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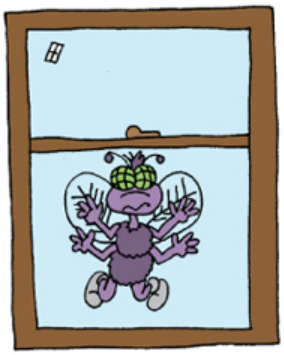
Mechanical Control

Mechanical controls are often referred to as physical controls. These are common-sense control techniques that are almost always used in combination with other management methods. Mechanical control methods range from tools as simple as a flyswatter, a window screen, or a vacuum to very complex and highly engineered methods such as insect electrocuters, high-frequency energy devices (microwaves), or specifically designed, high-pressure air curtains, to prevent entry.



Mechanical controls are very important options in integrated pest management. Any physical or mechanical device used for controlling insect pests falls into this category.

Techniques using atmospheric or temperature extremes provide pest management professionals alternative tools for resolving situations where other controls cannot be used or are not effective. Applications of gaseous changes such as ozone, CO_2 or others have been shown to kill insects.

Insect traps are a form of mechanical control. Examples of low-temperature controls include systematic freezing of library books and other archived materials, and taxidermy mounts of animals, in large, walk-in freezers. High-temperature controls include heating of stored grains and green lumber, and the recent use of whole-house heat treatments to destroy deeply entrenched bed bug populations. A wide variety of traps can be employed as effective methods of control, as well as monitoring.

Regulatory Control

Preventing pest entry or spread is an essential objective of IPM. On a national and a statewide basis, regulatory agencies help prevent the spread of pests by enforcing rules on shipping food products as well as sod and other landscape materials from one area to another. A great number of insect pests are held in check by these regulations. Regulatory pest managers must understand how pests move and are introduced into a new area. The spread of pests can be limited by routinely inspecting, cleaning, and disinfecting equipment, transportation vehicles, and other materials that could transfer pests from one site to another.

Additionally, efforts to eradicate a small pest population before it becomes established are desirable. Government agencies actively monitor for invasions of suspected pests and stand ready to perform localized, intensive eradication procedures in an effort to avoid permanent establishment of new pests. Urban pest managers using similar tactics can also help prevent movement and establishment of pests from an infected area to a new site.

Putting It All Together

IPM combines multiple strategies for controlling pest problems. One of the biggest challenges for pest managers is deciding which strategies to use in a particular situation. The guiding philosophy of IPM is to use the most effective control measures that will have the least potential for negative impact on people and the environment, including beneficial organisms such as honey bees and pest predators.

A significant part of pest management is done well before a building or a landscape is constructed. Designing with pest management in mind is one of the most effective urban IPM techniques available. Both structures and landscapes can be designed to make it difficult for a new pest to enter and thrive.

Simple and common-sense control methods, such as sealing up entry holes, placing screens on windows, or cleaning off equipment when moving from one field to another, will all help prevent pest problems. Educational efforts can be effective as well. One recent campaign has focused on informing the public that transporting firewood is risky because the emerald ash borer can hitchhike from infested to noninfested areas on the wood.

Professional pests managers know that if a pest does not arrive, they will not have to worry about controlling it. An ounce of prevention is worth a pound of cure!

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Selecting Treatment Strategies

Selecting the best treatment strategy for a particular pest requires:

- Accurate identification of the pest(s)
- Complete understanding of the pest habitat and treatment site
- Knowledge of pest biology
- Familiarity with the management system
- Knowledge of available treatment options and their effects

Within this framework, IPM favors treatment options that have the greatest potential for providing long-term solutions to pest problems while minimizing negative impacts. The following IPM tactics are presented in the order of general desirability:

1. Education
2. Habitat Modification
3. Horticultural/Agricultural Design (or Redesign)
4. Mechanical Controls
5. Biological Controls
6. Least-Toxic Chemical Controls

Not all options in each of these categories will be available or desirable in every situation. The types of available pest-control strategies vary considerably from one system to another. The pest manager must always consider:

- The pest involved and the risk it poses
- The resources and options available to the client
- The relative risks and benefits of available control options

Pest managers may use one category or method of treatment exclusively or in combination with other methods. Integrated pest management is always situation-specific, but it usually involves using two or more options or techniques in a logical way to achieve pest management goals.

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Categories of Treatment Options

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Evaluation and Record Keeping

Sound decision-making in IPM must be based on the best available information on pest activity and the conditions that promote infestations as well as on the success of previous control measures. After a pest-management practice is used, pest managers must follow-up to evaluate its effectiveness. Decisions to continue, increase or decrease, or suspend a pest-management practice should be based on it's past performance.

The pest manager is the person responsible for making pest-management decisions in an IPM program. Depending on the situation, the pest manager may be a farmer, private consultant, landscape manager, hospital administrator, school employee, or professional pest manager/contractor.
The pest manager inspects and monitors for pests, identifies pest problems, determines why the pests have become a problem, devises a solution for the problems, implements the solution, keeps thorough records on pest levels, documents actions taken and results obtained, and, based on this information, reevaluates the IPM program on an ongoing basis.

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Evaluation

Evaluation is an important and ongoing part of any IPM program and occurs at multiple levels:

- Evaluation of individual pest control actions
- Evaluation of program success

Evaluation of Pest Control Actions

In an IPM program, the pest manager must follow-up to evaluate the effectiveness of each pest-management action. For example, if a pest manager treated an ant infestation by removing a food source and sealing a crack in the floor, he or she should conduct a follow-up inspection to determine if ants are still active in the area. If so, additional actions may be necessary.

Continual evaluation of each pest control action allows the pest manager to accumulate a helpful database of information that can improve pest management decisions in the future.

Evaluation of Program Success

The record keeping aspect of IPM provides an opportunity for ongoing evaluation of program success and can provide the following benefits:

- Documentation from pest inspection and monitoring reports to determine general trends in pest populations
- A means of assessing the success of pest management programs over the long term
- Comparisons with data from previous pest control practices to determine the relative success of IPM versus other methods

Regular IPM program evaluation is recommended so that programs may be continually improved. It is up to pest managers and clients to determine the most appropriate schedule for evaluation of a particular program.

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Record Keeping

Records provide the historical data that can help a pest manager evaluate control techniques over time. In IPM programs, the pest manager collects data through monitoring and scouting activities, and keeps records on:

- Pests that are encountered
- Control strategies used, including pesticides and non-chemical controls
- The effectiveness of control methods

Records must include site-specific details, such as the size of the pest-infected area and its exact location, population estimates, damage amounts, symptoms, dates, and where appropriate, weather conditions leading up to pest infestation. Records maintained during previous years allow pest managers to make informed, science-based decisions when planning strategies for future monitoring, scouting, and control activities.

