**Biodiversity Module**

**Summary**

A team of researchers at UCR, Texas A&M University, and teachers from RUSD have developed a class module on Biodiversity for use in grades 9th through 12th grade. This module has different optional layers with more detail, and may be applicable for classes in Biology, Environmental Science, Geology and STEM Club.

The goals of this module are to teach students about the following key concepts:

* What is biodiversity?
* How are insects important?
* What are Hymenoptera? Most wasps are minute and do not sting humans.
* Why are wasps and bees important?
* What is the superfamily Chalcidoidea and how are they important?
* Why should we increase insect biodiversity?
* How common and how diverse are Hymenoptera on the school campus and other habitats?
* How we can increase biodiversity in the school and home environment?

The module includes:

1. A video presentation of graduate students at UCR presenting the module on Biodiversity (file 2a: ‘Class presentation – Biodiversity module – full version’ – or alternatively teachers can chose to use the files that split this module into three parts [files 2b-2e]);
2. A list of potential questions to ask students at ‘interactive points’ highlighted during the presentation (file 2f);
3. Details of companies that rear harmless chalcid wasps. Teachers can contact these companies and order wasps to show students and release on campus (see Laboratory Component section of this document). Additionally, teachers could order parasitoid-host-host plant system to demonstrate parasitism;
4. Directions for carrying out a pan trap experiment which aims to investigate the diversity of Hymenoptera in different habitats (files 3a-3e). This experiment would be conducted by groups of students and results combined across each class. Students can help researchers at UCR track the presence of a wingless wasp that was introduced into Texas from India in 1959. They can also try to find key wasps on the ‘wanted poster’ (file 3e);
5. A one page identification key with photos listing major points for identifying between predators, pollinators and parasitoids to supplement the pan trap experiment (file 3d).
6. A study box containing pinned dead insects of different groups of Hymenoptera that may be captured in pan traps to aid identification. The study box contains R&Q codes leading to more information that students can access with their smartphones;
7. Instructions for students to engineer a design for a bee hotel (see <http://www.foxleas.com/make-a-bee-hotel.asp>, <http://www.verticalveg.org.uk/how-to-make-a-bee-hotel-that-really-works/> , <http://www.nationalgeographic.org/media/build-your-own-bee-hotel/>
8. Instructions for students to engineer a hologram box to use with their smartphones (file 4)

**Background to the Biodiversity Module**

Insects are are all around us. There are over 1,000,000 described species of insect on earth and they represent 58-67% of all advanced life on Earth. Insects have a diverse range of lifestyles and biologies including herbivores, carnivores, scavengers, parasites and parasitoids. Hymenoptera is the third-largest order of insects, comprising the sawflies, wasps, bees, and ants. Over 150,000 species are recognized, with many more remaining to be described. Most people think of wasps as large and fierce. Students may initially be afraid of the concept of studying wasps. Through this module they will learn that most Hymenoptera wasps are minute, but they play very important ecological roles – predator, parasitoid or pollinator. They will learn how these roles are essential to the ecosystem.

****Most Hymenoptera are likely to be chalcid wasps (Superfamily: Chalcidoidea). Chalcidoidea (jewel wasps) are among the most species rich, ecologically important, and biologically diverse groups of terrestrial organisms. Their diversity is staggering, with more than 500,000 species thought to exist. These minute wasps (mostly 1–2 mm in size) are abundant and common in almost every habitat. The smallest of these wasps are smaller than a typical single-celled organism (much smaller than the dot at the end of this sentence), and yet the adults can fly, mate, locate their hosts, deposit their eggs, and as larvae, consume their insect hosts. Most chalcidoid wasps are parasitoids; they feed on other insects, attacking the egg, larval or pupal stage of their host, eventually killing them. They live and feed either internally or externally. Some are parasitoids of other parasitoids and some may even feed on their own species. If almost every insect species (estimated at 5-10 million species or more) has 3-4 parasitoids (mostly chalcid wasps), then how many parasitoids might there be? Because they kill other insects, these wasps are extremely important for the control of pests of agricultural and forest crops, as well as vectors of human disease and veterinary pests. The economic importance of these minute wasps in pest management is unparalleled. They are widely used in biological control programs against major pests, with outcomes documented to result in decreases in pesticide, increases in yield, and in landmark cases, savings of billions of dollars for permanent pest control. A few groups of wasps have also evolved to attack plant hosts, and some serve as pollinators.

Only 23,000 species of these minute chalcid wasps have scientific names, but *more than 500,000 species are estimated to exist*, and this is a conservative estimate! Students may trap an undescribed new species during their pan trap experiments!

*Can you spot the family Chalcididae?*

**Laboratory component:**

Live parasitoids

Teachers can contact one of the companies below and order live minute parasitoid wasps to show their class. Students can release the wasps outside and they will fly away and start to attack their pest host (none are harmful). Students will be helping to implement biological control of a pest!

*Parasitoids of flies*: Fly parasitoid wasps are nature’s own enemy of all common manure and rotting organic matter breeding pest flies, including the common house fly, horn fly, biting stable fly and lesser house fly. Fly parasitoids hunt out and attack fly pupae (cocoons) before the flies emerge and reproduce. They are tiny, completely biteless and stingless. They never become a pest themselves or bother people or animals.

