Science Unit: *Urban Biology*
Lesson 1: *Habitat Choice in Woodbugs*

School year:	2007/2008
Developed for:	Sir Matthew Begbie Elementary School, Vancouver School District
Developed by:	Dr. Abby Schwarz (scientist), Ms. MJ Moran, Ms. Tonya Holmes (teachers)
Grade level:	Presented to grades 6-7; suitable for 4-7 with age-appropriate modifications.
Duration of lesson:	Delivered in two separate sessions in the classroom, each 1.5 hrs.
Notes:	In session #1, the students will set up and do the experiment. In session #2, the 6/7 students will deliver a segment of the work to K (see section #3 under "In the Classroom", and section #1 of the Appendix). The 6/7 students used the statistics outline as their worksheet, and discussed the significance of the results to woodbugs "in the wild" in class afterwards. Therefore the only additional document for this lesson is the K worksheet, developed by the 6/7s and appended separately.

Objectives

1. Observe woodbugs in a terrarium that approximates a natural setting.
2. Explore preferences of woodbugs for different environmental conditions.
3. Practice developing hypotheses, formulating predictions, designing and completing an experiment in animal behaviour, and using simple statistics (X^2) to evaluate results.
4. Learn how to care for animals used in experiments.

Background Information

Woodbugs (aka pillbugs, sowbugs, woodlice) are often found in the upper layers of compost heaps, under rotting wood or logs, under surfaces and stones, and in plant litter. They are very useful in breaking down plant remains (e.g. autumn leaves, dead wood, scraps), and are important prey for predatory insects, spiders, centipedes, toads, shrews and some birds. They are crustaceans in the Phylum Arthropoda, which means that they have an exoskeleton and jointed appendages. Most crustaceans are aquatic, and though woodbugs are terrestrial they are not fully adapted to life on land. Unlike most arthropods they do not have a waxy coating over their exoskeleton, so they can quickly lose water. For this reason, they prefer humid places, and humidity is highest where it is cool and dark (sunlight dries and warms the air and the ground). Woodbugs can take in water through the mouth and possibly through the uropods. The name "pillbug" has been used for some species of woodbugs that can roll themselves into a ball when trying to escape predators. For more detailed information, see the Reference section.

In this experiment the woodbugs should prefer dark to light, cool to warm, and wet to dry (though there may be idiosyncratic individuals!).

Vocabulary

Compound eye	Eye having more than one lens
Thorax	Part of the body between the head and abdomen; equivalent to our chest
Uropod	Projections on the rear of the body, used for defense and possibly for water uptake
Cuticle	Waxy waterproof covering over exoskeleton, found in most arthropods but not in woodbugs
Diffusion	Tendency of a substance to move from greater to lesser concentration.
Arthropod	A phylum of animals having jointed appendages (arthros=joint) and exoskeletons
Appendage	General term for arms, legs, flippers, fins, antennae, etc. Usually appendages are attached to the thorax or abdomen, though antennae are attached to the head.
Antennae	Appendages on the head specialized for detecting odours, air currents and even taste in some arthropods. Crustaceans have two pairs but in woodbugs the inner pair is very small and difficult to see.
Exoskeleton	Outer skeleton forming an "armor" around the animal, flexible at the joints and permeable to O_2 and CO_2 but not to water (**IF** covered by a waxy coat). Muscles attach to the exoskeleton. By contrast, the skeleton of vertebrates is an "endoskeleton", i.e. it is inside, covered by muscle and other tissues.
Crustacean	A class of invertebrates in the phylum Arthropoda, primarily aquatic (fresh water and marine).
Isopod	An order in the Class Crustacea that includes the most successful terrestrial forms (the woodbugs). "Isopod" means "same foot" and indicates that all the appendages (except the antennae) look similar; they aren't differentiated into feeding structures, defense structures, swimming or walking structures, etc.