> Thorough record keeping provides critical information that can be used to make future pest-management decisions.

When information about pesticide applications is combined with data on pest activity levels, the true success and duration of pest suppression can be measured. This information should always be used as a basis on which to make future pest management decisions.

What Records Should Pest Managers Keep?

With so much information to keep track of, pest managers need a way to organize the information that they collect. They do this through various reports and logs. Depending on the situation, pest managers will prepare and maintain the following:

- Inspection reports
- Pest-sighting logs
- Pest monitoring logs
- Pesticide application records

Inspection Reports

Pest managers generally conduct detailed inspections at the start of an IPM program and continue to provide monitoring throughout the program. Pest managers use inspection reports to document the results of these site inspections and to inform clients about the presence of pests or pest-conducive conditions. The inspection report is a thorough, room-by-room, plant-by-plant, or field-by-field assessment of the building, landscape, crop, or other site being evaluated.

In many cases, inspection reports include specific recommendations about how to correct a problem.

IPM Pest Sighting Log

The pest-sighting log is a useful tool in structural IPM programs, particularly in schools, hospitals, nursing homes, and industrial settings. The first entry in a pest-sighting log is simply a record of pest sightings made by building occupants, including:

1. Location of sighting (as precisely as possible)
2. Types of pests sighted
3. Numbers of pests sighted
4. Date

The pest manager consults the pest-sighting log, investigates the recorded observation, then adds the pest identification and recommended actions to the log. When the recommended actions are completed, the date of completion is filled in by the pest manager.

Date:	Section 3: IPM Inspection Checklist				
Part of Building Check Points	Station	Activity Y/N	Assessable Y/N	Satisfactory Y/N	Comments for Maintenance
I. Building Exterior					
1. Garbage storage area					
2. Garbage handling system					
3. Parking lot and drainage areas					
4. Weeds and surrounding landscape					
II. Classroom/Hallways/Offices					
1. Ventilation/air ducts					
2. Doors and windows					
III. Food Storage					
1. Dry food storage					
2. Damaged/spoiled dry food					
3. Empty container storage					
4. Drains/pipes/sinks					
5. Overall sanitation					
Recommended 3-part NCR	White - Log		Yellow - Technician		Pink - Secondary IPM Contact

Pest-sighting logs are kept in a convenient location on site and consulted by pest managers during routine inspections. The pest-sighting log identifies the problem areas where the pest manager needs to follow up and ensures ongoing communication between clients and the pest-control professional. More importantly, it involves building clients in the process of pest control, which is the first step toward educating them about how their daily practices influence pest populations.

Pest Monitoring Log

Monitoring is an important part of any IPM program. A pest-monitoring log is a simple record of the number and type of pests encountered by the pest manager during scouting or visual inspections.

Monitoring logs serve both a preventive and an evaluative role in the IPM program. They are preventive because information obtained through monitoring can indicate the need for an immediate control action. They are evaluative because a review of long-term records reveals general trends in pest populations that can be used to evaluate the success of specific control measures, in particular, or the success of the IPM program, in general.

It is standard practice among commercial pest management services for the pest manager to provide the client with a report or invoice that describes:

1. The action performed
2. The cost of the service

In IPM programs, the service report is expanded to include:

3. Information about the pest species encountered
4. Documentation of conditions that promote pest activity
5. Non-chemical control recommendations, such as repairing leaks or removing clutter

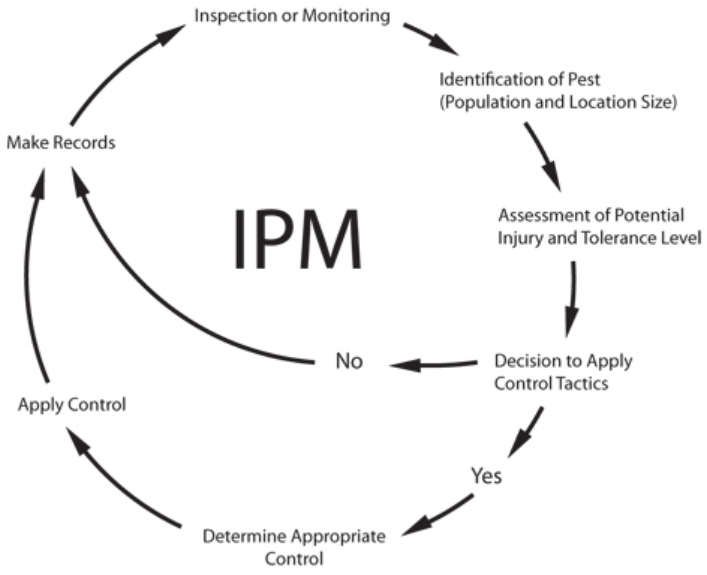
Pesticide Application Records

Many states have laws that require documentation for pesticide use. In most cases, the following records must be maintained for some set period of time (it is important to find out what laws pertain to your state):

1. Pesticide applied (brand name and active ingredient)
2. U.S. Environmental Protection Agency (EPA) registration number
3. Formulation
4. Rate of application
5. Location of application
6. Time and date of application

For most pesticide applications it is a good ideaâ€”and in some states, a legal requirementâ€”for the pest manager to provide the client with a copy of the EPA pesticide label and Material Safety Data Sheets (MSDS). Pesticide applicators, landscape managers, and facility managers should consult federal, state, and local regulations with regard to keeping pesticide application records to be sure that they are in compliance with all legal requirements.

Figure 1 The IPM Decision Making Flow Chart



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MANAGEMENT SUMMARY OF COMMON INSECTS

Students of entomology should be able to recognize and identify beneficial insects, insect pests, and pest-damage symptoms. Students also must know something of the biology of the various insects, be able to estimate potential injury, and recommend controls if needed. The following descriptions and accompanying photographs will help students identify common pest and beneficial insects. The images chosen are representative of those found in agricultural, horticultural, health, and urban environments. The beneficial insects include pollinators, parasites, and predators.

Insects may be detrimental only during their immature stage (nymph or larva). During this stage they may appear nothing like the adult. It is important for a pest manager to be able to recognize both the adult and the immature stages as well as to recognize typical damage symptoms in order to assess the need for control. Pest managers also must recognize the immature stages of naturally occurring beneficial insects if they are to help conserve and protect them.

Insects are not easily categorized simply by where they occur or what they do. For example, some insects may be pests in multiple settings such as agriculture AND urban environments. A few insects may even be both beneficial and pestiferous, depending on where or when they are found.

Fifty common insects will be examined in the next section. Opposite their photographs is a brief written description of the insects in both their adult and immature stages, pest status, their general biology, the benefit they provide or the damage they may cause and, where applicable, preferred control recommendations.

