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Integrated Pest Management in Sensitive Environments

A How To Guide



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Nonemergency Telephone Numbers

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(800) 858-7378

Emergency Telephone Numbers

The Poison Center

For aid in human poisoning cases

(800) 222-1222

Nebraska Department of Environmental Quality

To report chemical spills or releases

After hours, weekends, and holidays

(402) 471-2186

(402) 471-4545

Nebraska State Patrol

To report motor vehicle accidents

(800) 525-5555

Find more pesticide educational information at
Pesticide Education Resources

<http://pested.unl.edu>

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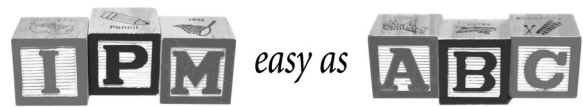
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UNL IPM in Schools Website:

<http://schoolipm.unl.edu>

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Preface



Why IPM in Sensitive Environments?

Integrated Pest Management for Sensitive Environments: A How-to Manual, replaces the *Integrated Pest Management for Schools* handbook originally adapted from the manual developed for the United States Environmental Protection Agency. The information contained in this manual applies to sensitive environments such as schools, public parks, child care centers, hospitals, retirement and nursing facilities, and homes. Sensitive environments can also include places where people or animals spend time in confined spaces, such as ships, airplanes, prisons, kennels, or zoos. IPM information in this manual also applies to home environments with residents that have health problems such as asthma, allergies, or immune system compromising diseases.

This manual is intended for school board members, facility (school, hospital, nursing homes, prison, etc.) managers/administrators, principals, teachers, child care providers, medical personnel, park or zoo managers, and parents as they work to establish IPM policies, pest control contract guidelines, and other administrative systems designed to institutionalize IPM. It also provides information for pest management personnel and others who may be involved in the day-to-day pest management in sensitive environments.

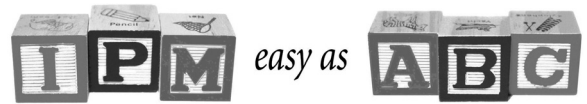
Additional copies of *Integrated Pest Management for Sensitive Environments: A How-to Manual* can be obtained from the Pesticide Safety Education Program Office, University of Nebraska–Lincoln, Extension, 377C Plant Sciences Hall, Lincoln, NE 68583-0971; telephone number: (402) 472-1632 or (800) 627-7216.

More IPM information is available at: <http://schoolipm.unl.edu>

More pesticide educational information is available at: <http://pested.unl.edu>

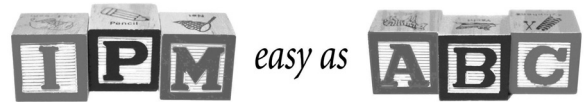
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Introduction



Pest Management Challenges in Sensitive Environments

Use of Integrated Pest Management (IPM) principles and practices in sensitive environments is a growing trend in communities throughout the United States. IPM's focus on pest prevention using effective, least-toxic methods is proving practical to apply and cost-effective to operate.

Sensitive environments, including schools, child care centers, nursing homes, prisons, hospitals, and zoos, are challenging places to operate a pest management program. Many locations are unintentionally designed with ideal entry points and harborage for pest insects, rodents, and other unwelcome wildlife. Inappropriate landscape design and plant selection often encourage weeds and other pest problems. Diminishing budgets and deferred maintenance exacerbate these predisposing conditions for pests.

Sensitive environments also include diverse physical spaces, indoors and out, that require customized solutions to pest problems. In addition, these locations host a wide variety of people, including teachers and students, vendors and community groups, patients and medical staff, prisoners, and administrators, all of which have differing opinions about pest tolerance levels and appropriate pest management methods. It is necessary to sensitively address the concerns of people and others who want a site free of nuisance or health-threatening pests but want this achieved with minimal use of toxic materials.

Since IPM is a decision-making process and not a rote method, an IPM program will always be able to take into account the wide spectrum of pest problems and the diversity of people involved. IPM methods equip pest management professionals (PMPs) and other members of the IPM team to design flexible, site-specific pest management plans scaled to the severity of the problem and the level of resources available.

The IPM approach also offers unique opportunities to incorporate pest management issues into a school science curriculum. It can offer students hands-on learning experiences in the biology, ecology, and least-toxic management of the pests that seek to inhabit school buildings and grounds.

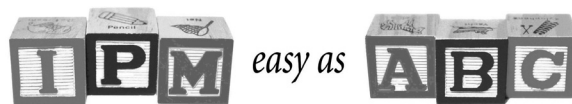
Chapters 1 through 4 provide a full discussion of IPM concepts pertaining to sensitive environments. These chapters will be of particular interest to school board members, facility (school, hospital, nursing homes, prisons, etc.) administrators, principals, teachers, child care providers, medical personnel, facility managers, park or zoo managers, and parents as they work to establish IPM policies, pest control contract guidelines, and other administrative systems designed to institutionalize IPM.

Chapter 5, "How To Develop An IPM Program," provides a step-by-step guide for implementing an IPM program and includes a discussion of the psychological and institutional barriers to IPM.

Chapters 6 through 20 cover IPM strategies for 15 of the most common pests or problem sites in Nebraska. These chapters are written primarily for pest management personnel and others who may be involved in the day-to-day pest management, but are also useful for anyone wanting to learn more about the life cycles and behavior of these pests.

Chapter 1

What Is Integrated Pest Management?



Integrated pest management (IPM) is an approach to pest control that utilizes regular monitoring and record-keeping to determine if and when treatments are needed. It employs a combination of strategies and tactics to prevent unacceptable damage or annoyance. Biological, cultural, physical, mechanical, educational, and chemical methods are used in site-specific combinations to solve the pest problem. Chemical controls are used only when needed and in the least-toxic formulation that is effective against the pest. Educational strategies are used to enhance pest prevention and to build support for the IPM program.

The Role of Pesticides in IPM

Although pesticides often have a role to play in IPM programs for sensitive environments, their use should be approached with caution. The risk of harm from exposure to pesticides is relatively higher for infants and children than for adults exposed at the same levels [see Box 1-A]. Other populations such as the infirm or elderly may also be more susceptible to pesticides. By using the least-toxic product effective against the pest and applying it as a spot treatment in combination with non-chemical methods such as pest-proofing and improved sanitation, risks from pesticide exposure can be minimized.

Box 1-A.

Special Vulnerabilities of Children to Pesticides

In 1993, the National Research Council, a committee of the National Academy of Sciences, published a report entitled *Pesticides in the Diets of Infants and Children*. This report documented that infants and children face relatively higher risks from exposure to pesticides than do adults exposed at the same levels. This is due to a number of physiological factors including the rapid growth and development of a child's central nervous system that makes this young nervous system particularly vulnerable to exposure to neurotoxins and the fact that children consume more food relative to their body weight so their actual exposure levels are often higher than those of adults. The report also points out that children can be exposed to pesticides from non-dietary sources (e.g., residues from pesticides applied in the home, school, park, etc.), and that when residues of two or more pesticides are combined, synergistic action between the compounds can significantly increase their level of toxicity.

For many years, the Environmental Protection Agency (EPA) has evaluated the safety of pesticides largely on potential risks to healthy adults, primarily males. However, in 1996, the 104th Congress unanimously passed the Food Quality Protection Act of 1996 that amends the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Food, Drug, and Cosmetic Act to require the EPA to take into account the special risks posed to infants and children (as well as pregnant women) when determining tolerance levels for pesticide residues in food. As a result, food tolerance levels are expected to drop significantly, and not all currently registered agricultural pesticides (many of which are also used in sensitive environments) will be able to meet the new criteria. How this will affect the availability of pesticides currently used in sensitive environments is not yet clear.

The term “least-toxic” refers to pesticides that have low or no acute or chronic toxicity to humans, affect a narrow range of pest species, and are formulated to be applied in a manner that limits or eliminates exposure of humans and other non-target organisms. Fortunately, there are an

increasing number of pesticides that fit within this “least-toxic” definition. Examples include products formulated as baits, pastes, or gels that do not volatilize in the air and that use very small amounts of the active ingredient pesticide, and microbial pesticides formulated from fungi,

bacteria, or viruses that are only toxic to specific pest species but harmless to humans.

IPM Program Goal

The goal of a sensitive environment IPM program is to protect human health by suppressing pests that vector diseases, to reduce losses from damage by pests, reduce environmental pollution, reduce human exposure to pesticides, particularly that of children, elderly, and the infirm, and to reduce costs of pest control. In IPM programs, treatments are not made according to a fixed schedule; they are made only when and where monitoring has indicated that the pest will cause unacceptable economic, aesthetic, or medical injury or damage.

“Economic injury” refers to damage to structures, plants, or personal property severe enough to cause an economic loss. Examples of economic injury might be loss of food due to rodent or insect contamination, or severe structural damage due to moisture accumulation and wood-destroying fungi. “Aesthetic injury” refers to annoyance or embarrassment from the visibility of a pest or damage to the appearance of plants that may reduce aesthetic appeal but does not necessarily adversely affect plant health. The tolerance levels for aesthetic injury differ: the tolerance for weeds in lawns might be much higher in a school playground than in the front lawn or entryway to the building. “Medical injury” refers to illness in humans, pets, or wildlife caused by organisms or compounds transmitted by pests. Two examples of health-threatening pests are rodents that can carry diseases and poison oak or ivy that cause painful skin rashes.

In an IPM program, if treatments are needed, they are selected and timed to be most effective on the pest, least disruptive to its natural controls, and least hazardous to humans and the environment.

Components of an IPM Program

One of the characteristics of an IPM approach that makes it so effective is that the basic decision-making process is the same for any pest problem in any location. The strategies and tactics may change, but the steps taken to decide if and when treatment is needed, and which methods to use, are the same each time. Thus, the pest manager does not need to try to remember reams of pest control “recipes” for specific pests. Instead, it is an understanding of the components of an IPM program that must be mastered. The IPM decision-making process is illustrated in Figure 1-1.

An IPM program is built around the following components:

- monitoring the pest population and other relevant factors (e.g., damage levels)
- accurate identification of the pest
- determining injury and action levels that trigger treatments
- selecting the least-disruptive tactics
- timing treatments to the best advantage
- spot treating the pest (to minimize human and other non-target organism exposure to pesticides and to contain costs)
- evaluating the effectiveness of treatments to fine-tune future actions

- educating all people involved with the pest problem

Each of these components is discussed in detail in later chapters of this manual.

The Decision-Making Process

The basic IPM process helps answer four key pest management questions, easily remembered by four words: IF, WHERE, WHEN, and WHICH.

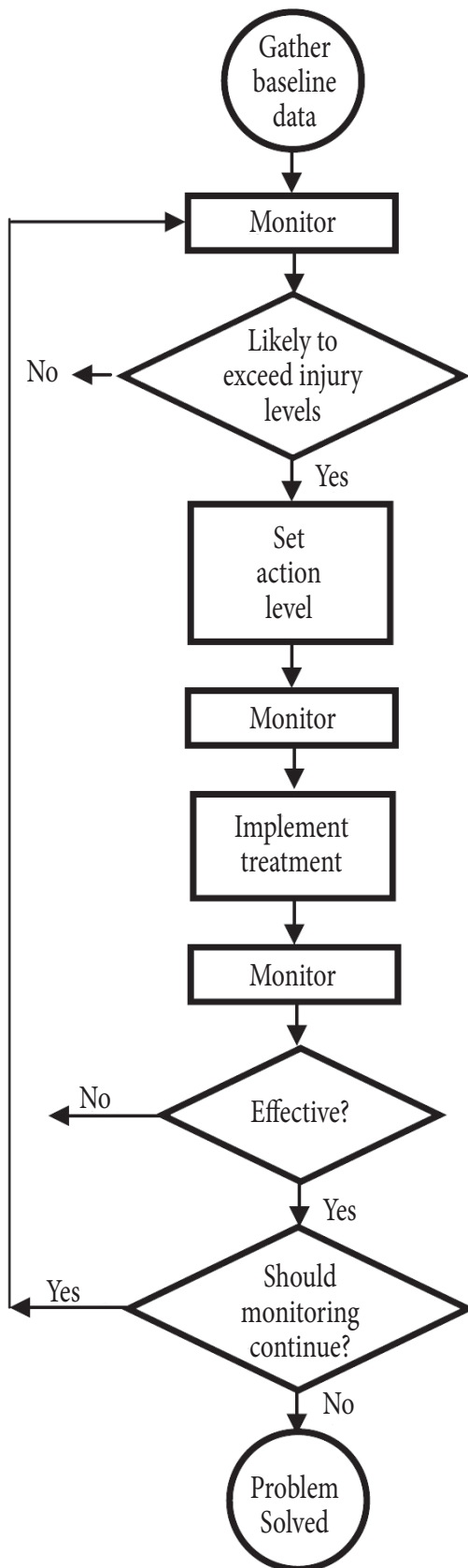
IF treatment action is necessary

Instead of taking action at the first sign of a potential pest, the IPM process begins with asking whether any actions at all are needed (see Chapter 3 for a discussion of injury and action levels). Sometimes, even a fairly large population of pests can be tolerated without causing a problem. In other cases, the presence of a single pest organism is considered intolerable. In still other cases, what is considered a pest by one group in society may be considered innocuous by another.

Example: Boxelder bugs often cluster under shrubs or on the shady side of tree trunks or enter buildings through open doors or broken window screens. The sight of them sometimes frightens people or raises fears that they will damage plants. In fact, these insects are harmless. They feed mainly on boxelder trees as well as silver maples and rarely harm even these trees since their main food source is the tree's seeds. Thus, concern about their presence is generally unwarranted.

Example: Large rodent droppings and grease trails suggest there is a rat in a crawl space under the eaves. Even one Norway rat can be a problem because it can gnaw on electric wire that can cause fires and leave fleas that can

Figure 1-1.
The IPM Decision-Making Process



transmit pathogens to humans. Treatment action is usually required even if only one rat is suspected.

WHERE treatment activity should take place

If it is decided that some treatment action is necessary, the IPM process encourages pest managers to look at the whole system for the best place to solve the problem. Treatment should be applied where actions will have the greatest effect.

Example: Although problems with mosquitoes are frequently handled by fogging buildings or yards with insecticides, it is not possible to control mosquitoes unless treatment is directed at the immature stages of the insect. Mosquito larvae develop in water (e.g., clogged gutters and drains, stagnant ponds, low-spots in playing fields, etc.). By locating such sites and eliminating them or treating them with non-toxic microbial materials to kill the larvae, mosquito problems can be solved before mosquitoes become biting adults without exposing the community to potentially hazardous pesticides.

WHEN action should take place

The timing of treatments is important. Often optimal times occur in the life cycle of the pest to apply control measures. Conversely, there may be times when treatments actually increase pest problems. The human social system will also affect the timing of treatments. A classroom in a school or child care center should not be treated during the day when children are present, for example. The IPM process encourages managers to discover the best timing for treatment actions (see “Timing Treatments” in Chapter 4) since long-term success of any treatment depends on timing and locating treatments properly.

Example of timing in the life cycle of a plant: Rose powdery mildew usually infects only succulent young growth on roses. Since mature leaves are rarely attacked, treatments are only necessary when growth spurts occur, and only new foliage requires treatment.

Example of timing in the life cycle of the pest insect: BT (Bacillus thuringiensis) is a naturally occurring bacteria developed into a commercial insecticide to control caterpillar pests. It must be applied to leaves when caterpillars are small and actively feeding for them to consume the bacteria and die. If BT is applied when caterpillars are large, they may have already stopped eating in preparation for spinning cocoons.

Example of timing in the social system: When switching to IPM, it is essential to coordinate the IPM program plan with the overall budget process of the institution. For example, improving rodent and fly management may require modifications in food storage facilities or in the disposal of kitchen garbage. Substantial repair to windows or plumbing may be needed. Requesting funds for minor construction, new containers, etc. must be done at the appropriate time in the school district's budget development process.

WHICH mix of strategies and tactics are the best to use

Three guiding principles are used to choose treatments: conserve and enhance naturally occurring biological controls; use a multi-tactic approach; and view each pest problem in its larger context.

Conserve and enhance naturally occurring biological controls

When we kill the natural enemies of pests, we inherit their work. In many cases, the combined action of all natural enemies present may

IPM Is Federal Policy

In 1979, the Council on Environmental Quality (CEQ), an advisory body President Carter, issued a report entitled Integrated Pest Management, which included recommendations that IPM be adopted as official policy in the United States. This new Federal policy was announced to the nation in the President's State of the Union address that year. It represented a significant shift in thinking about an appropriate approach to pest management for this country.

The new policy immediately influenced budget allocations and practice in Federal agencies such as the National Park Service, the Department of Agriculture, and the Environmental Protection Agency. During the following decades, state, county, and local public agencies, as well as arborists, landscapers, and nurseries began to adopt IPM as their standard. The National Park Service (NPS) was the first federal agency to adopt an IPM policy and to implement IPM programs throughout the 70 million acres of lands and facilities then maintained by NPS. Within three years after adopting IPM system wide (1981-1983), NPS reduced pesticide use by over 70 percent.

In urban settings, IPM has been used to manage insects, pathogens, weeds, and vertebrates in parks and gardens, on shade trees, in houses, apartments, office buildings, hospitals, restaurants, and at many other sites. The City of Berkeley, CA, used IPM to reduce pesticide use on trees on municipal streets by over 90 percent, saving the city \$22,500 in the first year of the IPM program.

School systems have also implemented IPM programs. Maryland's Montgomery County Public Schools have reported that their IPM program cut costs for pest control by \$6,000 in the first three years of the program, and IPM improved overall pest control by substituting monitoring, education, sanitation, physical controls, and least-toxic pesticides in place of routine use of conventional chemical controls. Similarly, schools and school districts in California, Oregon, Florida, Illinois, and elsewhere are adopting IPM and achieving a less-toxic environment for their teachers and students.

result in substantial pest control. Even when they are not able to do the complete job, natural enemies are nonetheless providing some help in protecting landscape plants from pest insects. The IPM program should be designed to avoid damaging natural enemies (see "Biological Controls" in Chapter 4 for more information).

Example: Many populations of spider mites on various trees and shrubs are kept under control by naturally occurring predatory mites. In fact, the predators keep them under such good control we many never be aware of their presence until we spray a pesticide intended to kill more obvious pests, such as aphids. For a number

of reasons, most pesticides are more harmful to the predatory mites than the pest mites. The pesticide kills almost all of the predators, the spider mites are only slightly affected, and now that they are free from their natural enemies, the pest mites quickly multiply and devastate the plant. By changing the tactics for controlling the aphids, a spider mite problem can be avoided.

Use a multi-tactic approach

Every source of pest mortality, no matter how small, is a valuable addition to the program. Biological systems are so complex that a single tactic, such as the application of a pesticide, will rarely solve the problem for long. Use as many non-toxic tactics as possible to manage the pest problem.

Example: Controlling cockroaches requires direct tactics. These tactics include the following: applying boric acid dust to cracks, crevices, and wall voids; placing baits in areas inaccessible to people and animals; using an insect-growth regulator; and releasing parasitoids for certain roach species. However, long-term cockroach control must also include habitat modification such as caulking or painting closed cracks and crevices; screening vents that may be used by cockroaches to travel between adjacent areas; and eliminating water leaks and cracks around plumbing fixtures.

View each pest problem in its larger context

Each pest problem must be considered within the framework of the larger system in which it has arisen. Textbooks and manuals commonly treat pest problems one by one. However, in the “real world” setting of a sensitive environment, pest

problems occur several at a time or in a sequence in which management of one influences the others. In addition, pest problems are influenced by other human activities such as waste disposal and food handling indoors, and mowing, fertilizing, and irrigating outdoors, as well as the attitudes of the many people who work and study within the facility.

Using IPM means taking a “whole system” or ecosystem management approach to solving a pest problem. A successful IPM program considers all of the components of an ecosystem. As biologists and ecologists use the term, an ecosystem is usually thought of as containing non-living (abiotic) and living (biotic) components. For instance, if you consider a building as an ecosystem, the abiotic components of the building would be the building itself and the equipment and furnishings within it. The biotic components would be the people, insects, spiders, etc. that live and work in the building.

In an IPM program, it is helpful to include another category—social/political components. For example, in a school system this category includes teachers, students, custodians, grounds maintenance staff, food handlers, clerical staff, health personnel, carpenters, plumbers, pest control companies, refuse collectors, and other outside service providers who might be contracted for specific work in or around the school. The school district administration and school board, school neighbors or adjacent landowners, associated public agencies or institutions, professional associations and community groups, and the general public must be included. The political and legal constraints of the society at large should also be taken into consideration.

The many components of an ecosystem can be thought of as a series of systems, each having an impact on the other, and all potentially impacted by a pest management program. To design and implement a successful IPM program, it is necessary, at least to some degree, to be aware of and obtain information from each of these components.

A classic problem in systems management is where to draw the boundary of your system. If you draw the boundaries too narrowly and include only the pest, you may miss something important like the fact that people are leaving food out at night that feeds the pest. Generally speaking, it is better to read, question, and observe as much as possible about the larger system in which the pest problem exists. Otherwise, there is a risk that the solution to the pest problem will be overlooked.

Example: A nuisance fly problem inside a nursing home may prompt the use of space sprays or pesticide-impregnated plastic strips. A less toxic quick-fix might be to purchase and install insect traps. A more long term solution would be to repair window screens and add weather-stripping around the frames to exclude flies. A still larger view might include either appropriately placing the dumpsters on the grounds or adequately cleaning them after each weekly pickup, thereby reducing the number of flies.

Changing these conditions will involve cooperation from the custodial and maintenance staff. Perhaps the dumpster needs to be moved a greater distance from the door. Perhaps more frequent removal and replacement of the dumpster may also be desirable. Undoubtedly, such actions have budgetary consequences and will involve negotiations outside

immediate personnel. Ultimately, it may be discovered that the flies are part of a community-wide problem. Perhaps little can be done about this directly, but complaints to the local municipal government may help in ultimately changing area-wide waste management practices.

At first, it may seem that there is little that a few individuals can do to influence the process of change in the larger ecosystem.

Individual sensitive environments, such as schools, nursing homes, child care centers, or hospitals, however, can assume a leadership role in educating their community about safer and more permanent methods of pest management. The education can occur indirectly through the community and directly through the participation of community forums on pest management-related matters.

IPM Policy Statement

Institutions should develop policy statements that direct how pest control will be performed. Chapter 5 contains a sample IPM pest management policy statement that can be modified to fit individual sensitive environments.

Contract Specifications for Pest Control Companies

Many facilities will find it necessary to contract out all or some of their pest management. It is important to specify in the contract that IPM will be used and to list the requirements of such a program (see next section for more information). In some areas of the country, facilities have developed requirements for pest control firms that wish to contract with

them. If pest control companies can fulfill these requirements, they can be included in a list of possible bidders from which individual institutions can choose. Such precautions prevent contracting with pest control companies that may be the lowest bidder, but may have little expertise in running an IPM program.

IPM Contract Performance Specifications*

The following gives an example of contract information that should be developed between a pest management professional (Contractor), the facility director, owner, or administrator, and the IPM Coordinator.

General Program Description

It is the intent of this contract to provide a comprehensive Integrated Pest Management (IPM) program for the property listed herein. IPM is a relatively new concept in the structural, turfgrass, and ornamentals areas. Traditional structural pest control is largely reactive to pest infestations and bases much of its response on routinely scheduled application of pesticides. Routine applications are probably unnecessary and have limited effectiveness in providing adequate long-term control.

Conversely, IPM is a decision-making process for achieving long-term pest suppression. In the IPM process, monitoring and the interpretation of data gathered provide estimates of the pest population in a given area. This monitoring allows ac-

curate decisions to be made about when intervention measures are needed, the type of control measure selected, and the method of application. Pest management practices in an IPM program extend beyond the application of pesticides to include structural, procedural, and landscape modifications. These practices establish physical barriers to pests; reduce the food, water, and harborage available to them; and establish landscape plants and designs that require less maintenance.

The Contractor shall furnish all labor, materials, and equipment to implement the monitoring, trapping, and pesticide application aspects of the IPM program. The Contractor shall also make detailed, site-specific recommendations for structural and procedural modifications to achieve pest suppression. The Contractor shall provide evidence in his/her proposal of sufficient expertise in pest management and IPM principles and practices to carry out these responsibilities effectively.

The facility should appoint an IPM Coordinator (often a head custodian, but can be a manager, child care director, or anyone who is responsible for pest management decisions in the facility), who will act as the manager of the IPM program. The IPM Coordinator's responsibilities will include overseeing and monitoring contract performance.

Pests Included and Excluded

The IPM program specified by this contract is intended to suppress the population of rats, mice, cockroaches, ants, silverfish, and any other pest included in the contract. Populations of these pests that are located outside the buildings listed herein but within

*Adapted from contract specifications prepared for the Federal Government General Services Administrator by Dr. Albert Green and colleagues.

the property boundaries of the buildings are included.

General Program Requirements

General requirements of the IPM program shall include the following for each site specified in this contract:

Initial Inspection

A thorough, initial inspection shall be conducted during the first month of this contract by the Contractor's representative, Administrator or Director or representative, and IPM Coordinator. The purpose of this initial inspection is to allow the contractor to evaluate the pest management needs of the property and to discuss these needs with the Administrator or Director and IPM Coordinator. The following specific points should be addressed:

- identification of problem areas in and around the building
- identification of structural features or personnel practices that are contributing to pest infestations
- discussion of the effectiveness of previous management efforts
- facilitation of Contractor access to all necessary areas
- informing the Contractor of any restrictions or special safety precautions, or other constraints

Submission of Plan

Following the initial inspection, the Contractor will develop a detailed Pest Management Plan and Service Schedule for each property. This written plan and schedule must be submitted to the IPM Coordinator for approval prior to initiation. The

plan and schedule must address the following:

- the structural and operational actions to inhibit pests
- the Contractor's means for monitoring pest populations in and around the building
- the proposed primary pesticides (accepted common name and generic name) and alternatives approved by the Environmental Protection Agency (EPA) and the Nebraska Department of Agriculture (NDA)
- the conditions requiring application
- the method(s) of application proposed
- the rationale for each type of use
- the proposed trapping devices for rodents, if any

Frequency of inspections, monitoring, and treatment by the Contractor shall depend on the specific pest management needs of the premises. At the minimum, inspections and monitoring shall be done monthly.

The Plan and Schedule shall be submitted not more than 10 working days following the initial inspection of the premises. The IPM Coordinator will render a decision regarding the acceptability of the Plan and Schedule within 10 working days following receipt. The Contractor shall be on site to implement the Plan and Schedule within 5 working days following notice of approval of the plan. If the Plan is disapproved, the Contractor shall have 3 working days to submit a revised Plan and Schedule.

Any subsequent changes in the Plan and Schedule must receive the concurrence of the IPM Coordinator.

The Contractor shall describe, in the proposal, the capability of meeting emergency and special service requests (e.g., radio-dispatched service, names of office personnel handling the account, availability of trucks and personnel, etc.).

Monitoring and Inspection

A critical aspect of the Pest Management Plan shall be the establishment of a monitoring and inspection program to identify infested zones and allow an objective assessment of pest population levels. Monitoring and inspection shall be continued throughout the duration of this contract. The Contractor shall describe in the proposal the approach to meet this requirement. Where appropriate, glue traps shall be employed to monitor cockroach populations in selected areas.

Pesticide Treatment

The Contractor shall not apply any pesticide which has not been specifically approved by the IPM Coordinator. In cooperation with the IPM Coordinator, the Contractor shall develop action thresholds specific to each pest and to site zones.

As a general rule, application of pesticides in any area inside or outside the premises — i.e. in any room, closet, hallway, stairwell, court, driveway, planting bed, and similar locations — shall not occur unless inspections or monitoring indicate the presence of pests that exceed action thresholds in that specific area. Signs of pest activity must be seen and identified. For instance, a relatively fresh rodent dropping or an active burrow or runway is sufficient to indicate the presence of rodents in an area. Use and effectiveness of alternative non-

chemical pest management methods must be documented in monitoring records prior to requesting the use of pesticides.

Preventive pesticide treatments of inside and outside areas where inspections indicate a potential insect or rodent infestation are generally unacceptable. In exceptional circumstances, however, preventive pesticide treatment may be allowed on a case-by-case basis. The Contractor must substantiate the need, indicating areas for preventive treatment in the Pest Management Plan for the building, and listing the preventive treatment methods of application. Each preventive treatment is subject to approval by the IPM Coordinator and can be eliminated by him/her at any time.

Structural Modifications

Structural modifications for pest suppression shall not be the responsibility of the Contractor. However, the Contractor is responsible for notifying the IPM Coordinator about structural modifications necessary to prevent access by pest populations, or for safety reasons.

Recordkeeping

The Contractor shall be responsible for maintaining a complete and accurate Pest Management Log Book. Each property specified in this contract shall have its own Log Book which will be kept in the Administrator or Director's office and maintained on each visit by the Contractor.

The Log Book shall contain the following items:

- A copy of the Pest Management Plan and Service Schedule for the property.

- A copy of the current label and EPA registration number for each pesticide used in the building, including the Material Safety Data Sheet.
- Pest monitoring data sheets which record, in a systematic fashion, the number of pests or other indicators of pest population levels revealed by the Contractor's monitoring program for the building, e.g., number and location of cockroaches trapped; number and location of rodents trapped or carcasses removed; number and location of new rat burrows observed, etc. The Contractor shall provide, in the proposal, a sample of the format for the data sheets and an explanation of all information to be recorded on them.
- The location of all traps, trapping devices, and bait stations in or around the property. This information can be in either tabular or in list format and should be accompanied by a map for each pest.
- The Administrator or Director's copies of a Pest Management Work and Inspection Report Form. These forms will be supplied to the Contractor to advise the Contractor of routine service requests and to document the performance of all work, including emergency work. Upon completion of a service visit to the building, the Contractor's representative performing the service shall complete, sign, and date the Form and return it to the Administrator or Director's office on the same or succeeding day of the performance of the service.
- The Contractor's Service Report forms, documenting arrival and departure time of the Contractor's representative performing the service, and all recordkeep-

ing information on pesticide application required by the FIFRA statute. These report forms may incorporate some or all of the pest monitoring data required above.

Special Requests and Emergency Service

The regular service shall consist of performing all components of an IPM program other than structural modifications, as described in the Contractor's detailed Plan and Schedule for each property, during the period of the contract. Occasional requests for corrective action, special services beyond the routine requests for emergency service shall be placed with the Contractor. The Contractor shall respond to requests for emergency service on the day of the request. The Contractor shall respond to special service requests within one (1) working day after receipt of request. In the event that such services cannot be completed within their time frames, the Contractor shall immediately notify the IPM Coordinator and indicate an anticipated completion date.

Specific Program Requirements and Restrictions

Personnel

The Contractor shall provide only qualified pest management personnel with adequate experience in the conduct of IPM programs. All personnel must understand current practices in this field and be able to make judgments regarding IPM techniques. Training and experience in IPM must be demonstrated.

Any proposed deletions, additions, or replacement of personnel from those cited in the Contractor's original proposal must be submitted, in writing, to the IPM Coordinator and approved prior to their becoming a part of this contract.

The Contractor must meet the following specific staff requirements:

Supervisor

A Supervisor and an alternate must be identified in the proposal. The on-site Supervisor shall have the Contractor's authority to act on matters pertaining to the performance of services required under this contract. This individual shall assure safety and carry out coordination and continuity of the program routine. The Supervisor and alternate shall both have a working knowledge of this contract and the detailed Pest Management Plan and Schedule for each building. The Supervisor and alternate must both meet the qualifications identified below under Pest Management Technicians.

Pest Management Technicians

The Contractor shall provide, in the proposal, the names of all pest management personnel assigned to this contract, and pertinent information regarding their qualifications, experience, and training. Throughout the life of this contract, all personnel providing on-site pest management services must be licensed as Commercial Pesticide Applicators in the Structural/Health related Pest Control (08) category, and the Ornamental and Turf Pest Control (04) category. No unlicensed personnel will be permitted to work on-site under this contract.

Manner and Time to Conduct Services

It shall be the Contractor's responsibility to carry out work according to the detailed Pest Management Plan and Schedule developed for each property. The Contractor's on-site Supervisor shall be responsible for coordination with the Administrator or Director or representative at the beginning of each visit. The purpose of this coordination is to review the Plan and Schedule and to receive information on problem areas needing corrective action.

Services which are not likely to adversely affect staff, resident, or student health or productivity may be performed during the regular hours of operation in the various buildings. Pesticide applications (except bait placement), however, shall not be made during normal work hours of staff. When it is necessary to perform work on weekends or outside the regularly scheduled hours set in the Contractor's Plan and Schedule, the Contractor shall notify the IPM Coordinator and the Administrator or Director at least 2 days in advance and all arrangements will be coordinated between the IPM Coordinator, the Administrator or Director, and the Supervisor.

