Unraveling the Plant-insect Interactions Taking Place in Your Native Garden *continued*

Figure 2: Live stilt bugs (*Jalysus wickhami*) next to two shed exuviae, hanging off the left side of the plant (evening primrose, *Oenothera elata* ssp. *hirsutissima*). *Photo courtesy Billy Krimmel*

the corpse is difficult, and often some further experimentation or observation is needed to get a better sense of the cause of death. Exuviae are used to determine whether multiple generations of insects are growing on the plant. For insects like bugs that do not have a larval stage, juveniles are similar in form to adults but smaller, and they shed their exoskeletons when they grow, leaving exuviae on the plant.

Finally, use your observation skills to pay attention to observable plant traits. Is your focal plant fragrant? If so, does it smell stronger when touched? Does it have hairs on the leaves, buds and/or stems? If so, are they clingy, and do they have debris or dead insects stuck in them? When you break a leaf, does it squirt out white latex? Do you see more or less of these traits on plants with higher or lower abundances of the insects you are observing? These are all important clues into how the plant may defend itself from insect herbivores.

Step Two: Do some preliminary research on your plant and insect species

Now that you've spent some one-on-one time out in the garden with your plant and its insects, it's time to identify the species in your system and learn about their basic natural histories. For the sake of this essay, I'm going to assume you already know the species of plant. Start by using Calscape (**www.calscape.org**) or Calflora (**www.calflora.com**) to determine your plant's natural growing range. This can give you a better idea of whether your plant naturally grows near your garden and will give you a sense of how likely it is that the insects that usually live on it will actually be in your garden.

Identifying insects can be intimidating at first, but there are some great resources available, especially if you live near a land grant university that has extension staff. In order to get an insect identified by a

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professional, it's important to collect it and prepare it properly so that once the professional has it, she can identify it efficiently. The best first step here is to call your local extension. Explain your goals and intentions, and ask whether they could help and, if so, how they would like the specimens prepared. Sometimes this involves sticking a few in some alcohol (especially for small insects), and in other cases, it's more helpful to mount the insect on an insect pin and keep it dry. In either case, the insect will need to be killed, unless the extension staff person says that live specimens are acceptable. For common insects, a photo is often sufficient.

If you are interested in learning how to identify insects yourself, a great place to start is BugGuide (**bugguide.net**), a free website with lots of pictures of insects and basic natural history and taxonomic information. "Seek" by iNaturalist is another good way to automatically identify insects (**www.inaturalist.org/pages/seek_app**) It's important to note that it is not always necessary to identify an insect to the level of species to know what it is doing; in fact, in some cases, this is not even possible, as many insect species have not yet been described. You may even discover a new species! In general, getting the identity to a level beyond family is important in order to understand its life history. Sub-family or genus are very informative, as feeding behavior tends to be the same for insects within these groups.

Once you know your plant species and some taxonomic information on your insects, do some quick internet research. Google the species of plant and one insect at a time. Make sure to check Google Scholar to see if these species pop up in any published research. Search for the insects and plants on BugGuide to see if other people have observed them and if so, what they noticed. See if there is information on Wikipedia or other free, reliable resources on the plant and insects, and read through what is known about their ecology and natural history. You may find some fascinating information and generate some ideas as to what is going on in your plant-insect system.

Unfortunately, peer-reviewed primary research papers are usually difficult or expensive to access unless you have an affiliation with an institution that subscribes to these. There are several open-source publications available, which are free to the public, but not all are as rigorously vetted as conventional publications. Luckily, the authors of peer-reviewed publications are also owners of the content and can send you PDFs of their papers for free. You just need to email them directly, or if you're lucky, they may have links to papers on their webpages. Even if you can't find all the original articles that are relevant to your plant/insect system, reading through the abstracts (which are free) can be very helpful.

Step Three: Come up with some research questions

This is a fun step in the process. What do you think is going on in your system? What insects are using the plant as a host? Which are herbivores? Which are predators? Which are likely causing damage to the plant? Which are likely helpful to the plant? How does the plant defend itself from the herbivores? You don't need to ask or answer all these questions, but perhaps some seem likely or obvious in your system. Or you may come up with more specific questions, like how do males of a species find mates, or how does a species of insect hide from predators? These questions can be re-written into hypotheses very simply.