Field Identification of Common Insect Pests and Beneficial Arthropods PDF

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CAREER OPTIONS IN INSECT PEST MANAGEMENT

When asked what "bug-ologists" (aka entomologists) do, many people immediately conjure up mental images of somewhat nerdy people of less-than sound minds, sporting pith helmets, and jungle shorts while chasing a butterfly with a bug net.

While entertaining, these stereotypical images of what an entomologist is are far from the truth. There are many different careers in which trained entomologists may find employment; many practicing entomologists may never even hold a butterfly net or make an insect collection. Entomologists work in laboratories, forests and offices. Some are employed in schools or universities, while others work for the government or the military. Many work in industries that are closely tied to entomology, such as pesticide research and development, or agriculture. In many cases, people in these careers many not be specialized entomologists, but will certainly be more productive and valuable because of their general entomology training.

It is important to gain an appreciation of the variety of employment opportunities associated with entomology. Quite often, professional entomologists must work together to solve particular problems and complete projects. Expertise from various disciplines is always an advantage. For that reason, it is valuable to know what fellow entomologists do.

In this section, you will be presented with several fictitious case studies or scenarios, in which entomologists may be employed. These represent only a few of the possible employment opportunities open to entomologists, but they should provide you with a general appreciation of the important contributions entomologists make in today's world. Following each scenario is a brief description of the educational requirements, interests and aptitudes of those who work in that specific area, be it government, industry or academia.

Military Entomologist

Case Study: *Save Our Troops!*

A colonel in the United States Army is stationed in Afghanistan for two years. He and his company are unaccustomed to the dry heat of the desert and have had to sleep in tents for three weeks. One day, a subordinate officer rushes into the colonel's tent and reports that a strange illness is affecting some of the soldiers. The colonel summons the Army Medic and goes to examine the patients.

When he arrives at the infirmary where sick soldiers are treated, he recoils in horror. Some of them have large, oozing skin sores and mouth ulcers. Others report difficulty in breathing and swallowing. In the most extreme cases, soldiers are also running an extremely high fever and their skin has taken on a dark hue.

The medic is baffled by these symptoms and cannot determine their cause. He remembers many of the soldiers complainting about small biting flies, but until now, he has had no reason to associate them with this disease. In order to be sure, he catches a few of the flies and places them in a specimen bottle. This practice is one that was taught to him a few years previously by a military entomologist who helped him solve a case of malaria. Their collaboration saved several lives by demonstrating the link between an outbreak of mosquitoes and the incidence of malaria.

The colonel calls for the squadronâ€™s military entomologist who arrives on the scene and immediately identifies the small flies in the bottle as sand flies (Psychodidae: *Phlebotomus papatasii*). He also recognizes the symptoms of a disease (Leishmaniasis) in the patients he sees. He explains to the colonel that this disease is caused by a protozoan parasite that is transmitted through the bite of the female sand fly, that is common in this part of the world. The good news is that if diagnosed early enough, the disease is treatable.

The soldiers with sores and ulcers are given specific medicines and most respond quickly; however, the few soldiers with high fevers are diagnosed with â€˜visceral Leishmaniasisâ€™ a much more serious and potentially fatal form of the disease. In these cases, the protozoans migrate to the liver and spleen

where they are much more difficult to treat. These soldiers are transferred immediately to the military hospital where they are treated much more aggressively.

As part of a preventative program, the military entomologist conducts a training seminar on the dangers of sand flies. He instructs the entire squadron to avoid areas of high infestation, and to wear protective clothing and insect repellent for the remainder of their time in the Middle East. He also recommends that all sleeping units be enclosed by fine mesh netting to prevent insect entry.

Thanks to the military entomologist, the disease is detected early enough so that no casualties result. His training of the soldiers on preventation practices averts further transmission of disease. The medical entomologist becomes a military hero to the soldiers in the unit and he receives a special commendation by the colonel for â€œgoing above and beyond the call of duty.â€

Summary

The outcomes of major wars and battles has sometimes been determined or influenced more by diseases than by soldiers. As recently as World War II, for example, more than 83,000 American soldiers suffered from serious diseases that were not caused by battle injuries. Diseases are often transmitted by insect bites.

All branches of the military - Army, Navy, Air Force, and Marines - employ and train entomologists to protect troops from attack by insect pests, especially ones transmitting infectious diseases. Military facilities, vehicles, foods, and uniforms also need protection from insect pests.

To become a military entomologist, a person must have an interest in the military, medical entomology, and pest management. Formal entomology training, by earning a bachelorâ€™s or masterâ€™s degree in college, may be required but often the degree can be completed while in the service - at a significant cost savings to the student.

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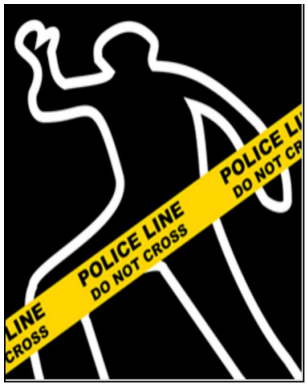
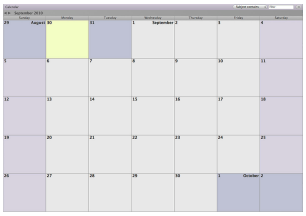
Forensic Entomologist

Case Study: *Maggots On Trial*

A dead body is found by some mushroom hunters in a patch of weeds near highway 47 in southeast Indiana. Police link the body to a report of a 27 year old female who has been reported as missing. Homicide detectives arrive to process the crime scene. They note that the body is laying face down with obvious gunshot wounds to the head and torso, and that there are many fly larvae (maggots) present.



Police investigators are immediately dispatched to question the victim's family and friends. The victimâ€™s brother recalls seeing his sister seven days earlier with her boyfriend and that they seemed to be arguing at the time. The boyfriend is brought in for questioning and says he was with her as recently as 2 days ago and that they had resolved all their problems of the previous week. However, the boyfriend says that his girlfriend has not contacted him for two days. He says he is very worried about her.



The police suspect foul play on the part of the boyfriend but have to be able to formulate a 'time of death' time frame. They have access to a forensics laboratory that can provide climatological data (air temperature, wind speed, and relative humidity) for the area in question. They suggest contacting a professional forensic entomologist.

A forensic entomologist is immediately called to the site. He collects some of the larvae found on the body and returns to his laboratory to conduct tests. His final report, based on the evidence he collected, is that the time of death was between six and eight days earlier. This report, along with other key pieces of evidence, lead to the arrest of the boyfriend.