Materials

- Terrarium (10-gal tank) (40L)
- Shallow pans
- Soft small brushes (cheap makeup brushes work well)
- Plastic spoons
- Cardboard
- Plastic cups
- Paper towels
- Masking tape
- Gel packs (can be heated or cooled)
- Data sheets for 6/7, K
- Scissors
- Collecting bucket
- Spray bottle for use in terrarium
- Pencils

Field trip

One week before **session #1**, the students, their teacher and the scientist should collect woodbugs and items such as soil, rotting wood, and vegetation to create the terrarium. In the coming week, encourage the students to jot down their observations about woodbug behaviour in the terrarium.

The terrarium can be a 10-gal glass tank. It should have a screen top so air can enter but the animals can't get out, but a solid top is acceptable if it is lifted off during viewing for air circulation. Inside should be soil, a few pieces of rotting wood, and pieces of fallen leaves or some other compostable material (carrot shavings or overripe banana are good choices). Be sure to keep the terrarium moist (not wet) by spraying it with water as needed, especially if the top is screen rather than solid. Keep it away from direct sunlight and from heat (room temperature is good). Cover 2 sides with dark paper; leave 2 sides open for viewing.

In the Classroom

1. Introduction (to be done in the week before session #1)

- "Hook": Ask students what they're experiencing at the moment re: warmth/cold, bright light/dim light, humid/dry. What would you do if you were too warm? Too cold? (If you have a jacket on, you're not allowed to remove it, and if you're too lightly dressed, you can't use a jacket!) This demonstrates the concept of moving from one place to another to find where you're most comfortable. Explain that other animals do this too, that **behavior is how we navigate our environment and that most animals have preferences for certain environmental conditions**. Point out that animals make choices, just as human animals do, and that for the next two weeks the focus will be on habitat choice. Tell the students that next week they will set up and do an experiment in animal behavior, using woodbugs.

- Give the synonyms (pillbugs, woodlice, sowbugs) and ask the students if any of them has seen a woodbug outside of the collecting trip. Have them describe what they saw: size, color, one or many individuals, location, any other details that interest them. Ask the students to describe the details of where they found the woodbugs while on the collecting trip, and have them suggest what benefits woodbugs might get from living in these locations. Write the observations on the board or a flip chart.

- Explain general woodbug anatomy, using a diagram (#2 in the reference list is good) and some of the background information (p. 1 of this lesson plan) **but do not tell the students that woodbugs lack a waxy cuticle and are subject to desiccation**. The students should learn this from the references they read. Have the students compare the diagram features with the appearance of woodbugs in the terrarium. Explain that the eyes are very small and the uropods are not easy to see but that they should recognize the antenna, head/thorax/abdomen, and the overlapping body segments. Note that the diagram shows the ventral surface as well as the dorsal surface, but the ventral surface doesn't have to be described, and do **not** encourage the students to turn the animals over.

- Describe the steps of the **scientific method**. In sequence, these are: observation, question, hypothesis (an educated guess about the answer to the question being asked), prediction, test, discussion, conclusions. Be sure that the students understand and are comfortable with the following terms:

  1) Null hypothesis (H_o): In an experiment, the hypothesis of no difference. For example, if we were asking whether woodbugs preferred pine to hemlock wood, the H_o would state that the woodbugs exhibited no preference.

  2) Alternative hypothesis (H_a): A hypothesis that there is a preference for one condition over the other; in this instance, that the woodbugs prefer hemlock to pine.

  3) Prediction: An "If…then…" statement that always follows from a hypothesis. Using the example above, the prediction for H_a would be "**If** woodbugs are given a choice between hemlock and pine wood, **then** they will choose hemlock." The corresponding prediction for

H_o would be "**<u>If</u>** woodbugs are given a choice of hemlock and pine wood, **<u>then</u>** they will exhibit no preference."

4) Test: An experiment is a <u>test</u> of the prediction.