Where service to vacated areas is required, it shall be the Contractor's responsibility to notify the IPM Coordinator and the Administrator or Director at least 2 days in advance of the treatment, provide and post all necessary signs (such as when an area may be reentered—in case of pesticide use, according to the product's label directions) and remove signs when the area is safe for entry.

The Contractor shall observe all safety precautions throughout the performance of this contract. Certain areas within some buildings may require special instructions for persons entering the building. Any restrictions associated with these special areas will be explained, in writing, to the Contractor and IPM Coordinator by the Administrator, Director or representative. These restrictions shall be adhered to and incorporated into the Contractor's detailed Plan and Schedule for the property.

All Contractor personnel, working in or on properties designated under this contract, shall wear distinctive uniform clothing. The uniform shall have the Contractor's name easily identifiable, affixed thereon in a permanent or semi-permanent manner. Additional personal protective equipment required for the safe performance of work must be determined and provided by the Contractor. Protective clothing, equipment, and devices shall as a minimum, conform to Occupational Safety and Health Administration (OSHA) standards for the products being used. Vehicles used by the Contractor must be identified in accordance with State and local regulations.

Pesticide Products and Use

The Contractor shall be responsible for the proper use of pesticides. All pesticides used by the Contractor must be registered with the EPA and State and/or local jurisdiction. Transport, handling, and use of all pesticides shall be in strict accordance with the manufacturer's label instructions and all applicable Federal, State, and local laws and regulations. The Contractor will follow all notification and warning procedures required

by the IPM Coordinator prior to the application of a pesticide. The environment and the public shall be protected at all times.

The Contractor shall minimize the use of synthetic organic pesticides wherever possible. Alternatives are:

- The use of crack and crevice application of pesticide to pest harborage areas rather than fan spraying exposed surfaces in the general vicinity of harborage areas.
- The use of containerized bait, for cockroaches, rather than sprays, wherever appropriate.

Pesticide fogs and sprays (including mists and ultra-low volume applications) will be restricted to unique situations where no alternative measures are available or practical.

In the unusual event that a space spray application is required, and prior to performing a space spray treatment, the Contractor shall submit a written request for approval to the IPM Coordinator at least 2 days prior to the proposed treatment time. The request must identify the target pest, document the need for such treatment, the time (when site is not occupied) and specific place(s) of treatment, the pesticide(s) to be used, the method of application, what precautions should be taken to ensure tenant and employee safety, and the steps to be taken to ensure the containment of the spray to the site of application. No space application of pesticides shall be made without the written approval of the IPM Coordinator. No space application of pesticide shall be made while tenant personnel are present. Products identifiable as fumigants shall be considered inappropriate for use and shall not be used in any space for any

purpose unless it determined that an emergency exists by the IPM Coordinator.

Rodent Control

Snap traps and trapping devices (including glueboards) used in rodent control must be checked daily. The Contractor shall dispose of rodents killed or trapped within 24 hours. Trapping shall not be performed during periods when maintenance will be delayed by holidays, weekends, etc. Traps shall be placed out of the general view and located so as not to be affected by routine cleaning procedures.

All rodenticides, regardless of packaging, shall be placed either in locations not accessible to children, pets, wildlife, and domestic animals, or in EPA-approved tamper-resistant (often termed “tamper-proof”) bait boxes. Frequency of bait box servicing shall depend upon the level of rodent infestation. All bait boxes shall be labeled, and dated at the time of installation and each servicing. All bait boxes shall be maintained in accordance with EPA regulations with an emphasis on the safety of non-target organisms. The following points shall be strictly adhered to:

- The lids of all bait boxes must be securely locked or fastened shut.
- Bait must always be placed in the baffle-protected feeding chamber of the box and never in the runway of the box. Bait may be placed inside an active rodent burrow if the burrow entrance (and the bait) is then buried or caved-in to avoid non-target access to the bait.
- All bait boxes must be securely attached or anchored to the floor, ground, wall, etc. so that the box cannot be picked up or moved.

- Baits, bait boxes, and stations should only be considered as a last option for use inside structures.

All traps, trapping devices, and bait boxes shall be accounted for, and their location recorded in the property Log Book; all shall be removed from the premises covered by this contract at its conclusion.

Inspection

Throughout the duration of this contract, the premises covered will be inspected periodically by the IPM Coordinator to determine the effectiveness of the program and Contractor compliance with the contract. Inspection results will be documented in writing. The Contractor shall promptly initiate actions within 5 working days to correct all contract performance deficiencies found by the IPM Coordinator.

It shall be the Contractor’s responsibility to furnish an adequate supply of materials necessary to inspect the interior of all rodent bait stations. These materials may include wrenches to loosen and tighten fasteners, keys to open locks, or replacement self-locking plastic ties. Implements to cut plastic ties or seals are not included under this provision.

Related Services

The facility reserves the right to negotiate with the Contractor for the purpose of related pest control services not specifically covered herein, such as subterranean and structural management of termites and other wood-boring insects, or bird control, and to add (or delete) properties or parts of properties to the contract.

Bid Submittal

Pre-Bid Building Inspection

All prospective bidders shall conduct a thorough and complete investigation of each property prior to submitting their proposal.

Selection for Award

Bidders should be aware that the facility will perform a “best-buy analysis” and the selection for award shall be made to the bidder whose proposal is most advantageous to the sensitive environment, taking into consideration the technical factors listed below and the total proposed cost across all contract periods.

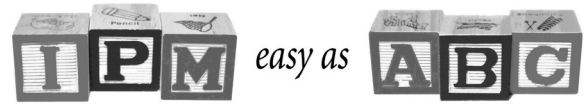
Technical Evaluation Criteria

The technical portion of the proposal will be the most important consideration in making the award; therefore, the proposal should be as complete and as specific as possible.

The merits of each proposal will be carefully evaluated in terms of the requirements and in relation to the criteria established below. The evaluation will take into consideration the technical and administrative capabilities of the bidders in relation to the needs of the program and reasonableness of costs shown in relation to the work to be done.

Chapter 2

Monitoring and Inspecting



Monitoring is the backbone of an IPM program. The purpose of monitoring is to supply recent, accurate information with which you can make appropriate decisions for managing pests in your school. By appropriate we mean informed, intelligent, pest management decisions that “fit” your particular situation. What is appropriate for you will depend on the injury levels you choose to adopt (see Chapter 3), the management techniques you wish to use, and the results you hope to achieve.

Since IPM was developed for agriculture, the original concept of monitoring was applied to agricultural crops and their pests. Over the years, this concept has been adapted for gathering information on pests of urban plants and human structures. In the loosest sense, we also speak of “monitoring” pests of the human body, such as lice; however, in this context monitoring is reduced to simply looking for the pest before initiating treatment. In most situations encountered in urban sensitive environments, monitoring the plants and the structures will be a bit more complex.

This chapter provides a general overview of how to set up and operate a monitoring program. More detailed discussions on monitoring techniques for individual pests are provided in *Chapters 6 through 20*.

Not Enough Time or Money?

Obviously, time and especially money will constrain what you will be able to do realistically. The most important thing is to go out, look at the problems, and write down what you see. To ensure that this job will get done, you may need to figure out how monitoring can be included along with routine maintenance activities. Make sure that personnel who are asked to monitor understand what to look for and how to record the information. Have them carry easy-to-use monitoring forms whenever they go out. An example of a monitoring form for the placement of cockroach traps in a commercial kitchen is provided at the end of this chapter. Data from this form is transferred to a simple computerized spreadsheet after each monitoring session in order to facilitate treatment decisions. If the institution is contracting out its pest control services, give the pest control company a copy of this form to use or have them develop their own forms subject to the approval of the institution.

Levels of Effort Used in Monitoring

Monitoring need not be time consuming. The idea is to match the level of monitoring effort to the importance of the problem. Monitoring can vary from the extremely casual to the statistically strict, depending on the

seriousness of the problem. The levels of effort, listed from casual to strict, are as follows:

1. Hearsay or reports from other people’s casual looking (not particularly helpful)
2. Casual looking with no record keeping (not particularly helpful)
3. Casual looking with written observations (useful for sensitive environments)
4. Careful inspection with written observations (useful for sensitive environments)
5. Regular written observations and quantitative descriptions (useful for sensitive environments)
6. Quantitative sampling on a regular basis (appropriate for research projects)
7. Statistically valid quantitative samples (appropriate for research projects)

What is Monitoring?

Monitoring is the **regular** and **ongoing** inspection of areas where pest problems do or might occur. Information gathered from these inspections is always written down.

Why Monitor?

A monitoring program helps you become familiar with the workings of the target system. This knowledge

allows you to anticipate conditions that can trigger pest problems and thus prevent them from occurring or catch them before they become serious. Monitoring enables you to make intelligent decisions about treatments.

Monitoring helps determine if treatment is needed.

- Is the pest population getting larger or smaller? If you are monitoring plants, is the natural enemy population getting larger or smaller? These questions affect whether or not you need to treat, and you can get the answers only by inspecting the problem sites on several different occasions.
- How many pests or how much pest damage can be tolerated? This is also referred to as setting injury and action levels, which is discussed in detail in Chapter 3.
- Even when tolerance for pest presence is at or near zero, as in the case of rats, monitoring will result in early pest detection, reducing the likelihood of unexpected pest outbreaks.

Monitoring helps determine where, when, and what kind of treatments are needed.

- This includes preventive treatments such as pest-proofing and sanitation. Monitoring will tell you where these are most needed.
- It is unnecessary (and expensive) to treat all parts of a building or all plants on the grounds for a pest when all areas may not be equally infested. Monitoring will pinpoint infestations and problem areas.
- On plants, monitoring will help you time treatments to target the most vulnerable stage of the pest.

The vulnerable stage may change depending on the type of treatment used.

Monitoring allows you to evaluate and fine-tune treatments.

Monitoring after a treatment will show you the success or failure of that treatment.

- Did the treatment reduce the number of pests below the level that causes intolerable damage?
- How long did the effect last?
- Did you have to repeat the treatments?
- Were there undesirable side effects?
- Do you need to make adjustments to your treatment plan?

What to Monitor

Monitoring plants and their pests includes the regular observation and recording of

- the condition of the plants (their vigor and appearance)
- the kind and abundance of pests (insects, mites, moles, weeds, etc.) as well as natural enemies (ladybugs, spiders, lacewing larvae, syrphid fly larvae, etc.)
- the amount of plant damage
- weather conditions (record any unusually dry, hot, wet, or cold weather in the last few weeks)
- human behaviors that affect the plants or pests (foot traffic that compacts the soil, physical damage to plants caused by people, insistence on having certain plants grow in inappropriate situations, etc.)

- your management activities (pruning, fertilizing, mulching, treating pests, etc.) and their effects on the plants and the pest population

Tables 2-1 and 2-2 provide more information to help you quantify the first three points, above. Using the four abundance ratings in Table 2-2 will make monitoring faster and easier and will help to standardize observations. If you get to a point where you need more precision in your data, you can count the number of pests or their signs in a given area or on a certain number of leaves. Table 2-3 provides information on appropriate monitoring tools.

Monitoring structures involves the regular observation and recording of

- the conditions of the building inside and out (structural deterioration, holes that allow pests to enter, conditions that provide pest harborage)
- the level of sanitation inside and out (waste disposal procedures, level of cleanliness inside and out, conditions that supply food to pests)
- the amount of pest damage and the number and location of pest signs (rodent droppings, termite shelter tubes, cockroaches caught in traps, etc.)
- human behaviors that affect the pests (working conditions that make it impossible to close doors or screens, food preparation procedures that provide food for pests, etc.)
- your management activities (caulking, cleaning, setting out traps, treating pests, etc.) and their effects on the pest population

Table 2-1. Plant Condition Rating*

PLANT CONDITION	INDICATORS OF PLANT CONDITION			
	Leaf Color	Amount/Size of Growth	Damaged Plant Parts	Presence of Pest Problems
EXCELLENT	Good	Adequate	None to few	No major ones
GOOD	Good	Slightly reduced	Few to common	A few minor ones
FAIR	Poor	Much reduced	Common to abundant	Either major or minor ones occurring frequently
POOR	Poor	Severely reduced	Innumerable	Both major and minor ones occurring frequently

Leaf Color: Note that there are healthy plants that do not have bright green leaves. Leaves can be purple, yellow, or sometimes a mottled yellow and green (variegated). “Good” leaf color will not always be the same; it will depend on the kind of plant.

Amount/Size of Growth: This refers to the length of the new growth for the season as well as the number of new leaves and the size of the leaves, flowers, or fruit.

Damaged Plant Parts: Look at the whole plant. Are there leaves with holes, spots, or discolorations? Are there wilted or dead leaves? Are there dead twigs or branches? Is the damage only on old leaves while new leaves look perfectly healthy?

Presence of Pest Problems: A major pest problem is one that has seriously affected or injured the plant and requires management. A minor pest problem may or may not have affected or injured the plant and may or may not require management.

*Adapted from Michigan State University 1980

Table 2-2. Pest and Plant Damage Abundance Rating*

Abundance Rating	Indicators of Abundance
Few	Organisms or plant damage occasionally found but only after much searching
Common	Organisms or plant damage easily found during typical searching
Abundant	Organisms or plant damage found in large numbers-obvious without searching
Innumerable	Organisms or plant damage extremely numerous-obvious without searching

*Adapted from Michigan State University 1980

Table 2-3 provides specific information on monitoring tools for both plants and structures.

Table 2-3. Tools Used in Monitoring

TOOLS	PLANTS	STRUCTURES
<i>Monitoring forms</i> — use these to write down what you see	X	X
<i>Maps or site plans of the buildings or grounds</i> — use these to mark where you find pests and where you put traps	X	X
<i>Clipboard</i> — use this to hold your monitoring forms and maps	X	X
<i>Flashlight with a halogen bulb</i> — use this to detect nighttime pest activity. A black light feature is also useful for detecting rodent urine.	X	X (for viewing areas under counters, in closets, etc. during the day)
<i>Sticky traps</i> — use these to monitor a variety of insects and spiders (for many insects the color of the trap is important, e.g., thrips are attracted to blue; whiteflies prefer yellow). <i>Snap traps</i> — use these to monitor and trap rodents.	X	X (snap traps monitoring rodents, roach motels, sticky traps)
<i>Hand lens</i> — This is a small magnifying glass. Use this to help you see mites and small insects. A lens that magnifies things at least 10 times (=10x) is usually adequate. A 15x lens can be used to distinguish among various mite species and other similarly small pest organisms such as thrips.	X	X
<i>Plastic bags or small vials</i> — use these to hold specimens for later examination or identification.	X	X
<i>Small knife or screwdriver</i>	X (use to dig up weeds for specimens or for control)	X (use to probe damaged wood, extract insect droppings from wood, etc.)
<i>Ladder</i>	X	X
<i>Camera</i> — use this for documenting pest damage to plants or structures before and after IPM methods have been applied.	X	X

Inspecting for Structural Decay and Pest Damage

Before monitoring for pests, it is wise to inspect the condition of the structure it self.

Check the following locations for structural decay and pest damage. Check both visually and by probing with a pointed tool, such as an ice pick or screwdriver. Look for signs of moisture, damaged wood, insect frass, and termite earthen tunnels. These signs may indicate underlying problems that will need correction.

Roofs, Overhangs, Gutters, Eaves, Trim, Attic

Roof Surface

Check the roof for cracks, missing shingles, and other openings where moisture might enter. Shingles should extend 3/4 inch or more beyond the edge of the roof and should form a continuous drip line at the eave and end rafters or at the rake boards that cover the end rafters.

Remove leaves from the roof surface and replace any missing shingles. Install flashing or an aluminum drip edge under the first course of shingles to divert rainwater from the fascia board and walls of the building.

Be careful not to block eave vents. Install flashing; it should curl over the forward edge of the fascia board about 2 inches and then run about 6 inches beyond a vertical line drawn from the inside face of the wall studs.

Check for the formation of masses of ice on the roof near the gutters that can lead to water filtration and/or excessive condensation on interior attic walls.

Gutters

Check for poorly sloped, clogged, rotted, or leaking gutters that can lead to eave, overhang, or siding leaks and rots. Remove leaves and twigs that absorb moisture and cause rot. Flush gutters with a hose prior to the

rainy season. Install downspout leaf strainers and gutter guards.

Attics

Extra effort is needed to inspect areas difficult to see or reach. Use a good light source and a probe. Search for rain seepage or decay around vent pipes, antennas, wall top plates, skylights, and other vents.

Eaves, Overhangs, and Fascia Boards

Make sure there are at least 18 inches of overhang to allow proper water runoff. Extend short overhangs. Search for soft, tunneled, cracked, or exposed areas. Check areas where algae, moss, lichens, or discoloration occurs; these symptoms may indicate moisture problems and termites.

Flashings

Make sure areas around vents, chimneys, and dormers are flush and sealed well. Rusty or broken nails can cause problems in flashings. Aluminum or galvanized nails are required to prevent electrolysis (a chemical reaction between dissimilar metals that causes the nails to disintegrate). Seal nail head and flashing joints with marine-quality caulk or silicone (tar preparations are cheapest, but they crack after a few years in the sun).

Damaged or discolored areas

Search for exposed areas that are soft, tunneled, cracked, rotted, or blis-

tered. Check for algae, moss, lichens, or discoloration since these areas indicate potential openings for fungi and/or insects. Locate the sources of moisture and make the necessary repairs.

Outside Walls

Rusty Nails

Check for rusty nails or nail-staining, which indicates moisture within the wall and/or the use of non-galvanized nails. Replace nails with aluminum or galvanized nails or screws.

Deteriorating Paint

Look for signs of deteriorating paint such as loss of paint sheen and bubbling and peeling; scrape and sand the surface and repaint. If the wood seems soft, weak, or spongy, scrape out the spongy parts. If holes are smaller than 1/2 inch in diameter, fill them with caulk. Larger holes can be filled with epoxy wood-filler. If holes are very large, replace the wood.

Stained or Buckled Building Siding

Stained or buckled siding (with or without peeling paint) is a symptom of underlying moisture, rot, or insects. Check for moisture caused by splashing rain or lawn sprinklers. If possible, remove the source of the moisture and refinish or replace the damaged wood. Consider using

a more durable material, such as aluminum siding or pressure-treated woods.

Damaged Wood Junctions

Moisture and insect problems often occur where wood pieces join or abut, particularly when there is shrinkage, splintering, or settling. Corners, edges of walls, roof-siding intersections, and siding-chimney contacts are particularly vulnerable. Apply water repellent and caulk to these joints, and monitor them regularly for building movement.

Weathering of Exposed Lumber/Beam Ends

Check for expanded, split, or cracked lumber ends that provide access for moisture and insects. Even previously treated wood is subject to attack if the openings are deep enough. Caulk cracks and monitor for further developments.

Loose Stucco or Cracks in Stucco

Search for cracks, especially stress cracks around windows and doors. These conditions can provide access to moisture and decay organisms. Caulk cracks. If they are large, consider replacing the old stucco.

Moisture Accumulation around Laundry Facilities, Especially Dryer Vents

Check for signs of moisture accumulation around the vent. Modify the vent to direct exhaust air away from the building.

Moisture Associated with Pipes and Ducts

Check for moisture where ducts pass through wooden parts of a build-

ing. Also check downspouts during heavy rains for leakage and proper drainage. Insulate ducts, install splash guards below downspouts, repair the spouts, and direct water away from buildings.

Moist Window Sills, Windows, or Doors

Check for cracked sills and casings, and poorly fitted windows and doors. Badly fitted doors may indicate warping of the door or its casing from excessive moisture or uneven settling. Moisture problems can alter doorjambs. Warped and cracked sills and poorly fitted windows and doors allow water access that aids decay and provides initial insect habitat.

Caulk cracks and monitor for further development. Warped door thresholds and jambs may need replacement, and casings may need repair if the cracks are too large to caulk effectively.

Foundation and Grade

Soil Surface

Make sure the soil surface slopes away from the school building in order to carry water away from the foundation. Seepage under the foundation will cause it to crack and settle. Add fill to direct the water away from the building but make sure there is at least 8 inches between the top of the fill and the sill. If clearance is small, consider installing foundation “gutters.” Install splash blocks and perforated pipe. Check their performance during rains or test the system with a hose. A sump pump can also be used to move water away from the foundation.

Low Foundation Walls and Footings Allowing Wood-to-Soil Contacts

Check for wood in contact with the soil. Wood should be at least 8 inches, and preferably more, above the soil surface. Low foundation walls or footings often permit wooden structural members to come in contact with the soil, providing access for subterranean termites. Repair these areas or install sub grade concrete “gutters” where the building sills sit too close to ground level. Remove wood that comes in contact with the soil and replace it with concrete.

Foundation Cracks

Check for cracks that allow decay organisms access to wood. Cracking may also indicate uneven settling. Monitor cracked walls for discoloration and seepage during rains. Termites use cracks to gain access to wood hidden from view. If the problem is serious, the foundation may need repair.

Brick Veneer or Stucco Applied to the Foundation

Check the bond between the veneer or stucco and the foundation wall. If it is failing, moisture and termites may have a hidden entrance to wooden portions of the building. Remove the loose covering and explore the extent of the decay.

Crawl Space, Basement, and Foundation

Make sure enclosed crawl spaces are vented to allow moist air to escape. Nebraska’s climate makes unvented crawl spaces vulnerable to dry-rot fungus. Shrubbery or other obstacles that block airflow through foundation

vents can cause air underneath the building to stay warm and moist — an ideal environment for termites.

Clean existing vents of dust, plants, and debris. Foundation vent openings should equal 2 ft² of opening for each 25 linear feet of outside wall. An opening should occur within 5 feet of each corner. Add more vents if needed. The top edge of the concrete under all vents should be at least 6 inches above the finished grade to allow sufficient ventilation. Vents located below grade may require wells to prevent surface water from entering sub floor and basement areas. Divert roof drainage away from vents.

Corners of the Building

Check for moisture accumulation and stains at junctions of wood surfaces in these areas. Install additional cellar or crawl space vents.

Enclosed Areas

Check for proper ventilation under staircases, porches, and other enclosed areas, since these are vulnerable to moisture accumulation. Look for decayed, discolored, or stained areas. Adjust or add venting.

Vapor Barriers

Check for condensation on the sub floor and/or sill, which may indicate the need for vapor barriers on the sub floor and on the soil surface in the crawl space. Such barriers can be installed to reduce the moisture resulting from poor soil grading, unexpected seepage, or high rainfall.

Cover the crawl space soil surface with a 6-mil polyethylene vapor barrier. Use polyethylene, not roofing paper, which can rot. A slurry of concrete can be placed over the plas-



Figure 2-1. Inspect basements for signs of cracks or moisture.

tic to protect it from rodents. Where condensation continues, consider installing extra vents or electric-powered vents whose fans and openings are operated automatically. A sump pump can be installed to remove standing water.

Wood-to-Stone or Wood-to-Concrete Contacts

Check to see whether the wood is pressure-treated (look for perforation marks from the chemical injection on the surface of the wood). Replace untreated wood with rot-resistant or pressure-treated wood. Be sure sealing material is used between the wood and stone or concrete, and place a metal washer between posts and footings.

Leaky Pipes or Faucets

Even small leaks keep the wood or soil underneath continuously moist, thereby setting up ideal conditions for termites. Areas where rain splashes on walls should be protected with rain guards. Do not allow sprinklers to spray the side of the building. Fix all leaks, and change irrigation practices where necessary.

Water- or Space-Heating Units

Check to see whether the heating unit is insulated. If the soil near the flame is kept warm throughout the year due to lack of insulation, microbial and insect development will be accelerated. Insulate the heater and cover the soil with concrete.

Paper Collars around Pipes

Since paper is almost pure cellulose, it is extremely attractive to termites and should be removed and replaced with other insulating materials not capable of being eaten by termites.

Miscellaneous Openings

Meter boxes, bathroom inspection doors, pet doors or openings, milk delivery doors, and air exhaust vents should be checked for water access, cracks, and soft areas.

External Areas

Porches

Check for wooden steps touching the soil, and inspect for possible decay or termite access. The porch surface

Photo: Barbara Ogg

must slope away from the building to carry rain away quickly. If the porch does not slope away from the building, check siding for moisture and termites. Tongue-and-groove flooring is a water trap. If there is a space between the porch and the building, check for drainage problems.

Caulk and repair cracks. Fill spaces between tongue-and-groove floorboards with caulk or resurface and refinish with wood-sealing compounds and appropriate paint. Another floor can be placed over the first.

Earth-Filled Porches

Soil should be at least 8 inches, (optimally 12 to 18 inches) below the level of any wood. Remove the excess soil where possible, regrade to enhance drainage, and redesign the porch to eliminate earth/wood contact.

Planter Boxes

Check planter boxes that are built against the building. If they are in direct contact with the building, they allow direct termite access to unprotected veneer, siding, or cracked stucco. One remedy is adding 2 to 3 inches of protective concrete wall between the planter and the building. An air space several inches wide must separate the planter wall from the building and must be kept free of dirt or other debris.

Trellises and Fences

Check for wooden portions of the trellis that touch the soil and are connected to the building since they provide a direct link to the building for wood-rot and termites. Check fence stringers and posts for decay. Cut off the decay and install a concrete footing for trellises and fence posts.

Replace decayed stringers and leave a small gap between the stringers to allow air circulation.

Wooden Forms around Drains

These are sometimes left in place after the concrete foundation is poured and provide termites with access routes to inner walls. Areas and joints around pipes rising from slabs should be sealed with tar or other adhesive to prevent water and termite access. Caulk the holes and monitor them for decay and excess moisture.

Gate Posts, Fence Tie-ins, Abutments and Columns

Inspect these for weakness and rot especially around areas adjacent to the soil. Exposed areas can provide cracks for termite invasion. If wooden posts go through concrete into the soil below, check the posts for evidence of termite attack. The bottoms of these posts should be cut and replaced with a concrete footing. Cut post tops at an angle to promote runoff and prevent water from penetrating the vulnerable end grain.

Balconies and Landings

Surfaces should be sloped away from the building. Check junction of floor and siding for moisture and insects.

Wood Debris under and around Buildings

Pieces of wood, particularly partially buried tree roots or construction lumber, can help support a termite colony. Since cardboard boxes are very attractive to termites, they should be removed from crawl spaces or basements with earthen floors.

Interior Locations

Areas with water stains or mold growth indicate excessive moisture and should be analyzed for corrective action. Pay special attention to areas listed below.

Kitchen Pipes

Look for condensation and leaks, especially where pipes enter walls. Repair leaks and insulate pipes where condensation is excessive.

Counter Areas

Check around and below sink surfaces for moisture and decay. Caulk or otherwise protect wall surfaces from moisture. Subsurface areas damaged by water leaking from above may be tolerated if the surface leaks are repaired.

Exhaust Vents

Check for moisture leaks from outside. Repair with caulk or water-resistant sealing material or replace the vent and the rotted wood around it. Use extra flashing to fill the gap.

Toilets

Check the integrity of the floor around each toilet base by thumping lightly with a hammer. Check the wax seal for leakage at the floor/toilet pedestal intersection. Check the cellar or crawl space beneath the toilets to see whether the leakage has caused damage. Replace the wax seal if necessary and repair the surrounding water damage.

Showers and Sinks

Check all sinks and showers for a sound caulk seal. Look for splash-over on the floors from inadequate water barriers or user carelessness. If

moisture is visible from crawl spaces, it may indicate a crack in the floor or in drainage pipes. If moisture is visible in the ceiling, it may indicate cracks in the delivery pipes.

Repair or replace flooring materials, pipes, drains, or sink basins if necessary. Sealing compounds may be useful when leaks are relatively recent and small, especially if termites have not been found; however, regular monitoring is necessary if sealing materials are used.

Tile Walls

Check for mildew stains. Make sure the grout in tile walls has a silicone coating to prevent water penetration. Clean the walls regularly to remove mildew and improve ventilation.

Ceilings

Check for blistered areas since these can indicate moisture leaks in the area above or inadequate installation of a vapor barrier. Repair leaks and faulty vapor barriers.

Windows

Check for moisture accumulation and/or water stains on window frames and walls. Search for evidence of decay or insect attack next to glass areas where condensation accumulates, at edges where moldings meet walls and casings, and in window channels and door jams. Gaps between window and door casings may be avenues for hidden moisture and insect access. Check interior walls beneath windows, especially if they are regularly wetted by garden sprinklers.

Open windows when feasible to improve air circulation. Install double- or triple-glazed windows when replacement is necessary. Use aluminum frames if wooden frames are decaying. Adjust or move sprinklers so water does not hit windows.

Closets

Check coat and storage closets for dampness. A light bulb left burning continuously in a damp closet will often generate enough heat to dry it out but make sure the bulb is far enough away from stored materials to avoid creating a fire hazard. Containers of highly absorbent silica gel, activated alumina, or calcium chloride also remove moisture from the air in enclosed spaces. These agents should be placed out-of-reach to avoid accidental exposures. Avoid use of silica gel where children may tamper with the containers. These chemicals can be reused after drying them in the oven. Small exhaust fans can also improve closet ventilation.

Floors

Sagging or buckling floors can indicate shrinkage or rot from excessive condensation or water leaks. Gaps between floor and baseboards can indicate wood damage from insects, fungi, or water-triggered swelling and shrinkage.



Photo: Erin Bauer

Figure 2-2. Check floors for sagging or gaps that indicate moisture problems.

Identifying the Target Pest

It is extremely important to correctly identify the pest that is causing problems. You cannot manage a pest effectively without knowing what it is. For instance, putting out mouse traps to control what is really a rat problem can only result in failure. If you are uncertain of the identity of your pest, take a specimen to a professional for identification or see the section on “*How to Collect and Preserve Specimens for Identification*.” Once the pest is identified, read about its life cycle, food sources, habitat preferences, and natural enemies. Chapter 6 through 20 will cover some of the most common pests found in and around sensitive environments. If only damage signs and not the pest itself are visible, a sleuthing job is in order. More observation or observation at a different time of day may be necessary. You can also talk to pest management professionals, local gardeners, nursery personnel, Extension staff, or university researchers.

How to Collect and Preserve Specimens for Identification

The University of Nebraska–Lincoln (UNL) Extension personnel will, for the most part, be able to confirm your identification. This can sometimes be done over the phone just from your description of the organism and/or the damage it caused; however, sometimes they must inspect the specimen directly.

Collecting Insects and Mites for Identification

Whenever possible, ask UNL Extension how they would like the specimens preserved, and try to collect more than a single specimen. If you aren't able to ask about preservation before you collect, the following are good guidelines.

Larger insects (those larger than aphids) or insects with hard bodies should be placed in an appropriately sized plastic container, such as a pill bottle. Do not use the original cap; instead, stopper the bottle tightly with cotton. (Be careful not to crush the insect with the wad of cotton.) The cotton prevents moisture from accumulating inside the container and encouraging mold that can destroy important characteristics needed for identification. If the captured insects are still alive inside the bottle, place the container

in the freezer for a day to kill them. If you are mailing the specimen to someone for identification, you must make sure the insects are dead. It is not a good idea to send live insects because they may escape and cause a pest problem where you are sending them. To mail the bottle, gently push the cotton wad down almost to the bottom of the bottle to prevent the insects from rattling around and losing body parts, then place the bottle in a box stuffed with crumpled newspaper.

Smaller organisms or organisms with soft bodies, such as aphids or mites, can be picked up with a paint brush and dropped into a small amount of rubbing alcohol in a container. In a dry container they might escape by tunneling around the cotton stopper or become entangled in the cotton, which can impair identification. Alternatively, insects and mites, even soft-bodied species such as aphids, can be left to dry out in a container and the identification specialist can rehydrate them for study later.

Collecting Plant Specimens for Identification

If you want to have a damaged plant inspected or a weed identified, place the plant and a moist paper towel

inside a plastic bag. If you are unable to deliver the specimen in person, place the bag inside a padded mailing envelope. If you cannot mail the specimen immediately, however, it is likely to shrivel or mold. In that case, use the process outlined below.

Preserving a Plant Specimen

Plants preserved in this manner can also be kept in a file for future reference regarding weeds, pest damage symptoms, etc.

Find a stiff index card or piece of white poster board large enough for the specimen, then cut a piece of clear contact paper that overlaps the card 3/4 inch on all sides. A sheet of aluminum foil spread over the work surface will prevent the contact paper from sticking in the wrong place. Separate the backing from the contact paper and lay the paper over the plant, pressing out air bubbles by moving your hand from the bottom to the top.

Cut off the corners of the contact paper and then fold the paper over the back of the card. Write the name of the weed (if known), the date, and the location where it was collected on the back.