In court, the forensic entomologist is asked what the basis is for his report and how fly larvae could possibly determine the young woman's time of death. The forensic entomologist provides the following answer: *Entomologists have*

studied the attraction a dead body holds for insects and have worked out their natural succession on a decomposing body. Based on the identity of the fly species, the developmental time period of the various larval forms, and the temperature data in the surrounding area, the time of death can be worked out very predictably and with a high degree of certainty. In this specific case, the fly larvae would have required 6-8 days to reach the stage in which they were found on the body. Given the evidence, it is clear the woman could not have been alive two days previous to the discovery of the body, as the suspect has stated.

Faced with the testimony provided by the forensic entomologist and other key pieces of evidence, the boyfriend confesses to killing the victim and is convicted of committing the crime of murder.

Summary

Students of entomology who have an interest in problem-solving, law enforcement and who have a strong stomach can specialize in forensic entomology. Forensic entomologists deal with the law and are usually called upon to reconstruct entomological events to solve problems. This includes, but is not limited to, murder investigations.

Forensic entomologists investigate complaints of human injury, disease, food contamination, plant injury, and structural damage caused by insects. Practical entomology and problem-solving is almost always followed by testimony in a court of law. This requires a person to be very precise, accurate, and verbally explicit. Skills in public speaking and writing are required, and forensic entomologists must be confident in their abilities because cross-examination can be very critical.

Some forensic entomologists work in law enforcement, while others work in private consulting. Most forensic entomologists are affiliated with a university because a Ph.D. provides the credentials that an expert witness needs.

Regulatory Entomologist

Case Study: *Who Let The Bugs Out?*

The United States Department of Agriculture (USDA) is charged with protecting America's agriculture. A part of that charge is to ensure that exotic insect pests do not enter and destroy U.S. produce and commodities. USDA inspectors regulate products that are brought into the country by certifying that they are 'pest-free' prior to import.

Frik Frak Foods is a large food and beverage producing company with headquarters in Europe. The company does over $60 billion a year in business and distributes their products throughout world including the United States. Their reputation rests squarely on providing healthy and nutritious food at a reasonable cost.

During a routine inspection on a large shipment coming from China, Tammy, a USDA entomologist, has discovered a strange insect that is apparently boring into the pallets upon which Frik Frak macaroni and cheese boxes are carried. Tammy immediately halts the shipment pending further analysis of the insect, even though representatives from Frik Frak loudly protest that they are being treated unfairly, and that holding the shipment costs their company untold profits.

The insect specimen is immediately rushed to a quarantine facility where a USDA identifier examines it under a microscope to determine what it is, if it is a potential pest, and from where it originated. The identification comes back confirming that this insect is Toonenjury horribilus, a native pine-boring beetle of East Asia. Research confirms that it is a very deadly pest to pine trees. It bores into the crown of the tree and kills within four to five months. Every species of pine in America is susceptible to the ravages of this exotic pest and once it is established, there is no known cure for it. The USDA inspector suspends all shipments of Frik Frak products to the U.S., and quarantines the entire shipment currently sitting at the dock. She mandates that the ship and all its contents immediately return to its point of origin.

Meanwhile, teams of USDA entomologists within the U.S. are advised of this occurrence and scurry to locate and determine if any pallets that arrived previously from this company were infested. If additional infestations are found, plans must be immediately implemented to isolate and contain these exotic pests and provide education for other inspectors, foresters, and nursery growers to be on the lookout for this dangerous pest.

Although the infestation proved to be costly to Frik Frak Foods, it could have been much worse for the U.S. economy. This observant USDA inspector saved billions of pine trees that would have otherwise been killed by this beetle. Protecting America from invasive pests is as important to our economy as military protection is to our peace and safety.

Tammy, the USDA inspector, was not given special accolades or medals for what she had done, but she went to work again the following day satisfied with the knowledge that because she had done her job, American forests were safe.

Summary

Government agencies provide entomologists exciting and meaningful employment in many areas. Entomologists working with the government understand and work well under a structured system of rules, policies and procedures. They must be able to work well as a part of a team and communicate effectively. They are often called on to enforce regulations so they must understand authority and yet be people oriented.

Federal and State Regulatory Agencies employ entomologists to oversee development and/or enforcement of policies and regulations that involve insect pests or pesticides. Quarantine and inspection services are a large part of what regulatory entomologists do on a daily basis.

Employers: U.S. Environmental Protection Agency, U.S. Food and Drug Administration, U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), Center for Disease Control (CDC). In addition to the numerous opportunities for employment with the USDA, State Departments of Agriculture also have responsibility for oversight of agriculture and land stewardship. At the state level, entomologists inspect shipments of nursery stock, produce, livestock, pets, etc. that enter the State. They employ entomologists to monitor for newly introduced species as well as train and educate pesticide applicators.

State Departments of Natural Resources (DNR) are also concerned with native and invasive species including insects and other invertebrates. They focus on protection of natural resources such as forests, lakes, and rivers, as well as the plants and wildlife that live there.

Federal Research Laboratories within the U.S. Department of Agriculture, National Institutes of Health, and U.S. Geological Survey all employ entomologists as part of their staff. Government laboratories research important agricultural, environmental, and health problems. Federal research laboratories occur throughout the U.S. and conduct a variety of entomology-based studies.

State, County, and City Departments of Health also occur in every state. These agencies are charged with protecting people and companion animals from pests and pesticides. Entomologists in these positions are often charged with making decisions about whether and when to apply pesticides, and which insecticide to use as they evaluate potential public health threats.

Requirements usually include a B.S. or M.S. level degree in entomology. Regulatory entomologists must have an eye for detail and an ability to work with

others while demanding that existing rules be followed.

Agriculture, Food and Drug Entomologist

Case Study: *Bug Scout*

Several golf courses in the area have been severely damaged by Japanese beetles each summer for the past three years. The beetles are annoying and eat all the flowers around the clubhouse, but even more importantly, the immature stage (grub) eats the roots of the turfgrass in August and the grass is dead by September. Because large sections of dead grass are left behind by the grubs, golfers complain that it is not only unsightly, but it also ruins their golf game. To make matters worse, raccoons and skunks invade the area by night and dig up even more sod while looking for grubs on which to feed. The once beautiful course begins to look like a war zone.

Grubs are difficult to find because they occur underground. By the time they are noticed, it is too late - the turfgrass is already beyond saving. It is very expensive and environmentally risky to treat the whole golf course with preventative pesticides, especially when it is possible that only four or five spots on the whole course will be damaged. The golf course managers have learned from the local university that scouting may allow them to determine exactly where the grubs occur in populations high enough to cause damage. Because they do not have people or expertise to â€˜scoutâ€™, they would like to hire an entomology-trained scout to provide the information they need.