5) Control test: The point of an experiment is to find out whether varying one condition causes a particular outcome, while holding all other conditions constant. A control test exposes the woodbugs to the same situation they will be in during the experiment, but without variation in the condition. For example, if exploring whether woodbugs prefer damp to dry habitats, the control would be a test pan that was dry on both sides. If the woodbugs exhibit no preference for either side of the pan, assume that there are no unknown factors that could influence the results of the experiment. The experiment testing the prediction for H_a could then proceed and the students would observe the woodbugs' response.

6) Variable: The factor being altered. In this lesson on woodbug habitat choice, the variables are moisture, light, and temperature.

7) Replicate: A copy. If two groups both working on moisture obtain the same response, that response can be relied upon more than if there were only one group doing the work, because two separate sets of woodbugs were used.

8) Introduce the concept of X^2. Explain how to do this statistical test before the day of the experiment. The reason for this is that the X^2 test must be done on the control before the experiment itself can be run. See the Appendix for an explanation of how to do this test. It's useful to make a handout of this section of the Appendix for the students to work with during the week.

- Organise the students into groups, and assign two groups to each variable (moisture, temperature, light; therefore 6 groups in total). Ask each group of students to use their terrarium observations of woodbugs to hypothesize what kind of habitat the woodbugs will prefer, and to predict what they think will happen when the woodbugs are given a choice. If a group is working on light/dark, for example, they might hypothesize that woodbugs would prefer the dark, and predict that given a choice between dark and light, the woodbugs would move toward the dark area. Remind them to state their prediction as an "If…then…" sentence. Have them verbalize the null hypothesis (in this case it would be that woodbugs "don't care" if it's dark or light).

- Have the students consider how they would set up the test for their assigned variable. Encourage them to work it out for themselves. If they have troubles, here are some suggestions: for light, cut a piece of cardboard to the size of half of a pan and position it over one half of the pan; for moisture, lightly spray one half of the paper toweling with water; for temperature, use gel packs that can be warmed (microwaved) or cooled (fridge). Do not use hot or ice-cold gel packs; warm and cool packs are best.

2. Session #1: science experiment

- Have the students set up their test pans. Each pan is approximately the size of a rectangular baking dish (9x12 inches), but each one must be clean (no odours! Ask the students why this is important). Enameled pans are best. Line each pan with a layer of paper towels, using masking tape to anchor the towels. Use one piece of masking tape to divide the pan in half down the short axis. As woodbugs like to hide under things, be sure there are no folds or holes into which they could crawl.

- Be sure that all brushes, spoons, cups and test pans are clean at the start and at the end of the work. Wash brushes, pans, cups and spoons with soapy water and rinse well. All items must be dried before using them on the woodbugs.

- Demonstrate how to handle the woodbugs, using the brushes, spoons, and cups. Emphasize patience and gentleness. Instruct the students to handle the animals with extreme care, using brushes to move them gently into the spoons or into the cup. They mustn't use their fingers to push the woodbugs around as these little animals are fragile. Try not to get soil in the cup. If soil is present, then when the woodbugs are tipped into the centre of the pan, the soil will go into the pan as well. **Ask the students why this would be undesirable**. **As well, ask the students why it is important to stress the animals as little as possible.**

- One student from each group should get the woodbugs from the terrarium.

- Make sure each group starts with their control, and that they understand why a control is needed. They should release the woodbugs into the middle of the pan so the results won't be biased. Use a 2-min observation period (i.e. 2 minutes after releasing the woodbugs into the pan, count the number of animals on each side of the centre line).

  Have each group do a X^2 test on its control. If the control is not satisfactory (i.e. if the X^2 test indicates that the woodbugs show a preference for one side even though the sides appear to be the same), the students should try to determine the possible reason(s) and decide what to do about it. Most commonly they might change the position of the pan (this may even out the effect of ambient light, or eliminate a breeze), or replace the paper towels with fresh ones.

- If the control works (i.e. if the X^2 test cannot disprove the H_o), the group can proceed with the experiment. The woodbugs must be gathered back into the plastic cup first, then the variable can be manipulated in the test pan and the woodbugs can be re-introduced into the middle of the pan. Use a 2-min observation period again.

