Biocontrol agents in the field

Summary
Students survey biocontrol agents in the field and examine the damage they cause to weeds.

Learning Objectives
Students will be able to:
- Identify biocontrol agents for gorse and broom.
- Use appropriate methods to sample biocontrol agents.
- Record observations and manipulate data about biocontrol agents found in the field.
- Make informed guesses about the probable impact of biocontrol agents based on observations.

Suggested prior lessons
What is a weed?
Choose your weapon
Adventures in biocontrol

Curriculum Connections
Science, levels 5-8

Vocabulary/Concepts
carrying capacity, density dependent factors, density independent factors, exponential growth, logistic growth, population, sample.

Time
1-3 hr in the field, plus possible 1 hr classroom follow-up

Materials
- clipboards / pencils
- paper or data sheets
- Gorse and broom biocontrol agents handouts
- calculators (optional)

Background information

Biocontrol agents can be found on weeds throughout New Zealand. By sampling biocontrol agents, students learn about the agents' life cycles, the damage they cause to weeds, and their population dynamics.

It may be useful to conduct a general lesson on population dynamics prior to, or as follow up to this lesson.

The following set of activities provides examples of agents and investigations students can carry out during a field trip. The activities focus on biocontrol agents for gorse and broom—common weeds in most areas of New Zealand. Not all agents are present in all areas—check for agents before you take your students out, and choose activities based on the agents present in your area.

Survey the same area over several years so students can examine trends in the populations of biocontrol agents over time.

Activities

Break the class into small groups (2-4 students each) to complete the following activities.

Gorse seed weevil (*Exapion ulicis*) and **gorse pod moth** (*Cydia succedana*) can be used to investigate how biocontrol agents affect seed production. Their effects are easily observed and quantified by students.

Collect gorse pods from a random sample of plants in your study area. Open each pod and record the number and type of insect in each pod. Also record

whether the pod is destroyed, but empty (indicating that a pod moth caterpillar has been through the pod). Calculate the percentage of pods destroyed by each agent.

Gorse spider mite (*Tetranychus lintearius*)
Though it is difficult for students to quantify the damage gorse spider mites cause, the colonies are easily located and counted during the warmer months, especially during long periods without rain. Students can survey an area and record the number of gorse plants with and without mite colonies.

Mites are also behaviourally interesting. Like all invertebrates they are cold blooded so their level of activity is temperature dependent. In cold weather they retreat to the centre of their web, becoming inactive and forming a dense ball. When they warm up, they become active again and disperse throughout the web. You can observe mite behaviour closely with a magnifying lens.

Gorse spider mites are a good illustration of the complexity of a biocontrol programme and how agents become part of the local ecology. A native black ladybird preys upon the mites and can be found in the spider mite webs. The behaviour of predator and prey can be observed in the field.

Broom seed beetle (*Bruchidius villosus*) can be surveyed in three ways. In spring, students can beat broom plants over a 1 x 1 m sheet or card to collect and count adults. Discuss with the students the importance of having a consistent collection method (i.e. the same number of hits to the plant, with the same force, using the same size collection sheet below), and establish the method with the students beforehand. If beetles are surveyed over several years, students can evaluate population trends in the beetles over time.

Also in spring, students can sample young broom pods and count the number of eggs laid on each pod. The number of seeds in the pod is also visible, even on young pods. Knowing that each beetle destroys one seed, students can calculate the percentage of seeds destroyed by the beetles (total # eggs ÷ total # seeds x 100).

Another survey method (for late summer) is to look for newly emerged adult beetles inside mature pods that have not yet burst open. Have students collect a random sample of pods from the study site. They should record the number of beetles found inside each pod, and the number of seeds per pod. Knowing that each beetle destroys one seed, students can calculate the percentage of seeds destroyed by the beetles (total # beetles collected ÷ total # seeds x 100).

Broom psyllid (*Arytainilla spartiophila*) can be difficult to see on the plant except as an adult in late spring on new growth. When adults are present, students can look for both the psyllids and the mirid bugs that prey upon them. This is a good illustration of the complexity of biocontrol, and how agents become part of the local ecology.

Psyllids can also be surveyed by beating broom plants over a 1 x 1 m sheet or card, as for broom seed beetle. If students are beating plants for seed beetles, they can count psyllids at the same time. Though it is difficult to quantify the damage the psyllid causes, if surveys are taken annually, students can evaluate population trends.

Discussion

Some questions for follow-up classroom discussion:

1. Which agent(s) do you think are doing the most damage in our study site? What evidence did you collect that supports your answer?
2. Did all the groups get the same results? Why might groups get different results? How can we improve the accuracy of our conclusions? What results do we get if we pool everyone's data?
3. Why do you think more than one biocontrol agent was released for each weed? What factors might be limiting the damage these agents cause to the target weeds?
4. Did you see any other biocontrol agents? What were they and what do they do?

Assessment/Extension

1. If you have more than one year of data, have students graph the populations of biocontrol agents over time. Ask them to interpret their results. Are the populations increasing, decreasing, fluctuating from year to year? Discuss what factors might be affecting the populations of biocontrol agents (they may be newly established at the site so populations are rising, the population may have reached its carrying capacity and levelled off, the populations may be being affected by parasitism, predation or disease, weather conditions may have increased or decreased survival of the agents, or human activities such as grazing, spraying, mowing, etc. might have affected the agents). Which of these factors are density dependent? Which are density independent?
2. If there are broom or gorse biocontrol agents missing from your study site, have students investigate the agents' habitat requirements and determine if they can possibly survive on the site. If possible, locate nearby populations where you can collect agents and release them on the study site. Monitor their establishment.
3. Record your observations on Nature Watch NZ (www.naturewatch.org.nz), a citizen science website where you can record observations, ask questions about them, and see others' observations.

Curriculum connections

Science—Nature of Science
Levels 5 & 6

Understanding about science

- Understand that scientists' investigations are informed by current scientific theories and aim to collect evidence that will be interpreted through processes of logical argument.

Investigating in science

- Develop and carry out more complex investigations, including using models.
- Show an increasing awareness of the complexity of working scientifically, including recognition of multiple variables.
- Begin to evaluate the suitability of the investigative methods chosen.

Communicating in science

- Use a wider range of science vocabulary, symbols, and conventions.

Levels 7 & 8

Investigating in science

- Develop and carry out investigations that extend their science knowledge, including developing their understanding of the relationship between investigations and scientific theories and models.

Communicating in science

- Use accepted science knowledge, vocabulary, symbols, and conventions when evaluating accounts of the natural world and consider the wider implications of the methods of communication and/or representation employed.

Science—Living world
Level 7

Ecology

- Explore ecological distribution patterns and explain possible causes for these patterns.

NCEA
Biology Level 1

Achievement standard 90925 – Carry out a practical investigation in a biological context with direction

Biology Level 4

Unit standard 26509 – Explain biodiversity of New Zealand
Unit standard 26510 – Demonstrate knowledge of ecosystems

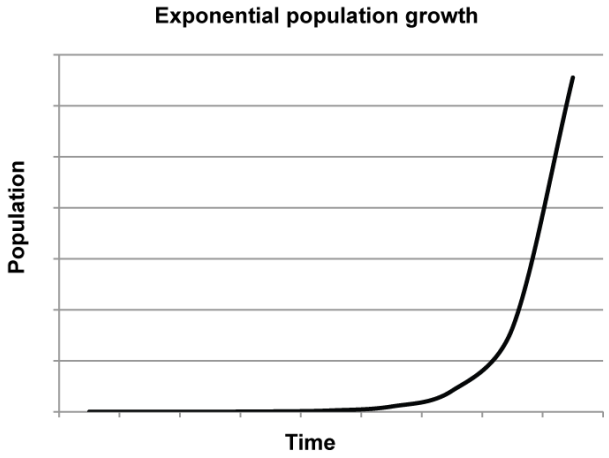
Vocabulary/concepts

Carrying capacity – the maximum number of individuals the habitat can support.

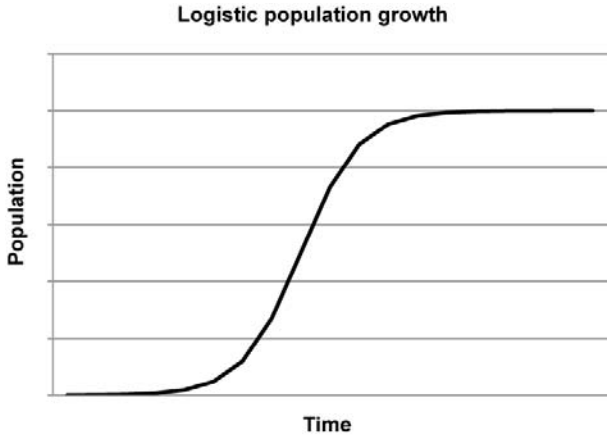
Density dependent factors – Factors affecting a population that vary with the size of the population. For example, diseases spread more easily among individuals (and will affect a greater percentage of individuals) in a dense population, so the effect of disease is density dependent.

Density independent factors – Factors affecting a population that do not vary with the size of the population. For example, a period of harsh weather may kill 50% of a population of insects, regardless of how many insects are in the population, so the effect of the weather is density independent.

Exponential growth—the growth of a population with no limits acting on it. In exponential growth, the rate of increase of the population increases as the population gets larger, as shown in the graph to the right.



Logistic growth – the growth of a population under the influence of a restraint (such as a limiting resource). In logistic growth, the rate of growth decreases as the population increases, as shown in the graph to the right.



Population – a group of individuals of the same species living in a specified area.

Sample – a selected subset. Because scientists cannot look at every single plant/animal/etc, they examine a small number of them, selected so as to be representative of the whole.

Gorse and its biocontrol agents

Gorse (*Ulex europaeus*) is a large spiny shrub that produces yellow pea-like flowers mainly in spring and autumn. It was originally introduced to NZ as a hedging plant and is still commonly used for hedges. Gorse is widespread throughout New Zealand and is a weed in agricultural and natural landscapes. Six biocontrol agents have been introduced to New Zealand to attack gorse, and two native species can also cause visible damage to the plant.

Common gorse biocontrol agents:

Gorse seed weevil (*Exapion ulicis*) Native to Europe, this beetle was released widely in the 1930s and 40s. It is common in most areas except the West Coast of the South Island. Adults lay eggs in green gorse pods in spring (up to 20 eggs per pod). Larvae grow and develop inside the pods, eating the seeds. They pupate, then emerge as adults inside the pod, but must wait until the mature pod bursts to escape. Gorse seed weevil attacks only the spring pods of gorse. Look in spring for the larvae feeding inside pods, or in summer for adults inside mature pods. If the pod has a single creamy-white caterpillar inside, it is the gorse pod moth (see below). If the pod is empty except for some frass (insect poo) then a pod moth caterpillar has fed on the seeds and moved on.

Gorse pod moth (*Cydia succedana*)
Native to Europe, gorse pod moth was released widely during the 1990s, and is now established throughout the country. Adult moths can be found flitting around flowering gorse. Adults lay eggs in gorse flowers. Caterpillars chew into the pod and eat the seeds within. When they empty one pod, they chew out and move on to another pod. Each caterpillar can eat the seeds of 2-3 pods, and there is usually only one caterpillar in a pod. Caterpillars are present in both spring and autumn produced pods, but it's best to look for them during the autumn when gorse seed weevil is not present to confuse you. Pods can also be checked in spring, but if you see several white grubs, you've found the seed weevil (see above).

Landcare Research
Manaaki Whenua

Gorse spider mite (*Tetranychus lintearius*)

This mite is native to Europe. It was widely released in the early 1990s, and is now established in all regions of New Zealand. The mites live in colonies and spin fine white webs that can cover entire gorse bushes. The tiny red mites suck juices of gorse plants, causing the foliage to look bleached or brown. Though the mites reduce the growth and flowering of gorse, they rarely stay on gorse bushes long enough to kill them. Mite colonies are largest in summer. Webbing is destroyed by rain, so it is best to look for colonies during warm, dry weather.

Gorse spider mite predator

This native ladybird (*Stethorus bifidus*) can be found in gorse spider mite colonies. It eats mites, chasing them down in the web.

Broom and its biocontrol agents

Scotch broom (*Cytisus scoparius*) is a large woody shrub with green stems. Juvenile plants can be quite leafy, but older plants are often almost leafless. Its yellow pea-like flowers are similar to gorse flowers. Broom is originally from Europe, and was planted by early European settlers. It soon became a weed, and today invades river beds, roadsides, plantations, tussock grassland, and pasture. Five broom biocontrol agents have been introduced to New Zealand, and one has self-introduced.

Common broom biocontrol agents:

Broom seed beetle (*Bruchidius villosus*)

This beetle is native to Europe, and was introduced widely to New Zealand in the 1990s. It is well established throughout the country. Adults lay eggs on green broom pods. Eggs are visible on the pods as whitish spots (see picture below). Larvae burrow through the pod wall and into the soft green seeds. Each larva destroys one seed. The beetles pupate inside the seeds, and new adults are released when the pods burst open at maturity.

Broom seed beetles are capable of destroying 80-90% of seed. Adults can be found on broom flowers in spring. Beat the bush with a stout stick over a 1 x 1 m card or sheet to easily locate adults. You can also find new adults and hollowed-out seeds in mature pods.

Broom psyllid (*Arytainilla spartiophila*)

Broom psyllid is a small insect that sucks the juices of new spring growth of broom. The insects are active from spring to early summer. Look for nymphs and adults feeding on new growth. You might also find psyllids by looking for sooty mould growing on the broom plants. Like many sap-sucking insects, broom psyllids produce honeydew. Sooty mould grows on the honeydew.

Broom psyllid predator
Look for mirid bugs around psyllids on broom plants. The bugs eat psyllids by stabbing them with their piercing-sucking mouthparts.