John has a degree in entomology and has been trained as a scout. He contracts with the golf courses to monitor for grubs. He first creates a map of the courses he will scout and then begins a systematic process of digging samples of the turfgrass and soil and recording the grubs he finds. When complete, he plots his findings on the map.

John knows that university studies have determined that any population higher than seven grubs per square foot will cause turfgrass damage. With this information John pinpoints exactly where grub damage will occur on each course and then is able to show the golf course managers exactly where problems will arise on their courses.

Golf course managers are able to take Johnâ€™s map and apply pesticides to the specific areas based on his recommendations. These calculate out to be only 1/100th of the total area of the golf courses. Golf course owners are ecstatic! They can save thousands of dollars that they would have spent by applying pesticides over the entire course. The golfers are happy that their play

is not interrupted by grub damage. John is happy because he knows that he has helped preserve the environment because unnecessary pesticide applications to the golf courses were avoided.

In addition, John is even happier because some local corn and soybean farmers have heard about his work and have asked him to scout for Japanese beetles in their fields as well. John has decided to start a business as a professional â€œbug scoutâ€ so that others can benefit from his expertise. The end result is that everybody is happy, except perhaps the raccoons and skunks that have to forage for grubs someplace else!

Summary

Many entomologists are employed in the food, agriculture or pharmaceutical industry. These positions are many, varied, and range from research and development to sales and customer relations. Applied entomologists such as bug scouts and agriculture consultants are sought after.

Major industries include the following:

Seed Industry entomologists evaluate new lines of plants, for susceptibility to major insect pests (both field and laboratory research). Entomologists work with high value agricultural crops, such as cotton, corn, and soybeans but may also consult about other crops and horticultural plantings. Insect rearing expertise is often needed to supply the insect pests for research.

- Requirement: Entomology at the B.S. or M.S. level.

Agrochemical Entomologists evaluate new chemical compounds against insect pests. Major employers work with agricultural pests but insects that are key pests of human health, veterinary health, forestry, household, turf grass, and other horticultural plants also require professional entomologists. Expertise in rearing insects is often needed for product testing.

- Requirement: Entomology at the B.S., M.S. and sometimes at the Ph.D. level.

Biomedical and Pharmaceutical Industries employ life science graduates with education and experience in a range of modern molecular technology skills.

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Because this industry is so broad, people are employed at many different levels and thus may require many different skill sets. In most cases, however, problem-solving aptitudes are required and excellent team working and people-skills are a must.

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Agriculture, Food and Drug Entomologist

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Urban Pest Managers

Case Study: *Pizza With One Too Many Toppings*

Cody and Karen, two college students, are headed out on their first date to a local pizzeria. Papa Timmy's Pizza is a town favorite and has the best pizza for miles around. Both Cody and Karen are looking forward to great food and a comfortable atmosphere where they can enjoy their first date.

They order a large "meat lovers" pizza, Karen's favorite, sip their drinks and gaze into each others eyes until the pizza arrives. Suddenly, just as they are digging in, a small insect scurries from behind the salt shaker, and crosses the table towards their pizza. Karen screams in horror and accidentally knocks her drink over as she frantically backs away from the table and climbs up on her chair. Cody tries heroically to swat the bug but it is too fast. In his attempts he knocks the pizza to the floor. Cheese and pepperoni are everywhere. Karen is screaming, Cody is cussing and everyone in the restaurant is glued to the chaos that is developing.

Unfortunately for Papa Timmy, the local health inspector is also eating at a table nearby. The inspector makes a note to himself to return the next day with a health inspection team. The safety officials search the entire restaurant and find a large population of cockroaches. They order that the establishment be closed until the problem is remedied.

Papa Timmy is distraught and calls George's Professional Pest Control to assess the situation. When George arrives, he quickly finds a roach and identifies it as a German cockroach (*Blattella germanica*). Knowing what he does about German roaches, George heads directly into the kitchen for a thorough inspection and to determine the extent of the infestation.

The news is devastating. There is a large cockroach population that started in the kitchen and has since spread throughout the restaurant. George pulls out

the dishwasher and finds many cockroaches congregating near a leaky pipe. He explains to Papa Timmy that these cockroaches prefer dark, damp areas and that such areas serve as breeding grounds for female cockroaches. He explains that the leak must be fixed and further that the appliances must be inspected and cleaned regularly in order to help prevent future insect infestations. He returns to apply a cockroach bait to the specific area where the roaches are located and designs a monitoring program to help assess the effectiveness of the insecticide and sanitation treatments. He also educates the kitchen and janitorial staff on the importance of proper sanitation techniques.

The cockroaches are eliminated, the restaurant is re-opened for business and Karen dumps Cody to date George because she just loves a hero. Devastated by this break-up, Cody switches majors, from medicine to entomology at Purdue University where he graduates and becomes a professional urban entomologist himself. He begins a very successful career in protecting people from insect pests.

Summary

Control of insect problems is essential to human health, comfort and food production. Those employed in pest management require many skills to properly manage pests. Professional pest management is a very large industry and crosses many urban institutions beyond just residential or home pest management. Large public buildings such as hospitals, schools, restaurants, hotels, nursing homes, and other governmental and private facilities employ professional pest managers. Urban pest management is commonly contracted to both large pest control companies such as Ecolab, Terminix, and Orkin as well as to small private pest control companies. Larger facilities such as hospitals and colleges may employ their own internal pest manager.

To apply pesticides for hire requires a license that documents appropriate training in human and environmental safety as well as an understanding of how to best manage pests. Most states provide pesticide applicator training and licensing through their land grant universities.

The minimum education requirement for urban pest control jobs is high school graduation, but more advanced training, both on the job and in a formal setting, is desired. In addition to knowing insects and insecticides, it is always an advantage to understand the basic architecture of buildings.

Professional pest managers must have good people skills as well as to be able to solve problems. Solutions are often complex and require synthesizing a lot of information in order to arrive at a successful solution. To properly inspect, pest managers must also be willing to get into areas such as crawl spaces, attics, and behind appliances where only the ‘bugs’ like to go.

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University Entomologist (Teaching/Research/Extension)

Case Study: *Call Someone Who Knows*

A six year old child complains to his mother of itchiness on his back. She discovers several large, red, welts on his neck and back but cannot think of what the cause may be. One morning, while making his bed, she finds some tiny insects in the sheets and wisely places them into a small vial for closer examination. They appear flattened, reddish-brown in color and have the general size of a grain of rice. She consults the web and finds, to her horror, that these look very much like bed bugs.

