Introduction to Applied Entomology

Exam 2 -- Review

Lecture	Key Things to Know (and terms to understand)
Insects as pests; integrated pest management	IPM. From the Powerpoint for this lecture, key things to know include: (1) dates and results of the Morrill Act, the Hatch Act, and the Smith-Lever Act; (2) the importance of insects as pests ranges from nuisance and cosmetic damage to crop destroying (locusts, boll weevil, etc.) to life threatening (mosquitoes and malaria); (3) the importance of cultural and chemical control practices through the centuries; (4) the idea of pest control (% dead) versus integrated pest management; (5) the definition of integrated pest management. Terms: resurgence; secondary pest; integrated pest management.
Thresholds for insect pest management	Know that "injury" is any physical impact of a pest on a plant or animal (percentage of leaf tissue removed, leaf curl, etc.); "damage" is a loss in host plant or animal utility (value). The economic injury level (EIL) is the PEST DENSITY at which loss in crop value would equal the cost of control. The economic threshold ... the term usually used ... is the PEST DENSITY at which control should be undertaken to prevent loss that exceeds the cost of control. Understand the curve and the stair-step-like graphs presented in class to represent the relationships between pest density and loss in crop value. Most calculations of thresholds are based on purchase prices of insecticides plus application costs; they rarely take into account any additional costs ... environmental damage, applicator poisonings, regulatory costs, etc. Efforts to calculate meaningful "environmental economic thresholds" that would include such costs are perpetually underway (without much traction in the real world). Terms: injury; damage; economic injury level (EIL); economic threshold.
Phenology models	Know: Insect growth and development are more rapid at warmer temperatures (up to a point). The lower development threshold for a local population of a given species is the temperature below which development is negligible -- this is the "base" for degree-day calculations. Know how to determine the lower threshold if given a series of rearing temperatures and the number of days required for the insects to complete development at each temperature. Know how to calculate the number of degree days that accumulates on a given day if provided with max and min temperatures and the developmental thresholds (lower and upper). Terms: biofix; lower developmental threshold; upper developmental threshold (= developmental optimum); diapause (a term from earlier in the semester, but important here).

Insecticides	Know the 5 major classes of mainstream insecticides covered in this lecture and their modes of action. (Bt toxins that disrupt the midgut lining of susceptible insects are a 6th class or category.) Be able to describe in general their relative persistence and toxicity in comparison with one another. Be able to explain why "alternative" insecticides might offer certain benefits in comparison to the major insecticides now in use, and be able to list examples of such alternatives. Terms: axon; sodium channel disruptor; synapse; acetylcholine; acetylcholinesterase.
How insecticides are used	Understand the use and function of soil-applied residual insecticides, seed-applied residual insecticides, soil- or seed-applied systemic insecticides, soil fumigants, foliar "knock-down" insecticides, foliar residual insecticides, surface and systemic insecticides applied to animals, surface residual sprays used in around livestock facilities, homes, and other buildings, aerosols, and space or commodity fumigants.
Pesticide toxicity, fate, and regulation	When pesticides present problems, it is usually because of their PERSISTENCE, TRANSPORT, and/or TOXICITY. In general, the chlorinated hydrocarbons and many of the old inorganic pesticides persist longer than the organophosphates, carbamates, and pyrethroids; these persist longer than botanicals, soaps, and microbials. Transport is an especially important issue when pesticides move into water supplies. Transport in (and to) water is determined by persistence (half-life), soil sorption (K_{OC}) and water solubility. (Know how these are important). One measure of <u>acute</u> toxicity is an LD_{50} -- the dose that is lethal to 50 percent of the population (insects or lab animals) tested. Other components of toxicity include effects on nontarget animals, nonlethal acute effects to humans (skin irritation, eye injury, etc.), and chronic effects in humans. Assessing chronic toxicity is difficult because outcomes (cancer, nervous system damage, etc.), may occur in only a very small percentage of a population. Using high doses in laboratory animal testing increases the likelihood of detecting carcinogens, but it also increases the likelihood of producing false positives. Terms: Half-life; solubility; LD_{50}; soil sorption (K_{OC}); toxicity; leaching; runoff.
Insecticide resistance	Know that resistance involves (1) a CHANGE over time in successive generation's responses to insecticide exposure and that (2) it occurs at the population level, not the species as a whole. (Some populations of Colorado potato beetle remain susceptible to many insecticides; other populations are resistant to many.) Individuals are "born" resistant; they do not develop resistance in the way that immunity to disease develops in humans. Resistance is most common where selection pressure is high ... that means that a high portion of susceptible insects are killed and their genes for susceptibility are removed from the gene pool. Resistance is measured in bioassays that expose several insects each to a range of doses of insecticide. The results (percent mortality at each dose) are graphed (with dose expressed in log-transformed units and mortality expressed in "probit" units)

