Mega Micro Metabolisms

Which insect has the greatest metabolism?

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Abstract

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The purpose of this project was to discover which insect had the greatest metabolism. The experiments involved placing ten insects of one particular species in a sealed baby food jar and measuring the rate per minute at which the pressure dropped within the jar as the insects used oxygen (controlled variables). Six different species of insects (manipulated variable) were used for each series of experiments, and an empty jar served as a control. Since animals expel less carbon dioxide than the amount of oxygen breathed in, the pressure in the sealed jar dropped faster when more oxygen was consumed (responding variable).

The data supported my hypothesis that earwigs would have the greatest metabolism of all of the species of insects I tested. Earwigs used the most oxygen because the drop in pressure in the jar was 1.6 millimeters per minute greater on average than that of crickets, the insects that used the second greatest amount of oxygen.

I discovered that people who collect insects in jars should put holes in the jars, especially if they are collecting large, active insects. I also discovered that activity increases metabolism, and people who want to increase their metabolisms to burn more calories should exercise more or increase their levels of activity through work or recreation.

Introduction

I enjoy collecting insects in the summer including butterflies, Asian beetles, caterpillars, ants, and grasshoppers to examine using a magnifying glass. I have read that there is enough oxygen in sealed jars for insects to live for long periods of time, and I wondered if certain types of insects used oxygen faster than other types. After reading an article in *National Geographic* about metabolism, I wanted to learn more about the metabolism of insects.

Through reading more about metabolism, I learned that it is the chemical transformation that occurs within cells in the body. Cells throughout the body take in food, use oxygen to break it down to release energy, and create waste in the form of carbon dioxide. The organelle in the cell that performs this job of breaking down food to produce energy is called the mitochondria.

The rate at which energy is produced and used by an animal is known as the animal's metabolic rate. This can be measured by heat production or the energy consumption of the body. The basal metabolic rate is the rate of energy use when an animal is not cold and has not eaten for twelve hours. Small animals have a basal metabolic rate that is less than large animals because there is less body mass in a small animal. However, the basal metabolic rate (B.M.R.) per gram of body weight of small animals is greater than the B.M.R. of large animals. Small animals use more energy than large animals per gram of body weight because they need to produce more heat per gram.

One can measure the respiration of an animal, or the amount of oxygen consumption by the mitochondria within cells, to determine the metabolic rate (metabolism) of an animal. It has been found that different species of animals require different amounts of energy. Turtles use very little energy and live to be very old, and shrews use a lot of energy and die at an early age.

I learned that respiration in insects occurs differently than with humans and other animals. Instead of having lungs with which to breathe in oxygen and transfer it to the blood, insects have spiracles, or breathing holes, on the sides of their abdomens. These openings lead to tiny air tubes that carry oxygen to every cell in the insect's small body.

I was curious about which insects in my backyard used the most oxygen during a certain period of time. I wanted to find out if size or activeness played a role in energy consumption. I decided to test the following insects that I could easily collect in great numbers around my home: Asian beetles, crickets, earwigs, box elder bugs, sap beetles and milkweed bugs.

As a result of my research, I formed the following hypothesis:

I believe that earwigs will have the greatest metabolism of all of the species of insects I am testing. My hypothesis is based on the following facts found through reading and my own experiences:

Earwigs are the most active insects of the species I am testing, and animals that are more active use more energy and have greater metabolisms.

Earwigs are the largest of the insects I am testing, and larger animals use more energy and have greater metabolisms.

Experiments and Summary of Results

Purpose: To determine which insect has the greatest metabolism.

Materials and Equipment

Materials

7 empty baby food jars with lids, cleaned and sterilized in a dishwasher
1 extra baby food jar lid, cleaned and sterilized in a dishwasher
1 tube silicone aquarium sealant
1 (20 cm.) piece of 3/16” OD X 1/8” ID clear vinyl tubing
1 metal nut through which the tubing will fit snugly
10 crickets
10 sap beetles
10 Asian beetles
10 box elder bugs
10 milkweed bugs
10 earwigs
blue food coloring
water
petroleum jelly
paper towels

Equipment

ruler
watch with a second hand
drill with bit about the same diameter as the vinyl tubing
hammer
nail
notebook
pencil

Procedure

1. Drill a hole through the center of the baby food jar lid. The vinyl tubing should just barely fit through the hole.

2. Attach a metal nut over the hole in the lid top, adhering the nut to the lid with aquarium sealant. Poke the vinyl tubing piece down through the nut hole so that the end of the tubing extends below the lid by about 3 centimeters. Run a thick line of aquarium sealant around the joint between the tubing and the nut. Then, gently push the tubing slightly deeper so that the cement is drawn into the nut and there is an airtight seal between the nut and the tubing. Run another thick line of sealant around the tubing on the underside of the lid. Allow the sealant to dry overnight.