In a panic, she calls Purdue University and pleads for someone who can (1) help her identify what the insects are for sure, (2) verify if they are causing her sons itchiness, (3) tell her if they will spread a serious disease and (4) offer control recommendations so that she can rid them from her home.

The university dispatches her call to the Purdue Cooperative Extension Service where she is warmly, greeted by the entomology diagnostician. She explains her problem, expressing that she believes these are bed bugs and add that â€˜she is a good housekeeper and cannot imagine where these bugs come from or why they chose her home.â€™ She asks if her sonâ€™s life is now in jeopardy and what she can do.

The diagnostician patiently listens to her concerns, and then immediately calms her panic by stating that these insects, even if they are bed bugs, will not transmit diseases. He also assures her that their occurrence has nothing to do with housekeeping or cleanliness.

The diagnostician carefully and methodically asks questions to ascertain the correct identity of the insect so that he may recommend proper management options.

The vial with the bugs is submitted to the diagnostician for verification. He expertly works the insects through a series of diagnostic keys that enable him to determine that this is NOT a common bed bug at all but rather a close cousin called a bat bug. He determines that bats are the primary host for bat bugs and that sometimes, if bats are exterminated, the bat bugs that are left behind in the roost will begin to migrate. He sorts through what he knows about this insectâ€™s biology and behavior and logically applies it to the facts of this case. He remembers that the mother stated that her sonâ€™s bedroom was upstairs,

just below the attic. He knows that, if close to where people dwell, hungry bat bugs may disperse and sometimes find and feed on people.

The diagnostician promptly returns a telephone call to the mother. After listening to this explanation, the mother remembers that pest control came just two weeks prior to remove some bats from the attic. She had never thought to associate the bat removal with this insect problem.

Knowing where the bats were located provides a clue as to where the bat bugs were gaining entry. This entrance into the bedroom is sealed up so that no further bugs can get in, and the bugs inside the bedroom are treated with a household labeled pesticide.

The bugs are exterminated, the child is cured of his itching, the mother is at peace again and the family has saved significant costs and headaches by not treating for bed bugs.

The insect diagnostician saves the day once again and becomes a hero for the six year old boy, who now wants to grow up and become an entomologist himself. Everyone lives happily ever after.

Summary

Most land-grant universities are home for Cooperative Extension Services and employ specialists to help solve problems for the general public. Included are many professionally-trained entomologists who assist in home horticulture, vegetable and ornamental production, agriculture production and home pest management. These specialists are assisted in their duties by many county based generalists (extension agents or educators) who work to solve problems of the general public. Education requirements are usually a Ph.D. for specialists and an M.S. for county personnel.

Most people recognize that professors at colleges and universities teach courses to students. Entomologists teach a large number of classes specifically dealing with insects. These include, insect behavior, taxonomy, ecology, physiology, morphology, genetics, evolution, pest management, toxicology and other less basic classes such as insect appreciation.

Entomology professors have completed a Ph.D. in entomology where they have specialized in one or more of the subjects that they teach. They are normally hired to teach certain classes but usually have other duties as well. Many college or university employees have duties in the area of research.

Have you ever wondered who conducts the research that is relied upon by industry, agriculture or the government? Private companies may employ researchers, but more often research is contracted out to university scientists to perform. Specific scientific methods and procedures must be used to ensure truthful, reliable and repeatable results. Publishing studies in peer-reviewed journals is an expected end-result.

Professors apply for funding, called grants, from various granting agencies to conduct research that is pertinent to their field of specialization and of value to the scientific community.

Some college professors are asked to teach in other places besides just the formal college classrooms. For example, a lot of community teaching and

education is done through colleges and universities.

Some university employees work in the Cooperative Extension Service, where training of adult learners, outside of formal university classes, is done. Most often extension training is done by commodity area such as master gardener training, 4-H and youth, turfgrass, ornamentals, fruits, vegetables, field crops, urban and structural, livestock, public health, or stored product protection.

Education and training of students in entomology and related biological and agricultural sciences requires teachers trained in these fields. Academic institutions of higher learning such as universities, colleges, and community colleges educate and train other teachers. Primary and secondary educational institutions benefit from teachers who are well-versed in entomological sciences. Entomology can be part of the curriculum in many studies.

Requirements for teaching and conducting research at a university are normally a Ph.D. but many laboratory staff and assistants with a M.S. degree are employed.

Entomologists who work in academia must have a degree of specialization, an ability to think creatively, an aptitude for scientific investigation and an ability to effectively communicate.

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Insect Education and Outreach

Case Study: *It's a Zoo around Here*

Linda recently finished college, where she majored in biology with an emphasis in entomology. She just landed her dream job with a city zoo. Her new boss explained that her duties include two primary responsibilities; keeping the animals at the zoo free from insect and mite parasites, and constructing an insect exhibit featuring live insects.

Linda is fairly confident regarding the first task because of her training in veterinary entomology where she completed two courses dealing with insect parasites of vertebrates. Constructing an insect exhibit is a bit more challenging, however. Linda contacts some of the major zoos around the country to learn what insects they recommend working with and exactly what is required to obtain, rear, house and display them. From her list of responses, she selects the most interesting, unique, and colorful insects, including her favorite, a giant walking stick (Phasmidae: *Megaphasma denticrus*).

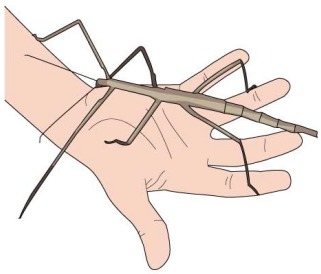
In order to raise them, however, Linda knows that she must learn much more about them. She knows that she must recreate their natural habitat and understand specific details about their biology, reproduction, and life history.

For example, she finds that fresh bramble leaves are the preferred food source for walking stick insects. She learns that the leaves must be supplied fresh and collected from areas away from pollution or road dust. Specific adjustments to their holding cages, including temperature, ventilation and humidity, are critical if the walking sticks are to thrive. Special care needs to be given when the stick insects molt, because that is one of their most vulnerable periods. Reproduction is important if the exhibit is to be self-sustaining. She now knows that a lot of work goes into creating a reproducing colony.

Linda is happy that she took a college class in insect behavior as she begins to research the specific needs of each insect she plans to house in the exhibit. She is now confident that she can complete her assignments and plans to become a respected and long-term employee of the zoo.

The recent popularity and proliferation of insect exhibits has created a demand for entomologists trained in insect husbandry, as well as interpretation and public speaking. Zoos, butterfly houses, and nature centers are all places where insect expertise is needed. Educational requirements vary across the board but

usually require, at minimum, entomology training at the B.S. or M.S. level.



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Associated Careers

Case Study: *Everybody Loves A Bugologist*

Many professions and careers tie into entomology at a smaller level. People in these positions may not consider themselves to be "practicing entomologists", but they do not deny the benefits that they have received by having had some entomological training. Health-care organizations, the many branches of agriculture, forestry, horticulture, food science, and many areas of environmental studies all practice entomology at some level.

Entomology majors often make very good biology teachers because they have the skills to incorporate insects as models into all facets of biology as well as other courses. Students with a B.S. or M.S. degree in entomology and an interest in professional medical training generally have the courses required for medical, veterinary, and dental schools.

People who work in the many areas associated with the agriculture or horticulture industry also benefit from entomological training. Questions about insects and their control are some of the most frequently asked questions to garden center personnel and nursery supply dealers. In addition, fly fishermen nearly worship entomologists who are able to assist them in creating, choosing and tying flies for their sport.

In short, because insects are recognized as such an important part of all life on earth, nearly everyone benefits from understanding insects in one way or another.

Entomology Career Development Event (CDE)

Mock CEF CDE - Rossivlle, December 11, 2015 (MockCDE.html)

Objectives:

- Develop leadership skills and practice good study habits.
- Learn about:
  - Insect damage to field crops, ornamentals, fruits, livestock, stored products, and homes.
  - Insects and public health, pesticides, and insect control methods.
- Learn to identify insects (by order, family, and common name).

Teams must qualify at an Area CDE, in order to attend the State CDE. Contact your county Extension Educator for more information.

Contest guidelines are available in the Indiana 4-H Career Development Events website, https://extension.purdue.edu/4h/Pages/CDE.aspx (https://extension.purdue.edu/4h/Pages/CDE.aspx)

Juniors

- **How to Make an Awesome Insect Collection!** (ID-401)
  - Online (http://extension.entm.purdue.edu/401Book/default.php?page=home)
  - Purchase from The Education Store, www.edustore.purdue.edu (https://www.edustore.purdue.edu/) - enter "ID-401" in the Store Search box (upper rhs)
  - App (https://itunes.apple.com/us/app/who-let-the-bugs-out/id591633063?mt=8)
- **Awesome Insect Fact n' Photo Cards (**ID-415) – available at Entomology 4-H and Youth website (http://extension.entm.purdue.edu/4hyouth/default.php?page=home) (http://extension.entm.purdue.edu/4hyouth/default.php?page=home (http://extension.entm.purdue.edu/4hyouth/default.php?page=home)).

Seniors

- The Junior resources (see above)
- **How to Make an Awesome Insect Collection!** (ID-401)
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  - App (https://itunes.apple.com/us/app/who-let-the-bugs-out/id591633063?mt=8)
- **Who Let the Bugs Out?** (ID-402)
  - Online (http://extension.entm.purdue.edu/radicalbugs/)
  - Purchase from The Education Store, www.edustore.purdue.edu (https://www.edustore.purdue.edu/) - enter "ID-402" in the Store Search box (upper rhs)
  - APP (https://itunes.apple.com/us/app/who-let-the-bugs-out/id591633063?mt=8)

Area Quizzes

- One quiz (JR & SR): 2003 (Area Quiz/2003/Questions-03.doc) (key (Area Quiz/2003/Key-03.doc)), 2004 (Area Quiz/2004/Questions-04.doc) (key (Area Quiz/2004/Key-04.doc)), 2005 (Area Quiz/2005/Questions-

05.doc) (key (Area Quiz/2005/Key-05.doc)), 2007 (Area Quiz/2007/Quiz,07.doc) (key (Area Quiz/2007/Key,07.doc))

- 2008: JR quiz (Area Quiz/2008/Entom,Jr,08.doc), JrKey (Area Quiz/2008/Entom,JrKey,08.doc), SR quiz (Area Quiz/2008/Entom,Sr,08.doc), SrKey (Area Quiz/2008/Entom,SrKey,08.doc)
- 2009: JR quiz (Area Quiz/2009/Entom,Jr,09.doc), JrKey (Area Quiz/2009/Entom,Jr,KEY,09.doc), SR quiz (Area Quiz/2009/Entom,Sr,09.doc), SrKey (Area Quiz/2009/Entom,Sr,Key,09.doc)
- 2010: JR quiz (Area Quiz/2010/Entom,Jr,10.docx), JrKey (Area Quiz/2010/Entom,Jr,Key,10.docx), SR quiz (Area Quiz/2010/Entom,SR,10.docx), SrKey (Area Quiz/2010/Entom,SR,Key,10.docx)
- 2011: JR quiz (Area Quiz/2011/JR Area Entomology Exam.docx), JrKey (Area Quiz/2011/JR AreaEntomology Exam Key.docx), SR quiz (Area Quiz/2011/SR Area Entomology Exam Key.docx), SrKey (Area Quiz/2011/SR Area Entomology Exam.docx)
- 2012: JR quiz (Area Quiz/2011/JR Area Entomology Exam.docx), JrKey (Area Quiz/2011/JR AreaEntomology Exam Key.docx), SR quiz (Area Quiz/2011/SR Area Entomology Exam Key.docx), SrKey (Area Quiz/2011/SR Area Entomology Exam.docx)
- 2014: JR quiz (Area Quiz/2014/Jr Area Entomology Exam and Key.pdf); SR quiz (Area Quiz/2014/Sr Area Entomology Exam and Key.pdf)

Other Resources:

- 4-H/FFA CDE Resource Database (http://extension.entm.purdue.edu/4h/default.php) from Purdue's Department of Entomology
- Nomenclature Question (Nomenclature Question.doc) (Why do different resources use different orders for some insects?)
- New for 2009! New 4-H and Youth website (http://extension.entm.purdue.edu/4hyouth/default.php?page=home) from Purdue's Department of Entomology - This site is designed to provide Indiana's youth with a link to all of the entomological related programs offered. These include but are not limited to information on how to identify insects, how to create insect collections, special training activities, and other links of interest to youth and their leaders. It also provides sample quizzes for the Career Development Event (CDE).
- Entomology Extension, http://extension.entm.purdue.edu/publications.php (http://extension.entm.purdue.edu/publications.php)
- Riker boxes: Bioquip (http://www.bioquip.com/default.asp) or Google "riker mounts" and several suppliers will be listed. (The ones we use are black with glass tops. They measure 4inches by 5 inches and are 3/4 inches thick.)
- Purdue Entomology Extension (http://extension.entm.purdue.edu/publications.php)
- An extensive collection of insect photographs, webpage (http://www.insectimages.org/)

Youth Development and Agricultural Education, 615 West State Street, West Lafayette, IN 47907, (765) 494-8423

Youth Related Activities

Insect Fact n' Photo Quiz Apps

Insect Fact n' Photo Apps contains information on 150 common insects encountered by beginning collectors. The photos depict one example of each of the 150 insects required in the Career Development Event (CDE) judging contest. Questions about the insect, its general biology and life cycle, and where it may be found, posed and then interactively answered and graded. Apps make these quizzes handy, fresh, and a great way to prepare for the insect judging competition.

Order bug quiz #1 here. (https://itunes.apple.com/us/app/awesome-insects/id591630368?mt=8)
Order bug quiz #2 here. (https://itunes.apple.com/us/app/who-let-the-bugs-out/id591633063?mt=8)

IPM Interactive Activity

Pest Detective Simple and fun activities to help children and adults learn to use Integrated Pest Management (IPM) to manage pests at school, home, or in the yard. Designed with children in mind, however anyone will enjoy these activities.
Click here to play! (video/pestDetective/index.html)

IPM in Schools Activity Book

The Department of Entomology at Purdue University is pleased to provide these fun integrated pest management (IPM) educational activities to help teach the most effective ways of managing pests.
Click here for a copy of the booklet (pdf/Act_book.pdf)

Recipes

Click on the book covers below to find printable recipes on how to make food look like insects as well as cooking with insects.

Make Food Look Like Insects

(cook_book/intro_without.html)

Cooking with Insects

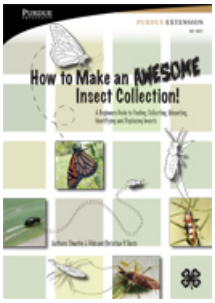
(cook_book/intro_with.html)

Butterfly House Plans

Butterfly houses have slots the perfect size to provide shelter from the wind and weather and to keep birds out. Place your butterfly house in a sunny location in your garden, away from prevailing winds. Mount it about 4 feet off the ground on a pole or tree in the garden.
Click here for Butterfly House Plans (pdf/Butterfly_House_Plans.pdf)

Publications

Recent Publications



How to Make an Awesome Insect Collection! (ID-401) is a first basic but comprehensive resource for students interested in collecting insects. It's a "must have" for beginning insect collectors in middle and high school, 4-H, and FFA. Based on an understanding of the principles of how insects live, behave, develop, and reproduce, the book teaches students how to collect, identify, and display insects. Its 200-plus pages are full of how-to illustrations, color photos, and descriptions of common insects. The book also includes a key to identifying insect orders and contains labels, card points, check lists, and many references on how to make or where to obtain essential insect collecting supplies. While there are other advanced texts about insects, this book focuses on the basics for all beginning entomologists, FFA and 4-H students interested in insect science.

Who Let the Bugs Out?

This book is designed to be a companion to the “How to Make An Awesome Insect Collection” book for beginning entomologists. It discusses the importance of insects generally and pest insects in particular. A series of photographs of many common pests is provided together with biological information to help the student recognize the insect, determine its damaging life stage, know its habitat, and predict its damage potential. Methods and strategies for employing controls are discussed with examples of each so that students gain an appreciation of the philosophy and implementation of Integrated Pest Management (IPM). click here (https://mdc.itap.purdue.edu/item.asp?Item_Number=ID-402#.VtCO3tsrLRY).

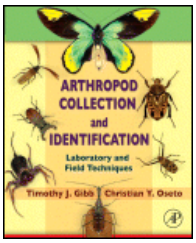
Click to enable Adobe Flash Player

Additional Publications

Arthropod Collection and Identification

Timothy J. Gibb and Christian Y. Oseto

This book describes effective methods and equipment for collecting, identifying, rearing, examining, and preserving insects and mites and for storing and caring for specimens in collection. It also provides instructions for the construction of many kinds of collecting

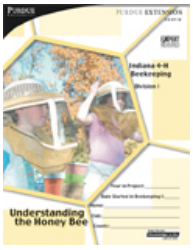


equipment, traps, rearing cages, and storage units, as well as updated and illustrated keys for identification of the classes of arthropods and the orders of insects. To purchase this book click here (http://store.elsevier.com/Arthropod-Collection-and-Identification/Timothy-Gibb/isbn-9780080919256/).

What's Buggin' You Now? Bee's Knees, Bug Lites, and Beetles *Tom Turpin*
Find out about Aesop's insects, Edgar Allan Poe's Gold Bug, and Ogden Nash's creepy crawlies. Dig up some facts on the Colorado and Japanese beetles, and cash in on the million dollar beetle. If you're in the dark, hook up with a firefly.Bugs have been around longer than your great-great grandma, 400 million years before to be somewhat exact. Insects strolled around with dinosaurs and kept on going even when the behemoths disappeared. What's Buggin' You Now? let's you catch the bug without the jar! To purchase this book click here (https://mdc.itap.purdue.edu/item.asp?Item_Number=28-5#.VtCPf9srLRY).

Entomology: Facilitators Guide
The Facilitator's Guide provides helpful information on exploring insect study, the contribution of insects to biodiversity, how to manage pests, invasive species, and forensic entomology. The Facilitator's Guide provides helpful information on exploring insect study, the contribution of insects to biodiversity, how to manage pests, invasive species, and forensic entomology. To purchase this book click here (https://mdc.itap.purdue.edu/item.asp?Item_Number=BU-8443#.VtCPnNsrLRY).

Entomology: Level 3
The Teaming with Insects curriculum is written for youth who enjoy learning about science and nature by studying insects. Level 3 delves even deeper into the basic concepts and encourages youth to take control of their learning by doing your own research using the scientific method and reference materials. To purchase this book click here (https://mdc.itap.purdue.edu/item.asp?Item_Number=BU-8442#.VtCPu9srLRY).



Indiana 4-H Beekeeping Division I: Understanding the Honey Bee
The 4-H Beekeeping Project helps youth learn about bees and how to be a beekeeper. Beekeeping offers many hand-on educational experiences, from learning about bees and honey plants to learning to raise bees and make honey. To view the pdf of this manual click here (http://extension.entm.purdue.edu/publications/4H-571.pdf).

Indiana 4-H Beekeeping Division II: Working with Honey Bees
Division II beekeeping is inteded to help youth learn many things including how to care for their own beehives, equipment that is needed, how to compile beekeeping records, and how to present the results of their work to others. To view the pdf of this manual click here

(http://extension.entm.purdue.edu/publications/4H-586.pdf).

Indiana 4-H Beekeeping Division III: Advanced Beekeeping Methods

Division III beekeeping is intended to help youth learn many things including how to increase the number of their honeybee colonies, how to increase honey production, more about bee societies, and how to compile beekeeping records. To view the pdf of this manual click here (http://extension.entm.purdue.edu/publications/4H-593.pdf).
