the winter with us inside the seed head. In the spring and summer, the larva will turn into pupa. Finally, the adults will emerge to eat, mate, and lay eggs and the same life cycle occurs again, year after year).

- Many people don't like this plant… does anyone know why? It's a non-native weed and when a non-native organism establishes itself in a new location its population can get out of hand because none of its natural enemies live here to keep the population under control. So an organism that isn't a problem in its native location can be a problem in a new habitat. To deal with this sometimes biologists use biocontrol. (Explain biocontrol).

- 13 different insects have been introduced to try and control knapweed. Some insects live in the roots, some live in the seed heads and hurt the plant be eating the seeds, and some, just by living in the plant, stress out the plant so that in doesn't grow as well and produces fewer seeds.

- Not only are you going to have an opportunity to see how some insects are spending the winter with us, you are going to see if these biocontrol are doing the job they were introduced to do (reduce the number of seeds). You will be given 5 seed heads. You will open each one and count the larva and seeds and record the information on the worksheet provided. When everyone is done we will decide as a class if the biocontrol are doing their job.

- Using the attached diagram *What's Inside of a Knapweed Seed Head*?, explain what students will find inside the seed head – seeds, larvae and galls with larvae in them. Explain what these look like. Explain that galls are hard and if they find something that's dense and not a seed, it might be a gall – and they should pick those apart.

- Demonstrate how to pick apart the seed head (essentially, just peel away the layers). Students should open one seed head at a time – count the seeds and the larva and then move all that to the side. Then, open the next seed head. When done, ask students to look at the larvae and seeds and sketch one of each.

- Hand out worksheet and 5 knapweed seed heads to each student. Depending on your students' abilities, you may just want to give them page 1 of the worksheet and do the graph as a class. (Try not to give students heads with holes in them. They are unlikely to find larvae in these).

b. Investigation work:

1) What evidence (data, samples) do students collect? Students dissect seed heads and record the number of larvae and seeds in each.

2) How do students present the evidence (data)?

When students are through collecting the data explain that to interpret the data, we need to organize it in a special way. Draw the graph from the worksheet on the chalkboard or overhead projector and explain how to graph the data. Ask the student's what the graph might look like if the biocontrol were working (more larvae= fewer seeds, so the points on the graph would generally show fewer seeds with more larvae, ie. a downward-sloping line). Call on students for their data and enter their data points on the graph.

3) What conclusions are drawn from the evidence students collect? After graphing some of the data, ask students whether they think the biocontrol are doing their job. Make sure they can back up their answers with the data on the graph. With only a few points on the graph, it might be difficult to draw any conclusions. But talk about what might happen when you add more data and why (are just a few points representative of what's really going on in the population?) What are some other reasons we might not be able to interpret the data? Perhaps we couldn't accurately count the seeds/ larva, other reasons for variability or error in our measurements. Explain that this is an important part of science and that we may not always get the answer we were expecting!

4) Include examples of data sheets (attached).

10. Assessment: Assessment can take place during the exercise and class discussion. You may collect worksheets to assess individual student's understanding of the inquiry.

11. Extension Ideas: See inquiry *Investigating Use of Biocontrol Agents for Controlling Spotted Knapweed* (http://www.bioed.org/ecos/Inquiries/Inquiries/Knapweed_Biocontrol_Inquiry.pdf)

12. Scalability: this inquiry has been scaled down for 1st and 2nd graders (see *Looking for Larva* http://www.bioed.org/ecos/NewPrograms.htm).