3. Use the hammer and nail to make one hole in the top of each of six baby food jar lids. Collect ten of each of the following insects from the outdoors: crickets, sap beetles, Asian beetles, box elder bugs, milkweed bugs, and earwigs. Put each species of insect in its own baby food jar and screw a lid with a hole on the top.

4. Dye a glass of water with about twenty drops of blue food coloring.

5. Dip the end of the tubing that extends from the top the lid into the colored water. While the long end of the tubing is submerged in the water, use your finger to plug the other end of the tubing and pull the long end out of the water. A droplet of colored water will remain inside the end of the tubing above the lid. Bend the tubing at a right angle so that the long part of the tubing is parallel to the lid. Put ten crickets into the jar. Screw the lid onto the jar tightly keeping the liquid inside of the tubing. Seal the area where the lid meets the jar with a thick layer of petroleum jelly.

6. Using a centimeter ruler and a watch, measure the rate at which the liquid plug moves inward along the tubing by counting the millimeters that the liquid moves over a one minute period of time. This measurement will represent the metabolism of the insects. Record the data in notebook.

7. Open the jar and allow the colored water drop to move about 5 centimeters from the end of the tubing that extends from the top of the lid while placing another baby food jar lid over the jar to keep the insects inside. Plug the other end with your finger to hold the drop in place. Bend the tubing at a right angle so that the long part of the tubing is parallel to the lid. Screw the lid with the tube onto the jar tightly keeping the liquid inside of the tubing. Seal the area where the lid meets the jar with a thick layer of petroleum jelly.

8.   Using a centimeter ruler and a watch, measure the rate at which the liquid plug moves inward along the tubing by counting the millimeters that the liquid moves over a one-minute period of time. This measurement will represent the metabolism of the insects. Record the data in notebook.

9. Repeat Steps 7 and 8 eight more times so that there are ten measurements recorded for that particular insect. Wipe out the jar with a paper towel and rinse the colored water out of the tube with running tap water after the tenth measurement is taken.

10. Repeat Steps 5, 6, 7, 8 and 9 with each set of the remaining five types of insects and also without any insects to serve as the control.