- Students will then collect the woodbugs from the test pan and re-introduce them into the terrarium for release at the collection site. The woodbugs should be released as soon as possible after the experiment; we released ours the same day.

- In the week following the experiment, students should do their statistics, write up their thoughts about the work, and list their conclusions. Groups working on the same variable should pool their results. Note that each group does its own control (these are not pooled). Discuss the results, both in terms of what students have learned regarding woodbug habitat preference, and what they have learned about experimental design. Do any of the results appear inconsistent? Why might this be?

3. Session #2: demonstration of science experiment by older students (grade 6/7) for younger ones (K), and closure discussion for older students

The 6/7s will set up and run the experiment for the Ks (without the controls), and give the Ks simple charts on which they can check off the choices the woodbugs have made. Give the 6/7s and the Ks some time to talk about the results. The two most important things for the kindergarten class to learn are 1) that other animals make choices about where they want to live, and 2) it is important to treat animals gently.

As soon as possible after this session the students (or teacher, or scientist) should return the woodbugs to the area where they did the collection.

This session should include a closure discussion for the 6/7s. Questions include the following:

a) How do most arthropods retain water? Why are woodbugs are subject to desiccation?

b) How does woodbug preference for dark, cool, humid habitats reduce water loss? (Heat encourages evaporation; sunlight is warm.)

c) How are the results of the experiments connected to the distribution of woodbugs outside the classroom? Where might woodbugs be least likely to be found?

d) Experiments in which the alternate hypothesis is rejected are just as valuable as experiments in which they are not rejected. Why?

4. Safety guidelines

- Students must wash their hands before and after working with the woodbugs.
- No food or drink in the classroom during the experiment!

5. References

1) <http://encyclopedia.thefreedictionary.com/Woodbugs> Contains photos, information on ecology, anatomy and physiology of woodlice. Accessed May 2008.

2) <http://www.geocities.com/~gregmck/woodlice/structr.htm> Labeled diagrams of dorsal and ventral surfaces of Porcellio scaber, a common woodlouse. Accessed May 2008.

3) <http://www.geocities.com/~gregmck/woodlice/habitat.htm> Description of habitat and behavior by Greg McKinnon (author of the second URL in this list). States that woodlice can take up water through their uropods as well as their mouths (this ability not mentioned in other references). Accessed May 2008.

4) <http://www.northern.edu/natsource/INVERT1/Pillbu1.htm> Habits, habitat, ecology of introduced species, and physiology of woodlice. Good suggestions for other experiments to do with woodlice in the classroom. Contains a useful glossary. Accessed May 2008.

5) http://www.enchantedlearning.com/subjects/invertebrates/isopod/Pillbugprintout.shtml Labeled diagram and brief general information on habitat, life cycle, anatomy, diet, predators, classification. Accessed May 2008.

6) Donahue, J.D. and M.J. Brewer, 1998. Sowbugs and Pillbugs. University of Wyoming Cooperative Extension Service, College of Agriculture. B-1050-2. February 1998. 3-page bulletin with general information on body form, life history, plant injury, and management.

6. Appendix

1) Kindergarten

Session #1: In the same week as session #1 for 6/7, introduce the Ks to the terrarium and give them diagrams and/or pictures of woodbugs that they can compare with the live animals. Ask them what they observe the woodbugs doing, and write down their answers for later discussion. Ask the children what parts of the terrarium the woodbugs seem to prefer, and some of the characteristics of those parts.

Session #2: See section #3 under "In the classroom". The Ks should watch as the 6/7s set up the pans and do the experiment. Throughout the session the 6/7s should explain what is happening, the Ks should be encouraged to ask questions about anything they don't understand. The older students should also help the children fill in their worksheets at the end of the experiment. At Begbie the 6/7s made up a simple worksheet for the Ks (see SRP_Urban Biology_Lesson #1_Habitat Choice in Woodbugs_K Worksheet_2008 draft.doc).