Timing Monitoring Activities

Timing and frequency of monitoring differs depending on the site and the pest(s). Outdoors, monitoring usually begins when plants put out new leaves in spring and ends when leaves fall in autumn. Plants with annually recurring pest problems receive more attention than relatively pest-free plants. Monitoring can be incorporated into routine grounds maintenance activities such as weekly mowing or can be a separate activity that occurs bi-weekly, monthly, or less frequently, depending on plant, pest, site, weather, etc.

Indoors, monitoring might occur weekly during the early stages of solving a serious pest infestation, and then taper off to monthly once the pest problem is under control.

Some pests are more active at night than during the day. Thus, some monitoring may need to occur after dark. However, this is usually only necessary when you are trying to identify a nocturnal pest or trying to determine its travel routes, feeding habits, etc. Once this is known, nighttime monitoring can often be replaced by daytime inspection of traps, plant foliage, etc. for signs of pest presence.

Recordkeeping

A monitoring program is only as useful as its recordkeeping system. Records function as the memory of the IPM program. Human memory is unreliable and can lead to erroneous conclusions when comparing effects of treatment or other variables on the pest problem.

Recordkeeping is important to you because

- you can learn about your specific pests and their management faster if you write down your observations
- you can learn more about your specific pest problems because you won't forget what you observed, which treatments you tried, and when you tried them

Recordkeeping is important to a sensitive environment system and the IPM program because

- monitoring records form the basis for making decisions on the most sensible distribution of available resources to the areas most in need of attention or observation
- information can be easily and accurately passed from one employee to another
- information is not lost when employees leave or retire

What Should The Record Show?

The record should always show

- what you are monitoring — name of the pest (common name and scientific name, if possible), stage of the pest (immature, adult), and for landscape pests, the name of the plant
- where you are monitoring — a map is always useful
- when you are monitoring — date and time
- who is doing the monitoring

The information in Tables 2-1 and 2-2 will help you to standardize some of your observations. Table 2-1 is specifically for plants, but Table 2-2 can be used for structural pests as well as plant pests.

It is important to standardize the format and the process by which the records are kept in order to maintain continuity from season to season and person to person. *See the end of this chapter for sample forms.* The forms can be photocopied and used as is or you may want to design forms with boxes to be checked off so less writing will be necessary.

Pest patterns emerge quickly when data gathered during monitoring is made visual, facilitating decision-making. This can be done by hand on graph paper or by using one of the many graph-making computer programs included in spreadsheet software. Figure 2-3 shows fluctuations in cockroach trap counts

No Time?

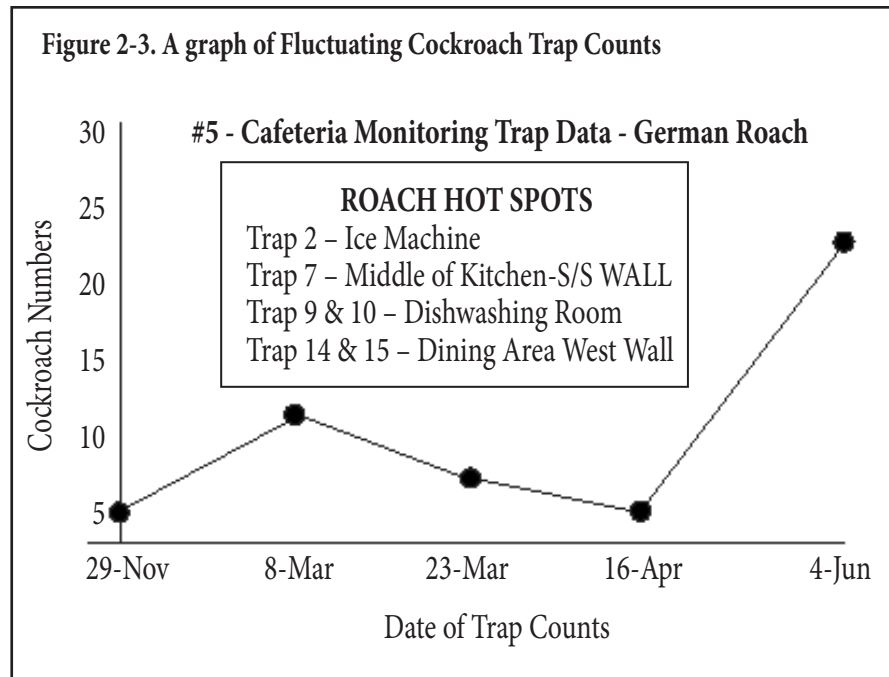
Try to make recordkeeping as easy and practical as possible. A person who is on the site frequently should be the person who monitors and keeps records. Try other solutions such as:

- asking an interested parent to help record monitoring information, either by following the pest manager or by interviewing the person later
- setting up a small student project to follow pest managers around and record what they do
- having a quarterly or monthly meeting to discuss monitoring and designate someone to take detailed notes.

Evaluating Your Actions

Without evaluating the actions you took to reduce the pest problem, you will not be able to improve your management program from year to year. Ask yourself the following questions:

- Was the pest problem a significant one?
- Were the actions I took necessary, or would the problem have gotten better if I had left it alone?
- Did the actions I took and the treatments I used adequately solve the problem?
- Could I manage the problem better next time? If so, how?
- Do I need more or better information to make treatment decisions in the future?



Sample Monitoring Forms

The following forms can help you in a monitoring program:

1. Roach Trap Monitoring
2. An example of how to fill out a Roach Trap Monitoring form
3. Landscape Monitoring
4. An example of how to fill out a Landscape Monitoring form
5. Plant Condition and Pest and Plant Damage Abundance Charts (for use with the Landscape Monitoring form)
6. Pest Control Trouble Call Log

Also included is a sample floor plan of a building.

These forms can be used as they are, or they can be modified to fit your particular circumstances.

Roach Trap Monitoring

Building # 3

Room or Area Cafeteria

Name of person monitoring John Doe

Trap#	Room# or Name	Date trap was		Trap Missing?	Location Description	Roaches		
		Set	Read			Adults	Nymphs	Total
1	Kitchen	3/5	3/26		SE Drain under grate	0	0	0
2	Kitchen	"	"		S Sink under electric box	1	1	2
3	Dishroom	"	"	yes	S under conveyor belt	—	—	—
4	Dishroom	"	"		N under conveyor belt	0	0	0
5	Storage	"	"		left side of door	0	0	0
6	Dining	"	"		W serving counter	0	2	2

EXAMPLE

6 **Total# of Traps**

0.66 **Average# of Roaches/Trap**
(total of roaches divided by total # of traps)

Total# of Roaches 4

Landscape Monitoring

Date 6/15

Name of Person Monitoring John Doe

Describe location of appropriate category:

Ornamental beds _____

Fence Lines _____

Sport turf _____

Paved Areas _____

Ornamental turf _____

Trees Northwest corner of school entrance

Playground _____

Other _____

Name of Plant	Condition* of Plant Excellent Fair Good Poor	Name of Pest (if any are present)	Abundance* of Pests Plant Damage		Presence of Natural Enemies	Management Activities	Comments
			Few Common	Abundant Innumerable			
Blue Spruce	Good	Cooley Spruce Gail Aphid	Common	Common	None	Prune 80% of Galls out of tree	Continue monitoring

EXAMPLE

*See accompanying charts for explanation

Charts for Use with the Landscape Monitoring Form

Plant Condition Chart

PLANT CONDITION RATING	INDICATORS OF PLANT CONDITION			
	Leaf Color	Amount/Size of Growth	Damaged Plant Parts	Presence of Pest Problems
EXCELLENT	Good	Adequate	None to few	No major ones
GOOD	Good	Slightly reduced	Few to common	A few minor ones
FAIR	Poor	Much reduced	Common to abundant	Either major or minor ones occurring frequently
POOR	Poor	Severely reduced	Innumerable	Both major and minor ones occurring frequently

Leaf Color: Note that there are healthy plants that do not have bright green leaves. Leaves can be purple, yellow, or sometimes a mottled yellow and green (variegated). “Good” leaf color will not always be the same; it will depend on the kind of plant.

Amount/Size of Growth: This refers to the length of the new growth for the season as well as the number of new leaves, and the size of the leaves, flowers, or fruit.

Damaged Plant Parts: Look at the whole plant. Are there leaves with holes, spots, or discolorations? Are there wilted or dead leaves? Are there dead twigs or branches? Is the damage only on old leaves while new leaves look perfectly healthy?

Presence of Pest Problems: A major pest problem is one that has seriously affected or injured the plant and requires management. A minor pest problem may or may not have affected or injured the plant and may or may not require management.

Pest and Plant Damage Abundance Chart

Abundance Rating	Indicators of Abundance
FEW	Organisms or plant damage occasionally found, but only after much searching
COMMON	Organisms or plant damage easily found during typical searching
ABUNDANT	Organisms or plant damage found in large numbers — obvious without searching
INNUMERABLE	Organisms or plant damage extremely numerous — obvious without searching

These charts were adapted from Michigan State University Pest Management Manual

Weed Monitoring Form for Turf*

Location of Turf _____ Date _____

Data collected by _____ Length of Pace _____

Distance between sampling points on transect _____
(for example, every nine paces)

Number of transects _____ Length of transects _____

Sketch of location of transects

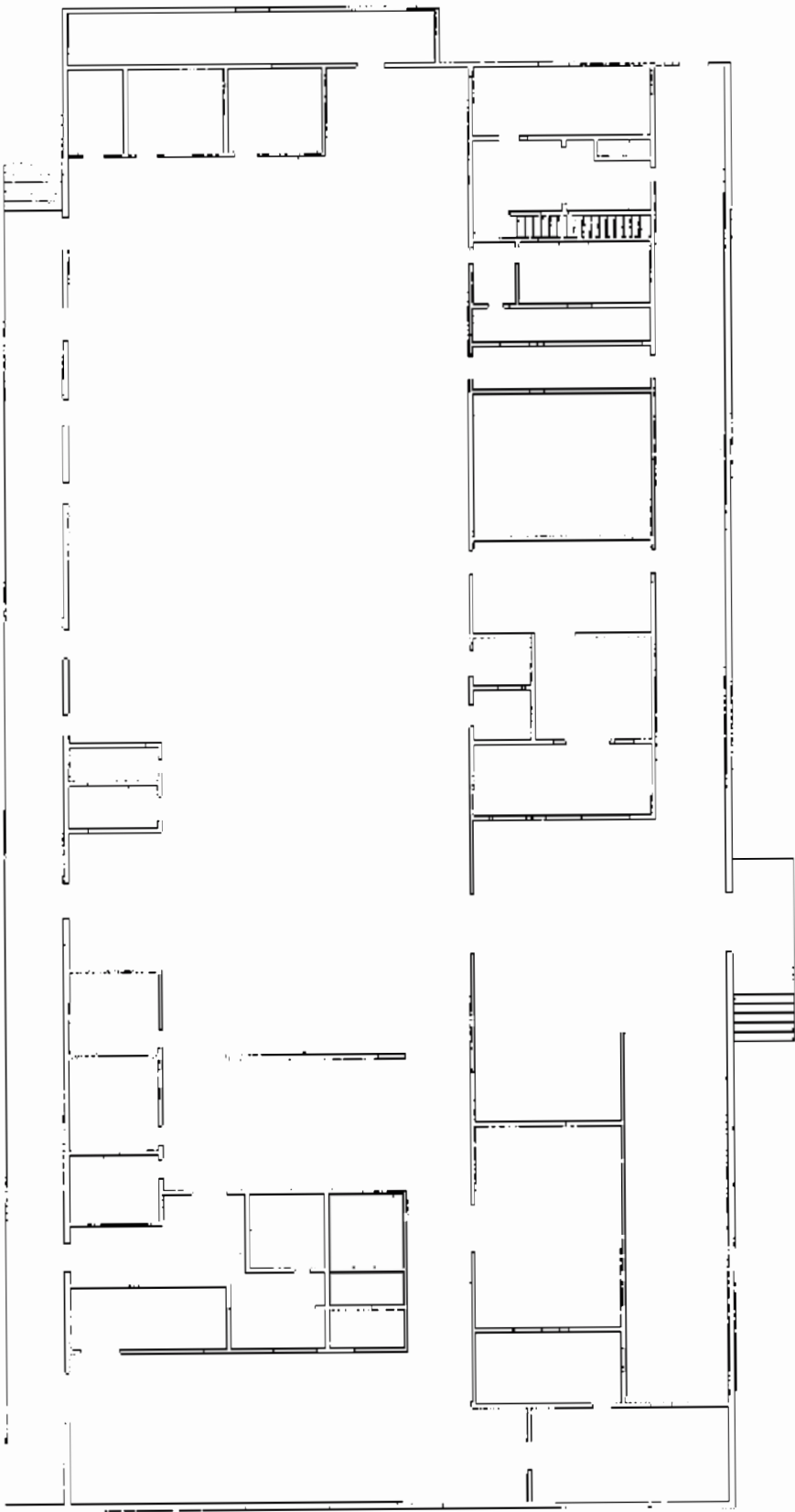
Transect A				Transect B				Transect C						
	Yes	No	Bare	Weed I.D.		Yes	No	Bare	Weed I.D.		Yes	No	Bare	Weed I.D.
1					1					1				
2					2					2				
3					3					3				
4					4					4				
5					5					5				
6					6					6				
7					7					7				
8					8					8				
9					9					9				
10					10					10				
11					11					11				
12					12					12				
13					13					13				
14					14					14				
15					15					15				
16					16					16				
17					17					17				
18					18					18				
19					19					19				
20					20					20				

Average % weed growth _____ Average % bare area _____

Total the number of boxes marked 'Yes' in each column. Multiply this number by 100 and divide by 60 [the total number of samples taken]. The result is the average percentage of weeds growing in the turf area. Follow the same procedure to calculate percentage of bare area.

*For information on how to use this form, see Chapter 10, Box 10-B

Sample Building Floor Plan



BUILDING 12
FIRST FLOOR



SCALE IN FEET
APPROXIMATE



Resources

For identification of diseases, weeds, insects and vertebrate pests, contact the nearest UNL Extension office, located in most counties. <http://www.extension.unl.edu/web/extension/officeslist>

A fee based pest identification service is available, contact *The Plant & Pest Diagnostic Clinic*. The clinic is operated by UNL Extension and offers skilled and objective diagnostic services by professionals from the Departments of **Plant Pathology, Agronomy and Horticulture, and Entomology**. In addition to accurate diagnosis of your pest problem, you will be provided with the most current information and recommendations. (<http://plantpathology.unl.edu/plantpestdiagnosticclinic>) The Internet Center for Wildlife Damage Management (<http://icwdm.org/>) may help identify wildlife and other vertebrate pests and their damage.

Injury and Action Levels



Total eradication of pest organisms is virtually impossible to achieve. A more realistic goal is to determine the “injury level” — the number of pests or the amount of pest-related damage that can be tolerated without suffering an unacceptable medical, economic, or aesthetic loss. The “action level” — the number of pests necessary for treatment to occur to prevent the injury level being reached — depends largely on pest biology and environmental conditions supporting the pest.

Determine Injury Levels First

Before you can determine the action level, you must first determine the injury level. This is the level of damage or the level of the pest population that causes unacceptable injury. The injury level will be higher than the action level (see Figure 3-1).

Three Types of Injury

There are three types of injury in IPM:

- Aesthetic injury is applied mainly to plants. This is injury that affects the appearance without affecting the health of the plant. There are few indoor pests or pests of structures that cause only aesthetic damage.
- Economic injury refers to pest damage that causes monetary loss, e.g., clothes moths destroying band uniforms or a plant disease that causes the death of a tree.

- Medical injury relates to human health problems caused by pests like rodents, flies, yellow jackets, poison ivy, etc.

Injury Levels Differ Depending on the Pest

The number of pests or amount of pest damage you can tolerate (another way to think of injury level) will depend on the kind of pest and its location. Columns of ants marching through an unused outbuilding is an entirely different situation from an ant invasion in the cafeteria. Many thousands of aphids can usually be tolerated on a tree, but one louse or nit on a child’s head cannot.

Don’t Set the Level too Low

One of the major causes of unnecessary treatments for pests is unrealistically low tolerance levels. Obviously, there is little leeway in tolerance for

pests that have consequences for human health or the facility’s budget, but for many other pests, the range of tolerance can be very wide. By understanding which kinds of damage are serious and which are unimportant and by simply changing the way we view pests and pest damage, we can avoid many unnecessary treatments. For instance, most trees and shrubs can support substantial populations of caterpillars, aphids, psyllids, or leafhoppers without coming to any harm. Lawns can still be very attractive and functional even though the grass is not all of one kind, and there are a number of weeds mixed in. As long as these weeds are not attracting other pests (such as bees attracted to clover close to building entrances, which could be a hazard to those allergic to bee stings), this is a situation that is generally tolerable.

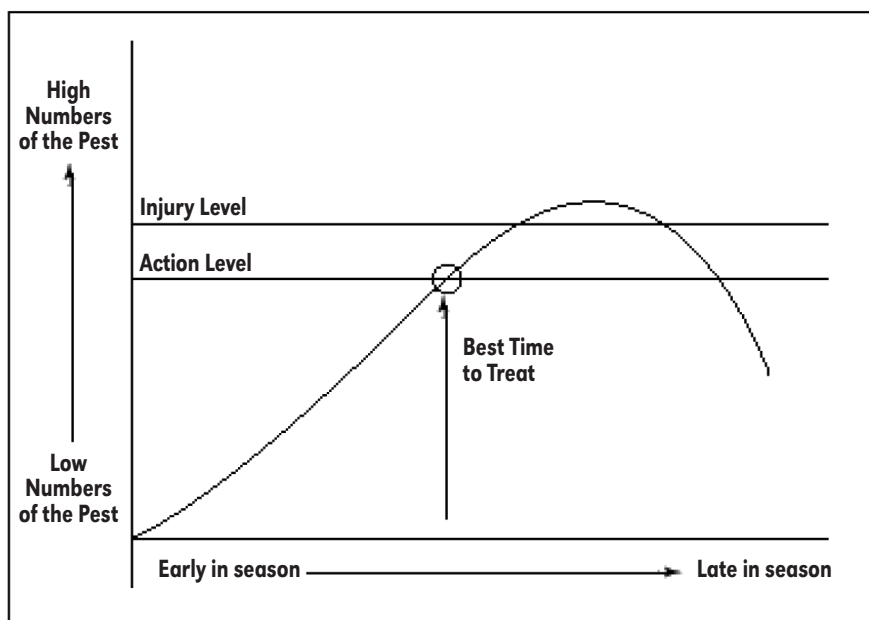


Figure 3-1. Graph illustrating injury and action levels.

Determining the Injury Level

We all have intuitive, unspecified notions of injury level in various pest management situations, but these may not be accurate. In an IPM program, the aim is to try to make injury levels explicit and accurate. Monitoring is the only way to do this. It also takes knowledge and experience to understand the life cycles of pests, how fast their populations grow, and whether or not their damage will have serious consequences.

Example: Last year, a chemical control was used when the aphid infestation in trees was first noticed by an employee. This year, a monitoring program was initiated. Data collected indicated that 100 to 200 aphids per leaf produced no significant damage to the tree. In fact, the data showed that only when there were over 500 aphids per leaf did leaves start to drop from the tree. This level of aphids also began to elicit complaints about the sticky honeydew raining down from the tree.

Periodically, the injury level should be re-evaluated for each pest and for each site. Changes in weather conditions, plant cultivars grown, horticultural practices, level of IPM experience of employees, building renovations, etc., can affect the setting of injury levels.

Determine Action Levels Based on Injury Levels

The action level is the level of pest damage or number of pests that triggers a treatment to prevent pest numbers from reaching the injury level. The action level will be lower than the injury level (see Figure 3-1). Determining action levels involves making educated guesses about the likely impacts of numbers of pests

present in a given place at a given time. In other words, you need to estimate how high you can let the pest population grow before you need to treat to prevent unacceptable injury. The action level must be determined and treatments applied before the injury level is reached.

Example: You know from previous observations that the injury level for the shade tree you are monitoring is 15 caterpillars per foot of branch. Current counts show 5 caterpillars per foot. These counts, weather data, and your experience lead you to expect the pest population will exceed the injury level in about two weeks unless there is a surge in natural enemy activity or the temperature drops. Your choices depend on available time and resources:

1. You can decide to set your action level at 5 to 7 caterpillars and schedule a treatment right away if it will be difficult to check again in a week.
2. Since the trees are extremely valuable and because you see that caterpillars are starting to die from attacks by natural enemies, schedule another visit in one week. At that time, if natural mortality does not appear likely to keep pest numbers below the injury level, there is still time to apply an insecticide. In this case, set your action level at 7 to 10 caterpillars.

When an IPM program is first implemented for a particular pest/site, guidance on setting the action level may be available from existing records, from the literature on the pest, through discussions with those who have experience managing the pest elsewhere, or from recollections of the problem in prior years by staff.

Set Conservative Action Levels in the Beginning

During the beginning phase of an IPM program, it is wise to be conservative when establishing an initial action level. Set it low enough (i.e., low numbers of pests trigger treatments) to ensure a wide margin of safety while learning monitoring methods. The initial action level should then be compared with other action levels for the same pest at different sites or locations. This is necessary to determine if the action level is set too high or too low, if treatments were necessary or not, and if they were properly timed.

The easiest way to collect comparative data is to set aside a portion of a facility that remains untreated at the time another area is treated or to monitor two facilities where different action levels are applied to the same pest. By monitoring both sites and comparing records, you can evaluate if initial action level should be adjusted.

Avoid “Revenge” Treatments

Sometimes action takes place after the injury level has been reached and the pest population has begun to decline naturally (see Figure 3-2). These “revenge” treatments are generally useless at controlling pests, damaging to the environment, and an unnecessary expenditure of time and resources.

IPM Program Evaluation

One of the most important components of an IPM program is evaluating whether or not it's working, and fine-tuning it when necessary. Evaluation is rarely done in conventional pest control. Many people have

become habituated to spraying on a regular basis, often without questioning the long-term efficacy or side-effects of what they are doing. An IPM-oriented program would view the need to regularly apply a toxic material as an indication that the program wasn't working efficiently and seek other solutions in order to reduce pesticide use and maximize effects of non toxic or natural controls.

For purposes of overall evaluation, it is helpful to view the IPM program as composed of many simultaneously occurring, interacting systems or processes:

- monitoring
- recordkeeping
- decision making regarding treatment activities
- delivery of treatments
- evaluation of treatments
- collection and cataloging of reference materials on management of the pests
- education and training of school personnel in IPM
- communication to school personnel regarding IPM program plans and progress
- budgetary planning
- evaluation of overall IPM program

Each of these components should have, as part of the development of the initial program plan, some expressed objectives or criteria by which the component is judged successful or not. In addition, it is important to determine the following:

- Were all the necessary components to the program actually developed?

- Were they integrated successfully?
- Were the right people involved in the integration of the components into a whole program?

Questions to Ask After Treatment Action

At the end of the year, use monitoring data to answer the questions below and make any necessary adjustments in methods for the next season. After two or three seasons of fine-tuning, including modifying the habitat, redesigning parts of the facility, or changing behavioral practices to discourage pests, you can generally expect problems to have lessened considerably, and in some cases, disappear. After reaching this point, periodic monitoring rather than active management may be all that is needed.

Was the pest population adequately suppressed (below injury level)?

- Was the pest population suppressed in a timely manner?
- Was the planned procedure used? If not, what was different?

- What damage was produced? What damage was tolerable?
- In the landscape, were natural enemies affected by treatments? How?
- If natural enemies were killed by treatments, will this cause later problems ?
- Were there any other side effects from the treatments?
- Any unanticipated consequences (good or bad)?
- If ineffective, should the treatments be repeated, should another kind of treatment be evaluated?
- Is the plant or structure worth maintaining? Can the site be changed to eliminate or reduce the problem for the same costs of treatment?
- What were the total costs of the treatment — costs of suppression vs. cost of damage, costs of side-effects or unexpected consequences, costs of risks from pesticides or benefits from reduction of pesticide, etc.

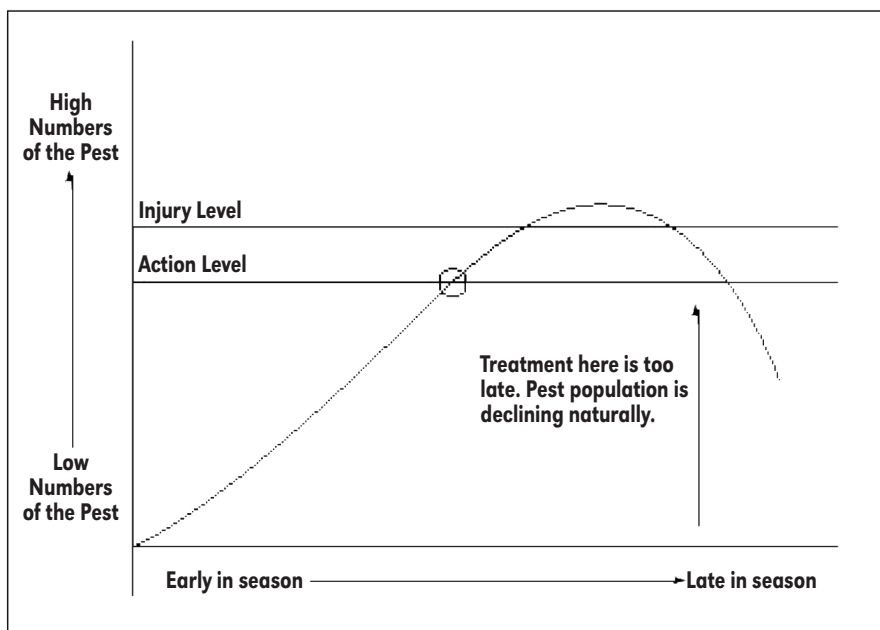


Figure 3-2. Graph illustrating “Revenge” treatments.

Assessing Cost Effectiveness

Cost effectiveness is central to a decision to continue an IPM program. Data from IPM programs in school systems and park districts across the country indicate that IPM costs no more than conventional spray programs and often costs considerably less. This should also apply to other sensitive environments.

The Ann Arbor School District in Michigan has found that hiring a contractor to monitor 35 schools on a regular basis and treat only if action levels were reached, resulted in only a single treatment (a crack and crevice application of low-toxic boric acid for cockroaches) during the course of a full year. In the first IPM year, this program cost the same as the previous conventional program. Costs were expected to drop the second year when in-house staff were scheduled to assume monitoring responsibilities.

Whether an IPM program raises or lowers costs depends in part on the nature of the current housekeeping, maintenance, and pest management operations. The costs of implementing an IPM program can also depend

on whether the pest management services are contracted out, performed in-house, or both. Prior to 1985, Maryland's Montgomery County Public Schools (MCPS) had a conventional pesticide-based program. Over 5,000 applications of pesticides were made to school district facilities that year. Public concerns about potential hazards to students and school personnel led to development of an IPM program that emphasized sanitation, habitat modification, and less toxic baits and dusts in place of conventional sprays. By 1988, annual pesticide applications had dropped to 600, and long-term control of pests had improved.

According to William Forbes, pest management supervisor for the school district, under conventional pest control in 1985, the district spent \$513 per building per year. This covered two salaries, two vehicles, and materials for two employees who serviced 150 sites. Only crawling insects and rodents were managed by in-house staff. An additional \$2400 per building per year was paid for contracted services at 11 sites. By 1988, under an IPM program, those same 11 sites were being managed by

in-house staff at a cost of only \$500 per site per year. In addition, a total of 200 school buildings (33 percent increase) were serviced for a cost of \$575 per building per year, which covered three salaries, three vehicles, and supplies. No outside contracting was needed and the program covered virtually every structural pest, from pigeons to termites.

During the start-up phase, there are usually costs associated with conversion to IPM. These might include staff training, building repair and maintenance, new waste storage containers, screening, traps, a turf aerator, etc. However, these expenses are usually recouped within the first year or two of the program, and benefits continue to accrue for years.

Whether such costs are budgeted as a pest control expense or distributed to the building maintenance budget or the landscaping account depends on the budgetary format of the institution. In the long term, training, repair and maintenance activities, and equipment purchases will reduce overall costs of the pest control operations, as well as other maintenance and operating budgets.

Treatment Strategies



IPM is not simply a matter of substituting “good” pesticides for “bad” pesticides. Too often we want an easy solution, a “magic bullet” that will solve all our problems in one shot. Unfortunately, pest management is complicated, and we cannot always expect a simple solution to pest problems. IPM is based on the fact that combined strategies for pest management are more effective in the long run than a single strategy. A good pest manager considers as many options as possible and tries to combine them into an effective program. The best pest managers have ideas for new and creative ways to solve pest problems. Wherever possible, IPM takes a preventive approach by identifying and removing, to the degree feasible, the basic causes of the problem rather than merely attacking the pests. This prevention-oriented approach is also best achieved by integrating a number of treatment strategies.

Criteria for Selecting Treatment Strategies

Once the IPM decision-making process is in place and monitoring indicates a pest treatment is needed, the choice of specific strategies can be made. Choose strategies that are as follows:

- least hazardous to human health
- least disruptive of natural controls in landscape situations

- least toxic to non-target organisms other than natural controls
- most likely to be permanent and prevent recurrence of the pest problem
- easiest to carry out safely and effectively
- most cost-effective in the short- and long-term
- appropriate to the site and maintenance system

Least hazardous to human health

It is particularly important around vulnerable populations to take the health hazards of various strategies into consideration.

Example: Aerosol sprays can kill cockroaches; however, they can also pose potential hazards to humans because the pesticides volatilize in the air. Thus, if they are sprayed in a school, for example, aerosols increase the likelihood of exposure of respiratory or lung tissue of students and staff. In addition, aerosol sprays may leave residues on surfaces handled by students and teachers. When cockroach baits are used, the pesticide is confined to a much smaller area, and if applied correctly, the bait will be out of reach of students and staff. Baits volatilize very little so lung exposure is not a problem.

Least disruptive of natural controls

In landscape settings, try to avoid killing off the natural enemies that aid in controlling pest organisms. Unfortunately and for a number of reasons, natural enemies are often more easily killed by pesticides than are the pests. When choosing treatment strategies, always consider how the strategy might affect natural enemies. When choosing a pesticide, try to use one that has less effect on natural enemies

Least toxic to non-target organisms

The more selective the control, the less harm there will be to non-target organisms.

Example: Populations of aphids in trees often grow to high numbers because ants harvest the honeydew produced by the aphids and protect them from their natural enemies. The ants that protect these aphid pests are often beneficial in other circumstances (aerating the soil and helping to decompose plant and animal debris). By excluding the ants from the tree with sticky bands around the trunk, it is often possible to achieve adequate suppression of the aphids without harming the ants.

Most likely to be permanent and prevent recurrence of the problem

Treatments that meet this criterion are at the heart of a successful IPM program because these controls work without extra human effort, costs, or continual inputs of other resources. These treatments often include changing the design of the landscape, the structure, or the system to avoid pest problems. The following are examples of preventive treatments:

- educating personnel about how their actions affect pest management,
- caulking cracks and crevices to reduce cockroach (and other insect) harborage and entry points
- instituting sanitation measures to reduce the amount of food available to ants, cockroaches, flies, rats, and mice,
- cleaning gutters and directing their flow away from the building to prevent moisture damage,
- installing a sand barrier around the inside edge of a foundation to prevent termites from crawling up into the structure, and
- using an insect growth regulator to prevent fleas from developing in an area with chronic problems.

Easiest to carry out safely and effectively

While the application of pesticides may seem comparatively simple, in practice it may not be the easiest tactic to carry out safely or effectively. Use of conventional pesticides often involves wearing protective clothing, a respirator, goggles, and chemical-resistant gloves. In hot weather, people are often reluctant to wear protective gear because of the dis-

comfort this extra clothing causes. By choosing not to wear the protective clothing, applicators not only violate the law but also risk exposure to toxic materials.

Most cost-effective in the short- and long-term

In the short-term, use of a pesticide often appears less expensive than a multi-tactic IPM approach; however, closer examination of the true costs of pesticide applications over the long-term may alter this perception. In addition to labor and materials, these costs include mandatory licensing, maintaining approved pesticide storage facilities, disposing of unused pesticides, liability insurance, and environmental hazards.

Other factors to consider are whether a particular tactic carries a one-time cost, a yearly recurring cost, or a cost likely to recur a number of times during the season. When adopting any new technology (whether it be computers or IPM), some start-up costs must be incurred. Once the program is in place, IPM generally costs less than or about the same as conventional chemically-based programs (see the discussion on “Assessing Cost Effectiveness” in Chapter 3).



Figure 4-1. Applying caulk to cracks and crevices is one treatment strategy that will help reduce pest harborage and entry points.

In addition, community concern about the use of pesticides may make any use of pesticide in and around sensitive environments problematic. Problems with public relations can develop over comparatively innocuous incidents, and require substantial amounts of time from the highest paid employees to attend meetings, prepare policy statements, and address the media. These costs should also be factored into the pest control equation.

