Investigating Use of Biocontrol Agents to Control Spotted Knapweed

Target Grade Level: 5th

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UNIVERSITY OF MONTANA GK-12 PROGRAM

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1) CONTRIBUTOR'S NAME: RACHEL LOEHMAN

2) NAME OF INQUIRY: INVESTIGATING USE OF BIOCONTROL AGENTS TO CONTROL SPOTTED KNAPWEED

3) GOALS AND OBJECTIVES:
   a) Inquiry Questions:
      i) Are biocontrol agents (insects) present in spotted knapweed plants in the schoolyard?
      ii) What species of insects are present?
      iii) Where in the plant do they live, and how do they help control noxious weeds?
      iv) Do we need to release more insects this spring and summer to control spotted knapweed?

   b) Ecological Themes:
      i) Density and distribution of organisms
      ii) Use of biocontrols to control invasive weeds
      iii) Sampling and hypothesis testing
      iv) Sustainable population concepts

   c) General Goals:
      i) Formulate and test ecological hypotheses
      ii) Hands-on exploration of a relevant real-world question
      iii) Better understanding of schoolyard community ecological interactions
      iv) Student investment in restoration garden

   d) Specific Objectives:
      i) Help students formulate ecological hypotheses
      ii) Design a sampling strategy for discovering the distribution and density of biocontrol agents
      iii) Identify insect species
      iv) Collect and analyze data and present findings to other teams

   e) Grade Level: 5

   f) Duration/Time Required: 6 hours
      i) Prep time 1 hour
      ii) Implementing Exercise During Class 4 hours (outdoor plus indoor components)
      iii) Assessment 1 hour

4) ECOLOGICAL AND SCIENCE CONTEXT:
   a) Background for teachers and students: During the past 10 years a number of different species of insects have been released into the Target Range schoolyard to control spotted knapweed. Insects functioning in this role are termed "biocontrol agents." Biocontrol agents are widely used in Montana to control the spread of noxious weeds. There are three types of insects that are used in biocontrol of knapweed: flies, moths and beetles (http://www.invasive.org/weeds/knapweed/) (figure 1). These insects are found in larval form internally in knapweed in flower heads, where they reduce knapweed seed production by as much as 50-90% by eating developing flowers and seeds, or in the root, where they have been known to reduce knapweed vigor through boring (http://ag.montana.edu/warc/biocontrol_agents_of_knapweed.htm). Knapweed biocontrol agents work best in combination: it is unlikely that any one of these species alone could successfully control knapweed. When released together bioagents create multiple stresses on the plant and have a greater chance of contributing to the suppression of knapweed.
   b) The insects you may be likely to find today are: seed head flies (*Urophora* spp), moths (*Metzneria* paucipunctella), and beetles (*Larinus* spp) and root-boring moths (*Agapeta* zoegana) and beetles (*Cyphocleonus achate).* These insects were released at different sites across the schoolyard, and have probably spread to many patches of knapweed within and near the schoolyard.

Depending on the type of insect (seed head feeders versus root borers) these insects overwinter (survive the winter) in different forms (figure 2). Seed head flies and moths overwinter as larvae in the knapweed seed head, seed head beetles overwinter as adults in litter near the root, and root-boring moths and beetles overwinter as mature larvae in the root. Today's investigation will determine 1) what species of insects are present in spotted knapweed within and near the schoolyard 2) whether the species have similar density and distributions 3) whether more insects should be released this spring and fall – do we have self-sustaining populations? Do we have a wide enough variety of biological control agents to reduce knapweed vigor?

5) MOTIVATION AND INCENTIVE FOR LEARNING: Use of biocontrol agents to control invasive weeds is a current and controversial ecological topic. Methods for investigating this topic are directly accessible in the schoolyard; builds on a previous investigation (Winter Entomology Investigation)

6) VOCABULARY:

   a) Biocontrol: Control of pests by disrupting their ecological status through the use of organisms that are natural predators, parasites, or pathogens.
   b) Sampling: A set of elements drawn from and analyzed to estimate the characteristics of a population.
   c) Hypothesis: A tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation.
   d) Overwinter: Survive through the winter.
   e) Species: A fundamental category of taxonomic classification, ranking below a genus or subgenus and consisting of related organisms capable of interbreeding.
   f) Invasive plant: A species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

7) SAFETY INFORMATION: WATCH FOR TRAFFIC, STAY WITHIN DEFINED SAMPLING BOUNDARIES.