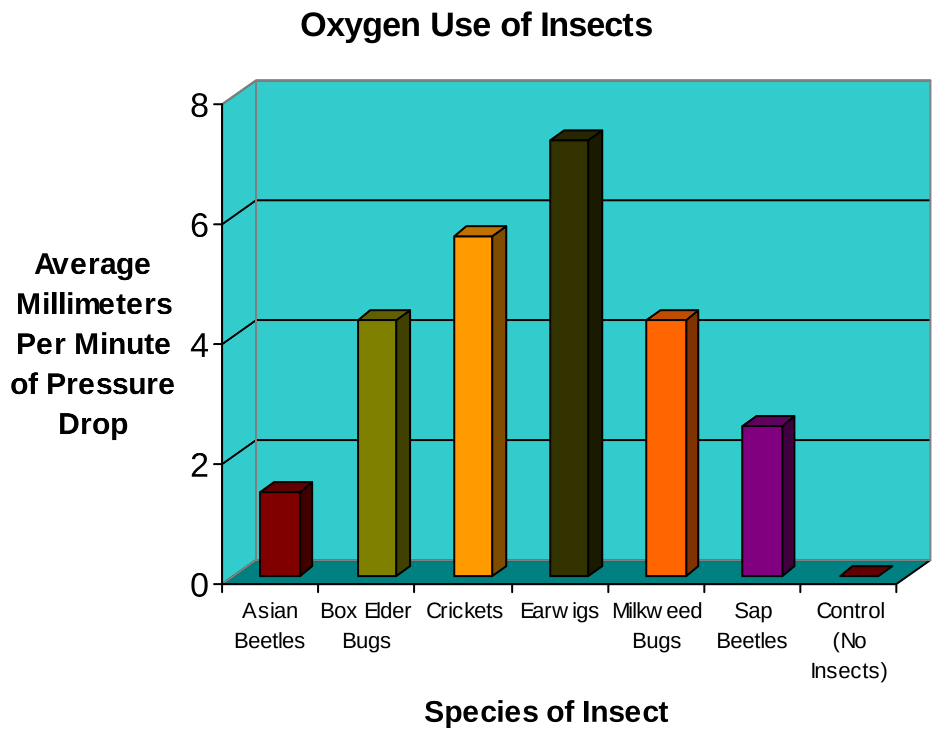
Summary of Results

I performed the experiments on August 15 and September 30, 2006. With the help of my sister, we collected 10 of each of the following insects: crickets, milkweed bugs, sap beetles, earwigs, Asian beetles, and box elder bugs and placed them in baby food jars. The Asian beetles and box elder bugs were tested on September 30, because that was when I was able to find them in great numbers. We performed the experiment 10 times with each species of insect and once with no insects and recorded the drop in pressure in the jar in millimeters per minute. After all the experiments were preformed, I averaged the drop in pressure for each species.

Oxygen Use of Insects
(Millimeters Per Minute of Pressure Drop)

Insect	**Trial #1**	**Trial #2**	**Trial #3**	**Trial #4**	**Trial #5**	**Trial #6**	**Trial #7**	**Trial #8**	**Trial #9**	**Trial #10**	**Average**
Asian Beetles	2	2	1	2	1	1	1	2	1	1	1.4
Box Elder Bugs	6	5	6	5	4	4	3	3	3	4	4.3
Crickets	6	7	5	6	4	4	7	5	6	7	5.7
Earwigs	7	9	7	8	6	8	7	8	7	6	7.3
Milkweed Bugs	4	5	5	4	4	4	5	3	4	5	4.3
Sap Beetles	2	3	3	2	3	2	2	2	3	3	2.5
Control (no insects)	0	0	0	0	0	0	0	0	0	0	0

The insects that used the most oxygen were the earwigs with an average of 7.3 millimeters per minute. The insects with the second greatest use of oxygen were the crickets with an average of 5.7. The milkweed bugs and box elder bugs both used the third greatest amounts of oxygen with averages of 4.3. The insects that were fourth were the sap beetles with an average of 2.5 millimeters per minute. The insects that used the sixth greatest amount of oxygen were the Asian beetles with an average of 1.4 millimeters per minute. There was no drop in pressure in the control experiments.



Through observing the activity of each species of insect during the experiments, I found that the most active insects were the earwigs, which were crawling and moving their antennae rapidly. The second most active insects were the crickets, which were crawling and standing still at times as well as moving their antennae. The third most active insects were the boxelder bugs, the milkweed bugs, and the sap beetles which were standing still most of the time and moving their antennae. The fourth most active insects were the Asian beetles which were not crawling and were showing very little antennae movement.

Conclusions

I accept my hypothesis that earwigs have the greatest metabolism of all of the species of insects I am testing. The experimental data supported my hypothesis. Earwigs used the most oxygen because the drop in pressure in the jar was 1.6 millimeters per minute greater on average than crickets, the insects that used the second greatest amount of oxygen. The reasons why the earwigs used more oxygen were because the earwigs were the largest and most active of the insects tested.

There was a correlation between the activity of the insects and the rate at which they used oxygen. The more active a species of insects was during the experiments, the more oxygen it used. The earwigs were the most active, and they used the most oxygen, while the least active Asian beetles used the least amount of oxygen. Every other species of insect fell between these species in the same order of both activity and use of oxygen. These results strongly suggest that animals that are more active have greater metabolisms.

My findings are important for several reasons. They are important for people who collect insects in jars. Without holes in jars, some insects might use up the oxygen in a jar faster than others. My findings are also important for people who want to increase their metabolisms to burn more calories. It seems that animals that are more active have greater metabolisms. People who want to increase their metabolisms should exercise more or increase their levels of activity through work or recreation.

An error that might have occurred in my experiment was that some of the insects may have eaten more recently than others that were tested. Insects that were digesting food may have used more oxygen. Also, healthier or younger insects may have used oxygen at a greater rate than others that were less healthy or older.

Some future experiments that involve metabolism might be testing the use of oxygen by insects at different temperatures or testing the metabolisms of other invertebrates or plants.

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