Appropriate to the weather, soils, water, and the energy resources of the site and the maintenance system

Skillfully designed landscapes can reduce pest problems as well as use of water and other resources. It is important to choose the right plant for the right spot. Plants that are forced to grow in unsuitable sites, where they are unable to thrive, will be a continual source of problems. When plants die on site, take the time to find a replacement that is suited to the landscape.

Timing of Treatments

Treatments must be timed to coincide with a susceptible stage of the pest and, if at all possible, a resistant stage of any natural enemies that are present. Sometimes the social system (i.e., the people involved or affected) will impinge on the timing of treatments. Only monitoring can provide the critical information needed for the timing of treatments, which makes them more effective.

Example: To control scales on plants using a low-toxic material such as insecticidal soap or horticultural oil, it is necessary to time treatments for the period (often brief) when immature scales (crawlers) are moving out

from under the mother scales, seeking new places to settle down. Scales are susceptible to soaps and oils only at this stage.

Spot Treatments

Treatments, whether pesticides or non-toxic materials, should only be applied when and where they are needed. It is rarely necessary to treat an entire building or landscape area to solve a pest problem. Costs and exposure to toxic materials can be kept to a minimum by using monitoring to pinpoint where pest numbers are beginning to reach the action level and confining treatments to those areas.

Summary of Available Treatment Options

The following is a list of general categories of treatment strategies. We have included some examples to help illustrate each strategy. The list is not intended to be exhaustive since products change, new ones are discovered or invented, and ingenious pest managers develop new solutions to old problems every day.

Education

Education is a cost-effective pest management strategy. Information that will help change people's behaviors — particularly how they dispose of wastes and store food — plays an invaluable part in managing pests like cockroaches, ants, flies, yellow jackets, and rodents. Education can also increase people's willingness to share their environment with other organisms so that people are less likely to insist on toxic treatments for innocuous organisms. Teaching children about IPM will have a long-term effect on the direction of pest management in this country as these students grow up to become consumers, educators, and decision-makers.

Habitat Modification

Pests need food, water, and shelter to survive. If the pest manager can eliminate or reduce even one of these requirements, the environment will support fewer pests.

Design or Redesign of the Structure

Design changes can incorporate pest-resistant structural materials, fixtures, and furnishings. Sometimes these changes can entirely eliminate pest habitat. For example, buildings designed without exterior horizontal ledges will reduce problems with pigeons. Inside, industrial, stainless steel wire shelving mounted on rolling casters helps reduce roach habitat and facilitates cleanup of spilled food.

Sanitation

Sanitation can reduce or eliminate food for pests such as rodents, ants, cockroaches, flies, and yellow jackets.

Eliminate Sources of Water for Pests

Fix leaks, keep surfaces dry overnight, and eliminate sources of standing water.

Eliminate Pest Habitat

Caulk cracks and crevices to eliminate cockroach and flea harborage, remove clutter that provides roach habitat, and remove dense vegetation near buildings to eliminate rodent harborage.

Modification of Horticultural Activities

Planting techniques, irrigation, fertilization, pruning, and mowing can all affect how well plants grow. Many of the problems encountered in school landscapes are attributable to using the wrong plants and/or failing to give them proper care. Healthy plants are often likely to have fewer problems with insects, mites, and diseases. It is very important that the person responsible for the landscaping has a good foundation of knowledge about the care required by the particular plants at the facility or be willing to learn.

Design or Redesign of Landscape Plantings

- Choose the right plant for the right spot and choose plants that



Photo: Erin Bauer

Figure 4-2. Fix leaks to reduce water resources available to pests.

are resistant to or suffer little damage from local pests. This will take some research. Ask the advice of landscape maintenance personnel, local nurseries, local pest management professionals, and UNL Extension educators or the master gardeners on their staffs.

- Include flowering plants in the landscape that attract and feed beneficial insects with their nectar and pollen, e.g., sweet alyssum and flowering buckwheat, species from the parsley family such as yarrow and fennel, and the sunflower family such as sunflowers, asters, daisies, marigolds, and zinnias.
- Diversify landscape plantings — when large areas are planted with a single species of plant, a pest can devastate the entire area.

Physical Controls

Vacuuming

A heavy-duty vacuum with a special filter fine enough to filter insect particles down to 0.3 microns is a worthwhile investment. Some vacuums have special attachments for pest control. The vacuum can be used not



Photo: Vicki Jedlicka

Figure 4-3. Vacuuming is an easy way to capture insect pests.

only for cleaning but also for directly controlling pests. A vacuum can pull cockroaches out of their hiding places; it can capture adult fleas, their eggs, and pupae; and a vacuum can be used to collect spiders, boxelder bugs, and cluster flies.

Trapping

Traps play an important role in non-toxic pest control. In and around sensitive environments, however, traps may be disturbed or destroyed by those who discover them. To prevent this, place in areas out of reach in closets and locked cupboards. A wide variety of traps is available to the pest manager. Some traps, including cockroach traps and various pheromone (insect hormone) traps, are used mainly for monitoring the presence of pests. If the infestation is small, these traps sometimes can be used to control the pest. Other traps include the familiar snap traps for mice and rats, electric light traps and flypaper for flies, sticky traps for whiteflies and thrips, cone traps for yellow jackets, and box traps for skunks, raccoons, and opossums.

Barriers

Barriers can be used to exclude pests from buildings or other areas. Barriers can be as simple as a window screen to keep out flying and crawling insects or sticky barriers to exclude ants from trees. More complicated barriers include electric fences to keep out deer and other vertebrate wildlife and L-shaped footings in foundations to exclude rodents.

Heat, Cold, Electric Current

Commercial heat treatments can be used to kill bed bugs or wood-destroying pests such as termites. The “Electrogun”, which passes an



Photo: Erin Bauer

Figure 4-4. Using snap traps or sticky traps can be an effective way to control pests.

electric current through wood, can be used for killing termites. A propane weed torch can be used to kill weeds coming up through cracks in pavement. Freezing can kill trapped insects such as yellow jackets before emptying traps, kill moths in clothes, kill cockroaches, and kill the eggs and larvae of beetles and moths that destroy grain.

Removing Pests by Hand

In some situations, removing pests by hand may be the safest and most economical strategy. Tent caterpillars can be clipped out of trees, and many insects can be picked up and killed in soapy water or alcohol.

Biological Controls

Biological control uses a pest’s natural enemies to attack and control the pest. We use the word “control” rather than “eliminate” because biological control usually implies that a few pests must remain to feed the natural enemies. The exception to this is a separate category of biological control called microbial control that includes the use of plant and insect pathogens. Microbial controls are generally used like pesticides to kill as many pests as possible. Strategies in biological control include conservation, augmentation, and importation.

Conservation

Conserving biological controls means protecting those already present in the landscape. To conserve natural enemies, you should do the following:

- treat only if injury levels will be exceeded
- spot treat to reduce impacts on non-target organisms
- apply treatments to be least disruptive in the life cycles of the natural enemies
- select the most species-specific, least-damaging pesticide materials, such as *Bacillus thuringiensis*, insect growth regulators that are specific to the pest insect, and baits formulated to be attractive primarily to the target pest.

Augmentation

You can increase the number of biological controls in an area by planting flowering plants to provide pollen and nectar for the many beneficial insects that feed on the pest insects or purchasing beneficials from a commercial insectary. Examples of the best known commercially available natural enemies include lady beetles, lacewings, predatory mites, and insect-attacking nematodes. Several other species are now commercially available for release against pests. Learning when to purchase and release natural enemies and how to maintain them in the field should be emphasized in any landscape pest management program.

Importation

People often ask if parasites or predators can be imported from another country to take care of a particularly disruptive pest in their area. It is true that the majority of

pests we have in North America have come from other parts of the world, leaving behind the natural enemies that would normally keep them in check. Classical biological control involves searching for these natural enemies in the pest's native area and importing these natural enemies into the problem area. Importation is not a casual adventure: it must be done by highly trained specialists in conjunction with certain quarantine laboratories approved by the USDA. Permits must be obtained, and strict protocols observed in these laboratories.

A great deal of caution must be used in the importation of natural enemies. Several cases have occurred in which the imported animal impacts the natural balance of the community and causes more damage than the original pest (mongoose, carp, and mosquito fish to name a few).

The entire process requires a considerable amount of money to pay for the research, travel, permits, and facilities. Unfortunately, the amount of money for biological control research and importation is dwindling, and the money that is available goes to the biggest pests. Unless funds increase in the near future, few of the pests that plague institutions will become the object of biological control importations. Public knowledge about the value of importation projects can help stimulate funding and additional importations. Once the imported natural enemies become established in their new home, they usually provide permanent control of the pest. Patience is needed, however, because establishment can take several years.

Microbial controls

Microbial controls are naturally occurring bacteria, fungi, and viruses that attack pests. A growing number of these organisms are being sold commercially as microbial pesticides. Since each of these microbial pesticides attacks a narrow range of pests, non-target organisms are much less likely to be affected.

The most well-known microbial insecticide is the bacteria *Bacillus thuringiensis*, or "BT." The most widely sold strain of BT kills caterpillars. Another strain kills only the larvae of black flies and mosquitoes, and a third strain kills only certain pest beetles.

Microbial herbicides made from pathogens that attack weeds are commercially available for use in agricultural crops. In the near future, commercial products may be available for use in urban horticultural settings.

Least-Toxic Chemical Controls

The health of the community and long-term suppression of pests must be the primary objectives that guide pest control in sensitive environments. To accomplish these objectives, an IPM program must always look for alternatives and use pesticides only when other methods have failed.

Many people are familiar with insecticides such as malathion and herbicides such as 2,4-D. These and similar materials have engendered controversy over possible hazards they pose to human health and the environment. Several chemical products are available that have less impact on the larger environment and, at the same time, are effective against target pests.

“Least-toxic” pesticides have all or most of the following characteristics: effectiveness against the target pest, low acute and chronic toxicity to mammals, narrow range of target pests, and little or no impact on non-target organisms. Such products include the following:

- pheromones and other attractants
- insect growth regulators (IGRs)
- repellents
- desiccating dusts
- pesticidal soaps and oils
- some botanical pesticides.

Pheromones

Animals emit substances called pheromones that act as chemical signals. The sex pheromones released by some female insects advertise their readiness to mate and can attract males from great distances. Other pheromones act as alarm signals.

Several pheromone traps and pheromone mating confusants are commercially available for insect pests. Most of the traps work by using a pheromone to attract the insect into a simple sticky trap. The mating confusants flood the area with a sex pheromone, overwhelming the males with stimuli and making it very difficult for them to pinpoint exactly where females are located.

Insect Growth Regulators (IGRs)

Immature insects produce juvenile hormones that prevent them from developing into adults. When they have grown and matured sufficiently, their bodies stop making the juvenile hormones so they can turn into adults. Researchers have isolated and synthesized some of these chemicals, and when they are sprayed on or around certain insects, these insect

growth regulators prevent the pests from maturing into adults. Immature insects cannot mate and reproduce so eventually the pest population is eliminated. Methoprene and fenoxycarb are used to suppress fleas, and hydroxyurea is used against cockroaches. IGRs are safe to use around humans and other mammals because they don't metamorphose as insects do.

Repellents

Some chemicals repel insects or deter them from feeding on treated plants. For example, a botanical insecticide extracted from the neem tree can prevent beetles and caterpillars from feeding on treated rose leaves. Current research shows that neem has a very low toxicity to mammals. Several neem products are currently available.

Desiccating Dusts

Insecticidal dusts such as diatomaceous earth and silica aerogel, made from natural materials, kill insects by abrading the outer waxy coating that keeps water inside their bodies or by absorbing water directly from their bodies. Without this coating, the insects die of dehydration.

Silica aerogel dust can be applied into wall voids and attics to kill dry wood termites, ants, roaches, silverfish, and other crawling insects.

Pesticidal Soaps and Oils

Pesticidal soaps are made from refined coconut oil and have a very low toxicity to mammals but can be toxic to fish, so they should not be used around bodies of water. Researchers have found that certain fatty acids in soaps are toxic to insects but decompose rapidly, leaving no toxic residue. Soap does little damage to

lady beetles and other hard-bodied insects but could be harmful to some soft-bodied beneficials. A soap-based herbicide is available for controlling seedling stage weeds; the soap kills the weeds by penetrating and disrupting plant tissue. Soap combined with sulfur is used to control common leaf diseases such as powdery mildew.

Insecticidal oils (sometimes called dormant oils or horticultural oils) also kill insects and are gentle on the environment. Modern insecticidal oils are highly refined. Unlike the harsh oils of years ago that burned leaves and could only be used on deciduous trees during the months they were leafless, the new oils are so “light” that they can be used to control a variety of insects even on many bedding plants.

Note that it is always wise to test a material on a small portion of a plant first to check for damage before spraying the entire plant.

Botanical Pesticides

Botanical pesticides, although they are derived from plants, are not necessarily better than synthetic pesticides. Botanicals can be easily degraded by organisms in the environment. Plant-derived pesticides, however, tend to kill a broad spectrum of insects, including beneficials, so they should be used with caution. The most common botanical is pyrethrum, made from crushed petals of the pyrethrum chrysanthemum flower. “Pyrethrins” are the active ingredient in pyrethrum, but “pyrethroids” such as resmethrin and permethrin have been synthesized in the laboratory and are much more effective and long-lasting than the pyrethrins. Neem, another botanical pesticide, is discussed under “Repel-

lents.” Some botanicals, such as nicotine, sabadilla, and strychnine, can be especially acutely toxic to humans and rotenone is very toxic to fish. The same care must be used with these materials as with all insecticides.

How to Select a Pesticide for an IPM Program

When contemplating the use of a pesticide, it is prudent to acquire a Material Safety Data Sheet (MSDS) for the compound. MSDS forms are available from pesticide suppliers and contain information on potential hazards and safety precautions. The following URL lists several databases where information about MSDS can be obtained online: <http://www.ilpi.com/msds/>.

You can also find other reference materials on pesticides and pesticide safety from the University of Nebraska–Lincoln Pesticide Safety Education Program at <http://pested.unl.edu>.

The following criteria should be used when selecting a pesticide: safety, species specificity, effectiveness, endurance, speed, repellency, and cost.

Safety

Safety for humans, pets, livestock, and wildlife, as well as safety for the overall environment is a priority. Questions to ask are as follows:

What is the acute (immediate) and chronic (long-term) toxicity of the pesticide? Acute toxicity is measured by the “LD₅₀,” which is the lethal dose of the pesticide required to kill 50 percent of the test animals (measured in milligrams of pesticide per kilogram of body weight of the test animals). The higher the LD₅₀ value, the more poison it takes to kill the

target animals and the less toxic the pesticide. In other words, high LD₅₀ = low toxicity. Chronic toxicity refers to potential health effects from exposure to low doses of the pesticide for long periods of time. Chronic effects can include carcinogenic (cancer-causing), mutagenic (causing genetic changes), or teratogenic (causing birth defects), or other health effects.

How mobile is the pesticide? Is the compound volatile so that it moves into the air breathed by people in the building? Can it move through the soil and into the groundwater? Does it run off in rainwater to contaminate creeks and rivers?

- What is the residual life of the pesticide? How long does the compound remain toxic in the environment?
- What are the environmental hazards listed on the label? What are the potential effects on wildlife, beneficial insects, fish, or other animals?

Species Specificity

The best pesticides are species-specific; that is, they only affect the group of animals or plants you are trying to suppress. Avoid broad-spectrum materials that kill many different organisms because they can kill beneficial organisms that keep pests in check. When broad spectrum materials must be used, apply them in as selective a way as possible by spot treating.

Effectiveness

This issue is not as straightforward as it might seem since it depends on how effectiveness is being evaluated. For example, a pesticide can appear to be very effective in laboratory tests

because it kills 99 percent of the test insects; however, in field tests under more realistic conditions, it may also kill 100 percent of the pest’s natural enemies, which will lead to serious pest outbreaks at a later date.

The best way to determine effectiveness is to consider research results from actual situations similar to your intended use.

Endurance

A pesticide may have been effective against its target pest at the time it was registered, but if the pest problem is now recurring frequently, it may be a sign that the pest has developed resistance to the pesticide.

Speed

A quick-acting, short-lived, more acutely toxic material might be necessary in emergencies. A slow acting, longer lasting, less-toxic material might be preferable for a chronic pest problem. An example of the latter is using slower-acting boric acid for cockroach control rather than a quicker-acting but more toxic organophosphate.

Cost

Cost is usually measured as dollars per volume of active ingredient used. Some of the newer, less-toxic microbial and botanical insecticides and insect growth regulators may appear to be more expensive than some older, more toxic pesticides. The newer materials tend to be effective in far smaller doses than the older materials. One container goes a long way. This factor, together with their lower impact on the environment, often makes these newer materials more cost effective.

Notification and Posting

Institutions and other facilities have the responsibility to inform occupants when they may be exposed to pesticides. Unless it is an emergency situation, the applications should be performed when the building is unoccupied. Notifications of all pending treatments using a pesticide should be done prior to the treatment.

Concerned individuals should be directed to the pest manager for more specific information. A voluntary registry of individuals with medically-documented problems who could be adversely affected by exposure to pesticides should be kept at each facility's office and in the pest manager's office for special contact in emergency situations.

Post in all areas that have been treated. Make sure that all occupants understand that posting is part of an overall effort to help reduce pesticide use.

Pesticide Use Guidelines

In addition to becoming informed about the characteristics of the material itself, it is important to develop guidelines to be followed each time a pesticide is used. Prepare a checklist to be used each time an application is made. The following are important items to include on the checklist:

- Make sure the pesticide is registered for use in Nebraska (pesticides can be registered in some states and not in others). What are the laws regarding its use? Check the following website to check registrations in Nebraska: <http://www.kellysolutions.com/NE/pesticideindex.htm>
- READ THE PESTICIDE LABEL. Follow directions for use, labeling, and storage exactly.
- Make sure that all safety equipment and clothing (e.g., chemical resistant gloves, goggles, respirator, hat, and other protective coverings as necessary) is available and worn when the pesticide is used.
- Verify that the person doing the application is certified and/or qualified to handle the equipment and material chosen and has been adequately trained. Check the following website to determine if an individual is currently licensed in the state of Nebraska: <http://www.kellysolutions.com/NE/Applicators/index.htm>
- Make sure that the application equipment is appropriate for the job and properly calibrated.
- Confine use of the material to the area requiring treatment (spot-treat).
- Keep records of all applications and copies of MSDS sheets for all pesticides used.
- Monitor the pest population after the application to determine if the treatment was effective and record results.
- Be prepared for all emergencies and compile a list of whom to call for help and the kinds of first aid to be administered before help arrives. Place the list in an accessible area near a phone.
- Dispose of pesticides properly. DO NOT pour pesticides down the drain, into the toilet, into the gutter, or into storm drains! If you are unsure about how to dispose of the pesticide, call the manufacturer or your local utility company that handles sewage and storm drains.

How to Develop an IPM Program



The Two Phases of IPM Program Development

IPM program development generally occurs in two major phases: the start-up phase and the operational phase. The start-up phase involves educating key decision-makers about the need for the program, adopting an IPM policy and addressing administrative issues, and identifying the roles and responsibilities of the various members of the institution or facility in operating a successful IPM program. The operational phase involves designing and implementing IPM programs for specific pests; training pest management, custodial, grounds maintenance, and health staff in IPM methods; and institutionalizing the IPM program.

Start-up Phase

Educating key decision-makers

The stimulus for development of successful IPM programs in sensitive environments has come from a variety of sources including concerned administrators or managers, the community, and state or local legislation. The key to success is educating school boards, superintendents, and principals; nursing home, child care, and hospital directors; business operations managers; zookeepers; prison wardens; and other decision-makers about the viable alternatives offered by the IPM approach.

Adopting an IPM policy

Adoption of an IPM policy by an institution is key to starting an IPM program. A sample IPM policy is provided under the section “Developing an IPM Policy Statement for Pest Management” in this chapter.

Identifying pest management roles and responsibilities

It is critical that representatives from all segments of the community be involved in setting up the IPM program from the beginning in order to foster their “buy-in” to the process and the program. Depending on the sensitive environment involved, this might include school board members, administrators and staff, child care, hospital, and nursing home directors, teachers, patients, students, parents, custodians, food service workers, ground maintenance personnel, nurses, and pest management professionals. When the respective roles of everyone in the institution involved are identified and agreed upon, and when these people communicate well with each other, effective protection of the site can be achieved. A discussion of roles and responsibilities is provided in Box A.

Operational Phase

The operational phase involves designing IPM programs for specific sites and pests, delivering IPM services, and evaluating program costs. Fully-developed, multi-tactic IPM

programs are generally implemented in three stages, although components of each stage often overlap. Stage 1 introduces monitoring and pest action thresholds to replace routine pesticide applications and develops preliminary pest management objectives. Facilities that have relied primarily on routine pesticide applications usually begin with a Stage 1 IPM program and work up to a more complex stage as they develop experience and confidence in the IPM approach. Box B outlines tips for getting programs started. Stage 2 formalizes pest management plans and maximizes pest-proofing, education, and non-chemical pest suppression. Stage 3 institutionalizes the IPM program.

Stage 1 IPM

Stage 1 IPM focuses primarily on moving away from routine use of pesticides by instituting a pest monitoring program to collect data and establish pest treatment (action) thresholds based on pest population levels (see Chapters 2 and 3). A pilot program can be initiated at one site so new skills can be gained and techniques fine-tuned before the program is expanded throughout the community.

Pesticides may remain the primary control agents used during this stage, but applications are made only when pest numbers reach action levels. Spot-treatments rather than area-

Box A: Identifying Pest Management Roles

In successful IPM programs, students, staff, parents, pest managers, and decision-makers all have important roles. These functions and responsibilities are identified below.

The Occupants

Staff, and in some cases either short-term (i.e. students, patients) or long-term (i.e. elderly, prisoners) residents, play a major role in keeping the facility clean. Sanitation should not be viewed as only the custodian's job. If staff is shown the connection between food and garbage and pests such as cockroaches, ants, flies, and rodents, they are more likely to take sanitation measures seriously and comply with them. Rules for sanitation should be clear and succinct and they should be strictly enforced.

The Pest Manager

The pest manager is the person who observes and evaluates (or directs others to do so) the site and decides what needs to be done to achieve the pest management objectives. The pest manager designs an IPM program that takes into account potential liability, applicator and occupant safety, costs, effectiveness, environmental impacts, time required, and customer or occupant satisfaction.

The pest manager draws on knowledge gained through experience and prior training and uses information from the site and the pest and its biology. Since the pest manager usually has the responsibility of keeping both the occupants and the decision-makers informed, he or she has the greatest need for information about the site, pest, and appropriate pest management methods.

The IPM program for the site must achieve the goals within the limitations posed by safety, time, money, and materials available. Pest managers monitor the site and the pest populations to determine if actions taken are successful and must keep accurate records of the amount and location of all treatments, including pesticides, dates of each treatment, and the level of effectiveness of the treatment.

Decision-Makers

Generally, people who authorize the IPM program and control the money for pest management are those involved in the administration, or as a director or manager. However, a person indirectly involved with the site may become a pest management decision-maker, e.g., the Health Department Inspector. On other occasions, the purchasing agent or contracting officer for an institution may be a major decision-maker for a site.

At this level of pest management decision-making, concerns about costs, liability, time expended, method effectiveness, safety, and customer or occupant satisfaction are foremost. Decision makers also determine if the pest manager is performing at an acceptable level and if the pest management objectives are being met. This can be done by monitoring complaints from occupants, periodic evaluation and review of pest management strategy and effectiveness, observation of the site environment, inspections by external sources, or by a combination of these and other methods. Decision-makers must also provide the necessary level of financial commitment for any IPM program to succeed. With adoption of an IPM policy and use of model IPM contract language, there is less chance of error in communication between the different parties involved.

wide applications are stressed, baits and dusts are substituted for sprays, and less-toxic materials replace more toxic compounds.

At the same time, a planning process is established to set pest management objectives, identify the root causes of pest problems in the institutional system, and assess methods to address these causes with primarily nonchemical solutions.

Stage 2 IPM

Stage 2 IPM involves a concerted effort to incorporate physical, mechanical, biological, and educational strategies and tactics into the pest management program and to further reduce pesticide use.

Most pests found in buildings can be attributed to faulty building design, lack of structural repairs, and poor food handling and waste management practices. To achieve permanent solutions to pest problems, pest management staff must devote time to educating building maintenance and custodial staff, food handlers, and occupants about their role in attracting or sustaining pests and enlisting their participation in solving the problems.

A similar process is needed to solve outdoor pest problems. For example, in a school setting, cooperation from physical education and coaching staff is needed to reduce stress on athletic turf that leads to weed problems. Landscape maintenance staff needs encouragement to locate pest-resistant plant materials, increase diversity in the plantings to attract natural enemies of pests, and experiment with non-chemical pest control methods. Assistance from grounds supervisors is needed to ensure that

food debris and other wastes are placed inside waste receptacles where rats, stinging insects, flies, etc. cannot gain access to the wastes.

The primary activities during this stage include developing site-specific pest management plans and educating all participants about their roles and responsibilities in helping to implement the plans.

Developing site-specific pest management plans

Written plans help move pest control from a reactive system to a prevention-oriented system. Annual plans enable pest managers to prioritize use of resources, justify planned expenditures, provide accountability to IPM policies, and coordinate with other components of the institutional system.

These plans emphasize repairing buildings, changing waste management procedures to deny food, water, and shelter to indoor pests, and modifying plant materials and landscape maintenance practices to relieve plant stress and improve plant health.

Costs of these repairs and changes may fall within ongoing operation expenses in existing budgets, or may require a one-time expenditure. In the long-term, however, these activities will reduce overall pest control costs as well as other maintenance and operating budget expenses.

Educating participants

Occupants such as food service and custodial staff, clerical and administrative staff, teaching and nursing staff, directors and managers, students, and nursing home residents must be educated about their role in reducing pest presence in order to enlist their cooperation.

Everyone must understand the basic concepts of IPM, whom to contact with questions or problems, and their role as participants in the program. Specific instructions should be provided on what to do and what not to do.

Staff should be discouraged from bringing pesticides to the facility and applying them on site. Instead, they should be provided with clear instructions on how and to whom to report a pest problem. One option is to provide staff with a “pest alert” card where they can write the date, location, and pest problem. The card can be returned to the observer with a notation of what was (or will be) done about the problem and what, if any, assistance is requested of that person (e.g., better sanitation, etc.).

In a school setting, if information on IPM can be woven into the current curriculum, students and teachers will better understand their roles and responsibilities in the program, but more than this, students will carry these concepts into their adult lives. Education is the only way to make a significant, long-term impact on pesticide use in this country, and what better place to start than in schools? The following ideas are just a few of the ways that this information can be included in the school curriculum:

- involve science classes in identifying pests and in researching IPM strategies
- involve art classes and English classes in developing simple fact sheets and other educational materials on various school pests (use information from the pest chapters in this manual)
- involve vocational classes in making site plans of the school to use for monitoring, in making site

Box B: Tips For Starting An IPM Program

The following suggestions will help overcome barriers and smooth the transition to IPM implementation.

Mandate staff training in IPM. When writing the IPM policy document, include a requirement for the continuing education of pest management personnel. Ensure that budgetary allocations are made to assist them in obtaining the information, skills, and equipment they need to carry out the policy.

Start small. Begin IPM implementation in one location (e.g., a kitchen or a section of lawn) and include short-term objectives. For example, when dealing with a number of pest problems, identify one of the pests likely to respond quickly to an IPM approach, such as cockroaches, so a short-term objective can be realized. Test the IPM methods and fine-tune them. When the program is working successfully in one area, or against one pest, expand the program further.

Develop a list of resources. Know where you can go when information is needed, and know when you need to seek outside help. University of Nebraska–Lincoln Extension personnel, faculty/staff in the Entomology, Agronomy and Horticulture departments and the School of Natural Resources at UNL, staff at the Folsom Children’s Zoo, and even the high school biology teacher can help identify pests and their natural enemies. As you talk to these people ask them if they know of experts in your particular pest problem. You can slowly compile a list of people whom you can call for advice. Also post The Poison Center telephone number (800-222-1222) in a prominent place.

Build a library for pest management personnel, staff, and occupants/residents to use. Extension publications are available from UNL Extension, (Educational Media, Box 830918, University of Nebraska, Lincoln, NE 68583-0918, or see them on-line at <http://www.ianrpubs.unl.edu/>) and are excellent sources of information on pests. Don’t change everything at once. To the degree possible, retain communication and accountability procedures already in use. Tailor new recordkeeping and reporting forms to fit existing agency formats. Recycle existing equipment to uses consistent with IPM methods rather than immediately eliminating the equipment.

Share the process. Involve all members of the staff, especially pest management personnel, in the day-to-day IPM program process as early as possible so they will understand and support the program during the sometimes difficult transition period.

Emphasize communication and plan for future training. During the IPM transition period, keep all personnel informed about what is planned, what is happening now, the expected outcome, and what will happen next. Prepare written records and visual aids that will remain when those associated with development of the IPM program are no longer there.

Publicize the program. Develop good rapport with district public relations personnel and with the local news media. For interviews and photo sessions, include pest managers, custodians, and landscape maintenance personnel as well as directors, managers, or administrators.

Involve the community. Form an IPM advisory committee composed of interested organizations, health specialists, and pest management professionals. They can help make IPM implementation a budgetary priority in the district and can donate or locate resources that may not otherwise be available to the school.

inspections for structural defects that may exacerbate pest problems, and in suggesting structural modifications to eliminate the problems

- involve journalism classes in reporting on the new IPM program use some innovative curricula (<http://pested.unl.edu/web/pested/teachipm>) available that emphasizes IPM, such as the educational video game, Pest Private Eye (<http://pested.unl.edu/web/pested/pestpi>)

Stage 3 IPM

Stage 3 IPM involves institutionalizing the IPM program. This includes developing on-going incentives and reward systems for achieving IPM objectives, establishing an IPM library of educational materials and staff training programs, and writing operations manuals that describe IPM policies and procedures to be followed by pest management personnel.

Develop incentives and rewards

Involve staff in establishing benchmark objectives (e.g., 20 percent pesticide reduction the first year, testing of gel baits in place of roach sprays, raising mowing height on turf to help shade out weeds, etc.). Reward them for innovations and achieving objectives (e.g., a letter of commendation, recognition at a staff awards picnic, article in local news media, travel authorization to an out-of-town IPM conference, etc.).

Contracted Services

Pest control companies should work with the responsible facility official to solve pest management problems. Using an outside pest control company may cost more initially than

Box C: Sources of Pest Management Services

IPM programs can be successfully implemented by “in-house” employees, by contracting with a pest control company, or by mixing and matching these options to meet the needs and capabilities of the facility. All three approaches have advantages and disadvantages, and individual sensitive environment systems must decide what is best for them under their unique circumstances. Whatever way you choose to implement your program, pest management personnel should be trained to do the following:

- understand the principles of IPM
- identify structural features or human practices that are contributing to pest infestations and know how to permanently improve them to reduce pest problems
- identify pests and recognize the signs or symptoms of their presence
- monitor infestation levels and keep records of pests and treatments
- know how to successfully apply physical, mechanical, cultural, and biological pest control methods
- know the full array of least-hazardous pesticides registered for use
- know recommended methods of judicious pesticide application
- know the hazards of pesticides and the safety precautions to be taken; be familiar with the pesticide label’s precautionary statement(s) pertaining to exposure to humans or animals

“In-House” Services

One of the most important tasks for an in-house program is training staff to function within an IPM context. The University of Nebraska–Lincoln Extension has the expertise to meet most IPM training needs. Training materials that are needed and are not already available can be developed jointly between the institution, Extension, and other resource organizations.

in-house staff but has the advantages of not having to hire and train personnel or, when necessary, incur the added costs of storing pesticides. The contract should specify the use of IPM principles and practices in meeting pest management objectives.

When choosing a pest control firm, local Better Business Bureaus or the Nebraska Department of Agriculture Pesticide Program (301 Centennial

Mall South, P.O. Box 94756, Lincoln, NE 68509-4756, (402) 471-2394 <http://www.agr.ne.gov/plant/index.html>) may provide information about whether they have or have not received complaints about a pest control company. The Ag Department can also provide information on pesticide applicator certification or search the database yourself at <http://www.kellysolutions.com/NE/Applicators/index.htm>.

The pest management services contract should include IPM specifications. Contracts should be written to provide expected results. Pest management objectives specific to the site should be jointly developed, agreed upon, and written into the contract. Any special health concerns (such as those for old or young people, for pets, or for individuals who are allergic, etc.) should be noted and reflected in the pesticides that can be utilized or excluded from use. See Chapter 1 for sample contract performance specifications.