8) MATERIALS LIST (including any handouts or transparency masters): COLLECTION KIT (PAPER GROCERY BAG, ADHESIVE LABELS, MARKING PEN), SCHOOLYARD MAP, PENCIL, GARDENING GLOVES, SCISSORS, HAND LENSES AND MAGNIFYING BOXES, TWEEZERS, DATA SHEET, GRAPH PAPER, RULER, INSECT IDENTIFICATION SHEETS, MICROSCOPES, PETRI DISHES.

9) METHODS/PROCEDURE FOR STUDENTS:
   a. Pre-investigation work: Students learn about biocontrol (insects: lifecycle, species ID; how biocontrol works) and where and why these insects were released into their schoolyard. Students are asked to formulate hypotheses about where they might find these insects (i.e. nowhere, only at release sites, at margins of schoolyard, equal vs. unequal distributions), and what that distribution means for control of invasive weeds and resource needs and limitations of the insects. Students will be divided into groups and assigned a quadrant of the schoolyard in which they will collect data to test their hypotheses.

   b. Investigation work: Each group of students will be assigned to an area of the schoolyard, in which they will collect whole knapweed plants (dried vegetation plus rootmass) if ground is thawed; otherwise students can cut plants off at ground level. Students will collect plants along a transect moving away from the center of the schoolyard, labeling and locating each specimen on a schoolyard map. Students can field-check for the presence of insect larvae in the knapweed seed heads (background material presented in a recent Winter Entomology investigation) using hand lenses and magnifying boxes. In the classroom groups will dissect knapweed seed heads and root masses to collect insects present. Students will record the following for each plant specimen collected: ID, collection location, number of seed heads dissected, total number of fly, moth, and beetle larvae found within seed heads, and total number of larvae found within root

mass. Students will use microscopes, hand lenses, and insect identification guides to separate larvae into groups (beetles, moths, flies) and, if possible, distinguish species. Students will graph insect counts by group or species and by distance from the center of the schoolyard.

ii) What evidence (data, samples) do students collect? Whole knapweed plants with location of collection site noted on schoolyard map.
iii) How do students present the evidence (data)? Record data on Knapweed Biocontrol Data Sheet; graph data by number of each type of insect and total insects per transect, abundance of each type of insect within the total sample area.
iv) What conclusions are drawn from the evidence students collect? Distribution and density of biocontrol agents as a function of distance from the release site, differences in abundance of different insect types by location, and total abundance of each type within the schoolyard. Students may conclude whether these insects are self-sustaining populations, and determine whether more or different types of insects need to be released in the future to help control knapweed.
v) Include examples of data sheets. See Knapweed Biocontrol Data Sheet.doc

10) ASSESSMENT: Use student enthusiasm to gauge effectiveness of the introduction and in-field portions of the investigation; evaluate graphs and data sheets to determine whether students understood and benefited from the investigation.

11) EXTENSION IDEAS: STUDENTS PRESENT THEIR FINDINGS IN A SCIENCE-FAIR-LIKE FORMAT AND TEACH OTHER CLASSES ABOUT THEIR RESULTS. STUDENTS MAKE RECOMMENDATIONS FOR IMPROVING EFFICACY OF BIOCONTROL AT THE SITE (EX. RELEASING MORE OF SPECIFIC TYPES OF BIOCONTROL AGENTS, OR VARYING RELEASE SITES TO INCLUDE AREAS WHERE INSECTS ARE NOT CURRENTLY FOUND).

12) SCALABILITY: VERY SCALABLE; CAN ADD COMPLEXITY USING SAMPLING TECHNIQUES AND ADVANCED DATA ANALYSIS AND STATISTICS

13) REFERENCES:
a) Biology And Biological Control Of Knapweed, USDA Forest Service FHTET-2001-07. 2nd Edition (http://www.invasive.org/weeds/knapweed/)
b) MSU/Western Agricultural Research Center (WARC): http://ag.montana.edu/warc/biocontrol_agents_of_knapweed.htm

14) LIST OF EXPERTS AND CONSULTANTS: NONE

15) EVALUATION/REFLECTION BY FELLOWS AND TEACHERS OF HOW IT WENT: Students and teachers seemed to enjoy this investigation because it took place within the schoolyard, involved survey and sampling of schoolyard vegetation, and was very relevant to material they have studied in class and in other ECOS investigations. Students liked the idea of being involved in developing management strategies for the schoolyard, especially because there is a direct tie-in with development of the schoolyard outdoor ecology laboratory.