The point here is to come up with simple *questions that can be answered through observation and/or experimentation.* For example, if your question is *Which insects are causing damage to the plant?*, your hypothesis may be *We hypothesize that the caterpillar is causing damage to the plant by feeding on its flower buds.*

Don't worry about revolutionizing the field of science for your first hypothesis. Keep it simple. Your priority should be coming up with a hypothesis that you can resolve through simple observation and/or experimentation. As you become comfortable with this process, you can begin asking questions aimed at advancing the field, but first, you need to get a sense of what questions can be answered and what gaps in understanding exist.

Step Four: Collect data to test your hypothesis

Now that you have some hypotheses, it's time to collect data that will support or reject them.

Here are some examples of simple, testable hypotheses, and what information is needed to test them:

> **Example 1 Hypothesis:** *We hypothesize that INSECT SPECIES 1 uses PLANT SPECIES as a host.*
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> Information needed: Are juveniles and adults both commonly found on the plant species?
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> **Example 2 Hypothesis:** *We hypothesize that INSECT SPECIES 1 causes damage to PLANT SPECIES.*
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> Information needed: Does the insect feed on the plant? How so? Is this type of damage observed on plants? Is it more common when more of the insects are seen on the plant? Can you replicate this damage by putting insects on the plant in controlled conditions? For extra points, if you can demonstrate that the insect causes a reduction in seed set for the plant, you can then conclude that it is reducing the plant's evolutionary fitness (i.e., reproductive output), which is the currency of evolution.
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> **Example 3 Hypothesis:** *We hypothesize that INSECT SPECIES 2 is beneficial to PLANT SPECIES by preying upon INSECT SPECIES 1.*
>
> Information needed: Is *INSECT SPECIES 1* harmful to the plant (see example 2)? Is *INSECT SPECIES 2* found where *INSECT SPECIES 1* is found? Is *INSECT SPECIES 2* known to feed upon, or scare away, *INSECT SPECIES 1*? Have you observed *INSECT SPECIES 2* feeding on or scaring away *INSECT SPECIES 1*? Some experiments could be helpful to

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further understand what is going on, such as caging *INSECT SPECIES 2* on plants with *INSECT SPECIES 1* and observing whether there is a resultant decline in *INSECT SPECIES 1* — note that a control would also be needed in which *INSECT SPECIES 1* is caged without *INSECT SPECIES 2*. This 'control' would be used to compare with the 'treatment' in order to understand how the cage might also affect the interactions between *PLANT SPECIES* and *INSECT SPECIES 1*.

The ease of testing your hypothesis comes down to the way in which you ask your research question and word your hypothesis. The key here is that you want to collect data that supports or rejects the hypothesis, and you want to make sure you are using some kind of standard data collection protocol when collecting the data. Hypotheses can be tested with observational data and also with experimental data. Experimental data tends to be more powerful because you can manipulate specific variables, so you know that the factors you manipulate cause the changes you see, but in some cases, observational data can be more realistic because you are observing interactions in their natural settings. The best research often includes both: observational data gives a holistic sense of field conditions, and experimental data can isolate individual factors.

Statistics are often needed to turn the data you've collected into a result. This is because the world is a messy, complicated place and no matter how good your observations are or how well you control conditions in an experiment, you will not see the same result every single time. But perhaps you usually do see the same outcome; statistics are a scientist's way of defining "usually". We won't go very far down this rabbit hole, but in general, simpler questions can be answered through simple statistics.

Conclusion

Native landscapes are beautiful and full of fascinating stories — some known and others untold. The more you learn about what is happening in these miniature ecosystems, the more special they become. This basic methodology of observation, question generation, and data collection is the foundation of science in any field, not just ecology. But ecology offers a uniquely accessible door into science, especially when it occurs in your backyard. Interactions can often be seen with the naked eye. Relevant plant traits can be touched, smelled, counted. Think about helping your kid do an ecological study in your backyard for next year's science fair or use these tips to unravel some of the mysteries unfolding in your garden! For further reading on making ecological observations and testing hypotheses, check out the book *How to do Ecology* by Karban & Huntinger.