MJ and I felt strongly that explaining the work to the Ks enhanced the experience for the 6/7s. The students interacted easily ("swimmingly"!) and learned from each other. The buddy system worked for this lesson, as it did for the other lesson we did (woodbugs).

There were 30 grade 6/7 students in MJ's class, and 11 K students in Tonya Holmes' class. At the start of term the 6/7s were invited to buddy up with a K student, so 11 pairs were established. Throughout the term there was time each week for buddies to interact. The younger children had come to trust the older ones and seemed to be very receptive to learning from them.

2) X^2 test explained

a. Introduction

If every time you do the experiment, the entire population of woodbugs is found in the same environment, you could conclude that the woodbugs have a preference directly from your observations. If exactly half of the bugs go to each environment, a lack of a preference is also easy to see. However, during an experiment there is usually an unequal number of woodbugs found in the two environments (i.e.: 13 on one side, 7 on the other). This makes it harder to determine if the woodbugs have a preference.

Statistics is the science of collecting, organizing and interpreting numerical data. Statistics are used to calculate the probability of an event occurring randomly and the purpose of statistics is to form unbiased conclusions. Statistical analysis has many diverse applications including sports predictions, the polling of election outcome(s) and analysis of experimental data.

Did your woodbugs really have a preference for one of the environments you offered them or was the variation you saw simply due to chance? To answer this question, we will use the **Chi-squared (χ^2)** test.

The χ^2 test tells us whether or not we can reject the null hypothesis (**H_o**). Remember: the null hypothesis states that the woodbugs have no preference for one environment over another. If, as a result of the χ^2 test, you **can** reject the null hypothesis, the **alternate hypothesis (H_A:** there **is** a preference) may offer a plausible explanation for the results. Alternate hypotheses are never truly accepted, but do indicate a direction for further experimentation. This is one of the central maxims of science.

If as a result of your calculated χ^2 value, you **cannot** reject the null hypothesis, the alternate hypothesis is rejected. **This DOES NOT mean that your experiment was a failure. Why?**

If you find yourself in this situation, what would be your next step?

Realize also that accepting a hypothesis does not necessarily mean the hypothesis is true. Although most of your evidence may support this hypothesis, conflicting evidence may invalidate your hypothesis in time. Remember that years ago the world was believed to be flat. The Earth was also believed to be the centre of the universe!

b. <u>How to do the χ^2 test</u>

Suppose you want to know whether there are different numbers of cars and bicycles passing by the window of your classroom between noon and 1 pm. The variable is the type of transportation being used.

Hypotheses for this experiment: H_A: Commuters have a preference for one type of transportation. H_O: Commuters have *no preference* for either type of transportation.

You count the cars and bicycles during this time on two different days and gather the data as in the example below:

Results:

	Cars	**Bicycles**
Day 1 (Replicate 1)	21	47
Day 2 (Replicate 2)	35	37
Observed Totals	56	84

Observed ratio: 56 cars: 84 bicycles

Note: You must ADD the data from replicate 1 and replicate 2 together (you do NOT average it) to get the **observed totals** and the **observed ratio.**

For the χ^2 analysis, you also need an **expected ratio.** This will be based on the null hypothesis. The null hypothesis predicts that there will be no difference in mode of transportation, and it therefore predicts an expected ratio of 1 car: 1 bicycle. To get this ratio from your data, add together the observed ratio (56 cars + 84 bicycles = 140 vehicles) and divide by 2 = 70. Since your null hypothesis states that there is no preference for one mode of transportation, there will be 70 cars and 70 bicycles (a 1:1 ratio).

The χ^2 **formula** is:

$$\chi^2 = \Sigma \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

In order to facilitate the use of this formula, we can arrange our data in table form.