Provide IPM educational materials and staff training programs

IPM programs are information-intensive rather than treatment-intensive. This necessitates motivating pest management staff to try new approaches and broaden their professional skills. Build an IPM library of literature and training videos and provide release time for staff to attend training seminars or take courses in pest identification.

Prepare an IPM operations manual

Written policies and procedures are needed to ensure clarity about responsibilities, authorized activities, permitted materials, and other program elements. A manual serves as an accountability mechanism, and helps ensure program continuity despite personnel changes.

A loose-leaf binder that allows for addition or deletion of materials over the years is a convenient format. In addition to official policies, procurement practices, etc., the manual should specify the following:

- pest management objectives

- the overall IPM process for managing each pest
- biological and ecological information on the pest and its natural enemies
- the monitoring system for each pest (and natural enemies when appropriate)
- injury levels and action thresholds for pests
- the recordkeeping system to be used
- how to interpret field data
- how to obtain, use, and maintain equipment and supplies required to carry out monitoring and treatment activities
- the range of treatment tactics authorized for use against the pest and how to employ them
- safety procedures and resources for emergencies
- how to evaluate treatment effectiveness

Building Support for the IPM Program

Once an IPM policy has been adopted, it is up to the in-house pest management staff or outside contractors to implement the policy (see Box C for a discussion of pest management services and Chapter 1 for sample IPM contract specifications).

Change never comes easily, and there are a number of predictable obstacles within any facility — both psychological and institutional — to be overcome when initiating IPM programs. At the same time, even if the public has been involved with development of a policy, there are likely to be occasional complaints and controversies,

especially as pests, pest control practices, and public concerns change.

Psychological Barriers to IPM Adoption

Psychological resistance to change

The Problem

When pest management personnel are asked to make pest management decisions in a new way and to use new methods, they may feel that there is a negative implication regarding their past performance so they resist making the changes or drag their feet.

How to Address It

It is important to avoid an adversarial relationship with the personnel. If you want to secure their cooperation, you cannot think of them or portray them as “the bad guys.” Pest management personnel will have information about current pests and pest management practices as well as historical information that will be invaluable to you. Let them know that you consider their knowledge important and that you need their expertise in planning the implementation of the IPM program. Try to foster a sense of team spirit and point out that a pilot IPM program at your facility could be used as a model for other institutions in the community.

Loss of authority

The Problem

Adopting an IPM approach may engender fear of many kinds of loss, including loss of personal or supervisory authority. In the first case, individuals may fear that their experience in the field will become devalued,

particularly if their expertise has been in pesticide application. In the second case, supervisors may fear that the system will become more efficient, and they will lose positions beneath them.

How to Address It

Actually, successful IPM implementation enhances both personal and supervisory authority. Many of the new, less toxic pest control materials, such as pheromones, microbial and botanical pesticides, and insect growth regulators (IGRs) require the same or similar application skills and equipment as conventional pesticides. Mastering the techniques of monitoring, for example, enhances individual skills and can lead to an upgrading in job classification. In terms of supervisory authority, IPM programs provide managers with greater flexibility in staff assignments. For example, by emphasizing monitoring rather than prophylactic pesticide applications, staff time previously spent spraying can be redirected to other tasks, increasing overall productivity within a department.

Imagined difficulty in learning new technology

The Problem

The techniques used in IPM may initially appear to require conceptual and operational skills beyond those of the current staff.

How to Address It

This fear can be overcome by building staff training into the IPM implementation program and by establishing a transition period during which pest management personnel experiment with and fine-tune IPM methods. Once personnel have a

basic understanding of IPM concepts, these people will become the source of the most useful innovations in pest management because they have the most extensive knowledge of how their system works.

Fear of IPM program failure

The Problem

Supervisory personnel may believe that the IPM program will not work for them even though it has been successful in another facility.

How to Address It

In fact, IPM programs are designed for the particular circumstances of each location. While the IPM decision-making process remains the same no matter what the pest or site, the specific tactics and products used may vary greatly from one location or circumstance to another. This flexibility usually assures an appropriate solution to the pest problem.

Institutional Barriers to IPM Adoption

Fear that IPM means no access to pesticides

The Problem

Some people think IPM means never using chemical controls.

How to Address It

While IPM definitely encourages alternatives to pesticides when feasible, chemical controls are used when they are the best option. However, in an IPM program, pesticides that are least-disruptive and most-selective to specific pests are preferred over broad-spectrum materials. When chemical controls are used in an

IPM program, every effort is made to “spot-treat” specific areas rather than spraying large areas.

Fears that IPM is more expensive than traditional pest control

The Problem

Until facilities have experience with IPM, they expect it to cost more than their current program.

How to Address It

While there are short-term start-up costs for any new technology, in the long run IPM has usually proven more cost-effective than a strictly chemical control program. When possible, IPM programs substitute information gathering (monitoring) in place of other pest management activities, such as preventive pesticide applications.

This can be very cost-effective. For example, by monitoring their 1100 elm trees rather than prophylactically spraying them against elm leaf beetles, the City of San Rafael, CA, found that only a small portion of the trees required treatment. As a result, the city saved \$1400 (including monitoring costs) in the first year of its IPM program, compared to the previous year when all trees were sprayed.

IPM methods emphasize reducing the source of pest problems (e.g., designing out pest habitat and food sources) rather than treating symptoms (e.g., spraying). This type of pest prevention program is more cost-effective than a continuing program of pest reduction that does not address the underlying cause of the infestation and is therefore repeated again and again. For example, by permanently reducing habitats for rats (i.e., by filling rat holes with concrete,

changing the design of garbage cans, and increasing frequency of garbage pickup) the National Park Service was able to permanently reduce rat populations in certain parks. Previous rat control programs that had relied on poison baits had not been successful despite large expenditures of labor and money.

Lack of in-house IPM expertise

The Problem

Staff may be unfamiliar with IPM and may not know where to go for information.

How to Address It

While it is true that IPM education and training resources are not as widely available as those for chemical controls alone, good resources can be found in any community. Many agencies have found it feasible to hire an IPM specialist to work as a consultant to in-house pest management staff during the initial year or two of IPM implementation or to create an IPM coordinator position and recruit nationwide. Other sources of information include UNL Extension faculty/staff, UNL Agronomy and Horticulture, Entomology or School of Natural Resources faculty, and pest management advisors. Periodicals providing practical technical advice on IPM methods for specific pest problems are increasingly available. Box D provides contact information for the IPM team at the University of Nebraska–Lincoln. The team representatives will help you identify resources, local and state-wide contacts that can help with questions of IPM program design, implementation and technical information.

Box D: Contact to Help Implement an IPM Program

Clyde L. Ogg, Extension Educator
Erin C. Bauer, Extension Associate
IPM team representatives
377C Plant Sciences Hall
University of Nebraska–Lincoln
Lincoln, NE 68583-0971

800-627-7216 or 402-472-1632

email: cogg@unl.edu, ebauer2@unl.edu

IPM in Schools web site: <http://schoolipm.unl.edu/>

Pesticide Safety Education Program web site: <http://pested.unl.edu>

Developing an IPM Policy Statement For Pest Management

A clear policy statement is needed to develop agreement about how pest management will be performed. The sample IPM policy included here does not exclude the use of a pesticide, but places all pesticide use within a context where such use will be minimized. A policy statement for pest management should state the intent of the facility's administration to implement an IPM program and should briefly provide guidance on what specifically is expected. The sample policy statement can be adapted and modified to fit your own situation. This model has been used by a variety of institutions as a way to resolve conflicts and redirect pest management efforts toward least hazardous practices.

Sample Pest Management Policy Statement

Structural and landscape pests can pose significant problems to people, property, and the environment; however, the pesticides used to solve these problems carry their own risks. It is therefore the policy of this [insert name of facility or institution] to use Integrated Pest Management (IPM) programs and procedures for control of structural and landscape pests.

Pests

Pests are living organisms (animals, plants, or microorganisms) that interfere with human purposes in a sensitive environment. Strategies for managing pest populations will be influenced by the pest species and the degree to which that population poses a threat to people, property, or the environment.

Pest Management

Pests will be managed to:

- reduce any potential human health hazard or to protect against a significant threat to public safety
- prevent loss or damage to structures or property
- prevent spreading in the facility, or to plant and animal populations beyond the facility

- enhance the quality of life for students, staff, residents, and others

Pest management strategies must be included in an approved pest management plan for the site.

Integrated Pest Management Procedures

IPM procedures will determine when to control pests, and whether to use physical, horticultural, or biological means. Chemical controls are

Box E: Cautionary Labeling for Pesticides

Law requires that precautionary statements and signal words be included on pesticide labels, with the exception of EPA minimum risk active ingredients. The signal words (see below) indicate the level of acute (immediate) toxicity of the pesticide to humans (primarily applicators). The chronic (long-term) toxicity is not indicated on the label. Note that chronic toxicity may be important for materials used frequently or extensively, or used in areas where people may receive regular exposure (for example, lawns on which young children play, sit, and lie). Currently, chronic toxicity information must be obtained from scientific journals. Most labels bear the child hazard warning “Keep Out of Reach of Children.”

Signal Words

DANGER — (indicates higher toxicity) A taste to a teaspoonful taken by mouth could kill an average-sized adult.

WARNING — (indicates moderate toxicity) A teaspoonful to an ounce taken by mouth could kill an average-sized adult.

CAUTION — (indicates lower toxicity) An ounce to over a pint taken by mouth could kill an average-sized adult.

Note that these signal words are based on amounts taken by mouth; however, most actual exposure is through the skin. The dermal (skin) exposure route is the easiest to prevent through the correct use of personal protective equipment (PPE) and strict adherence to pesticide label instructions. By following the label and using PPE, pesticide exposure is minimized. Thus, the signal word system is sufficient to minimize potential risk. However, no materials with the DANGER signal word should be used near children. It follows that WARNING materials should be used only rarely when no CAUTION materials are available to control a particular pest.

used after other control means have been considered. IPM practitioners depend on current, comprehensive information on the pest and its environment, and the best available pest management methods. Applying IPM principles prevents unacceptable levels of pest activity and damage. These principles are implemented by the most economical means and with the least possible hazard to people, property, and the environment.

It is the policy of this [insert name of facility or institution] to utilize IPM principles to manage pest populations adequately. While the goal of this IPM program is to reduce and ultimately eliminate use of more toxic chemical controls, these chemicals may become necessary in certain situations. The choice of using a pesticide will be based on a review of all other available options and a determination that these options are unacceptable or are infeasible, alone or in combination. Cost or staffing considerations alone will not be adequate justification for use of chemical control agents. The full range of alternatives, including no action, will be considered.

When it is determined that a pesticide is to be used in order to prevent pest levels from exceeding action thresholds, the least-hazardous (see Box E) material that is effective will be chosen. The application of such pesticides is subject to the Federal Insecticide, Fungicide, and Rodenticide Act, your facility's policies and procedures, Environmental Protection Agency regulations in 40 CFR, Occupational Safety and Health Administration regulations, The

Nebraska Pesticide Act and associated regulations, and other state and local regulations.

Education

Staff, students, administrative personnel, directors, managers, residents, custodial staff, pest managers, and the public will be educated about potential pest problems and the integrated pest management policies and procedures to be used to achieve the desired pest management objectives.

Recordkeeping

Records will be kept on the number of pests or other indicators of pest populations both before and after any treatments. Records must be current and accurate if IPM is to work. Records of pesticide use shall be maintained on site to meet the requirements of the Nebraska Department of Agriculture and sensitive environment involved, and records will also document any non-chemical treatment methods being used. The objective is to create records from which programs and practices can be evaluated in order to improve the system and to eliminate ineffective and unnecessary treatments.

Notification

This [insert name of facility or institution] takes the responsibility to notify students' parents or guardians, residents, and staff of upcoming treatments which will involve a pesticide. Notices will be posted in designated areas at the facility and, if appropriate, sent home with students or family.

Pesticide Storage and Purchase

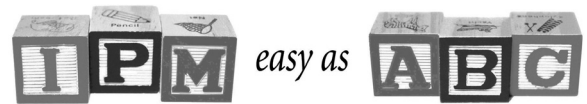
Pesticide purchases will be limited to the amount authorized for use during the year. Pesticides will be stored and disposed of in accordance with the EPA-registered label directions and State or Local regulations. Pesticides must be stored in an appropriate, secure site not accessible to students or unauthorized personnel. A cabinet with a locked and labeled door is advised. The door label should include a warning sign including visual signals for non-English reading adults or children.

Pesticide Applicators

Pesticide applicators must be educated and trained in the principles and practices of IPM and the use of pesticides approved by this [insert name of facility or institution], and they must follow regulations and label precautions. Applicators must be licensed by the Nebraska Department of Agriculture and comply with this [insert name of facility or institution] IPM Policy and Pest Management Plan. Under no circumstances should applications be made while facility activities are in progress.

Chapter 6

IPM for Ants



Introduction

Most ants are nuisance pests when they invade buildings searching for food; others, like carpenter ants, can nest in structural wood and damage the structural integrity of wood-framed buildings.

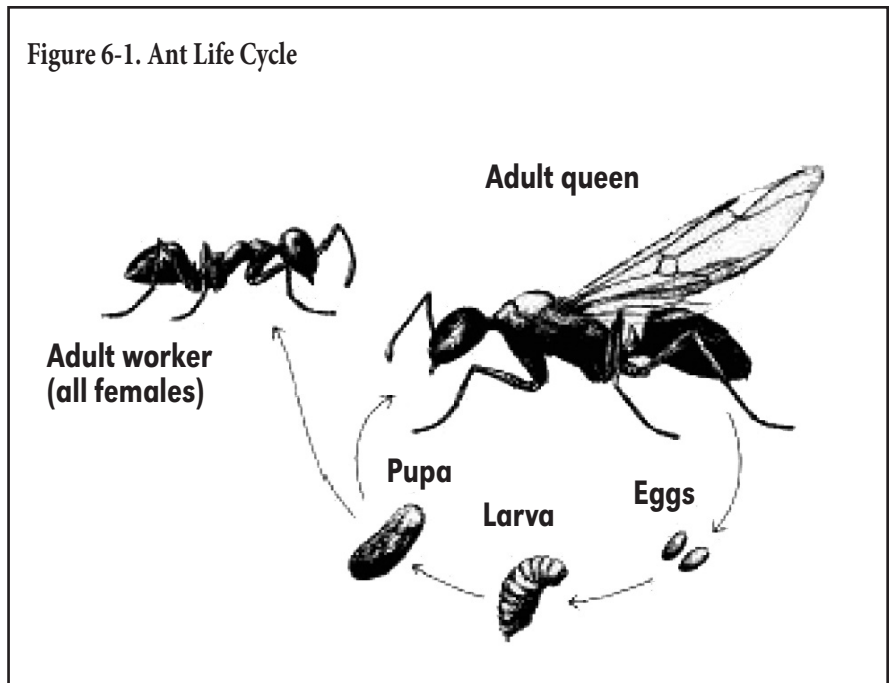
It is important to recognize that an ant species can be both pestiferous and beneficial. Ants kill numerous other pest insects, including fly larvae and termites, and they aerate the soil outdoors and recycle dead animal and vegetable material. From that point of view, ants provide an important ecological cleansing and fertilization service. Since most ant species are not destructive, the first management strategy should be to keep them out of structures. Identification can help distinguish nuisance species from those that are damaging and determine if additional treatment measures are needed.

Identification and Biology

Ants are social insects and live in colonies. The colony is divided into three main castes: workers, queens, and males. The workers enlarge and repair the nest, forage for food, care for the young and queen, and defend the colony. The queens lay eggs, and the males serve only to mate with the queens.

Ants pass through four stages of development: egg, larva, pupa, and

Figure 6-1. Ant Life Cycle



adult (see Figure 6-1). Queens mate with males and lay eggs that hatch into blind, legless larvae. The larvae are fed and cared for by worker ants. At the end of the larval stage they turn into pupae that do not feed. Eventually, the adult ants that we recognize emerge from the pupal cases.

It is important to identify your problem ant before you design your management program because ants differ in their habits and food preferences. Use Box 6-A and Table 6-1 to assist you.

Damage

Certain species of ants, such as odorous house, thief, and Pharaoh ants, are particularly prone to getting into

food. Inside buildings, these ants are mainly a problem of nuisance since they almost never sting or bite.

Since ants walk over many different kinds of material and sometimes feed on dead animals and insects, it is possible they can carry disease-causing organisms to human food. At the very least, you should assume that food they have swarmed over has been exposed to organisms that can cause spoilage, and the food should be thrown away.

Detection and Monitoring

Visual inspection is the most useful monitoring technique for ants, and can be very useful in preventing an

incipient ant infestation. Often it takes detective work and ingenuity to discover where the ants are coming from.

- Begin by constructing a map of the facility on which you can note problem areas and areas needing repair.
- Kneepads, a mirror, and a good flashlight will be helpful.
- Carry a caulking gun and seal all small holes found during the inspection.
- Keep accurate records during the monitoring program to help formulate an IPM plan and evaluate its effectiveness.
- Ants are most likely to be pests indoors, especially in kitchens and food preparation areas.
- An ant infestation may indicate that there has been a change in the methods of storing food or food waste that allows increased access for ants. Note how food and food wastes are stored in the area, and whether refuse containers are emptied and cleaned regularly. Check recycling bins to see if recyclables have been cleaned before storage.
- Speak to the kitchen staff and custodians to learn more about the problem from their perspective.
- Ants can be attracted to snacks kept in classrooms or the teachers lounge, or to something like a sweet drink accidentally spilled on the floor.

Management Options

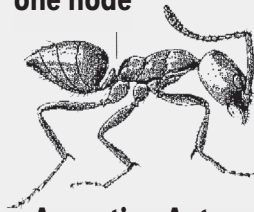
Habitat Modification

The environment should be modified to reduce ant entryways and access

Box 6-A. Identifying Ants

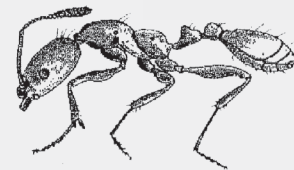
Since ant species can differ widely in their food requirements, it is important to identify the species before choosing a bait. Like all insects, ant bodies are divided into head, thorax, and abdomen. Unlike many other insects, however, ants have a constriction between the thorax and abdomen that gives them their pinched-waste appearance. The constricted part of the abdomen is called the pedicel, and the fat, main part of the abdomen is called the gaster. An important identification characteristic is the number of segments or “nodes” in the pedicel (see the figure below). For example, one-node ants include the Argentine ant and odorous house ant. Two-node ants include the Pharaoh ant, pavement ant, and little black ant. Final identification is made from size, color, other body characteristics, habits, or other information. Table 6-1 provides more information to help you identify your problem ant.

one node



**Argentine Ant,
*Linepithema humile***

two nodes



**Pharaoh Ant,
*Monomorium pharaonis***

to food. With good quality materials and a careful job, the alteration will be permanent and make a long-term impact on the number of ant invasions.

Caulking

- Caulk actual and potential entryways with a silicone caulking compound.
- Use mildew-resistant caulk in moist areas.
- It is not necessary or practical to seal all cracks, but begin with the access point that the current trail of ants is using.
- Always carry caulk when making inspections and seal as many cracks as time allows, especially those around baseboards, cup-

boards, pipes, sinks, toilets, and electrical outlets. Silicone caulks are flexible, easy to apply, and long-lasting.

- Weather-strip around doors and windows where ants may enter.

Sanitation

Sanitation eliminates food for ants. Thorough daily cleaning of kitchens and food preparation areas is essential.

- Sweep and mop floors.
- Drain all sinks and remove any food debris.
- Vacuum and/or mop floors daily if people regularly eat there.
- Periodically, give all food preparation areas an all inclusive cleaning,

focusing on areas where grease and food debris accumulate. These include drains, vents, deep fat fryers, ovens, stoves, and hard-to-reach areas behind or between appliances. Thoroughly vacuum the area with a powerful vacuum.

- At the end of each day, remove from the building all garbage containing food.
- Use soapy water to wash any bottles, cans, wrappings, and other items that have food residues clinging to them before storing them for recycling.
- Rinse dishes to remove all food debris if they cannot be washed right away.
- Place garbage in sealed plastic bags before it is placed into a rodent-proof dumpster (see Chapter 13) or other storage receptacle.
- Keep garbage cans and dumpsters as clean as possible to deny food to ants, roaches, flies, mice, and rats.

Since ant species can differ widely in their food requirements, it is important to identify the species before choosing a bait. See Table 6-1 and Box 6-A for helping to identify your problem.

Proper Food Storage

- Food not kept in the refrigerator should be kept in tightly closing containers. Cardboard boxes and paper are not ant- or roach-proof.
- During ant invasions, keep particularly attractive substances, such as sugar and honey, in a refrigerator.
- Although refrigerator storage is usually safe, ants sometimes get into refrigerators and freezers even when the seals appear intact. When this occurs, a light, tempo-

rary coating of petroleum jelly on the edge of the refrigerator seal will exclude the ants. Once ants have left, the petroleum jelly can be wiped off. Freezer storage is safe because any ants that manage to get past the seal will die.

- Screw-top jars are ant-proof only if the lid has a rubber seal since the ants can follow the spiral ridges to get into the jar.
- Glass containers with rubber gaskets or plastic containers with tight-fitting, snap-top lids are also ant-proof.
- As soon as they arrive in the building, transfer food packaged in paper to plastic or glass containers. Advise staff not to leave unsealed food items in their desks. Any food kept in offices, classrooms, or staff lounges should be stored in ant- and roach-proof containers.

Physical Controls

Before ants become highly visible in long columns marching through a room, there have been a few “scouts” wandering around looking for food or water. It is always a good idea to kill these scouts before they have a chance to go back to the colony and summon their nest mates. Instruct staff to squash lone, wandering ants whenever they see them.

Vacuuming

- Use a strong vacuum to vacuum up trails of ants effortlessly and quickly.
- Although the dust in the vacuum bag will usually clog the ants’ breathing apparatus and suffocate them, you can vacuum up a tablespoon of cornstarch to be sure they die.

Detergent Barrier

Temporary “moats” of detergent and water may be useful during heavy ant invasions.

- Containers of food or food waste that must remain open during working hours can be placed in larger, shallow pans filled with water mixed with a small amount of detergent. Water alone is insufficient since ants can float across using the water’s surface tension; the detergent breaks the surface tension, and the ants sink and drown.
- Use this technique to protect potted plants from ants that may be attracted to nectar produced by the plant or to honeydew produced by plant-feeding insects. Elevate the pot above the detergent-and-water mixture by placing it on an overturned saucer. Make sure the plant is not touching anything that ants could use as a bridge.

Flooding

Ants sometimes build nests in potted plants. Rather than disposing of the soil and the plants, water the soil until the ants are driven out.

- It is easiest to do this outside where the ants will find their way to another suitable nesting place, but if this is impractical, use a container of loose dry soil or compost to catch the ants.
- Place the infested pot in a wide and deep container and use a stick to make a bridge from the pot to the ground or to the bucket of soil or compost.
- Water the plant heavily. As the soil becomes saturated, the ants will pick up their white pupae and look for drier ground.

Table 6.1. Common One-Node and Two Node Structure-Invading Ants



Identification of

EC1570

Structure-Invading Ants

in Nebraska

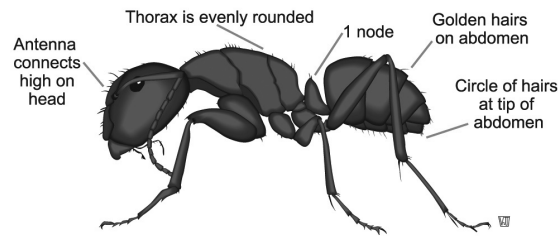
Barbara Ogg, Extension Educator
Vicki Jedlicka, Publication and Resource Assistant
Clyde Ogg, Extension Educator — Pesticide Education
Shripat T. Kamble, Extension Urban Entomologist

One-Node Ants

Black Carpenter Ant

Camponotus pennsylvanicus

Many sizes of workers.

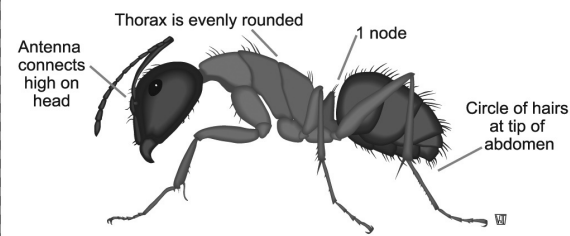


Major workers: about 7/16" Minor workers: about 1/4"

"Red" Carpenter Ant

Camponotus sayi

Many sizes of workers. Two-toned red and black.

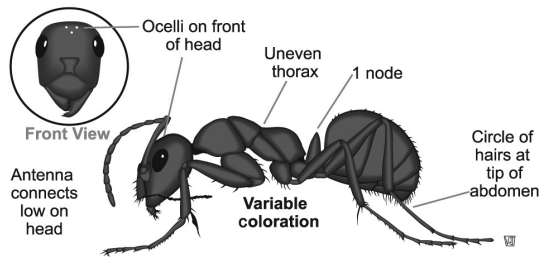


Major workers: about 1/4" Minor workers: about 3/16"

Field Ant

Formica spp.

Field ants may be black, brown, tan, reddish, or red and black. Often confused with carpenter ants.

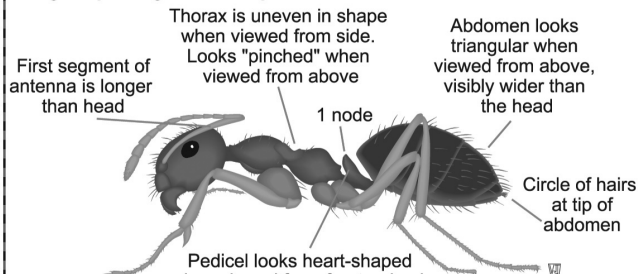


Actual size about 3/8"

Small (False) Honey Ant

Prenolepis imparis

When these ants are swollen (full of food), the gasters (abdomen) are greatly enlarged and shiny.

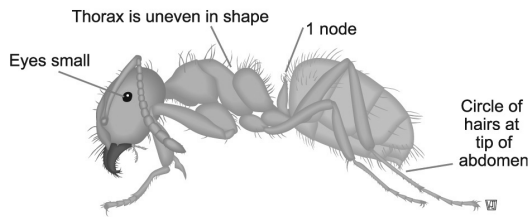


Actual size about 1/8"

Large Yellow Ant

Acanthomyops interjectus

Also called citronella ant or foundation ant. Gives off "lemony" odor when crushed.

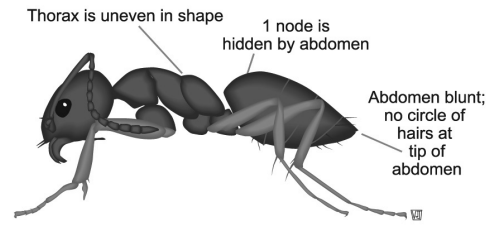


Actual size about 1/4"

Odorous House Ant

Tapinoma sessile

Has rotten coconut-like odor when crushed.



Actual size about 1/8"

Two-Node Structure-Invading Ants

Species	Workers	Habits/Management
Thief Ant <i>Solenopsis molesta</i>	Tiny, about 1/32 to 1/16 inch (1.0-1.5 mm); yellowish; often confused with Pharaoh ant, but has two segments in the club-like structure at the end of the antenna. Small eyes.	Often lives in association with other ants as a predator of brood; omnivorous but prefers grease or high protein foods over sweets; frequent house invader, may nest indoors in cracks and cupboards. In Nebraska it is more common than the pharaoh ant. Management: Treat colonies in wall voids with dusts. Baits are not effective.
Pharaoh Ant <i>Monomorium pharaonis</i>	Tiny, about 1/16 to 3/32 inch (1.5 to 2 mm); yellowish to red; often confused with thief ant, but has three segments in the club-like structure at the end of the antenna.	Nests in secluded spots and prefers temperatures of 80 - 86½ F. Pharaoh ants often are found around kitchen and bathroom faucets where they obtain water. This ant feeds on sweets but also eats fatty foods. It is predacious on other insects and will even eat dead insects. More common in warmer climates than in Nebraska. Management: Residual insecticides are not useful because colonies tend to split. Baiting is the preferred management strategy.
Little Black Ant <i>Monomorium minimum</i>	Tiny, about 1/32 to 1/16 inch (1.0 to 1.5 mm); jet black.	Small craters of fine soil mark nest openings in the ground; will also nest in woodwork or masonry of buildings; omnivorous, not a common invading ant in Nebraska. Management: Drench or dust outdoor colonies. Treat colonies in wall voids with dusts. Baits also may be effective.
Acrobat Ant <i>Crematogaster spp.</i>	Small, about 1/8 inch long (3 mm); brown to blackish. The pedicel attaches to the upper part of the abdomen. When viewed from front or back, the abdomen is heart-shaped.	Acrobat ants often tunnel and nest in wood. They have similar habits to carpenter ants and can live in decaying tree stumps. Inside they live in wall voids and door or window frames or foam insulation under siding. They may nest in wood already damaged by carpenter ants or termites. Nest locations often are associated with moisture problems and water leaks. Acrobat ants feed on honeydew and tend aphids. Management: Eliminate conducive moisture conditions before treating colonies. Baits are not effective.
Pavement Ant <i>Tetramorium caespitum</i>	Small workers, about 1/8 inch (2.5 to 3 mm); light to dark brown or blackish; head and thorax furrowed by parallel lines. One pair of spines on thorax and a sting on the tip of the abdomen.	This ant gets its name because it often nests under sidewalks, driveways and building foundations. A mound of displaced soil along a paved area is a sign of pavement ant activity. During the winter, pavement ants may nest inside structures near a heat source. Trailing ants feed on a wide variety of foods, including dead insects, greasy foods, seeds and sweets, as well as aphid honeydew. Management: Locate and treat colonies with an appropriate insecticide. Commercial baits may be effective.
Big-Headed Ant <i>Pheidole spp.</i>	Small workers, about 1/16 to 1/8 inch (1.5 to 3 mm); yellowish or light to dark brown. Two sizes of workers. Major workers have a very large head in proportion to their body.	Most common in warmer areas of the United States, but found in Nebraska. This ant primarily lives outdoors and only occasionally invades structures. Colonies have multiple queens and can be very large. Nesting is usually in the soil in protected locations, such as under rocks, logs, firewood, patio blocks, and landscape timbers, but they also will nest in open areas. Big-headed ants will construct mud tubes on foundations, similar to termite tunnels. Management: Treat colonies, depending on location. Using outdoor granular baits may be effective unless colonies are large.

Identifying Winged Ants: Mature ant colonies produce winged ants that swarm periodically. These winged ants, called swarmers, emerge from the nest and fly off to start new colonies. When colonies are found outdoors, swarming occurs outside. Indoor swarming usually indicates the ant nest is in or under the structure. Swarming ants include females (queens) and males (kings) that look quite different from the worker ants. Compared with workers, queens are much larger and more robust; kings are skinny and much smaller than workers. Queens and kings also may be colored differently than workers, so color is not a good feature when identifying winged ants. Swarming ants have some of the key features of workers, but ant identification is most accurate with worker specimens.

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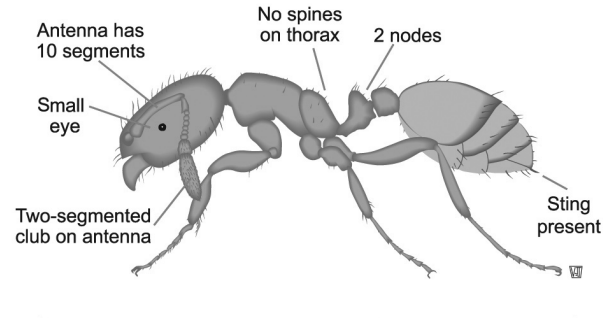
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Two-Node Ants

Thief Ant

Solenopsis molesta

Also called grease ant. The thief ant is most often confused with the pharaoh ant.

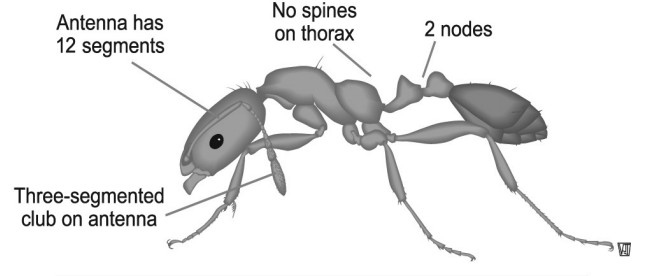


Actual size 1/32" to 1/20"

Pharaoh Ant

Monomorium pharaonis

The pharaoh ant is most often confused with the thief ant. The primary difference between the two species is the pharaoh ant has a three-segmented antennal club while the thief ant has a two-segmented antennal club.