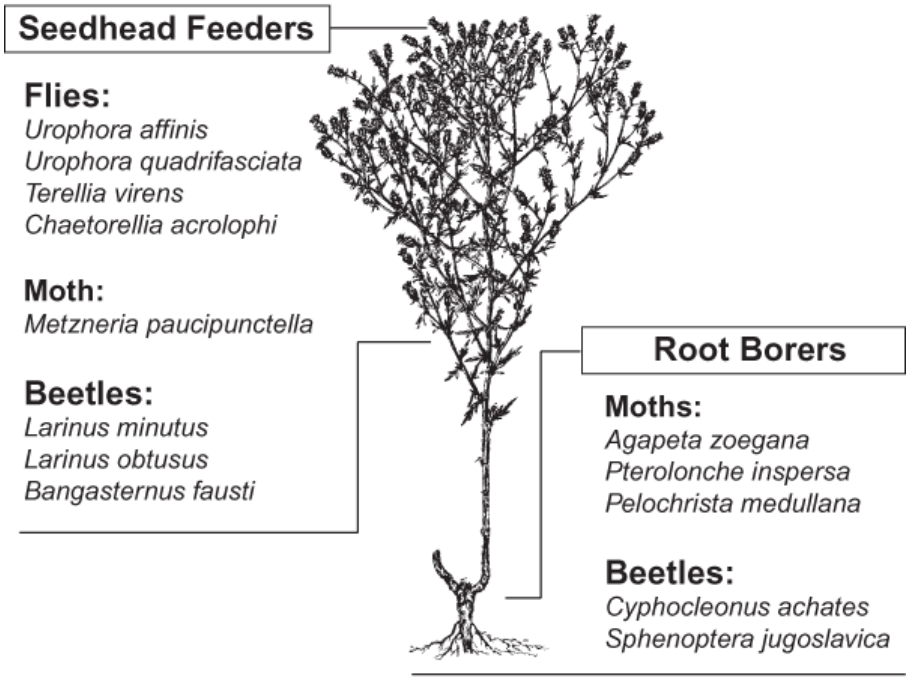


Figure 1. Distribution of knapweed biocontrol agents in a knapweed plant.