	Cars	**Bicycles**
Observed	56	84
Expected	70	70
Observed – Expected	-14	14
(Observed – Expected)^2	196	196
$\Sigma \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$	2.8 + 2.8 = 5.6 = χ^2	

The **Σ** in the χ^2 formula means that we **add** the results from the two columns in the table, e.g. 2.8 + 2.8, to yield our final χ^2 value of **5.6.**

Now that you have calculated a χ^2 value for your control experiment, compare it to a predetermined **critical value**, to determine whether you can reject the null hypothesis or not. The critical values are found in the attached table. The selection of your critical value depends on two factors: **degrees of freedom** and **probability.**

Degrees of freedom: The degree of freedom (df) is calculated as one less than the number of conditions (in this case, transportation) that you are testing. The formula is written: df = n – 1. As there were two types of transportation, df = 1. Degrees of freedom are listed in the left-hand column of the table.

Probability: In any experiment, some of the results will be due to chance. Think of tossing a coin 100 times. You should get heads exactly half of the time, but you probably won't due to chance. The probability or **p-value** makes allowances for this. Scientists around the world have agreed to accept a 5% probability (p = 0.05) that their results are due to chance. Probability or p-values are tabulated in the accompanying chart. Look for the $P_{.05}$ column.

Align the $P_{.05}$ column with the df = 1 line on the table. You should arrive at **3.84**, which is your **critical value.** Since we arrive at our critical value by aligning $P_{.05}$ with the degrees of freedom, you can see that it is important that you know the correct degree of freedom in your experiment.

If your calculated χ^2 value is *greater than 3.84***,** you can *reject the null hypothesis.* The difference between your data and the null hypothesis (no preference) was too large to be explained by chance. The commuters *appear* to be demonstrating a preference for one type of transportation. The alternate hypothesis may offer a plausible explanation of your results. Remember that this does not make the alternate hypothesis true; new data may change the picture in time.

If your calculated value is *less than or equal to 3.84, you cannot reject the null hypothesis.* You have insufficient evidence against the null hypothesis to reject it. This means that any apparent preference you observed was *due to random variation or chance.*

In our car/bicycle example, our calculated χ^2 value of 5.6 is greater than 3.84. We reject the null hypothesis; the alternate hypothesis *may* be true. There was a statistically greater number of bicycles than cars passing our window during that hour. If χ^2 had been less than or equal to 3.84, we could not reject the null hypothesis. We would have to refine our experiment or test a new alternate hypothesis.

3) Worksheet: Analysis of your results

a. Control Test

As you now know, this is set up exactly the same way as your experimental test, but without the variable being tested. Put the woodbugs into your pan and see where they go. After your 2-minute observation time, count the number of woodbugs in each half of the pan, and record the data.

Set up your data in this table to calculate the χ^2 value of the control experiment:

Control Test	Right side of pan	Left side of pan
Observed		
Expected		
Observed – Expected		
(Observed – Expected)^2		
Σ (Observed – Expected)^2 / Expected	+	=

What is the calculated χ^2 value for your control experiment? ______________________

Is your calculated χ^2 value higher or lower than the critical value? __________________

What can you conclude from these results? ___________________________________

If the calculated χ^2 for your control experiment is <u>lower</u> than your critical value, you can be confident that your control is valid and no other variables are influencing the behavior of the woodbugs. You can now complete the experiment.

If your calculated χ^2 for the control experiment is <u>higher</u> than the critical value, you should adjust your control set-up and try again.

b. <u>Experimental Test</u>

Run your experiment, using the 2-minute observation time again.

Variable chosen: ____

Now arrange the data from your experiment in table form to calculate the χ^2:

Experiment 1	Form of variable (e.g. dry)	Form of variable (e.g. damp
Observed		
Expected		
Observed – Expected		
(Observed – Expected)^2		
Σ (Observed – Expected)^2 / Expected	+	=

Therefore, the χ^2 value for your experimental trials is______

For your woodbug experiment: was your calculated χ^2 greater, less than or equal to the critical value?

Can you reject your null hypothesis? What conclusion can you draw from these results?

NAME____________________ DATE_____________

1) After 2 minutes: There are ________ woodbugs on the _______side and___________woodbugs on the _______side. The woodbugs prefer __________ over ___________.

2) My drawing of a woodbug: