Beetles Are Supercool!

Understanding the Life Cycle of Mountain Pine Beetles

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I like being a scientist because of the excitement of learning new things and the rewards of being creative. I became interested in natural resources as a young boy enjoying the out-of-doors in the Rocky Mountains.

Meet Dr. Barbara Bentz:

I like being a scientist because I enjoy the art of discovery. I became interested in natural resources when I was a young child, traveling and camping with my family.

Thinking About Science

Many plants and animals live in *annual* cycles. They respond to seasonal temperature changes and changes in the length of the day. Some scientists are interested in studying the effect of these seasonal changes on the life cycle of plants and animals. The science that investigates these effects is called *phenology* (fe **näl** uh je). The science of phenology also investigates the influence of *climate* on the life cycle of plants and animals. This is important, because many scientists now believe that our climate is changing. In this study, the scientists were interested in understanding how a change in climate might affect the life cycle of a particular species of beetle. Because they could not wait a hundred or more years

Glossary:

annual (**an** yoo ul): Covering the period of 1 year.

climate (**kli** met): The average condition of the weather at a place.

larva (**lär** vuh): Wormlike feeding form that hatches from the egg of many insects.

metabolize (muh **ta** buh liz): Chemical changes in a living body that provide energy to the cells for survival, growth, and reproduction.

carbohydrate (kär bo **hi** drat): Starches and sugars that are used as food by animals.

phloem (**flo** em): Tissue that transports nutrients from the leaves to the rest of the plant.

pupa (**pyoo** puh): Intermediate stage of insect growth between larva and adult.

resin (**rez** in): Cloudy, sticky substance that oozes from some trees.

population (pop yoo **la** shun): The whole number of individuals of the same type occupying an area.

stand (stand): A group of trees growing in a continuous area.

complexity (kälm **plek** suh te): The state of being complicated or having many related parts.

simulate (**sim** yoo lat): To create the appearance or effect of something for purposes of evaluation.

indicator species (in di **kat** ür **spe** sez): Type of plant or animal that serves as a measure of the environmental health of an area.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

for the climate to change, the scientists used a computer program to predict what might happen.

Thinking About the Environment

Mountain pine beetles *(Dendroctonus ponderosae Hopkins)* are sometimes supercool! This is what scientists call the beetles' ability to "chill out" during the cold winter months, during their *larva* stage (Figure 1). During the winter, the beetle larvae live in the interior of pine trees. Because mountain pine beetles are composed partly of water, they must have made adaptations to keep from freezing in the cold of winter. When water freezes, it forms six-sided crystals. The crystals have sharp edges that could damage the other structures inside of the beetle. Mountain pine larvae have found a way to *metabolize carbohydrates*, which contain water, into glycerol (**glis** ür ol) during the winter months. Glycerol is a form of alcohol, and therefore will not freeze – it is insect antifreeze! When the temperatures turn warm again, the larvae turn the glycerol back into carbohydrates. Carbohydrates are a source of energy for the beetles. Mountain pine beetles have adapted to cold conditions, and this allows them to survive.

Introduction

Mountain pine beetles live for only 1 year. Most of the year is spent "chilling out" in a condition scientists call supercool. Because they live in high mountain environments where it is very cold, they spend most of their short life span being supercool. That does not give them much time to lay eggs and reproduce. When these beetles reproduce, they lay eggs in the *phloem* of pine trees (Figure 2). These eggs become the larvae that live in the phloem during the cold months. In late summer, *pupa* become adults and emerge from the pine trees. As adults, the beetles must bore holes in other pines trees so they can lay their eggs. When they bore holes in the trees and lay eggs, the beetles usually kill the tree. Pine trees produce *resin* to repel the beetles. To successfully lay their eggs, the beetles must work as a team. They bore holes in pine trees in large numbers (Figure 3). When you think about it, you can see that the *population* of mountain pine beetles needs to coordinate its activities. If each individual beetle did these things on its own schedule, the species would not survive.