	... the line that fits the points shifts to the right for resistant populations. (The lines are called LDP lines for Log-Dose / Probit mortality lines). Resistance may result from one or more of four mechanisms ... (1) behavior (avoiding the insecticide), (2) reduced penetration (pesticide moves through the cuticle more slowly), (3) enhanced metabolism (enhanced ability to detoxify the pesticide); and (4) target site insensitivity. Resistance to more than one pesticide can result from a single mechanism (cross-resistance) or more than one mechanism (multiple resistance). Managing resistance is best accomplished by reducing selection pressure ... spraying less often, using the lowest effective rate, using pesticides of short persistence, treating only where necessary, spot spraying, etc. ... minimizing pesticide use. Resistance management should be ongoing before resistance is detected. High-dose strategies, mixtures, and rotations do not reduce selection pressure ... their utility is limited unless coupled with untreated refugia. Terms: insecticide resistance; selection pressure; bioassays; LDP line; resistance mechanism; behavioral resistance; penetration resistance; metabolic resistance; target site insensitivity; synergist; detoxification; multiple resistance; cross resistance.
Neonicotinoids	Not all neonicotinoids pose the same problems, but clothianidin, imidacloprid, and thiamethoxam are more persistent, more water soluble, and more toxic to honey bees than usually accepted for their range of labeled (approved) uses. Applications as seed treatments on corn, soybeans, and vegetables and their use as soil applications for systemic uptake in landscape plants all result in insecticide presence in pollen and nectar. Their toxicity to honey bees is (more or less) 2,000 - 2,500 times greater than many other commonly used insecticides. Expect regulatory changes in allowable uses of some neonicotinoids. The return on investment for neonics as seed treatments on soybeans is not, overall, favorable ... but they are widely marketed and used in this way.
Biological control (1 and 2)	Biological control is the use of predators, parasites, or pathogens to reduce, delay, or prevent the buildup of pest populations. Methods include conservation, augmentation, and importation of natural enemies. The classic example of importation involved the Vedalia beetle (a lady beetle), *Rodolia cardinalis*, from Australia to control the cottony cushion scale in California citrus in the late 1800s, but many other imported natural enemies contribute to biological control of introduced pests. Steps that conserve natural enemies include (1) recognizing them; (2) minimizing insecticide applications; (3) using selective insecticides or selective application methods; (4) maintaining a stable habitat; and (5) providing supplemental foods. Many types of pathogens infect insects ... although all of them exert some control on pest populations, only the bacteria have been widely commercialized. (Other groups of pathogens are also available for specific pest control uses.) Different subspecies of *Bacillus thuringiensis* are toxic to different groups of pests ... *Bt kurstaki* and *Bt aizawai* are toxic to caterpillars; *Bt tenebrionis* is toxic to Colorado potato beetle (primarily larvae) and elm leaf beetle; *Bt israelensis* is toxic to mosquito, black fly, and fungus gnat larvae. All

	these strains have been formulated for use as insecticides. They must be eaten to be effective, and they are short-lived in the environment. Answer … 1. What is the difference between natural control and biological control? 2. What are the 3 sets of 3? 3. What are the different categories of pathogens? Give an example of each (and what it does). 4. Explain the advantages of using microbial insecticides (pathogens). 5. Explain the limitations of using microbial insecticides (pathogens). 6. The various forms of *Bacillus thuringiensis* and the groups of insects that each affects. 7. The habitat in which *Steinerrnema* and *Heterorhabditis* are most likely to be successful (and who they are). 8. Why the Vedalia beetle is famous. 9. The identity and primary prey or hosts of: lady beetles in general, *Cryptolaemus*, lacewings, *Orius*, and *Encarsia*. 10. Give an example of how biological control can be integrated with other IPM tactics. Terms: biological control; predators; parasites; pathogens; conservation; augmentation; importation; Vedalia beetle; *Bacillus thuringiensis; Bt kurstaki; Bt aizawai; Bt tenebrionis; Bt israelensis.*
Host plant resistance.	From traditional plant breeding for insect resistance, know the meaning of the terms nonpreference, antibiosis, tolerance, oligogenic, and polygenic. "Virulent" insect biotypes may develop … they overcome the plant's resistance mechanisms; this is similar to the evolution of insecticide resistance, and methods of gene deployment to slow the evolution of virulent biotypes may be attempted by the use of sequential cultivar release, pyramiding, gene rotation, and crop multilines. These approaches resemble efforts used to manage insecticide resistance. Know that "transgenic" organisms contain genes taken from another species by means of molecular techniques. MVP and M-Trak are microbial insecticides that contain *Bacillus thuringiensis* toxins produced in *Pseudomonas syringae* cells that were then heat-killed to produce an encapsulated toxin (more stable). In *Bt* corn, *Bt* cotton, and *Bt* potatoes, genes that direct *Bt* toxin production have been inserted into plants so that seeds carry the instructions for plants to produce *Bt* toxins for insect resistance (host plant resistance). Although crop yields and effectiveness of insect control vary among *Bt* hybrids and transgenic technologies, *Bt* plants are very effective for control of Lepidopteran larvae. Pest resistance has already reduced the value of Bt crops for corn rootworm control.
Transgenics	Why Bt crops? Other GMO's … what is the difference between transgenic, cisgenic, and subgenic? What two Bt crops are grown widely in the US? What is the scientific consensus on the safety of foods derived from GMO crops, and what are two of the scientific groups who have come to these views? What have been

	some of the opposing viewpoints on the safety of GMO crops? Real issues include effectiveness, resistance management, conflicts with other cropping systems (especially for herbicide-resistant crops and drift). Be sure to read the summaries from the Center for Science in the Public Interest and the National Academy of Sciences. Realize that science and facts do not drive all public opinion.

For the "Integrated Pest Management Revisited" topic on November 30, an outline distributed in class provides a framework to be used to fill in the details of this topic as covered in class. Be sure to study the information covered.