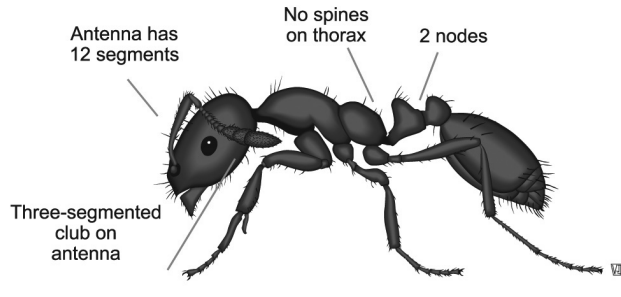


Actual size about 1/16"

Little Black Ant

Monomorium minimum

Similar in appearance to pharaoh ant except black in color.

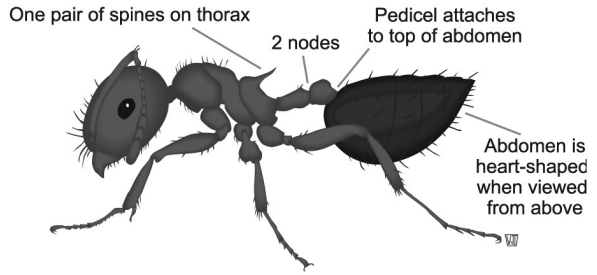


Actual size about 1/16"

Acrobat Ant

Cremastogaster spp.

Acrobat ants get their name from the habit of holding their abdomen above their thorax when the workers are disturbed.

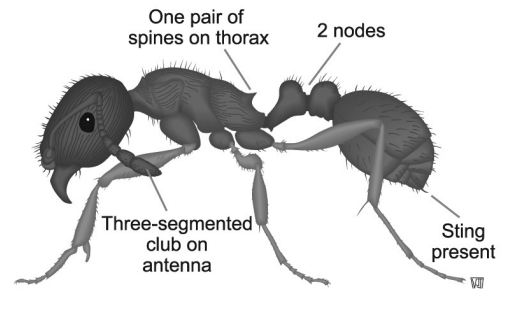


Actual size slightly longer than 1/8"

Pavement Ant

Tetramorium caespitum

Head and thorax are covered with visible grooves.

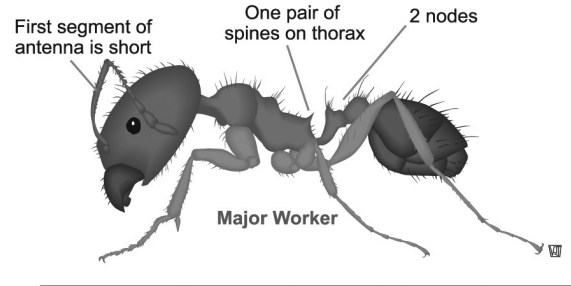


Actual size about 1/8"

Big-Headed Ant

Pheidole spp.

Two sizes of workers. Major workers have a very large head. Minor workers have heads more proportional to their bodies.



Actual size Major workers: about 1/8" Minor workers: about 1/16"

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One-Node Structure-Invading Ants

Species	Workers	Habits/Management
Carpenter Ant <i>Camponotus spp.</i>	Medium to large workers, 1/4 inch to 1/2 inch (7-15mm). Thorax evenly rounded. Workers are not all the same size. Black carpenter ants are most common, but workers of a second species, <i>C. sayi</i> , have a reddish-brown head and thorax and black abdomen. <i>C. sayi</i> is a slightly smaller species than the black carpenter ant. It is unofficially called the "red" carpenter ant to distinguish it from the black species.	Carpenter ants do not eat wood, but nest in water-soaked wood. Outdoor locations include dead tree stumps and limbs, railroad ties and firewood. Indoors, colonies are found around leaky plumbing, under windows, and in soffits, where the roof has leaked. They produce sawdust that looks like fine wood shavings, but is not powdery. It may contain foam insulation. Workers of <i>C. pennsylvanicus</i> will travel 300 feet from a colony, so finding ants inside may not mean there is a colony within the structure. Colonies consist of a primary colony that may be outdoors or where moisture is abundant. When the primary colony becomes large, workers often move part of the colony to another location. These are called <i>satellite colonies</i> and may be found in homes. Carpenter ants are most active at night, emerging after dusk and returning to their colony before dawn. Following ants may be helpful in finding the colony location. Carpenter ants make a noise that sounds like crinkling cellophane and may be heard inside walls. A stethoscope may be helpful in locating colonies in wall voids. Management: Eliminate moisture problems associated with interior colonies to correct conducive conditions. Treatment involves locating and treating both primary and satellite colonies.
Field Ant <i>Formica spp.</i>	Medium ants, 3/8 inch (11mm), often confused with carpenter ants. Wide variation in color: black, brown, tan, reddish, or red and black. Thorax is bumpy in appearance. Key distinguishing feature: three ocelli on head.	These ants are common around structures, but often are not found inside. Field ants are soil nesters and often construct sizeable mounds in open fields. In lawns nests have a low profile, rarely reaching above the top of the grass. They also nest under objects like rocks, landscape timbers and firewood piles. Displaced soil is often evident. Items such as stones, logs, and bricks should be overturned and inspected underneath for colonies. Management: Treatment of colonies includes drenching with a labeled residual liquid using a compressed air sprayer. Outdoor granular baits may be effective.
Odorous House Ant <i>Tapinoma sessile</i>	Small, 1/16 to 1/8 inch in length (1.5 to 3 mm); dark brown to black. Pedicel cannot be seen when viewed from above. Smells like rotten coconut when crushed.	Odorous house ant is the most frequent structure-invading ant in Nebraska. It nests in a wide variety of places outdoors and inside. Nests are often underneath objects, such as stones, patio blocks and debris. Inside, it prefers areas with moisture such as around hot water pipes and heaters. Odorous house ants have multiple queens. This ant forages when temperatures are cool, even down to 50½ F. A strongly trailing ant, it tends aphids for honeydew and prefers sweets in kitchens. Management: Treatment includes correcting conducive conditions and locating and treating colonies, which may include drench treatments, dusts in wall voids, and baits, depending on colony location.
Small Honey Ant <i>Prenolepis imparis</i>	Small, about 1/8 inch long (3 mm); golden yellow to brown. Stiff hairs on the abdomen and thorax. First segment of antenna is longer than the top of the head. Pedicel looks heart-shaped when viewed from front or back. After feeding, abdomen is swollen with food.	Small colonies. Small honey ants build nests in soil in open, well-shaded areas, seldom under items such as logs or stone. May be found in soil under shrubs and landscaping beds. The nest consists of numerous small galleries dug in the soil; excavated soil particles are deposited in a crater-shaped mound. Ants forage in easily detected trails. Active even in early spring or autumn when temperatures are well below 45½ F. This ant tends aphids for their honeydew, but may forage on sweets in the kitchen during periods when aphids are not active. Management: Treat colonies by injecting 1-2 ounces of liquid insecticide into nest entrance using a crack and crevice tip. Baits also may be effective.
Large Yellow Ant, also called "Citronella Ant" <i>Acanthomyops interjectus</i>	Medium-sized workers, 1/4 inch (7 mm). Easily recognized by yellow-orange color and the fact that it has an odor like citronella or lemon when crushed.	This is a soil-nesting ant. Nests are found under items, such as logs, rocks, patio blocks, porches and concrete patios, but also may be found in open areas. This ant often excavates large amounts of soil as it builds galleries. If the colony is under a concrete slab of a structure, the soil may pile on the slab. These ants swarm nearly any time of the year and may occur inside buildings when colonies are located next to or under the structure. Management: Drench treatments or subslab treatment can be used, depending on colony location. Baits are not effective. Vacuum swarming ants and dispose of them.

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- Many ants may walk out on the stems and leaves, but eventually, they will find the bridge.
- When the trail of ants leaving the pot has disappeared, the plant can be drained and returned to its usual location.

Chemical Controls

If non-chemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted. Pesticides must be used in accordance with their EPA-approved label directions. Applicators must be certified to apply pesticides and should always wear protective clothing during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials when buildings are occupied and never apply them where they might wash into the sanitary sewer or into outside storm drains. When treating ants, only crack and crevice treatments with dust or bait formulations should be used. See Box 6-B for tips on controlling specific ant species.

Detergent and Water

When ants invade an area, the best emergency treatment is detergent and water in a spray bottle. This mixture will quickly immobilize the ants, and they can be wiped up with a sponge and washed down the drain. Each room, cafeteria, and food preparation area should be equipped with such a spray bottle so staff can safely deal with emergencies.

Boric Acid

Boric acid is one of the most valuable chemical control tools in an

integrated program against ants. It is formulated as a dust, gel, and aerosol. It acts as a stomach poison, and since it is a general enzyme inhibitor, ants are unlikely to become resistant to this material. If kept dry, boric acid dust remains effective for the life of the building.

- When applying boric acid dust, wear a dust mask to avoid breathing the material.
- Use a bulb duster to apply a light dusting in cracks and crevices. This is superior to dusting large, open areas.
- Boric acid is approved for crack and crevice treatment in kitchen and food preparation areas.
- Boric acid can be blown with the duster into wall voids and spaces behind and under cabinets.

Diatomaceous Earth and Silica Aerogel

These are insecticidal dusts that can be used for ant control. Diatomaceous earth is made from fossilized diatoms, and silica gel is produced essentially from sand. Both kill insects by desiccation; they abrade the wax and oil from the insect's outer covering, causing dehydration and death. Although these materials are not poisonous to humans directly, the fine dust travels freely through the air and can be irritating to the eyes and lungs; therefore, use a dust mask and goggles during application.

Diatomaceous earth and silica aerogel are especially useful in wall voids and similar closed spaces. During construction and remodeling these dusts can be blown into such spaces, and in finished buildings, they can be applied by drilling tiny holes in the walls. These dusts are also useful in

crack and crevice treatments. Some products combine diatomaceous earth or silica gel with pyrethrins. The pyrethrins provide a quick knock-down of the ants, and the dusts provide the long-term control.

Ant Baits

Baits greatly reduce the amount of pesticide that must be used to kill ants. Foraging ants take the bait back to the nest to feed to other members of the colony, and if the bait kills the queen, the colony will die. Even if the queen is not killed, baits will usually stop an ant invasion. If a colony has been starved by effective sanitation measures, baits will be more readily accepted.

In schools and child care centers, always place baits out of sight and reach of children or use baits at night or on weekends. Remove when children are in school.

Some ants are very susceptible to baits, some are less so. There are many reasons for these differences, only some of which we understand. If you are having difficulty in controlling your problem ant(s) with a bait, the following points may be helpful:

- It is important to correctly identify the species of ant that is invading since each species differs in its food preferences. Some baits use a sweet attractant and some use a protein or oily attractant so the bait must be matched with the ant. If you cannot determine the type of attractant by looking at the label, call the manufacturer for more information. You should also ask if the company has data to support the efficacy of their product against the ant species with which you are dealing.

Box 6-B. Tips For Controlling Specific Ants

Carpenter Ant — Carpenter ants normally build their nests outdoors in hollow trees, logs, posts, and landscaping timbers. They prefer water-damaged wood. These ants keep their galleries clean by pushing sawdust outside; a pile of sawdust underneath the nest is a sign of a colony. Carpenter ants nesting inside also need a moisture source so common nest locations include areas where wood is wet from plugged drain gutters, leaky roofs, damaged siding, leaking door and window frames, and leaky plumbing. The key to successfully managing carpenter ants is finding the colony and may require a pest control professional to do so. A thorough inspection includes looking inside and outside for colonies. Interior areas listed above should be examined carefully. Since carpenter ants are most active at night, inspections after dark may be most fruitful.

Pavement Ant — Start inspections at the ground floor or subfloor level because even if pavement ants are on upper floors, they usually originate from ground floor and outside colonies. Follow trails of ants to locate colony/colonies. Outside, trails are usually hidden by grass or mulch next to the building foundation or the edges of pavement. Inside, you can often find trails under edges of carpets along the tack strip. Pavement ants use electrical wires, conduit, and water pipes as highways throughout the building. Performing an inspection at night around 10 or 11 PM can be useful since pavement ants are most active at night, and you are more likely to find trails that will lead back to the colony. Outside, piles of soil near slabs and concrete are a good indication of underground galleries. Effective pavement ant control requires caulking cracks and crevices and placing baits in the path of ant trails near colonies. Observe carefully to ensure ants are feeding on bait. If not, change baits until you find one they will accept. Baiting is a slow control process and will take several days or longer for satisfactory treatment and will probably not eliminate the problem.

Pharaoh Ant — This is a tropical ant that likes inaccessible dark places with a relative humidity of 80 percent and a temperature of around 80°F. Workers are attracted to baits that contain protein, peanut butter oil, liquid sugars, and granulated silkworm pupae. Place the baits in door or window frames, light switches, and fuse boxes; at floor level in corners and along baseboards; near toilets, sinks, drains, heating pipes, and radiators; and in food cupboards. In warmer areas of the U.S., Pharaoh ants may nest indoors and forage outside. If you find foragers outside, place baits in areas of high activity. Use enough bait stations so that feeding will not deplete the bait before the colonies are dead. It may also be advantageous to use baits that combine 2 different attractants or use several different kinds of bait at once. A bait product for Pharaoh ants containing the insect growth regulator methoprene controls the colony because the queen is sterilized and no new larvae are produced even though the workers are unaffected. Although this kind of bait can take 10 weeks or more to kill a colony, it is a useful ant management tool.

- After setting out bait, observe closely to see if the target ant is taking the bait.
- Ant colonies have changing nutritional requirements that can pose problems in baiting. A colony that accepted a protein bait one week may be more interested in a sugar bait the next.
- The nesting and foraging environment can also affect bait acceptance. Ants nesting and foraging in dry areas will be more interested in liquid baits than will ants nesting in moist environments.
- When there are several competing ant species in one area, ants that you are not trying to control may attack your bait more readily than the pest ant, and in some cases, prevent the pest ant from getting to the bait.
- Do not spray pesticides when using baits. Bait stations contaminated with pesticide are repellent to ants, and sprays disperse the ant infestation, making it harder to place baits effectively.
- Place bait stations along foraging trails but do not disturb ant trails between the nest and the bait. Killing the ants or disturbing the trails prevents the ants from taking

enough bait back to the colony to kill nest mates.

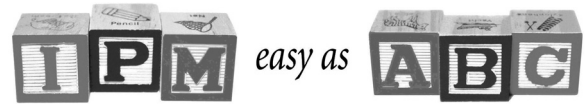
- Do not put out bait until you have an ant problem. If you use baits preventively, you may attract ants into the building.
- Some baits come packaged in plastic disc “bait stations” that come with double-sided tape so they can be glued to various surfaces out of view. It is important to remove bait stations once the ant problem is under control because they are ideal harborage for cockroaches. Likewise, if there is bait left in them, it may eventually attract ants back into the building. Other baits come in granular or gel formulations that can be injected into wall voids through small holes. Gel baits can also be placed near ant trails in unobtrusive places where they will not be disturbed.

Resources

For management practices and pesticide recommendations on ant control, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Educational resource guides and an ant photo gallery are available at: <http://lancaster.unl.edu/pest/ants.shtml>

IPM for Cockroaches



Introduction

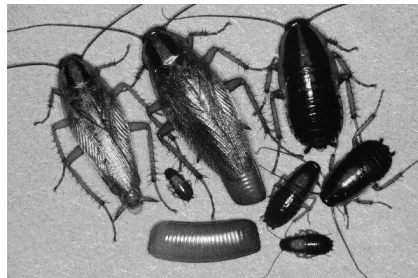
Cockroaches are one of the most important pests in schools, homes, nursing homes, child care centers, restaurants, and other indoor spaces. They consume human foods and contaminate them with saliva and excrement, produce secretions that impart a characteristic fetid odor, and shed skin scales that cause allergic reactions.

Identification and Biology

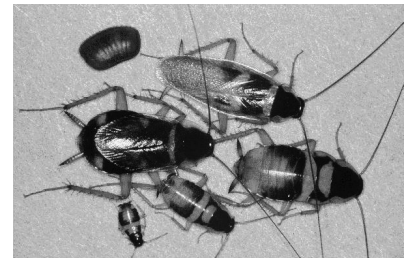
Except for size and markings, all cockroaches are similar in overall appearance: flattened cricket-like insects with long antennae. The most common cockroaches in Nebraska are the German, brownbanded, oriental, and American cockroaches. See Table 7-1 for a list of their important characteristics. Figure 7-1 shows pictures of each.

In general, roaches like to squeeze into cracks and crevices in warm places; the specifics of their habitat differ with the species of roach. The American and oriental roaches can live outside but are forced indoors by cold weather.

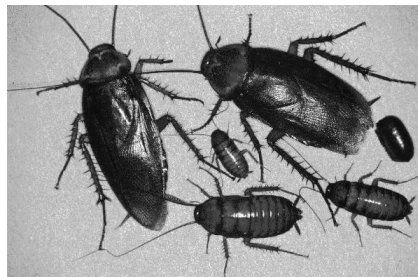
The life cycle of the cockroach begins with the egg case or ootheca. In some species the female carries the egg case around with her until just before the eggs hatch, and in other species, she deposits it in a sheltered place (see Table 7-1). Roaches undergo a



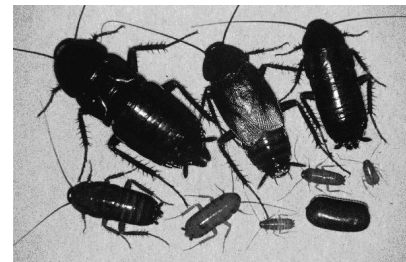
German cockroach



Brownbanded cockroach



American cockroach



Oriental cockroach

Photos: Jim Kalisch

Figure 7-1. Common Nebraska cockroaches.

gradual metamorphosis in their life cycle. An immature roach, or nymph, looks very much like an adult but is smaller and wingless. As the nymph grows, it sheds its skin (molts) a number of times. The number of days it takes a cockroach to mature is affected by the temperature: the warmer it is (up to a certain point), the faster the roach grows.

Cockroaches prefer carbohydrates to protein and fat. They will discriminate among foods if given a choice, but when hungry, they eat almost anything. Some products not normally considered food — starch-based paints, wallpaper paste, envelope glue, and bar soaps — contain

carbohydrates, and hence are food for roaches.

Cockroaches are generally active at night and remain hidden during daylight. Daylight sightings usually indicate a high population that has overrun available harborage or a recent emigrant roach seeking shelter.

Damage

Cockroaches have not yet been proven to be involved in the natural transmission of any particular human pathogen (this means that they are not a necessary part of the life cycle of a disease organism); however, evidence has been collected that

Table 7-1. Characteristics of Common Cockroach Species

Roach Species	Length	Color and Markings	Eggs ¹	Egg to Adult	Reproductive Characteristics
German (<i>Blattella germanica</i>)	9/16 in. (14 mm)	Light brown with two dark stripes on the pronotum (the section of the thorax behind the head)	37	55-68 days	Female carries egg case until about 24 hours before hatching, then drops it anywhere
Brownbanded (<i>Supella longipalpa</i>)	9/16 in. (14 mm)	Tan-golden with faint V-shaped lighter bands on wings	16	95-276 days	Egg case glued to the ceilings, beneath furniture, or in closets or other dark places
Oriental (<i>Blatta orientalis</i>)	1-1/4 in. (32 mm)	Dark red-brown-black throughout	14	300-800 days	Egg case deposited in debris or food in a sheltered place
American (<i>Periplaneta Americana</i>)	1-1/2 in. (38 mm)	Reddish brown throughout with a pale band on the edge of the pronotum; a very large roach	14	285-616 days	Egg case carried up to six days before depositing in a sheltered area

¹Average number per egg case. The number actually hatched can be fewer.

clearly indicates that cockroaches can mechanically transmit a long list of disease-causing organisms. Since roaches wander at will through all types of organic wastes, then travel over kitchen counters, cooking utensils, plates, and silverware, their presence indicates potential contamination of foods and utensils. They can also trigger allergic reactions in sensitive individuals and are implicated as a major asthma trigger in children.

Detection and Monitoring

Efforts to control roaches should begin with a monitoring program. Roaches are rarely dispersed everywhere throughout the building. Once they have located a suitable harborage, they tend to concentrate there, leave periodically to forage for food and water, and then return to the same place. Thus, the first step in monitoring is to locate these roach concentrations. Note that the places

where you see signs of roaches are often where they forage and not where they harbor. You may also need to inspect adjacent rooms (above, below, beside). Monitoring must continue after treatment has begun to determine whether control efforts have satisfactorily reduced the cockroach population.

Establishing a Communication System

A successful monitoring program depends on clear and frequent communication with custodians, food service, and other personnel. These people have first-hand knowledge of pest sightings, sanitation problems, and other contributing factors, as well as the history of control measures in their buildings. With a small investment of time, these personnel can be trained to serve as additional sources of valuable information for the monitoring program.

Make sure personnel understand the following:

- the goals of the cockroach IPM program and the role monitoring plays
- their role in the IPM program (what they can do to help reduce the number of cockroaches and the kind of information they can provide)
- how they can communicate with the pest management technicians (you may want to post log sheets in various locations where people can write down pest sightings and other information)

Visual Inspection

- Construct a map of the premises.
- Mark all the locations where roaches are sighted, or where you see signs of their presence, such as fecal matter, shed skins, egg cases, etc.
- Mark any places that are likely harborage or food sources.
- Note any sanitation problems such as food or grease spills, food or

Box 7-A.

Tools Used To Monitor For Cockroaches

- **Flashlight.** Use a heavy-duty, corrosion-resistant model with a bright-colored body, shatter-proof lens, and halogen bulb. A smaller halogen flashlight with a flexible neck is useful in tight, confined locations. Flashlight holders that can be attached to a belt are available.
- **Telescoping Mirror.** Use a furnace inspector's or mechanic's metal mirror with a telescoping handle and rotating head. To illuminate areas inside equipment, fixtures, etc., reflect the flashlight beam off the mirror.
- **Clipboard and Pen.** Use the clipboard to carry monitoring forms, floorplans, etc. during inspections.
- **Floorplan Maps and Building Plans.** Carry a floorplan with the major equipment and fixtures marked. In large buildings, construction drawings that show utility lines, heating/cooling ducts, shaft connections, pipe chases, etc. are very useful for locating entry points, harborages, and runways.
- **Sticky Traps.** These are used to locate harborage areas and estimate populations.
- **Flushing Agent.** A pocket-sized can of pyrethrin is useful for spot-flushing roaches out of inaccessible areas where trapping is not sufficient.
- **Utility Tools.** A pocketknife equipped with various blades, screwdrivers, and forceps allows you to open grills, electrical boxes, and other equipment for inspections. Carry small vials and adhesive labels to collect cockroach specimens. A 10-power (10x) hand lens (small magnifying glass) will help you identify roach species. Colored adhesive labels can be used to mark hot spots, location of traps and bait stations, etc. These tools can be stored in a tool pouch worn on a belt.
- **Knee Pads and Bump Cap.** These are useful when crawling around for floor-level inspections.
- **Camera.** A camera is useful for communicating specific conditions (e.g., unsanitary conditions, areas needing pest-proofing, etc.) in reports to decision-makers or sub-contractors not on the premises.

grease buildup behind or under kitchen equipment, or improper garbage disposal procedures.

- Note any leaks or condensation.
- Look for roach entry points such as holes in walls or floors, or around pipes where they enter a wall, around electrical conduits, in vents, etc.
- Use the list of preferred habitats in Table 7-1 to help you decide where to inspect and see Box 7-A for a list of monitoring tools.

When to Inspect

Schedule at least one inspection after dark. This will give you more information about where the cockroaches are and the level of sanitation at a time when the building is supposed to be clean. Leave room lights on for your inspection. If you have to enter a dark room, turn on the lights and remain motionless for a few minutes. The roaches will soon resume their activity. Once you see the roaches, you can move. Your movement will frighten them into running back to their hiding places. Inspect these spots to determine whether they are actual harborage or pathways to harborage in another area. Note this information on your map.

Flushing with a Repellent Insecticide

This should not be necessary, especially if you conduct thorough inspections and include at least one night inspection. Do not use this technique in rooms with cockroach traps, baits, or bait stations because roaches will avoid them after you have sprayed.

If you do encounter situations where it is necessary to flush roaches from a suspected hiding place, use just a 1-second blast from a small can of

aerosol pyrethrin; no more is required for effective flushing.

Where to Inspect

When inspecting for roaches, check the following areas:

- in corners of rooms at floor or ceiling level
- under, behind, and around sinks, toilets, showers, bathtubs, drinking fountains, ice machines, dishwashers, beverage dispensers, floor drains
- the engine compartments of refrigerators, beverage dispensers, toasters, air conditioners, and other equipment
- in and under stoves, hot plates, heaters, and near hot water pipes and radiators
- in and around stove vents, hoods, grease traps
- between equipment and walls
- behind picture frames, mirrors, bulletin boards, wall-mounted shelving
- in false ceilings, vents, light fixtures, ceiling-mounted fixtures, and railings
- in cupboards, linen closets, drawers, filing cabinets, lockers, cluttered areas
- in and under cash registers, computers, telephones, electric clocks, televisions, switchboxes, and fuse boxes
- in and around check-out stands, vegetable bins, and meat counters
- cracks and crevices in walls, baseboards, etc.
- under edges and in corners of equipment, tables, desks, counters, and other furnishings and equipment
- indoor and outdoor trash containers, dumpsters, and recycling containers
- loading docks, and storage areas where incoming food, supplies, equipment, and other potential sources of migrating roaches are received and stored

Trapping

A visual inspection may not provide all the information you need about where roaches are harboring or how many roaches there are; you may need to use sticky traps as well. Many brands of sticky traps are available, but most are of a similar design — a rectangular or triangular cardboard box with bands of sticky glue inside and, in some models, a dark strip of cockroach attractant.

The best sites for traps are along the roaches' normal travel routes as they move from harborage to feeding areas. Roaches will not seek out traps located outside these travel routes. Avoid placing traps in extremely dusty areas because they will quickly lose their stickiness. Initially, put out as many traps as possible. The more traps used, the sooner the concentrations of roaches can be located. Later, you can use fewer traps for ongoing monitoring. Try to “think like a roach” as you decide where to place the traps. Your monitoring map and the following examples will help you to determine the best spots.

Trap Locations

Keeping in mind the habitats preferred by roaches (refer to Table 7-1), place the traps in the following types of locations:

- near and under sinks and stoves
- in or near motors of refrigerators and other appliances or vending machines
- in or near electric clocks, switch plates, and conduits
- next to computer equipment (where possible)
- near plumbing fixtures



Photo: Erin Bauer

Figure 7-2. Inspect under cafeteria tables, desks, counters, and other furnishings for signs of roaches.

- near steam pipes or hot water pipes with insulating jackets
- near drains
- in drawers and cupboards
- in closets, on their floors, and upper shelves
- in false ceilings or subfloor areas
- in areas where packaged goods and equipment are delivered and stored

Trap Placement

Once the general locations for setting out traps have been decided, it is important to place the traps along the periphery of rooms or other objects as this is where roaches travel. Place traps near the corners of cabinets and rooms. Traps set out in the open away from walls or other “edges” are unlikely to catch roaches.

Examples of edges include the intersection of the following:

- floors and walls
- floors and cabinets or other solid furnishings
- floors and appliances such as stoves, refrigerators, vending machines
- counters and walls
- hanging cabinets or shelves and walls.

Place each trap so the opening is perpendicular to the wall, counter-top, etc. so a roach traveling along the edge of the floor or wall can walk into the trap (see Figure 7-3).

Number and date each trap, and mark on your monitoring map. After 24 to 48 hours, count and record the number of roaches in each trap. Record the date and the number of roaches on both the trap and the monitoring form.



Photo: Clyde Ogg

Figure 7-3. Proper sticky trap placement.

Evaluating Trap Counts

- Traps with the highest numbers of roaches indicate a nearby harbor-age, and this is where management efforts should be concentrated.
- Traps with few or no roaches should be moved to other locations until all main harbor-age areas are pinpointed.
- When traps contain large numbers of small nymphs, this may indicate that the roach population is being stressed by such factors as scarcity of food and water, or it may indicate overcrowded harbor-age since nymphs generally remain within the harbor-age.
- Large numbers of adults in the traps can indicate a population explosion.

On-Going Monitoring

Sometimes it is useful to continue counting the roaches in each trap every 24 to 48 hours for a week or two. This can give you a clearer picture of the population and, if it is small, the trapping may eliminate it. Where roaches rarely invade, you can check traps every 2 or 3 months (be sure to replace traps when they are full or no longer sticky). In cafeterias and other food-handling areas, check traps every month.

Monitoring to Evaluate Treatment Efficacy

Monitoring traps can provide information on the effectiveness of management efforts. To see how well treatment efforts are working, put out fresh traps a week or so after implementing the treatment methods selected from the “Management Options” section, and count the roaches in the traps 24 hours later. If the roach population has dropped considerably, progress has been made. If not, greater efforts must be made to eliminate food and water sources and reduce harbor-age. In order to assess the continued success of treatments and detect any new infestations, continue to monitor after the IPM program is underway. Vigilance is important.

Monitoring to Determine Roach Tolerance Levels

It may be impossible to eliminate cockroach infestations completely, especially in urban situations. Very old buildings may have more roach harbor-age than can be eliminated in any practical way, and there is always the possibility of reinfestation from roaches traveling in handbags, backpacks, clothing, used furniture and appliances, and packing materials. Because of these problems, it may be necessary to live with a small number of roaches. The sticky traps can help determine what this number is, since it is possible for the roach population to be low enough that the traps catch a few roaches, but no one notices any in the course of a normal day. This is considered the tolerance level and will differ depending on location, time of year, health department regulations, and availability of management resources.

Determining the number of roaches that can be tolerated will take time and experience and will have to be done after you have reduced the cockroach population through the appropriate treatments. First, you will need to ascertain the average number of roaches caught in a designated area, and then, you must correlate this figure with the perceptions of the people using the area.

Set out a certain number of traps (say 10) in a certain area (perhaps the kitchen), and leave them there for a certain period of time (a week). The number of traps that you use in the area and the length of time you wait before counting must remain the same each time you make an assessment if your estimation is going to be accurate. When you make your counts, find the average number of roaches per trap by dividing the total number of roaches by the total number of traps. Record this information on your monitoring form, and write on each trap the date and the number of roaches inside. Question the people using the area you are monitoring to see if they have noticed any evidence of cockroaches. Record this on your monitoring form. If the traps are still sticky, leave them out for another week and count the roaches again.

Once you have done this for a number of weeks, you will be able to correlate the number of roaches caught in your traps with the number that can be tolerated. Use this number as a baseline, and be aware that it may differ depending on the area and the people using the area. When the number of roaches caught is above the baseline, renewed sanitation efforts and other treatments may be justified. When the number is at or below the baseline, you don't need to do anything except continue to monitor.

Box 7-B.

Sample IPM Program for a Cockroach Infestation in a Kitchen

1. Use sticky traps to locate roach habitat and prioritize areas to be treated.
2. Knock-down the roach population by vacuuming areas where traps indicate roaches are harboring; steam-clean infested kitchen equipment and appliances if possible.
3. Initiate an education program for staff such as custodians, and building maintenance personnel to gain cooperation for the next steps.
4. Improve sanitation and waste management procedures to reduce roach food sources.
5. Reduce roach access to water and habitat by repairing water leaks, caulking cracks, and scheduling other building repairs.
6. If the previous activities have failed to reduce roach numbers sufficiently, apply insecticidal dusts, baits, or gels in cracks and crevices in hard-to-clean areas; blow boric acid or silica aerogel into wall or ceiling voids, underneath appliances, or in other inaccessible areas where roaches harbor.
7. After the adult roach population has been reduced, apply an insect growth regulator to help prevent future roach problems.
8. Monitor weekly and fine-tune management methods as needed until the problem has been solved. Continue monitoring monthly or quarterly to ensure sanitation measures are maintained and to detect any incipient buildup of roach numbers.



Figure 7-4. Monitor sticky traps to determine the extent of a roach infestation.

Box 7-C.

