MegaJump Experiment

This experiment uses insects to teach students how to use the scientific methods to formulate and test a hypothesis. The experiment is based on a case study involving an insect used as a biological control agent that targets an invasive weed, and the rigor of the experiment can easily be tailored to different grade levels. Using roughly 1 m^2 arenas set up in the classroom, students measure insect jumping or walking distances as a proxy for dispersal capabilities in the field, and more advanced classes can investigate variables that affect jumping or walking distance and direction.

Methodology from: Goode, A. B. C., and Halbritter, D. *In press.* Bringing entomological research to the classroom: A case study in the dispersal of biological control agents. American Biology Teacher. (Accepted 12/4/17)

Experimental Setup

The goal of the experiment is to measure the distance an insect moves (Table 1). Students can accomplish this by releasing an insect onto a large sheet of paper (i.e., arena) and marking and measuring its movements. Insects can be gently encouraged to jump or move with a small paintbrush, cotton tipped applicator, or even the eraser end of a pencil. Students should work in pairs or groups where one student observes the insect and the other stimulates the insect to jump or move. After completing this basic experiment, students should be encouraged to identify any problems they had with the procedure and to make additional hypotheses about the test insect's behavior (e.g., perhaps the size of the insect affects the distance it moves).

To make this experiment more focused on inquiry-based learning, students can use the scientific method to make observations and develop hypotheses about insect behavior (Table 2). Students should observe insects in the wild and in captivity, then hypothesize what would make the insects move (vibrations on the table, loud sounds, air movement, tactile stimulus, etc.) or where the insects would go once they begin to move (towards light, towards darkness, to a high point, etc.) (Table 3). As a control, the insect should be tested in the arena with no stimulus or arena modifications (just released at the starting point and any movement recorded for 1 minute). Then, students can release a new insect of the same kind and employ the hypothesized stimulus and mark the insect's positions. To test hypotheses on direction of movement, students can modify the arena with dark hiding spots, extra light, or other features and then encourage the insect to move and observe where it goes. If the experiment includes two independent variables (e.g., the type of stimulus and the design of the area), only change one variable at a time so that changes in insect response can be attributed to the variable manipulated. To broaden the applicability of the experimental outcomes, different types of insects can be tested using the selected stimuli or arenas. Afterwards, students can compare reactions between individuals of the same type and between different types.

As with any experiment, it is important that students follow the instructions and perform each step as consistently as possible so that the data collected will be comparable. This is especially important when working in a group; students should try to be in the same positions around the arena for each replication and sample within. With either variation, students will need to measure the insect's movements at the end of the experiment. Each individual insect is a replicate, and each measured movement is a sample. Students should attempt to get five to ten samples before the insect becomes fatigued (stops reacting to the stimulus), at which point the insect should be put back in its container and a new insect brought out to sample. They can calculate the average distance for each individual insect (from the samples), and then averages with respect to each type of insect, stimulus, or arena tested.

Materials and Preparation

Collecting and observing insects and developing a hypothesis should take ~45 minutes, but students should observe the insects' behavior for as long as time permits. The experiment should take ~60 minutes for groups to sample five to ten insects each.

1. Insects – Jumping insects, such as pinhead crickets, can be ordered from scientific supply companies or purchased at local pet stores. Students can capture other insects at home or on their school campus (beetles, crickets, grasshoppers, and plant or leaf hoppers will work well). Students should avoid flying insects as

they will not work well in this experiment and many are dangerous to collect (e.g., wasps, bees, mosquitoes, etc.). Students should also avoid other common biting, stinging, or venomous arthropods, such as ants, spiders, and ticks. Try to collect at least ten of each type of insect used. Insects should be placed individually in containers (plastic vials, Eppendorf tubes, or any small plastic container) immediately prior to beginning the experiment. To ensure healthy and active insects, collection should occur no more than 24 hours prior to the experiment, and preferably the morning of the experiment. Students should observe common safety practices, including using the buddy system, collecting only in areas designated by their instructor, and avoiding poisonous plants (e.g., poison ivy). Insects in containers should be kept at room temperature and out of direct sunlight. After the experiment, insects captured outside by students can be released, insects purchased should be put in a freezer overnight and then discarded.

2. Materials per pair/group – The following items should be ready the day of the experiment: large sheet of paper roughly 1 m by 1 m (e.g., easel pad or a roll of parchment paper), pen or pencil, paint brush, cotton-tipped applicator or other items that can be used as probes, manila folder, insects in their containers, metric tape measure or ruler, and datasheets (Table 4).
3. Testing arena – Use the large sheet of paper as the “arena”. Before releasing any insect, mark a starting point in a corner or near an edge for the basic experiment. The starting point for the advanced experiment should be in the center of the arena. The upright manila folder will later be useful for corralling the insect and keeping it in the arena.
4. Student groups and individual tasks – Students should work in groups of at least two. At least one person should have eyes on the insect at all times so no data points are missed and so that the insect is not lost if it leaves the arena. Minimally, one student should corral the insect with the file folder and stimulate it to jump using the paint brush and one should record the data points. Other students can help corral and keep an eye on the insect. With multiple observers, there is less of a chance the insects’ movements will be missed.
5. A note on recording data points:

a. Jumping insects – Each point the insect jumps to needs to be marked. There should be two points for each jump: a beginning and an end. The insects will likely walk between jumps and this distance is not recorded.
b. Walking insects – These data can be recorded two ways, either in discreet time increments (the location is recorded every 10 seconds) or the location is recorded whenever the insect stops moving. This should be decided before testing begins and with the nature of the insect in mind.

Table 1. Student procedures for the basic experiment.

1.	Release one insect onto the arena at the starting mark.
2.	Use the manila folder to direct the insect's path so that it stays in the arena. Gently encourage the insect to move with the paint brush or selected probe.
3.	Record starting and end points for each jump or movement.
4.	Repeat until the insect leaves the arena or after 1 minute.
5.	Repeat the procedure with a new insect.
6.	Measure the distance between each set of points and record.
7.	Determine the average jump or movement length for each individual insect.

Table 2. Student procedures for the advanced experiment.

1.	Observe the insect(s).	Observe the insect(s) to be used and note behavior in regards to movement.	
2.	Determine hypothesis to be tested.	From the observations, decide what can be tested and how.	
3A.	Run the no stimulus treatment (negative control).	a.	Release one insect onto the arena at the starting mark. Limit student movement around the arena and do not prompt the insect to move.

		b.	If/when the insect moves, record starting and end points or each jump or movement for 1 minute.
3B.	If changing the arena, run the control stimulus treatment.	a.	Starting with a new insect, release it onto the unaltered arena at the starting mark.
		b.	Use a paintbrush to encourage the insect to move.
		c.	Record starting and end points or each jump or movement for one minute.
4.	Run the first experimental treatment (new stimulus/new arena).	a.	Starting with a new insect, release it onto the arena at the starting mark.
		b.	If your treatment changes the stimulus, use the new stimulus to encourage the insect to move. If your treatment changes the arena, use the control stimulus method.
		c.	Record starting and end points or each jump or movement for 1 minute.
		d.	Repeat the procedure with a new insect.
5.	Collect data		Measure the distance between each set of points and record.
6.	Analyze data	a.	Determine the average jump or movement distance for each individual insect.
		b.	Compare the different treatment distances to the control distances (e.g., compare the distance moved with arena alterations to the distance moved without area alterations, or compare the distance moved without a stimulus to the distance moved with different stimuli).

Table 3. Examples of observations and treatments that could be used in the advanced experiment. Students should take time to make a few observations in order to formulate a hypothesis before beginning the experiment. Insects react to their environment in many different ways.

Observation	**Potential Treatment (Stimulus or Arena Modification)**	**Reasoning**
Planthoppers climb the sides of the jar they are in.	Arena modification with cardboard tubes (toilet paper or paper towel rolls) in one corner.	Planthoppers like to be up high so that they have a clear area to jump if they feel threatened.
Crickets move around a lot if there is a lot of noise.	Clapping hands or snapping fingers as a stimulus.	Crickets use sound to communicate to each other.
Beetles will stop moving if they feel vibrations in the substrate they are on.	Tapping on the arena to cause vibrations.	Beetles may think that vibrations indicate a potential predator approaching and will stop moving so they do not draw attention to themselves.

Table 4. Example data sheet for the advanced experiment.

Insect Dispersal	
Observation	*Crickets are more active than planthoppers when it is noisy.*
Hypothesis	*Crickets are more sensitive to an auditory stimulus than planthoppers.*
Prediction	*If clapping is used as the stimulus, then crickets will travel a farther average distance than planthoppers.*
Data	

Treatment	Species/Type	Replicate	Distance jumped/moved (cm)	Average distance (cm)
Control (no stimulus)	Planthopper	1	5, 7, 1, 10	5.75
	Planthopper	2	2, 3, 8, 11	6
	Cricket	1		
	Cricket	2		
Stimulus 1	Planthopper	1		
	Planthopper	2		
	Cricket	1		
	Cricket	2		
Stimulus 2	Planthopper	1		

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Materials:

- Insects
- Vials or small plastic containers
- Large sheet of paper (~$1m^2$; e.g., easel pad or a roll of parchment paper)
- Pen or pencil
- Probe (e.g., paintbrush, cotton-tipped applicator)
- Manila folder
- Metric tape measure or ruler
- Datasheet

Procedure (Basic experiment):

1.	Release one insect onto the arena at the starting mark.
2.	Use the manila folder to direct the insect's path so that it stays in the arena. Gently encourage the insect to move with the paint brush or selected probe.
3.	Record starting and end points for each jump or movement.
4.	Repeat until the insect leaves the arena or after 1 minute.
5.	Repeat the procedure with a new insect.
6.	Measure the distance between each set of points and record (Jump/Movement Distance).
7.	Determine the average jump or movement length for each individual insect.

Procedure (Advanced experiment):

1.	Observe the insect(s).	Observe the insect(s) to be used and note behavior in regards to movement.	
2.	Determine hypothesis to be tested.	From the observations, decide what can be tested and how.	
3A.	Run the no stimulus treatment (negative control).	a.	Release one insect onto the arena at the starting mark. Limit student movement around the arena and do not prompt the insect to move.
		b.	If/when the insect moves, record starting and end points or each jump or movement for 1 minute.

3B.	If changing the arena, run the control stimulus treatment.	a.	Starting with a new insect, release it onto the unaltered arena at the starting mark.
		b.	Use a paintbrush to encourage the insect to move.
		c.	Record starting and end points or each jump or movement for one minute.
4.	Run the first experimental treatment (new stimulus/new arena).	a.	Starting with a new insect, release it onto the arena at the starting mark.
		b.	If your treatment changes the stimulus, use the new stimulus to encourage the insect to move. If your treatment changes the arena, use the control stimulus method.
		c.	Record starting and end points or each jump or movement for 1 minute.
		d.	Repeat the procedure with a new insect.
5.	Collect data		Measure the distance between each set of points and record.
6.	Analyze data	a.	Determine the average jump or movement distance for each individual insect.
		b.	Compare the different treatment distances to the control distances (e.g., compare the distance moved with arena alterations to the distance moved without area alterations, or compare the distance moved without a stimulus to the distance moved with different stimuli).

MegaJump Datasheet

Sample #								
Jump Length (cm)	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
	2	**2**	**2**	**2**	**2**	**2**	**2**	**2**
	3	**3**	**3**	**3**	**3**	**3**	**3**	**3**
	4	**4**	**4**	**4**	**4**	**4**	**4**	**4**
	5	**5**	**5**	**5**	**5**	**5**	**5**	**5**
	6	**6**	**6**	**6**	**6**	**6**	**6**	**6**
	7	**7**	**7**	**7**	**7**	**7**	**7**	**7**
	8	**8**	**8**	**8**	**8**	**8**	**8**	**8**
	9	**9**	**9**	**9**	**9**	**9**	**9**	**9**
	10	**10**	**10**	**10**	**10**	**10**	**10**	**10**
	11	**11**	**11**	**11**	**11**	**11**	**11**	**11**
	12	**12**	**12**	**12**	**12**	**12**	**12**	**12**
	13	**13**	**13**	**13**	**13**	**13**	**13**	**13**
	14	**14**	**14**	**14**	**14**	**14**	**14**	**14**
	15	**15**	**15**	**15**	**15**	**15**	**15**	**15**
	16	**16**	**16**	**16**	**16**	**16**	**16**	**16**
	17	**17**	**17**	**17**	**17**	**17**	**17**	**17**
	18	**18**	**18**	**18**	**18**	**18**	**18**	**18**
	19	**19**	**19**	**19**	**19**	**19**	**19**	**19**
	20	**20**	**20**	**20**	**20**	**20**	**20**	**20**
	21	**21**	**21**	**21**	**21**	**21**	**21**	**21**
	22	**22**	**22**	**22**	**22**	**22**	**22**	**22**
	23	**23**	**23**	**23**	**23**	**23**	**23**	**23**
	24	**24**	**24**	**24**	**24**	**24**	**24**	**24**
	25	**25**	**25**	**25**	**25**	**25**	**25**	**25**

Average								
Mode								
Maximum								

MegaJump Datasheet

Observation				
Hypothesis				
Prediction				

Treatment	Species /Type	Replicate	Distance jumped/moved (cm)	Average distance (cm)
Control (no stimulus)		1		
		2		
		3		
		4		
		5		
		1		
		2		
		3		
		4		
		5		
Stimulus 1		1		
		2		
		3		
		4		
		5		
		1		
		2		
		3		
		4		
		5		
Stimulus 2		1		
		2		
		3		
		4		
		5		
		1		
		2		
		3		
		4		
		5		
Stimulus 3		1		
		2		
		3		
		4		
		5		
		1		
		2		
		3		
		4		
		5		