Mountain pine beetles are part of an ecosystem. When beetles kill a *stand* of weakened trees, natural fire may follow. When fire burns the trees that have been killed by the beetles, the area becomes favorable for new trees to grow. This helps the forest to renew itself. On the other hand, when beetles kill a stand of trees, there are fewer trees that can be used for wood products for human needs.

Remember that mountain pine beetles are dependent on warm weather to reproduce, and they only have part of one summer to lay their eggs before dying. If the climate changes in the future, how will the beetles adjust? The scientists in this study wanted to explore how mountain pine beetles detect when it is time to emerge from pine trees. This information would help the scientists to predict what might happen to the beetles if the climate changes in the future.

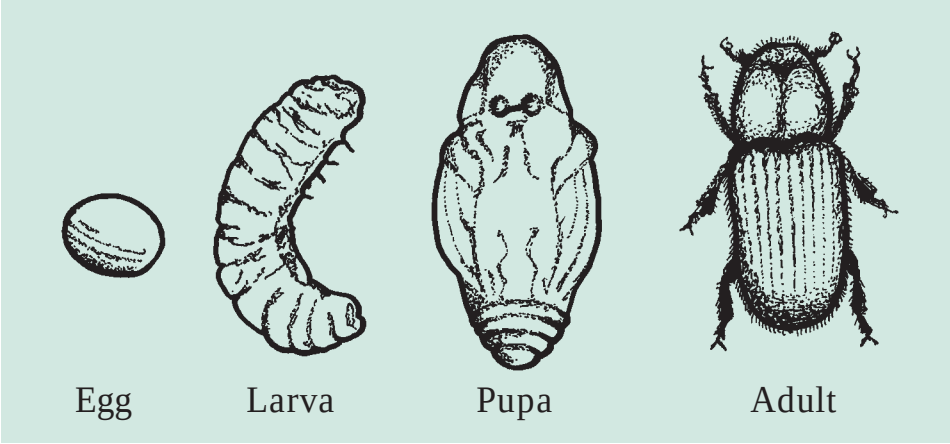

Figure 1. The life stages of the mountain pine beetle, including egg, larva, pupa, and adult.

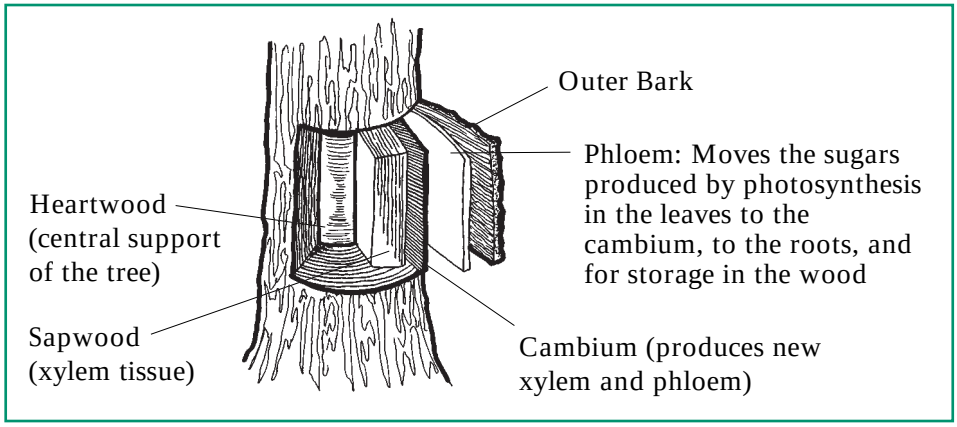

Figure 2. Mountain pine beetles spend much of their life in the phloem of pine trees.

Reflection Section

- Think about the variation in springtime temperatures. How do scientists know that the first very warm day is not the signal used by the beetles to emerge from the trees? What would happen to the beetles if they emerged from the tree on the first warm day?