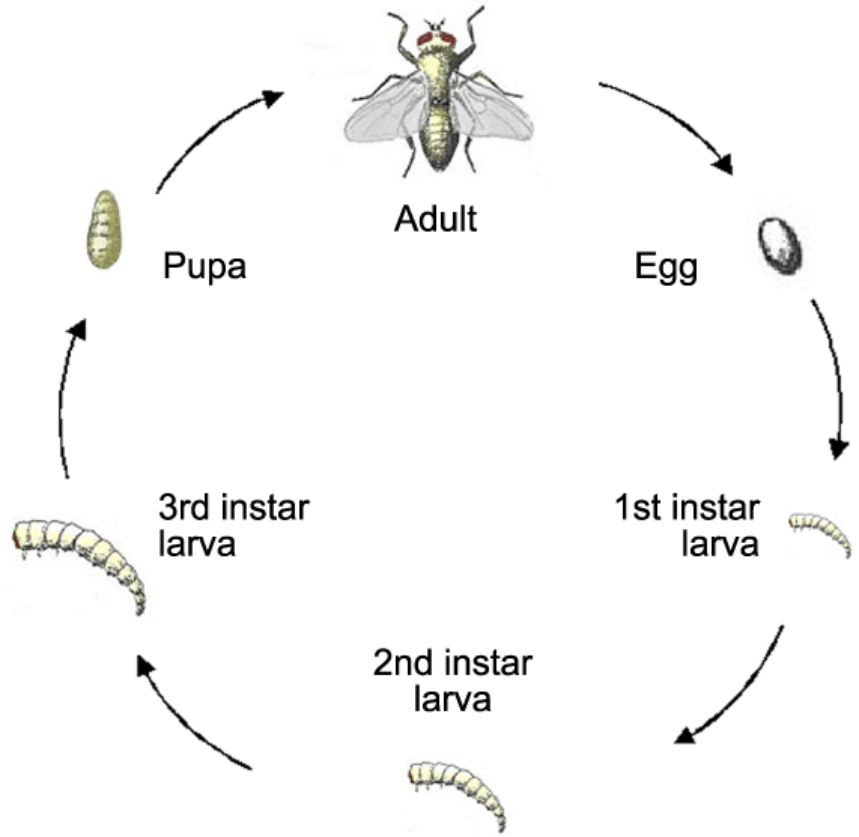


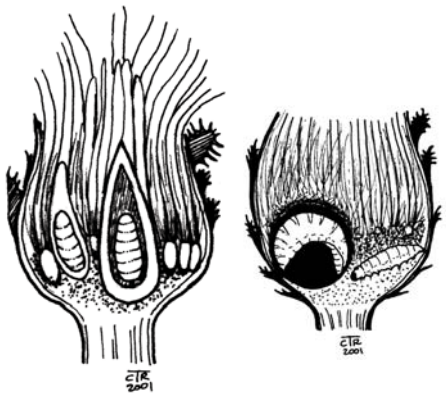
Figure 2. Example of an insect lifecycle showing complete metamorphosis.

GUIDE TO INDENTIFYING INSECTS USED TO CONTROL SPOTTED KNAPWEED

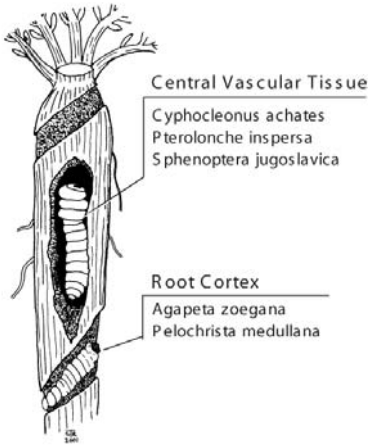
For today's investigation we'll identify insects as (1) **SEED HEAD FEEDING INSECTS** or **ROOT-BORING INSECTS** and identify larvae as (2) **FLY, MOTH, or BEETLE**

1. WHERE DOES THE INSECT LARVA LIVE?

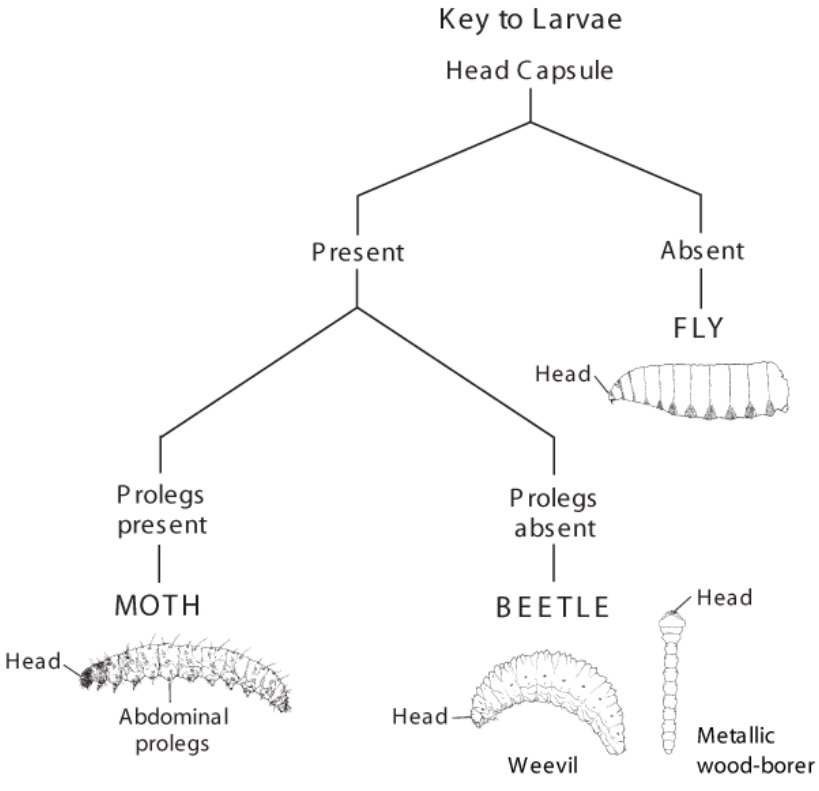
Knapweed seed head



Knapweed root



2. IS THE LARVA FROM A FLY, BEETLE, OR MOTH?



Names_____

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Target Range Spotted Knapweed Biocontrol Data Sheet

Plant ID	Collection Location	Number of seed heads dissected	Number of seed head feeding larvae			Root-boring larvae?
			Beetle	Moth	Fly	