13. Science Standards Accomplished:

National Science Standards

Unifying Concepts and Processes
Evidence, Models, and Explanation

K-4
Science as Inquiry
Abilities necessary to do scientific inquiry
Understandings about scientific inquiry
Life Science
The characteristics of organisms
Life cycles of organisms
Organisms and their environment
Science in Personal and Social Perspectives
Changes in environments

5-8

Science as Inquiry
Abilities necessary to do scientific inquiry
Understandings about scientific inquiry
Life Science
Reproduction and heredity
Regulation and behavior
Populations and ecosystems
History and Nature of Science
Science as a human endeavor

14. References:
Wilson, L.M. and C.B. Randall. 2003. Biology and Biological control of Knapweed. USDA-Forest Service FHTET-2001-07. 2nd Edition. http://www.invasive.org/weeds/knapweed/

15. List of Experts and Consultants:
Marijka Wessner, Weed Education Coordinator, Missoula County Weed District (http://www.mslacountyweed.org/)
Nancy Sturdevant, Entomologist, USDA Forest Service (http://www.fs.fed.us/r1/centennial/index.shtml)

16. Evaluation/Reflection by Fellows and Teachers of how it went: Students LOVED picking apart the seed heads and were thrilled to find the tiny larvae inside. Many took this knowledge home to share with their families and friends. Teachers were excited by this inquiry and felt that it would be fun and easy to conduct on their own. It was a great example of "bringing the outdoors in," and was especially well-received on days when the weather was bad!

Assessing the Effects of Insects

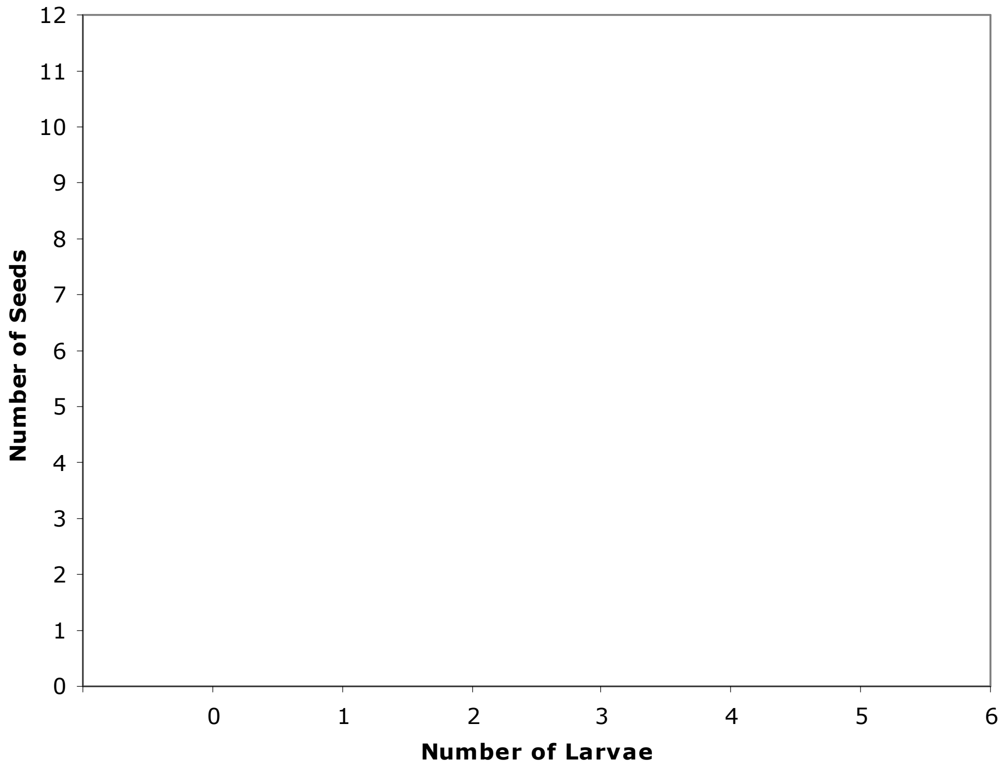
Name: ______________________________

Count the number of larvae and seeds in five seed heads.

Seed Head	Number of Larvae	Number of Seeds
1		
2		
3		
4		
5		

Draw a larvae:	Draw a seed:

Plot the number of larvae and the number of seeds in each seed head.



Do you think the number of larvae in a seed head impacts the number of seeds the plant can produce? _______________

Why or why not? ____

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