Sample IPM Program for a Roach Population in an Office or Classroom

1. Initiate an education program for students, staff, nurses, directors, administrators, custodians, and building maintenance personnel to gain cooperation with the program. Since monitoring and management activities will probably involve desks, computers, lighting fixtures, and other equipment in use by staff, it is essential that they be given prior warning of work to be done and that the problem cannot be solved without their cooperation.
2. Place sticky traps to locate roach habitat and prioritize areas to be treated.
3. Vacuum areas where traps indicate roaches are harboring.
4. Improve sanitation and waste management in office, snack, and lunch areas to reduce roach food sources.
5. Caulk cracks and schedule other building repairs to reduce roach habitat.
6. If traps indicate roaches have infested computers or other electrical equipment, place insecticidal bait stations next to infested machines. Never put baits directly on or inside computers or electrical equipment.
7. Never use aerosol insecticides around computers because of the danger of shorting out the equipment.
8. Give office, food service, and custodial staff a map showing where bait stations have been placed and request that the stations not be moved.
9. If traps indicate that roaches have infested an electrical conduit and are moving into the room through lighting switch plates, spot-treat the switch box with insecticidal bait or gel.
10. If traps indicate storage boxes containing paper files are infested with roaches, enclose file boxes in large plastic bags and place in freezer overnight, or if possible, fumigate with carbon dioxide.
11. If the previous activities have failed to reduce roach numbers sufficiently, apply insecticidal bait, gel, or dust in cracks and crevices and blow insecticidal dusts into wall or ceiling voids, underneath counters, or in other inaccessible areas where roaches harbor.
12. After the adult roach population has been reduced, apply an insect growth regulator to help prevent future roach problems.
13. Continue monitoring until the roach population has been reduced to a tolerable level. Circulate a memo announcing that the roach problem has been solved and thank staff for their cooperation. Return monthly or quarterly to place and inspect traps to ensure roach numbers remain within tolerable levels.
14. If monthly monitoring indicates roach populations are starting to rise, renew sanitation efforts and consider experimenting with releases of cockroach parasitoids while roach numbers are still relatively low.

Management Options

Education

Food service and custodial staff play an essential part of any successful roach management program. Provide them with information on how to maintain roach-free kitchens, dining rooms, and waste disposal areas by applying the methods described below. Teachers, nurses, students, residents, and other staff also play a significant role in maintaining a high level of sanitation in other areas of the building so they must be informed of their responsibilities in that regard.

Habitat Modification

Cockroaches need food, water, and harborage to survive, and the harborage must be at the proper temperature. By modifying the environment of an infested building, you can reduce roach access to these resources. With good-quality materials and a careful job, the alterations will produce a long-term reduction in the capacity of the structure to support roaches. It is important to note that the simple act of increasing the distance between food, shelter, and water will dramatically reduce the number of roaches an environment can support. Eventually the cockroaches, especially the young, will have to expend excessive energy to get from harborage to food or water, and they will die.

Limiting Areas for Eating

If you expect to contain and limit pest problems (ants and rodents as well as cockroaches), it is very important to designate appropriate areas for eating and to enforce these rules. The fewer designated areas, the easier it will be to limit the pests.

Eliminating Cracks and Crevices

- It is not necessary to seal all cracks. Start by caulking where roach populations are highest. If roaches remain a problem, caulk additional areas.
- Use silicon caulk or mildew-resistant caulk around sinks, toilets, and drains.
- Before beginning the sealing process, vacuum and wash the area to eliminate all egg cases, fecal material, or other debris.
- Caulk or paint closed cracks around baseboards, wall shelves, cupboards, pipes, sinks, toilets, and similar furnishings in the locations suggested by trap results.
- Repair small holes in window screens with clear caulk.
- Weather-strip around doors and windows where cockroaches may enter.
- Where gaps can't be sealed, they can be widened to make them less attractive to roaches. For example, the crack between free-standing shelving and adjacent walls can be widened by simply moving the shelving one inch away from the wall. An inch-wide gap is not attractive to roaches.

Eliminating Clutter

Removing clutter from areas near prime habitat such as sinks, stoves, refrigerators, vending machines, etc. is one of the most important components of sanitation. Clutter in these areas vastly increases the available harborage that is conveniently near the cockroaches' food and water sources. For example, in kitchens, boxes should be broken down and stored in a cool or unheated area

preferably near the loading dock but definitely isolated from the main kitchen.

Sanitation

Sanitation eliminates food and harborage and can play a part in slowing the cockroach life cycle by scattering them as they search for new harborage (their life cycle is shorter when they are grouped together). This disruption can also help to bring more individual roaches into contact with toxic baits or insecticidal dusts (see "Chemical Controls").

Thorough daily cleaning of kitchens is essential.

- Sweep and mop the floors.
- Drain all sinks and remove any food debris.
- In a school or child care setting, vacuum and/or mop classroom floors daily if children receive snacks there.
- Periodically, give all food preparation areas an all-inclusive cleaning, focusing on areas where grease accumulates: drains, vents, deep fat fryers, ovens, and stoves. Steam-clean drains and infested appliances.
- Thoroughly vacuum the area with a powerful vacuum cleaner .
- At the end of each day, remove from the building all garbage containing food to prevent cockroaches from feeding at night.
- Use soapy water to wash any bottles, cans, wrappings, and other items that have food residues clinging to them before storing them for recycling.
- Rinse dishes to remove all food debris if they cannot be washed right away.

- Place garbage in sealed plastic bags before it is placed into a rodent-proof dumpster or other storage receptacle.
- Keep garbage cans and dumpsters as clean as possible to deny food to roaches as well as ants, flies, mice, and rats.

Brownbanded cockroaches can survive with less water than other roaches, so simple sanitation will not make as significant an impact on a brownbanded roach population as it will on German roaches.

Proper Food Storage

- Food not kept in the refrigerator should be kept in tightly closing containers. Cardboard boxes and paper are not roach-proof.
- Screw-top jars are roach-proof only if the lid has a rubber seal since the roaches can follow the spiral ridges to get into the jar.
- Glass containers with rubber gaskets or plastic containers with tight-fitting, snap-top lids are also roach-proof.
- Transfer food packaged in paper to plastic or glass containers as soon as the food arrives in the building.
- Do not bring shipping boxes into the food preparation area. Instead, boxes should be broken down and stored away from the kitchen in a cool area until removed for recycling.
- Advise staff not to leave unsealed food items in their desks. Any food kept in areas such as offices and staff lounges should be stored in ant- and roach-proof containers.

Installing Roach-proof Fixtures and Appliances

Whenever food preparation areas are scheduled for remodeling, the institution can take the opportunity to install roach-proof kitchen appliances and fixtures, such as stainless-steel open shelving units. The round shape of the metal and the general openness of the design offer few hiding places for roaches. Freestanding storage units and appliances on castors enable them to be rolled away from walls to facilitate thorough cleaning.

Eliminating Water Sources

The German roach survives longer on water alone than on food alone. It also survives longer without food or water if the relative humidity is higher; thus reducing the available drinking water and humidity are high priorities. Roaches find drinking water in the following places:

- sink traps
- appliance drip pans
- drain pipes
- wash basins and tubs
- toilet bowls and flush tanks
- spills
- condensation on cold-water pipes and windows
- leaky pipes and faucets
- pet dishes and aquariums
- vases
- beverage bottles
- various high-moisture foods

Much can be done to cut back this supply through repairs and barriers. Repair dripping faucets and any other leaks, and drain or ventilate moist areas. Keep kitchen surfaces

dry whenever they are not in use, especially overnight.

Physical Controls

Screening Vents and Windows, and Sealing Off Runways

Cockroaches can travel throughout a building and from building to building on runways such as electrical conduits, heating ducts, and especially plumbing pipes. Seal these runways with caulk, window screen, or other appropriate materials.

Roaches may also travel up the outside of the building and enter through an open window, weep hole, or ventilation duct. Screening these openings prevents roaches from using them as entry points. Screens can also be placed behind grill covers and over vents or floor drains to prevent roach entry. Use caulk around the edge of the screen to make a tight seal.

Vacuuming

A strong vacuum can be used to pick up roaches, including their egg cases and droppings, as well as debris that drops behind appliances or furniture and feeds the pests. If you are dealing with a huge roach population that must be knocked down immediately, a thorough vacuuming will be very effective. Once you have vacuumed up a large portion of the roach population, it will be easier to begin habitat modification.

A crevice attachment will suck roaches out of cracks, and the hose end alone can pull roaches out from under appliances, or from cupboards or upholstered furniture. If the vacuum is capable of filtering out very small particles (0.3 microns), it will greatly reduce the amount of cockroach effluvia that is blown around

during cleaning. It is this effluvia that can cause allergic reactions.

Although the dust in the vacuum bag will usually clog the roaches' breathing apparatus and suffocate them, you should dispose of the vacuum bag promptly.

Trapping

In certain limited situations traps can also be used to reduce roach numbers. For example, the University of California used sticky traps to help control roaches in animal-rearing rooms where no insecticides were allowed. Traps can also capture a few roaches that might be dislodged during construction, introduced into roach-free areas on furniture or packaging, or forced into the area when an adjacent room is sprayed with an insecticide.

When traps are used to reduce populations of roaches, leave them in place until they are full. In most situations, however, trapping alone will not produce a sufficient degree of control.

Freezing

Freezing can be used to kill cockroaches when they have infested cartons of papers, clothes, or other stored materials.

- Loosely fill a heavy-duty plastic garbage bag with the infested items, and insert the end of a vacuum hose into the bag to suck out as much air as possible.
- Tightly seal the bag using duct tape to reinforce all seams.
- Finally, place the bag into the freezer compartment. Leave the bag sealed in the freezer overnight.
- When the bag is opened, roaches will either be dead or extremely

sluggish and will die a short time later without further treatment.

Biological Controls

One parasitoid has been used in a precedent-setting project to control the brownbanded cockroach in a large research building on the campus of the University of California at Berkeley. The roach population had become a significant problem, but since laboratory animals were being raised in this research facility, pesticides could not be used.

Researchers imported the egg parasitoid *Comperia merceti* from Hawaii, where it was known to be effective against the brownbanded roach. The parasitoids are so tiny — less than half the size of the roach egg capsule — that even the periodic releases of 20,000 at a time went unnoticed by the people who worked there. The fact that the building contained animal-rearing labs where food, water, and animal fecal matter were always available for roaches to feed on makes the high degree of control achieved in this project even more impressive.

Although *Comperia merceti* only attacks the brownbanded roach, another parasitoid, *Tetrastichus hagenowi*, has been found to be effective against the German, American, oriental, and smoky brown roaches.

The use of natural enemies of roaches cannot by itself be expected to solve cockroach problems. Roach control must always involve sanitation and habitat modification as described above, and, in most cases, the judicious use of chemical controls.

Chemical Controls

If non-chemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your

management program may be warranted. Pesticides must be used in accordance with their EPA approved label directions. Applicators hired by the school district must be certified to apply pesticides and all applicators should wear protective clothing during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials when buildings are occupied and never apply them where they might wash into the sanitary sewer or into outside storm drains.

When insecticides are needed, they should be applied as crack and crevice treatments or in bait form. Broadcast spraying of insecticides may scatter the cockroaches. This could make them more difficult to find and the pest manager must expend more time and effort baiting in the new scattered locations.

Resistance to Insecticides

Insecticide resistance in cockroaches is a problem. Many residual insecticides no longer affect cockroaches. So far, there is no documented resistance to boric acid, diatomaceous earth, or silica gel, and because of the way these insecticides work, resistance in the future is unlikely. There is no guarantee, however, that the other insecticides mentioned here will be useful forever.

There are three preferred types of materials available for roach control: insecticidal dusts, insecticidal baits, and insect growth regulators. These materials take 5 days or longer to kill substantial numbers of roaches, and it can take weeks to suppress large populations to the point where none are seen. However, once this point

has been reached, and if parallel steps are taken to reduce roach food and harborage, you can expect long-term relief from roach infestations.

Boric Acid

Boric acid can be one of the most valuable chemical control tools in an integrated program against roaches. It is formulated as a powder, paste, and aerosol. It acts as a stomach poison and is one of few materials that does not repel cockroaches so they are not able to avoid it as they do other compounds. The powder and paste formulations do not vaporize into the air as do conventional sprays. Furthermore, if kept dry, it remains effective for the life of the building.

Wear a dust mask when applying boric acid powder. A very light dusting in cracks and crevices is superior to dusting large open areas. Cockroaches will avoid piles of boric acid. Boric acid is approved for crack and crevice treatment in food handling areas. It can be applied with a duster into areas of prime habitat, such as under refrigerators or into cracks in the inner recesses of cabinets and cupboards, whether or not roaches are present.

Boric acid has also been formulated into baits (see discussion below for general information on baits).

Diatomaceous Earth and Silica Aerogel

These are insecticidal dusts that can be used for roach control. Diatomaceous earth is made from fossilized diatoms, and silica gel is an inorganic compound. Both kill insects by desiccation; they abrade the wax and oil from the insect's outer covering, which causes dehydration and death. Although these materials are not poisonous to humans directly, the

fine dust travels freely through the air and can be irritating to the eyes and lungs; therefore, use a dust mask and goggles during application.

Diatomaceous earth and silica aerogel are especially useful in wall voids and similar closed spaces. During construction and remodeling these dusts can be blown into such spaces, and in finished buildings they can be applied by drilling tiny holes in the walls. These dusts are also useful in crack and crevice treatments.

Some products combine diatomaceous earth or silica gel with pyrethrins. The pyrethrins provide a quick knockdown of the cockroaches, and the dusts provide the long-term control.

Cockroach Baits

In general, baits help to reduce the amount of pesticide used against a pest because the pest is attracted to discreet locations where it comes into contact with the poison; the pesticide doesn't need to be spread around all over the environment. Baits work best where sanitation and physical modifications are also employed so that the bait is not competing with freely available roach food.

Bait Placement Tips

According to Dr. Austin M. Frishman, there are a number of tricks to placing bait properly.

- Large blobs of baits in a few locations do not work well because German cockroaches don't easily find food that is any distance from their harborage. Put out small amounts of bait in many locations.
- Put bait near harborage and between harborage and food. Review the Monitoring section for examples of roach harborage and

use the information collected from your monitoring traps.

- Once you have pinpointed harborage areas, place the baits along edges or in places where roaches are most likely to travel or congregate. If the bait is between the harborage and the food but not in a place where roaches are likely to run into it, the baiting program will fail.
- Sometimes an inch one way or the other can make all the difference in bait placement. If air currents are moving the bait odors away from the cockroach harborage, they will never find the bait.
- Make sure that the surface of the bait will not get covered by excessive grease, flour, or dust. In areas where this might be a problem, such as near French fry preparation, the bait must be protected.
- Harsh environments pose various problems in a baiting program. In very warm areas, baits can melt and run; in cold environments, the cockroaches don't move far and may miss the bait; and in very warm and wet environments, the baits may grow mold that renders them unattractive to roaches. Boric acid baits hold up better in the last situation because boric acid naturally inhibits mold growth.
- Check baits frequently to make sure that someone has not inadvertently painted over them or accidentally knocked them off while cleaning, etc.
- If new cockroaches are moving in so fast that it appears that the baits are failing, you may need to elicit more help from the staff in preventing contaminated goods from coming into areas of prime habitat.

As Dr. Frishman notes, "Keep in mind that you are trying to control living organisms. It is not a simple mathematical formula that works every time. You sometimes have to adjust what you did to get the baits to do the job. I call it 'tweaking the baits to perfection.'"

Active Ingredients Used in Baits

Abamectin — an extract from the naturally occurring soil microorganism *Streptomyces avermitilis*.

- works both as a lethal internal toxicant and as a contact insecticide when roaches groom themselves and ingest the bait
- takes a week or longer to kill 70 to 90 percent of the roaches, may take 12 weeks to achieve 100 percent kill
- should be used in cracks and crevices and in other inaccessible places near harborage

Boric Acid — a general enzyme-inhibitor.

- available as a paste either in bulk or in a cartridge for bait gun application.
- available as a weather-resistant, granular bait
- also available as a "fine granular" bait that can be used in a bulb duster for interior crack and crevice treatment (the advantage of a granular bait is that roaches are exposed by contact as well as by ingestion)
- use respirator or dust filter mask and goggles during application

Hydramethylnon or fipronil — slow-acting insecticides that must be ingested to be effective.

- Roaches die within 2 to 8 days after feeding on the bait.

- Available in a plastic disk as well as a gel.
- Disks come with a double-sided tape so they can be glued to various surfaces out of view. The tape also facilitates placement of the bait stations on the undersides of drawers, or on walls.
- If you see roaches inside stations, they are probably using the disks as harborage after having eaten all the bait. Put these disks into a plastic bag, seal, and discard.
- Inspect bait locations each week and reapply if bait has been depleted. Do not place bait gels on surfaces that will be washed because the bait will be washed away.

Insect Growth Regulators (IGRs)

IGRs, such as hydroprene, are synthetic versions of the juvenile hormones insects produce to regulate development from their immature to adult stages. Since many of the worst cockroach infestations occur

in settings where migration from one infested area to another takes place, new adults can continue to move into areas where IGRs have been applied and the new roaches will not be affected. As a result, use of IGRs makes sense only if they are combined with other tactics such as roach exclusion, reduction of access to water, food, and harborage, and application of an adulticide such as boric acid.

- IGRs do not kill insects directly. Their most important effect is to cause immature roaches to become sterile adults and eventually die without reproducing. However, those roaches that are already adults before they come into contact with an IGR will keep on reproducing.

IGRs are best applied after heavy roach infestations have been reduced to low levels and every effort has been made to eliminate harborage or opportunities for roaches to migrate in from other areas. When IGRs are used this way, the small number of immature roaches that survived

suppression efforts (perhaps because they were still inside egg capsules when the cleanup took place) will encounter the IGR and fail to mature and reproduce. Adults that survived the cleanup may produce young before dying, but their young will be sterilized by the IGR.

- Theoretically, the IGR will eventually eliminate the remnant cockroach population.
- To monitor the effectiveness of IGR use, place sticky traps in areas where roaches are known to travel.
- Immature roaches that have been exposed to an IGR become adults that are darker in color and have a somewhat distorted appearance (they have twisted wings). When you begin finding these roaches in the traps, you know the reproduction rate is being lowered.

Resources

For management practices and pesticide recommendations on cockroach control, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

For detailed information on cockroaches and their control, see the *Cockroach Control Manual* available from the Lancaster County Extension office, 444 Cherrycreek Rd., Lincoln, NE 68528, (402) 441-7180, or on-line in English, Spanish, and Japanese at: <http://lancaster.unl.edu/pest/RoachManual.shtml>.

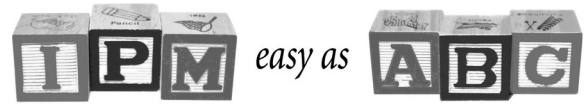
Educational resource guides, including *Least-toxic Cockroach Control*, which is available in English, Spanish, Arabic, and Vietnamese, can be found at: <http://lancaster.unl.edu/pest/cockroaches.shtml>



Photo: Erin Bauer

Figure 7-5. Apply gel bait in cracks and crevices where roaches will find it.

IPM for Bed Bugs



Introduction

Bed bug infestations are increasing in the U.S. and continuing to spread through single-family and multi-unit homes. More people are living with bed bugs than ever before, which means there is an increased likelihood that people may transport bed bugs from home to other locations. Children living with bed bugs at home will bring bed bugs to school and childcare facilities. Adults will be taking them to the doctor's office, the hospital, their public library, their workplace, and other locations they visit.

Because the focus of this publication is to address pest management in sensitive environments, the approach to managing bed bugs will differ greatly depending on whether bed bugs have been introduced into a facility or if a full-blown infestation is found.

Identification and Biology

Bed bugs are reddish-brown, wingless, and very flat (Figure 8-1). Adults are about 3/8 to 1/4-inches long. The tiniest bed bugs are light colored — almost translucent — before feeding. After a blood meal, bed bugs have a distended body and can look like a completely different insect (Figure 8-2).

Bats and birds may serve as hosts for other blood-feeding bugs that look

nearly identical to bed bugs (Figure 8-3). It is important to make sure the infestation is actually *Cimex lectularius*, the human bed bug, because the first step in solving a bird or bat bug infestation is to eliminate bird nesting sites or bat colonies. Follow-up chemical treatments will often differ

depending on the location of the bat or bird infestation. Consult your local Extension educator or professional entomologist to verify the species in question.

Bed bugs are nocturnal and feed on sleeping individuals after following



Photo: Barbara Ogg

Figure 8-1. Bed bugs are flat and hide during the day in cracks and crevices. This is an adult bed bug.



Photo: Vicki Jedlicka

Figure 8-2. Each bed bug needs a blood meal about once a week. As it feeds, its body fills up and enlarges, and it looks quite different from the unfed bed bug.

carbon dioxide plumes and heat. They probably don't bite through nightwear, but feed on exposed skin. The bite is painless and the host is usually undisturbed during feeding.

Bed bugs are attracted to carbon dioxide, but also have heat sensors to help them find a warm-blooded host. They prefer humans, but will feed on dogs, cats, and birds. Bed bugs feed on blood as their only source of nutrition. An immature bed bug feeds once during each of its five developmental stages and after it feeds, each stage takes about a week to digest its blood meal. It then sheds its outer skin (exoskeleton), through a process called molting, and is again ready to feed. Each individual bed bug only comes out to feed every three to seven days. Female bed bugs lay 1-5 eggs each day and can live for two months or more. An egg-laying female needs periodic blood meals to continue to produce eggs.

During the time the bed bug digests its blood meal, it excretes brown or black feces on linens, mattresses, box springs, and other hiding places (Figure 4a-b). Male and immature bugs produce aggregation pheromones in the feces; these pheromones attract other bed bugs to these hiding places. Time of development depends on host availability and temperature. Because bed bugs only feed on blood, availability of humans or other warm-blooded hosts determines how quickly bed bug populations grow. When bed bugs can find a blood meal any time they are hungry and the home is at room temperature, they can grow from egg to adult in 5 to 6 weeks.

Bed bug eggs are light-colored and smaller than the size of a pinhead. These eggs develop red eyespots prior



Photo: Jim Kalisch

Figure 8-3. Bed bug (left) and bat bug look similar, but can be distinguished with magnification. Bat bugs have hairs longer than the width of their eye.

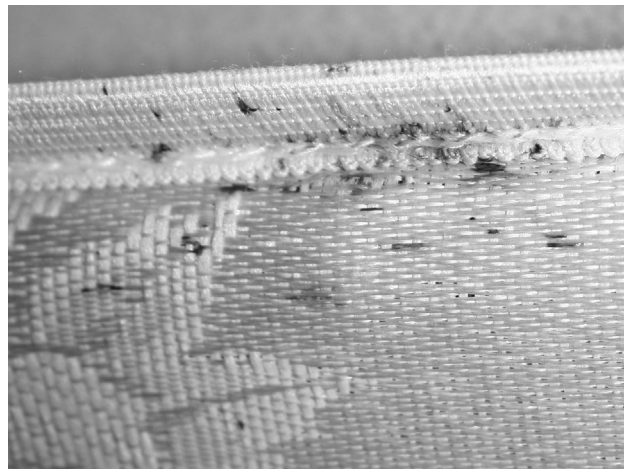


Photo: Barbara Ogg

Figure 8-4a. Typical bed bug spots near cording of a mattress.

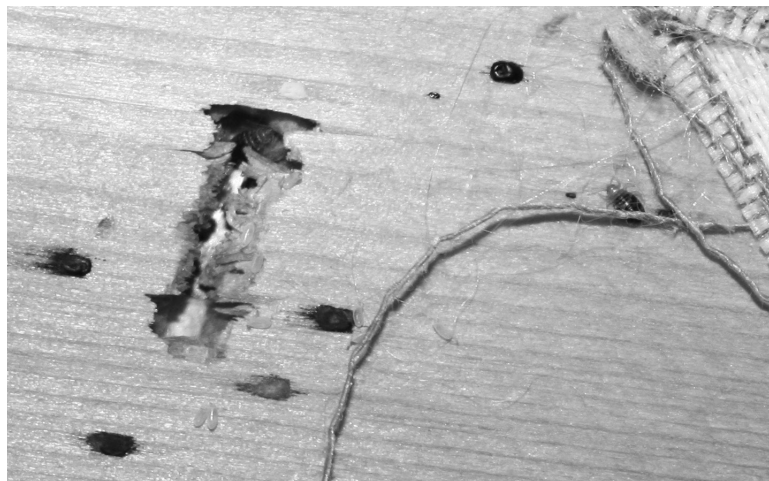


Photo: Barbara Ogg

Figure 8-4b. Signs of bed bugs on the wooden framing of box springs, fecal spots, spent eggs and two bugs (one is in the staple groove, the other is near the fabric thread.)

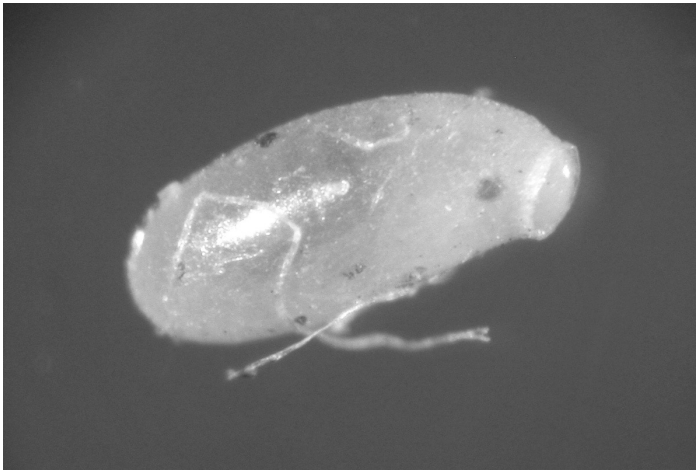


Photo: Jim Kalisch

Figure 8-5. Human bed bug egg is pale pink with eyespots.

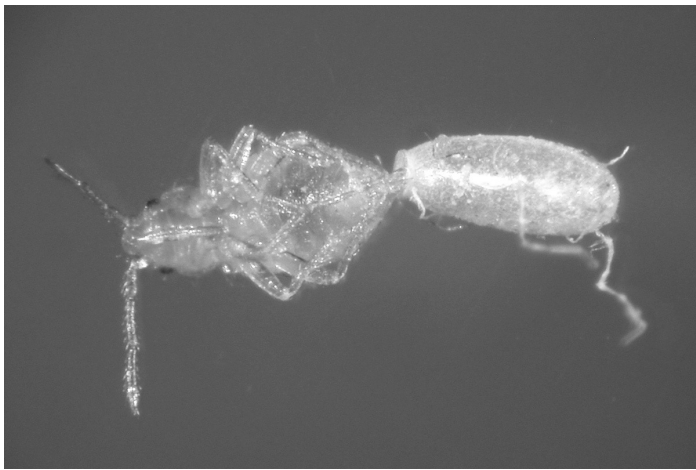


Photo: Jim Kalisch

Figure 8-6. A bed bug hatches 5-7 days after being laid, the tiny bed bug is about the size of a pinhead. It needs to feed within a few weeks to be able to survive.

to hatching (Figure 8-5). At room temperatures, eggs hatch in about five days (Figure 8-6).

How long can bed bugs live without feeding? Bed bugs, especially larger nymphs and adults can live several months at room temperature without feeding. Eventually if bed bugs cannot feed, they will die of dehydration. This happens more quickly at warmer temperatures. Researchers at Virginia Tech have found unfed bed bugs live longer at cooler temperatures than warmer ones. They also found field-collected, insecticide-resistant, unfed bed bugs lived a shorter time than insecticide susceptible strains. In their lab study, no bed bug lived longer

than 3 months at 78°F. In homes and apartments, it is likely that unfed bed bugs can live five or six months at room temperatures. When temperatures are cooler, they may live longer.

Infestation vs. Introduction

Infestation

A bed bug infestation is one where most, if not all of the life cycle stages are present (egg, nymphs and adults). Infestations are usually found in homes or other locations where people sleep every night. Regularly occupied motel and hotel rooms can

readily become infested; remember each bug only needs to feed weekly. Sensitive environments where infestations can be found include hospitals or nursing and retirement homes.

Introduction

A bed bug *introduction* is one where a bed bug is brought into a facility, but cannot readily breed. Schools, most childcare facilities, and office buildings are examples where bed bugs may be introduced, but the population cannot grow because a blood meal is not available during most of the time when bed bugs are active. A hospital waiting room is another example. When a bed bug gets hungry, even during the day, it may crawl onto someone's clothing or backpack to be taken to another location. If it is a mated female and taken into a person's home, it may start an infestation. Introductions are worrisome to people who work in these places, but not as serious a problem as an infestation would be.

Why are bed bugs found in non-sleeping locations? As bed bug populations increase in a home, bed bugs crawl into purses, backpacks, briefcases, and onto clothing and travel with inhabitants to workplaces or other places where people spend time. They will then crawl away and hide in their new surroundings. Bed bugs can be transported with children to daycare or school where they crawl out of diaper bags or backpacks and hide.

Damage

There is a wide variation of how individuals react to bed bug bites. Approximately 25% of people between the ages of 12-65 do not react to bed bug bites — no spots,

no itching whatsoever. A survey by the University of Kentucky found no difference between ethnic groups in bite reaction, but they did find a higher proportion (~42%) of non-reactive individuals in individuals greater than 65 years old. Because elderly people may also have reduced eyesight, it is possible for many to be living in a bed bug infested home without realizing there is a problem.

Among individuals who do react to the bite, the reaction can be mild — red spots that do not itch. For many people the bites are very itchy. In rare cases, some people get hives, a more serious reaction to the bites.

At least 27 agents of human disease have been found in bed bugs, including viruses, bacteria, protozoa, and parasitic worms. Researchers have not found that any of these agents reproduce or multiply within bed bugs, and very few survive for any length of time inside a bed bug. There is no evidence bed bugs are involved in the transmission (via bite or infected feces) of any disease agent, including hepatitis B virus and HIV, the virus that causes AIDS.

The toll on individuals living with a bed bug infestation is primarily psychological. Many people report being stressed and anxious and experiencing insomnia. Some may try to solve the problem by using inappropriate products, methods or application sites that can harm them and their home.

Eradicating bed bugs is expensive because it usually requires a skilled pest control professional who has the know-how to use specialized equipment and chemicals not available to the do-it-yourself consumer. For institutions, like schools and hospitals with large facilities, the cost

of widespread treatments can be prohibitive.

Detection and Monitoring

Finding bed bugs early is an advantage because treatment is easier and will be less costly.

1. If someone has found a bed bug, the first step is to have an expert identify it to make sure it is a bed bug. If it is a bat or bird bug, contact a wildlife management company to inspect for birds or bats. Eradicating these is the first step in dealing with a bat or bird bug infestation.
2. Next, it is important to know if this was a bed bug introduction or if there is actually an infestation. First inspect the area near where the bug was found. If it was found on a student or person, inspect his desk, locker, and backpack. In residential living situations, inspect the bed, the mattress and box springs. Most bed bugs will be found in the immediate sleeping area, but a few are often found farther away from the bed. If residents often sleep on the sofa or a recliner, these should be inspected as well.

A visual inspection is the simplest method of detection, but it relies on someone experienced in doing bed bug inspections. Other methods of detection include:

1. Canine detection. Companies using dogs trained to detect the odor of live bed bugs have increased in the last few years. Some dogs work for “bed bug detection only” companies; other dogs are owned by pest control companies that may benefit when dogs find bed bugs. Research by the University of Flor-

ida showed canine detection to be 95-98% accurate in controlled conditions, but this high level of accuracy has been shown to be much lower in real-world field conditions. A Rutgers University research study using different dog-handler teams showed dogs sometimes gave a false alert, indicating bed bugs when they were not present (a false positive). Dogs sometimes also did not detect bed bugs that were present (a false negative). Researchers found a large variability between detection firms (i.e., some canine-handler teams performed better than others). Still, a properly trained and maintained canine detection team can be useful in conducting large scale inspections where other types of inspections are difficult or impractical. They may be most useful in detecting bed bug introductions in schools, office buildings, hospital waiting rooms and patient rooms, and childcare facilities.

2. Monitoring devices. A number of monitoring devices containing chemical lures have been developed for bed bug detection. Because bed bugs come out to feed every 5-7 days, small infestations may require monitors to be installed multiple nights before bugs are caught.

Some examples using carbon dioxide include the CDC 3000 (Cimex Science, Portland, OR.) and NightWatch™ (BioSensory, Putnam, CN). A do-it-yourself trap using dry ice was developed by Rutgers University (<http://njaes.rutgers.edu/pubs/publication.asp?pid=FS1117>).

A small, wall-mounted trap, Verifi™ (FMC, Philadelphia PA), uses carbon dioxide, an aggregation pheromone, and human scent. Research studies have shown these devices will catch bed bugs, although small infestations may require increasing the number of trapping nights. Because Verifi™ traps are meant to remain in place indefinitely, this makes them an advantageous tool for this purpose.

Climbup® Insect Interceptor is another trap that uses the attractiveness of sleeping humans and it catches bed bugs attempting to climb bed legs. This type of trap is highly efficient, and would be extremely useful in residential housing situations, such as dorms, retirement, or nursing homes.

Management Options

There are two treatment approaches currently being used to eradicate bed bug infestations: insecticidal treatments and heat.