- When an ecosystem is balanced, it is healthy. A balanced ecosystem means that everything depends on everything else, and no one plant or animal takes over the rest. The pine beetle/pine tree ecosystem is usually balanced between the beetles and the pine trees. This is because the beetles select the weakest trees in which to lay their eggs. Then, the weaker trees die and make room for new, healthier trees. In what ways could the pine beetle/pine tree ecosystem become unbalanced?

Figure 3. A stand of pine trees killed by mountain pine beetles.

Methods

To understand the scientists' methods, you will have to think about the *complexity* of the beetles' life cycle. Thousands of adults must emerge from pine trees at the same time in the late summer. They must emerge after all danger of frost is gone. They cannot wait too long past that date, because they only have a short time to lay eggs before they die in the fall or winter. All of them must bore holes into the pine trees at the same time, or the pine trees will successfully repel them with resin. The scientists needed to know the temperature for the whole life cycle of the beetles (How many days is that? – Hint: Re-read the first sentence of the Introduction.) The scientists used measurements of the temperature that were made every hour of every day for a year. (How many measurements did they use?) They used measurements for 4 different years. (Now multiply the number of measurements by four – how many measurements did they use?)

The scientists already knew a lot about the beetles' life cycle. Using a computer program that contained all of the temperature measurements, they guessed what would happen to a beetle if it emerged from a tree's interior on every day of the year. Using the computer program, they were able to identify which days would be the best ones for the beetles to emerge. Then, they added 2.5 °C to each of the

temperature measurements. They did this to *simulate* what might happen when the climate changes in the future, since the general trend is for the Earth to be getting warmer.

Reflection Section

- What are the advantages of using a computer program to simulate the emergence of the beetles? Could the scientists have done the calculations by hand? Why or why not?

- What do you think will happen to the beetle population if the temperature rises by 2.5 °C?

Results

The scientists found that temperature was the most important factor affecting the emergence of beetles from pine trees. The scientists predicted that if global warming occurs (represented by the addition of 2.5 °C to the temperatures), mountain pine beetles could move farther north and into higher mountains. This means that their range could expand. The scientists also predicted that if mountain pine beetles live in warmer climates, they may produce a larger number of eggs. Changes in temperature could also change the timing of their life cycle. The beetles would probably not always emerge from the trees at the same time. Unfortunately for the beetles, this would mean that the teamwork they use to lay their eggs in pine trees would not be as strong.

Reflection Section

- If global change creates warmer temperatures in the future, what do you think might happen to the population of mountain pine beetles? Why?

- If the population of mountain pine beetles begins to increase, what might happen to the population of pine trees? Could any changes be balanced by the lack of beetle teamwork? Why or why not?

Implications

It is clear that global climate change would cause a change in the ecosystem that includes mountain pine beetles and pine trees. The scientists believe that studying mountain pine beetles may help people understand if and how the global climate is changing. If populations of beetles living in high mountain environments are monitored, any change in their patterns of emergence, egg laying, or range might indicate a change in climate. The scientists believe that the mountain pine beetle is a good *indicator species* for environmental change.

Reflection Section

- From what you have observed and learned from school, newspapers, and other places, do you think the global climate is changing? Why or why not?

- What other ways might global climate change be monitored?

- What can humans do to reduce the possibility of global climate change?

FACTivity

Did you know that beetles are one of the most numerous types of life forms on Earth? Beetles live everywhere across the Earth, except in the open ocean. And, beetles are even older than the dinosaurs! To be so successful, beetles have many advantages that help them survive. In this FACTivity, we are going to get to know beetles close up! Get a bug box (a clear plastic box with plenty of room for air). Look outside in your school yard or at home for beetles. Find a beetle, and gently put it in the bug box. After you observe the beetle, you should release it back outside, in the same place where it was found.

We will examine three parts of the beetle: the back legs, the wings, and the mouth. See the

When Scoring Zero Wins

As the pine beetle research shows, climate change will change conditions for the living creatures of the Earth. One way to slow climate change is to reduce the production of carbon dioxide, or CO_2. Carbon dioxide is produced by cars, busses, and any other thing that burns fossil fuels. The Olympic Winter Games of 2002, or any event with many people, requires a lot of vehicles. Can you guess what that means? Right! Lots of carbon dioxide! Planners of the 2002 Games wanted to find a way to keep carbon dioxide emissions from the 2002 Games at zero. It sounds impossible, doesn't it? This is how they did it. Along with using the latest in emissions-reducing technologies, they asked large companies and individuals to reduce their energy consumption equal to the amount the Olympic Winter Games of 2002 would produce.

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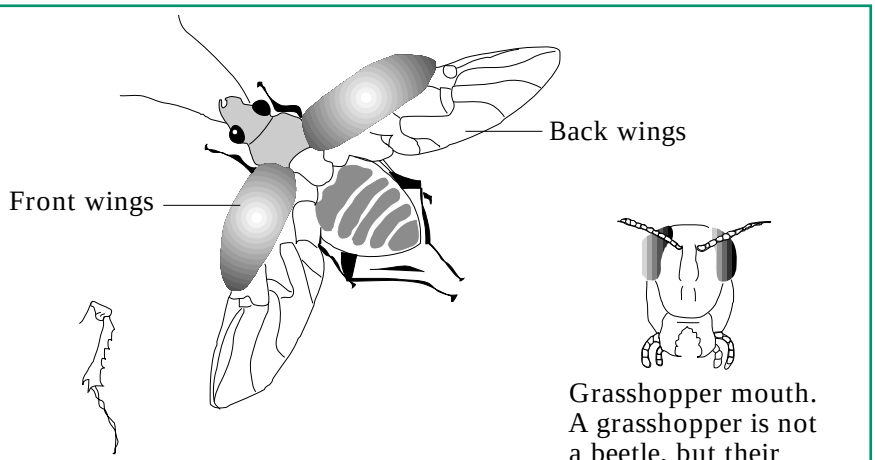
illustrations below and compare them with the beetle you are observing. Let's start with the back legs. Can you see how they are constructed? What do you think the beetle does with its back legs? Beetle legs are designed for digging into wood or soil. Which do you think this beetle digs into? Now look at the wings. Beetles have two sets of wings. The back wings are similar to those of many other flying insects. You may not be able to see the back wings when the beetle is not flying. The most unusual thing about a beetle is its front wings. They are hard, and when folded create a hard shell around the beetle's body. Can you see the hard front wings? What purpose could the hard wings serve? (Hint: Think about what the beetle has to do to get its food or lay its eggs.) Finally, look at the beetle's mouth. A beetle's mouth is made for chewing. Other things that a beetle can do with its mouth are grasp, tear, and crush. Think about the mountain pine beetle. You can see that it is well designed to dig into the bark and phloem of trees.



Hind legs used for pushing

Grasshopper mouth. A grasshopper is not a beetle, but their mouths look the same.

Now, get a large piece of paper and draw the beetle you are observing. Use crayons to complete the drawing. You may want to focus your drawing on one of the three parts that we examined above. When you have finished drawing the beetle, don't forget to release it back into the same place where you found it!

FACTivity adapted from: Hogan, K. (1994). Eco-Inquiry: *A guide to ecological learning experiences for the upper/elementary/middle grades.* Dubuque, Iowa: Kendall/Hunt. 1-800-228-0810. Reprinted with permission.

From Logan, Jesse A. and Bentz, Barbara J. (1999). Model analysis of mountain pine beetle (Coleoptera: Scolytidae) seasonality. *Environmental Entomology,* 28(6): 924-932.

From Bentz, Barbara J. and Mullins, Don E. (1999). Ecology of mountain pine beetle (Coleoptera: Scolytidae) cold hardening in the Intermountain West. *Environmental Entomology,* 28(4): 577-587.

Thank you to Dr. Dan Miller, USDA Forest Service, Southern Research Station, for helping us to understand that mountain pine beetles are sometimes supercool!

Websites:

http://www.usu.edu/~beetle/