Teachers can **call 888-562-5696 and** order a shipment of 5,000 “Fly Predators” from the company called “Spalding Fly Predators” to be shipped to their classroom for $19.95 + tax. The current mixture of parasitoid species marketed under the trade name “Fly Predators” include: *Muscidifurax raptorellus*, *Spalangia cameroni* or *Spalangia endius,* and *Muscidifurax zaraptor*. Teachers could ask students to research these species before the shipment arrives. The fly parasitoids are shipped in the black pupal stage. Normally they start emerging within 2-7 days after arrival in summer (later when cooler).

**Parasitoid wasp**

A video with information about how to release the wasps: <https://www.spalding-labs.com/products/fly_control_products/fly_control_for_horses/w/guide_to_fly_control_for_horses/default.aspx#!313_Video>



*Parasitoids of aphids*: Aphids are among the most destructive insect pests on cultivated plants in temperate regions. Around 250 species are serious pests for agriculture and forestry as well as an annoyance for gardeners. Tiny parasitoids that are biteless and stingless hunt out aphids and lay their eggs inside the aphids. The resulting parasitoid larvae hatches and eats the aphid from the inside, eventually killing the pest. Teachers can demonstrate this amazing form of biological control to their students by ordering a ‘banker plant’ system from Biopest. The small banker plant system (4 x 5 x 3 inches) contains a barley plant inoculated with 50-100 cherry oat aphids feeding on the barley plant (~$20). The barley plant can be cut into 2-4 pieces and repotted if the teacher would like small groups of students to demonstrate parasitism. Teachers then can order 500 aphid parasitoids for $25-30 which arrive as pupae. When adult parasitoids start to emerge from the pupae they can be placed into cages with the inoculated barley plants and students can observe parasitism. If desired, students can also rear the developing parasitoid larvae, and observe adult parasitoid emergence from parasitized aphids mummies. To order, teachers contact Mary Fernandes at Biopest: [order@biobest.ca](mailto:order@biobest.ca); ph: 519-322-2178. Prices do not include shipping. There is a minimal of $50 per order, therefore teachers may need to combined orders.

A video of aphid parasitism: [https://drive.google.com/file/d/0B1Py3kwu7MsvbEQtVGV3X1hxX3c/view?usp=sharing](https://urldefense.proofpoint.com/v2/url?u=https-3A__drive.google.com_file_d_0B1Py3kwu7MsvbEQtVGV3X1hxX3c_view-3Fusp-3Dsharing&d=DwMFAw&c=ODFT-G5SujMiGrKuoJJjVg&r=IeoqTEcS907Y5Hg4Si5_yUAwsqfsUzH1JYYqT8NeT88&m=enJVz-D5Ihuf31_TKgf0npXEshYCrUpOqbsukEngR04&s=YAx7cEz4VGhdPxms5mVCYko3pp1aNVnE7XjdGuK-WnU&e=)

**Pan trap experiment**

Current pedagogical theory suggests that student learning is enhanced when teachers allow students to assume more responsibility for the class. One way of doing this is through offering students hands-on activities to demonstrate subject concepts. The following experiment aims to investigate the diversity of Hymenoptera in different habitats (grass field versus flowers, dripping faucet, desert, chaparral, concrete, native flora, etc). This experiment uses pan traps, which are a small yellow bowls with water and a drop of soap, supplied to teachers by UCR (contact- John Heraty: johnheraty@ucr.edu). This experiment would be conducted by groups of students and results combined across each class. Ideally, teachers would present the “Biodiversity Module” video (file 2a, or 2b-e) before this pan trap experiment. Teachers have the following resources available for this study:

*1. Teacher instructions* includinga list of materials needed, before class preparations, and details about conducting the experiment (file 3a).

*2. Pan trap experiment worksheet* explaining methodology and questions for students to answer (file 3a);

*3. Pan trap experiment supply list* explaining what teachers will need to obtain for their class (file 3b);

*4. A slide presentation* to present to students before they carry out the experiment recapping ideas about biodiversity, introducing students to pan traps, explaining the methodology to the pan trap experiment, and giving some example results (file 3c).

*5. A one page* *identification key* with photos listing major points for identifying between predators, pollinators and parasitoids to supplement the pan trap experiment (file 3d).

*6. A study box* containing pinned dead insects of different groups of Hymenoptera that may be captured in pan traps to aid identification. The study box contains R&Q codes leading to more information and photos that students can access with their smartphones.

The example results reported at the end of the slide presentation (no. 2 above) describes a wingless wasp species (Neodusmetia sangwani), not previously known in California, that was found in large numbers in pan traps placed on UCR campus. This wasp was introduced into Texas from India in 1959 for the control of rhodegrass mealybug insect. The wasp has no wings and cannot fly. Students can look for this wasp in their pan traps and help track the movement of this biological control agent. They can report the numbers captured, date of capture, and location of their pan traps to John Heraty at UCR ([john.heraty@ucr.edu](mailto:john.heraty@ucr.edu)).