Insecticidal treatments

Some non-pyrethroid insecticides have been shown to be effective against bed bugs when placed in cracks and crevices where bed bugs hide. Researchers have found high levels of resistance in bed bugs to pyrethroid insecticides, which include most of the over-the-counter products. Because bed bugs are resistant to these treatments, they are not likely to be very effective. However, currently the more effective, non-pyrethroid products are only available to pest control professionals. Any insecticidal treatment should be done by a licensed pest control applicator experienced in successfully eradicating bed bugs.

Heat treatments

The second method is to use large heaters to heat the infested environment to temperatures lethal to bed bugs. Heat works because adult bed bugs die at about 120°F.; eggs die at 130°F. To make sure temperatures get hot enough everywhere where bed bug can hide, the air must be circulated with fans. Some heat systems use heat sensors or thermocouples, placed in different locations, which are used to track temperatures. A threshold temperature of at least 122°F must be maintained for 3-5 hours (or more) to make sure heat penetrates all the bed bug hiding places. Furniture is often pulled away from walls, dressers drawers are removed from dressers, and closet drawers are opened. Because of the risk of damage and fire when heaters are used, a licensed pest control company experienced in heat treatment should do this. Heat is a good non-toxic method, but is not practical in all situations. For example, it would be impractical to use heat in an office building or a school...the cost would be too prohibitive.

In the case of an introduction of bed bugs, as in a school classroom, it would be preferable to locate the isolated bed bug and remove it using a vacuum cleaner. A spot treatment in that location could be used to follow-up.

Sensitive Environments

Schools and Non-24 Hour Child-care Facilities

Actual bed bug infestations — eggs, nymphs and adult bed bugs — in schools and daycare centers are uncommon. It is more common for bed bugs to hitchhike to school from an infested home on a student's cloth-

ing or in a backpack. These bed bugs could be carried home by another student, teacher, or staff member, making the school a potential hub for bed bug spread.

What should be done if bed bugs are found on a student or child? If possible, it is advisable to discretely separate the child's backpack, outerwear and other items to prevent the transfer of bugs onto belongings of others. A large tub or sealed garbage bag may be used for this purpose.

1. An inspection protocol, developed by administration, should be followed. A nurse or equivalent should inspect the child's clothing and items brought to school to see if other bed bugs are present. The desk or locker area should be inspected as well. The child's parents should be contacted to see if they are aware of a bed bug problem at home. If possible, the child's clothing should be changed to a second set that is known to be bed-bug free.
2. If bed bugs are found, the surrounding environment should be vacuumed to remove bed bugs. In the case of a single bed bug introduction, this is all that might be necessary, but checking this area for new introductions would be prudent. If many bed bugs are found, or in the case of an infestation, a pest control company experienced in treating bed bugs should be contacted.

Hospitals

There is a real potential for bed bug infestations in hospitals or other medical facilities where people sleep overnight. Bed bugs may hitch a ride on incoming patients or visitors or their belongings. Initial locations

for bed bug introductions include the emergency room, out-patient rooms, consultation rooms, and hospital rooms themselves. Visitors may introduce bed bugs to waiting rooms. Because many hospitals have a high room occupancy and high turnover, these institutions are at high risk of having bed bug infestations. The introduction of a single, mated female bed bug could result in a full-fledged infestation. But, if patient intake procedures are thorough, bed bugs may be discovered on the patient or a home infestation may be revealed, which would trigger actions to prevent movement of bugs. It is important to educate nursing and custodial staff so they will be able to identify bud bugs.

Recommended steps if bed bugs are found on a patient include: isolating the patient, if possible, bagging personal items, including purses and backpacks, and vacuuming rooms immediately after exposure.

Low income public housing, retirement homes and dormitories

Bed bug infestations have been increasing in the last 10 years, and managers of high-density public housing, retirement homes, and dormitories or fraternities/sororities are likely to experience increased problems with them. It is important for institutions to take the time to develop a bed bug procedural policy. This policy will help management personnel make rational decisions when bed bugs are found.

Bed bug infestations get started in these high-density housing units in several ways. The most common ways include individuals simply moving in

from an infested home, purchasing infested used furniture, or bringing bed bugs back after traveling. Visiting family or friends is another way bed bugs can be brought into a unit.

Because the inhabitants are most likely going to see bed bugs, property managers should focus considerable efforts on educating their tenants to be able to recognize bed bugs. Individuals should be encouraged to capture insects they see and take specimens to a designated person who will have them identified. If people are complaining about getting bitten, those units should be inspected thoroughly for bed bugs. (Remember though, a quarter of the population age does not react to bites and won't ever complain about bites. And, among the elderly, this non-reactivity is even greater.)

If bed bugs are found in a unit, a thorough inspection of the facility should begin before treatments are done. Units on either side, across the hall, above, and below the infested unit should be carefully inspected. Because bed bugs are such good hitchhikers, units of close friends should also be inspected. Letting other inhabitants know of the infestation is a good idea, as it will remind them to check their beds and to let management know if they find insects. Inhabitants should be discouraged from purchasing their own pesticides, explaining to them that over-the-counter products are not very effective against bed bugs. A professional pest controller should only treat infested units. It is not advisable to treat all the units...not only is it a waste of money to treat non-infested units, treating only infested units will reduce pesticide exposure.

Discussion

Because bed bugs are becoming so entrenched in our society, all institutions, schools, childcare centers, hospitals, universities, low-income public housing, and retirement homes eventually will be confronted with a bed bug problem. As time passes and bed bug infestations increase even more, these issues will become more and more common. It is important for administrators to realize that it is impossible to completely prevent a bed bug introduction; there are simply too many ways for bed bugs to hitchhike into a building. It is unwise to believe this is a problem that only happens to others. Vigilance and early recognition of bed bugs and their signs by key individuals will locate introductions and infestations early when most easily treated and before they have spread to other locations.

Even though bed bugs do not transmit diseases, most people have an aversion to them. If poor decisions are made early on, the situation can quickly become a public relations nightmare. All institutions should develop a carefully reasoned bed bug policy to guide management decisions to a intelligent and safe resolution of the problem.

IPM for Fabric and Pantry Pests



Introduction

Dermestid beetles, such as carpet and hide beetles, are sometimes referred to as fabric pests. They can digest keratin, the “hard” protein of which hair, horns, nails, claws, hooves, feathers, and reptile scales are formed. These insects can also attack a wide variety of other natural materials and even some synthetic ones.

Identification and Biology

Adult beetles are small and have short, clubbed antennae but are otherwise

varied in appearance (see Table 9-1). Their bodies are covered with small scales or hairs, which are visible with a magnifying glass. Larvae are brownish, 1/8 to 1/2 inch long, and characteristically hairy or bristly.

The larval stage is the most damaging. Females lay eggs throughout the year, and the eggs hatch after less than two weeks. The larvae feed for varying periods, depending upon the species and the environmental conditions. When ready to pupate, the larvae may burrow farther into the food or wander and burrow elsewhere.

Damage

Dermestid beetle holes are usually concentrated in a few areas and can be quite large. Carpet beetles damage materials made from wool such as sweaters, uniforms, felt, wool yarn, etc. They can also destroy insect collections, furniture, and carpets. Hide beetles feed on animal carcasses and hides, and also damage furnishings, carpets, and fabrics. Some species also infest stored, dried foods such as cereal (Table 9-2 provides more detailed information on the food preferences of both hide and carpet beetles).

Table 9-1. Important Carpet or Hide Beetles (Dermestids)

Common Name(s)	Scientific Name	Description of Adults
Furniture carpet beetle	<i>Antbrenus flavipes</i>	<ul style="list-style-type: none"> • 1/10 inch to 1/5 inch long • definite cleft at rear • mottled with black, white, and yellow scales
Varied carpet beetle	<i>A. verbasci</i>	<ul style="list-style-type: none"> • 1/10 inch to 1/8 inch long • mottled with white, brownish and yellowish scales
Black carpet beetle	<i>Attagenus megatom</i>	<ul style="list-style-type: none"> • 1/10 inch to 1/5 inch long, oval • Shiny black and dark brown with brownish legs
Black larder beetle	<i>Dermestes ater</i>	<ul style="list-style-type: none"> • 3/10 inch to 2/5 inch long • black with yellowish gray hairs • black rounded and hook-shaped spots on underside of abdomen
Larder beetle	<i>D. Lardariu</i>	<ul style="list-style-type: none"> • 3/10 inch to 2/5 inch long • dark brown with pale grayish yellow hair • yellow band at base of wing covers with about six black spots
Hide beetle	<i>D. Maculatus</i>	<ul style="list-style-type: none"> • 1/5 inch to 2/5 inch long • black with white hairs on sides and undersides • apex of each wing cover comes to a fine point
Warehouse beetle	<i>Trogoderma variabile</i>	<ul style="list-style-type: none"> • 1/8 inch long • brownish black

Table 9-2. Some Food Sources for Carpet and Hide Beetles

Beetle	Food Sources
Furniture carpet beetle (<i>Anthrenus flavipes</i>)	horse-hair filled furniture, wool, hair, fur, feathers, bristles, horn, tortoise shell, silk, animal excreta, stained linen, cotton, rayon, jute, Softwood, leather, bags, dried silkworm pupae and cocoons, dead mice, dead insects, dried cheese, old grain, casein, dried blood, and the glue of book bindings
Varied carpet beetle (<i>A. verbasci</i>)	nests of bees, wasps, and spiders; carpets, woolen goods, skins, furs, stuffed animals, leather book bindings, feathers, horns, whalebone, hair, silk, fish manure, dried silkworm pupae, rye meal, cacao, corn, red pepper, and dead insects in collections
Black carpet beetle (<i>Attagenus megatoma</i>)	feathers, dead birds, birds' nests, bird manure, dry horse and cow carcasses, seeds, grains, cereals, woolen rugs, clothing, carpeting, felts, furs, skins, yarn, velvet, silk, hair-filled mattresses, upholstered furniture, wool-filled blankets, house insulation with sheep wool or cattle hair, meat, insect meal, kid leather, milk powders, casein, books, cayenne pepper, dried pupae of silkworms, pet food, spilled flours, and pollen (for adults, particularly of <i>Spiraea</i>)
Black larder beetle (<i>Dermestes ater</i>)	mouse cadavers in walls of building; partially burned food and other kitchen wastes in incinerators; pet foods
Larder beetle (<i>D. lardarius</i>)	stored ham, bacon, meats, cheese, dried museum specimens, stored tobacco, dried fish, dog biscuits; can tunnel slightly in wood; can penetrate lead and tin but not zinc or aluminum; pest of silkworm cultures; reported to attack newly hatched chickens and ducklings
Hide beetle (<i>D. maculatus</i>)	prefers hides and skins; used to clean carcasses; known to survive on smoked meat and dried cheese, but cannot live on fat alone; larvae can tunnel short distances into wood
Warehouse beetle (<i>Trogoderma variabile</i>)	prefers barley, wheat, animal feeds, grains, and pollen; also found in seeds, dead animals, cereals, candy, cocoa, cookies, corn, corn meal, dog food (dried and "burgers"), fish meal, flour, dead insects, milk powder, nut meats, dried peas, potato chips, noodles, spaghetti, and dried spices

Detection and Monitoring

Look for holes in fabric, for larvae, cast skins of beetle larvae, or insect excreta in stored materials.

Carpet beetle larvae may be found wandering far from their food, particularly to pupate so they are sometimes encountered on materials they do not actually eat. Also, adult carpet beetles do not shun light and may be found crawling on windows. This is often the first place they are noticed.

These beetles are easy to catch: cover the insect with a jar and slowly slide a

card under the open end. Seal the jar and place it in the freezer overnight. The dead insect can be examined with a magnifying glass or taken to a professional for identification.

An inspection should include the following locations:

- around carpets or furniture covered or filled with susceptible materials; infestations may be under the slipcovers, where it is dark and quiet, or in the pads under the carpet
- around accumulations of lint and other organic debris, particularly under and behind furniture that

is rarely moved, in wall and floor cracks, in cracks behind filing cabinets, shelves, or other built-in items that may not be flush with the wall, behind baseboards, moldings and window trim, and in cold air and heater ducts

- around stored animal specimens, feathers, garments, blankets, or other items made of susceptible materials
- around bags or boxes of dried milk, fish or meat meal, dog food, etc; note that carpet beetles can bore through cardboard and paper packaging

If the infestation does not appear large enough to account for the number of pests found, or if cleaning up the infestation does not seem to diminish their number, then a further search should focus on less obvious sources:

- bird, wasp, bee, squirrel, or other animal nests on, or very close to, the walls of the building
- animal carcasses or trophies, insect collections, or leather or horn goods
- cut flowers, or blooming bushes near open, unscreened windows or doorways
- incompletely incinerated garbage

In some circumstances, sticky traps placed in areas where activity is suspected may be useful for monitoring. Hang them where you suspect you might have a problem and check them daily

Management Options

There is rarely a need to use an insecticide to control carpet beetles and other dermestids. The following physical controls should be adequate.

Physical Controls

Storage in Tight Containers

If clean materials are placed into tightly sealed containers, they will be safe from infestation. The problem with closets and similar storage areas is that they are almost impossible to seal because newly hatched larvae are so tiny they can crawl through very small gaps.

All grains, cereals and other similar susceptible substances should be stored in tight-fitting containers to deny beetles access. Containers can be placed in the freezer for a few days

to help reduce the possibility of an infestation developing.

Cedar Products

Cedar chests have long been thought to protect against fabric pests, but it has been known for many years that although cedar oil can kill very young larvae, the oil does not affect eggs, pupae, adults, or larger larvae, and that cedar lumber loses its oil in only a few years. Commercial repellents made from cedar, cedar oil, or herbs cannot be counted on to give adequate control to protect goods, either.

Vacuuming

Accumulations of lint, human and animal hair, and other organic debris in cracks and crevices of floors, baseboards, closets, and shelves provide food for fabric pests. These areas should be cleaned thoroughly and regularly to prevent infestations. It is particularly important to clean under furniture that is rarely moved (e.g., desks, bookcases, cabinets, etc.); in closets where fabric items, furs, and feather-filled materials are stored; and inside and behind heaters, vents, and ducts.

Caulking

Caulking or otherwise repairing cracks and crevices where lint and hair can accumulate will reduce the number of fabric pests that are able to live in the environment. Areas of particular concern are the spaces inside cabinets where shelves do not meet the wall and similar spaces in drawers holding susceptible materials. These same habitats are likely to be inviting to cockroaches.

Removal of Animal Nests

Carpet beetles can sometimes move into buildings from the abandoned

nests of birds, rodents, bats, bees, and wasps, as well as from the carcasses of dead animals. Remove nests in the eaves, in the walls, or close to the walls of the building. Problems with birds' nests usually occur after the nestlings have left.

Nests should be removed before the cold weather sets in and the beetles begin searching for sheltered hibernation spots. If there is a problem with rats and mice, these should be trapped rather than poisoned. If poisoned rodents die in inaccessible places, their carcasses can become food sources for fabric pests and flies. (See Chapter 13 for management of mice and rats.)

Pantry Pests

Stored foods can become infested with various pantry pests. They commonly infest flour, cereals, cracked grains, baking mixes and processed foods, crackers, macaroni, cured meats, powdered milk, dried fruits, nuts, popcorn and spices. Insects that feed on these products may also infest other grain-based items such as pet foods, birdseed and ornamental corn. Dried flower arrangements may also be attacked.

Identification and Biology

Indian Meal Moth (*Plodia interpunctella*)

The Indian meal moth (adult Figure 9-1) is the most common food-



Photo: UNL Department of Entomology

Figure 9-1. Indian Meal Moth Adult

infesting moth found in schools, homes, grocery stores and any place where dried pet foods are produced or stored. It feeds on a large variety of stored food products, but infestations often are started through dried pet food or birdseed. Nuts are a favorite breeding source; infestations have been found in nut caches of squirrels in attics and chimneys.

The larva (Figure 9-2) prefers coarse grades of flour, whole grains, cereal, dried fruits, seeds and spices. Foods infested with these insects will have silk webbing present, especially near the food surface.



Figure 9-2. Indian Meal Moth Larvae and Adult

Adult moths are nearly 1/2-inch long and have distinctive wing markings. The base of the forewing is pale grey and the outer two-thirds is reddish-brown with a coppery luster. They have a distinctive way of “resting” on the wall at an angle with their wings folded. The larvae are generally dirty-white in color with shades of yellow, pink, brown or green. Mature larvae, which are about 1/2-inch long, usually move away from the feeding site before pupating within silken cocoons.

Dermestid Beetles (Family: *Dermestidae*)

As mentioned earlier, dermestid beetles scavenge and feed on animal matter like dried meats, dead insects, hides and woolens. Some species, such as the warehouse beetle, varied carpet beetle and larder beetle (Figure 9-3 and 9-4), have expanded their diet and also feed on grain and grain-based products. They are especially common in flour and cereals but also are found in candy, cocoa, cookies, corn meal, nuts, pasta, dried spices, and many other dry foods.

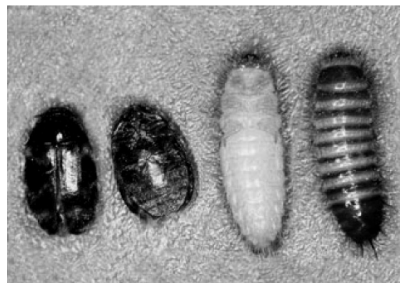


Figure 9-3. Warehouse Beetle Adult and Larvae

The adult beetles are small, oval and variously colored. The full grown larvae are similar in size to the adults for each species and tend to be cigar-shaped and banded with dark, long hairs. In some species, the larvae have a tuft of hair at the tail-end of the body.

Typically, only larvae will be seen in infested food because the adults feed on pollen and leave the food once they have emerged from their pupal stage. Sometimes only the larval

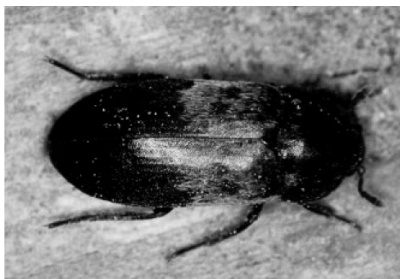


Figure 9-4. Larder Beetle - Adult

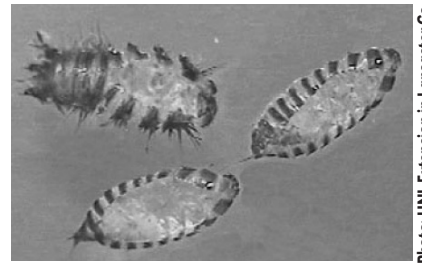


Figure 9-5. Cast (Shed) Skins from Dermestid Beetle Larva

“skins” will be found (Figure 9-5). Dead adults are often found in windowsills because they fly to the light, trying to get outside.

Since some of these species feed on woolens, infestations in the pantry may spread and damage valuable clothing, woolens and furs. Proper cleaning and storage of natural fabrics will help prevent damage.

Sawtoothed Grain Beetle (*Oryzaephilus surinamensis*)

The Sawtoothed grain beetle (Figure 9-6) is another very common pantry pest. It does not feed on intact whole grains but feeds on many processed food products such as breakfast food, bran, dried fruits, nuts, sugar, chocolate, and macaroni. It is especially fond of oatmeal and birdseed. These flat beetles can even get into sealed boxes and packages of food.

Adults are nearly 1/4-inch long, slender, brownish-red and active. Their name comes from the six saw-like teeth on either side of the thorax behind the head. After finding a potential food source, the female



Figure 9-6. Adult Sawtoothed Grain Beetle

lays white, shiny eggs that hatch into yellowish-white larvae. There can be as many as seven generations each year, but sawtoothed grain beetles often stop breeding in the winter unless buildings are heated and moisture is sufficient. Adults are very long lived and remain active in the winter.

Cigarette and Drugstore Beetles

These small, stout beetles (Figure 9-7) are common in locations where they can attack pet food, cereals, spices, and other packaged foods. Since they closely resemble each other, they are often confused. The heads of both beetles are tucked under the prothorax and are not visible from above. Both are brown and about the same size.

The two beetles can be distinguished by their wing covers. The wing covers of the drugstore beetle have rows of longitudinal grooves while those of the cigarette beetle are smooth. Another distinguishing feature is the



Photo: UNL Extension in Lancaster Co.

Figure 9-7. Drugstore Beetle Adult (Left) Cigarette Beetle Adult (Right)

antenna. The drugstore beetle has a three-segmented club while the cigarette beetle has an antenna that looks a little like a saw blade.

Both the cigarette and drugstore beetles belong to the family *Anobiidae* and can be confused with some wood-boring beetles of the same family. It is important to have the beetle identified because wood-boring beetles have greater damage potential than the cigarette and drug-

store beetle. However, if the beetles are found in food or grain products, it is most likely a cigarette or drugstore beetle.

Drugstore beetles (*Stegobium paniceum*): The drugstore beetle will feed on bread, but it will also feed on any dried, food-based material. It will damage book bindings. It has been found to perforate tinfoil and sheet lead and easily chews through most food packaging material.

Cigarette beetles (*Lasioderma serricorne*): The cigarette beetle derives its name from its serious infestations of stored tobacco. Adult beetles are about 1/8-inch long, light brown, and oval. The most common food materials include pet food, cereal, peppers, spices, raisins, and seeds.

Flour Beetles (*Tribolium spp*)

There are a number of species of tiny beetles that infest flour, but the two most common flour beetles are the confused (Figure 9-8) and red flour beetles. These beetles are scavengers in that they cannot attack whole grains but rely on other insects to damage the kernels first. In buildings they can be found feeding on flour, cracked grains, cake mixes, beans, peas, dried fruits, nuts, chocolate, and spices.

These red and confused flour beetles are very similar: both are reddish-brown and about the same size, 3/16-inch long. They can be distinguished by their antenna. The antenna of the red flour beetle ends abruptly in a three-segmented club while the antenna of the confused flour beetle gradually enlarges toward the tip, ending in a four-segmented club. In addition, the sides of the red flour beetle's thorax are curved while the confused flour beetles thorax has straighter sides.



Photo: UNL Department of Entomology

Figure 9-8. Adult Confused Flour Beetles

The biology of these two beetles is very similar. The primary difference is the red flour beetle flies and the confused flour beetle does not. If you see a red flour beetle crawling on the counter, the breeding source is probably nearby, but not necessarily. A confused flour beetle crawling on the counter is almost certainly from a nearby food source.

Granary and Rice Weevils (*Sitophilus spp*)

These insects (Figure 9-9 and 9-10) damage whole grains or seeds. They generally do not feed on flour or cereals unless it has become caked.

Adult weevils are very similar. Both are dark reddish-brown and range in size from 1/8 to 3/16-inch long. They have a long snout projecting from the head and wing covers with distinct ridges.



Figure 9-9. Granary Weevil - Adults



Photos: UNL Department of Entomology

Figure 9-10. Rice Weevil - Adults

Females lay eggs on seeds, kernels or other suitable foods. The larvae chew into the seed and feed on the inside of whole kernels/seeds. Pupation normally occurs within hollowed-out kernels or seeds. There can be as many as three to five generations each year. Weevil-damaged grains are typically hollow and have small round emergence holes.

Since they feed on whole grains, these insects are more likely to be a problem in grain bins and warehouses, but it is possible to have infestations in other facilities. Most common sources are popcorn, birdseed, decorative Indian corn, and nuts.

Bean Weevil (*Acanthoscelides obtectus*)

The most common pest of stored legumes, such as beans, cowpeas, and peas in Nebraska is the common bean weevil (Figure 9-11). The bean



Photo: Kansas State University

Figure 9-11. Bean Weevil - Adult

weevil is not a true weevil, like the granary and rice weevils, discussed earlier. They are members of the closely related seed beetle family. Their body shape is more round than the rice and granary weevils, and they do not have the slender protruding snout of these true weevils.

Bean weevils are common in the field. Sometimes, gardeners harvest beans from the garden that look perfectly good but can be infested. People may notice bean weevils for the first time on windows and doors as they emerge

from stored seeds. They are attracted to light and are attempting to escape. Usually, there is little concern for their presence until a sack of dried beans or peas, especially homegrown, is emptied and found full of holes. Occasionally, one may take a package of dried beans or peas out of storage to find it infested with small, stout beetles with a short, broad snout.

The adult bean weevil is a short chunky beetle, about 1/8 inch in length. It is olive-brown with darker brown and gray patches on the wing covers. The elytra are shorter than the abdomen leaving a few segments exposed. Legs are reddish.

With beans stored indoors at warm temperatures, bean weevils breed continuously as long as there is food left in the beans. Populations can become very high.

Spider Beetles (Family: *Ptinidae*)

Spider beetles (Figure 9-12) get their name because many actually resemble small spiders in appearance with their small head, prothorax and large globular-shaped abdomen. With a quick glance, their six long legs and two long antennae look like the eight legs of a spider.

Adults vary in size from 1/8 to 1/4-inch long, are reddish-brown to black. Females lay eggs within the food mass, such as grain, seeds, cereals, dried fruits, meats, wool and hair. Mature larvae are approximately



Photo: UNL Dept. of Entomology

Figure 9-12. Spider Beetle - Adults

1/4-inch long, cream to tan in color and curved. Larvae usually curl their bodies when disturbed. Most spider beetles have two or three generations each year.

Spider beetles are mainly scavengers but will infest grain-based products that are old, moist, and possibly moldy. There is often an association with spider beetles and infestations of rodents, birds, bats, or bee/wasp nests in walls or attics. These beetles will feed and breed in accumulations of animal excrement. Older buildings and warehouses tend to have more spider beetles due to the likelihood of these food sources. As infestations become severe, beetles will crawl and emerge from walls between floors, attics, basements, and crawl spaces. When associated with an animal infestation, removal of animal wastes is an essential component of managing spider beetles.

Grain Mites (*Acarus siro*)

The grain mites (Figure 9-13) are pests of food and feed products, like cereals, dried vegetable materials, cheese, corn and dried fruits. These mites proliferate under high

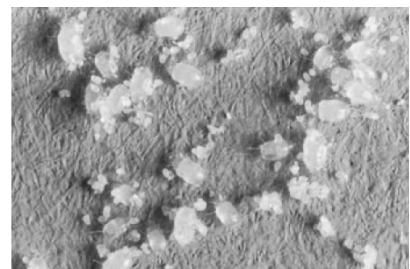


Photo: University of Idaho

**Figure 9-13. Grain Mites
Adults, Immatures, and Eggs**

moisture conditions and are often found in conjunction with fungal growth. Severe infestations result in brownish tinge over the commodity, called "mite dust" because of the light brown coloring of the mite legs. This "mite dust" gives off a "minty" odor if the mites are crushed.

The life cycle from egg to adult takes only about two weeks at normal room temperatures. Overcrowding in heavily infested products will force mites to move off in search of other food sources.

Damage

Several stages (egg, larva, pupa and adult) of these insects may be present at the same time in infested products. Since we keep our buildings warm, these insects may continually reproduce and many stored product infestations can be found nearly any time of the year.

The first indication of an infestation is often presence of small brown beetles, moths, or worms in storage areas or on counters. Upon closer inspection, insects may also be found in opened packages or containers of food and in the cracks and crevices of shelves. Unopened packages may also become infested because some of these insects can readily chew into cardboard and foil packaging. Insects can be brought into the facility along with infested food products. They can multiply and spread to other stored foods.

Prevention

Once a pantry pest infestation is suspected, identify the pest and try to locate the source. Occasionally, the source of an infestation can be very hard to find. It may be in an unopened package. Consider the possibility that food may have been spilled next to or behind hard-to-move appliances. Mice will sometimes collect seeds or dry pet food and hoard them in walls, under cupboards or dishwashers where the infestations are nearly impossible to find.

The following tips may be useful.

- Purchase food in package sizes that can be used up in a short time. Do not store food products more than two to four months, if possible. Use older packages before newer ones and opened packages before unopened ones.
- When purchasing packaged foods, be certain containers are not damaged, and seals are intact.
- Store dried foods in insect-proof containers such as screw-top glass, heavy plastic or metal containers. This will prevent entry or escape of insects. Cardboard, paper or plastic wrapping will not prevent insect infestations.
- Keep food storage areas clean and do not allow crumbs or food particles to accumulate, as exposed food will attract insects. Cleanliness is especially important in areas where pet foods and birdseed are stored.

Management Options

Inspection and identification of all potential food sources is essential to controlling the infestation. Control requires locating and discarding all infested items. Do not overlook intact boxes or containers because many insects can chew their way into cardboard and foil.

Infested items can be thrown away or salvaged by freezing three to four days. Food can be heated in a 140°F oven for an hour with the same result. You should empty and thoroughly vacuum cupboards or shelves holding infested items. Pay particular attention to cracks and corners.

Vacuuming picks up hiding insects and spilled or infested material. Empty the vacuum cleaner or discard the vacuum cleaner bag after use to prevent reinfestation.

Do not use insecticides for controlling these or other insects in pantry areas. Washing shelves with detergent, bleach, ammonia or disinfectants will not have any effect on these pests since these insects lay their eggs on suitable food. Removing infested items and thoroughly cleaning with a vacuum is usually sufficient. As a precaution against reinfestation, store susceptible foods in tightly sealed glass, metal or heavy plastic containers or in the refrigerator or freezer.

If insects continue to appear, go through stored items again and also check other rooms in the building for possible sources. Tree seeds blown into ventilators or around windows may harbor these pests. If insect problems persist, seek assistance from a pest management professional.

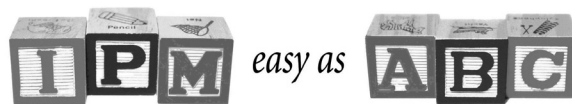
Resources

For management practices and pesticide recommendations on fabric and pantry pest control, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Educational resource guides on pantry and fabric pests are available at: <http://lancaster.unl.edu/pest/resources/pantrypests304.shtml>.

Chapter 10

IPM for Fleas



Introduction

Fleas are small, reddish-brown jumping insects that cause problems occasionally in buildings. In general, cat fleas (*Ctenocephalides felis*) are the most commonly found. This flea feeds on cats, dogs, and humans, as well as rodents, chickens, opossums, raccoons, and other wild animals. The dog (*C. canis*) and human (*Pulex irritans*) fleas are rarely encountered.

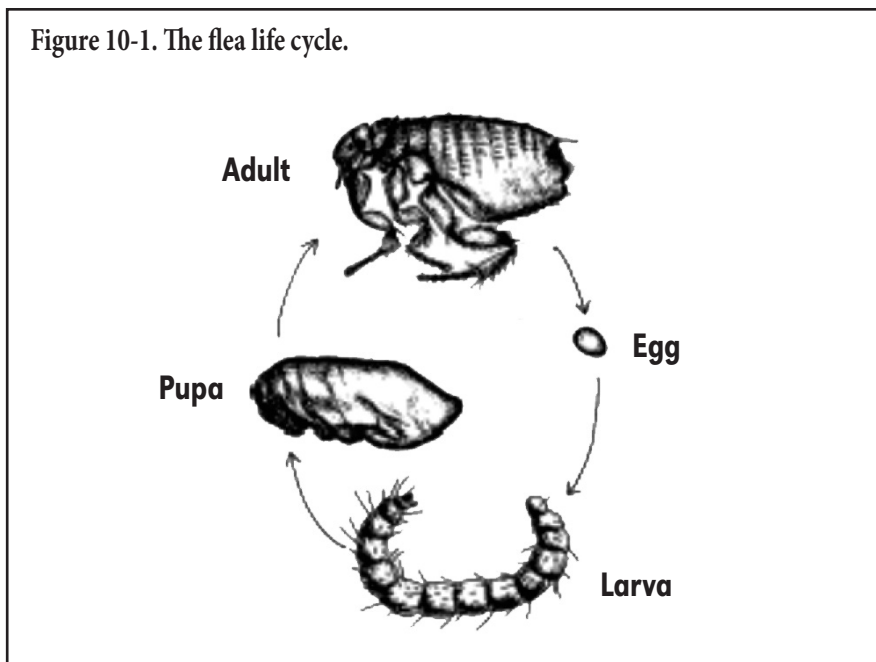
Identification and Biology

Adult fleas are 1/12 to 1/8 inch long, wingless, and reddish brown. They pass through four life stages: egg, larva, pupa, and adult (Figure 10-1). The adult body is oval and compressed from side to side allowing the insect to glide through the narrow spaces between the hairs of its host. The newly emerged adults without their first blood meal are almost black but appear lighter brown after feeding. The larvae are white, hairy, worm-like, and 1/16 to 3/16 inches long with a distinct brown head.

Under the best conditions, a female flea can lay about 25 eggs a day for at least two to three weeks. Eggs are laid either on the host or in its bed or nest. Eggs laid on the host fall off and accumulate in floor cracks, rugs and carpets, dust, and damp soil.

Eggs hatch in 2 to 6 days. Optimal conditions for egg hatching and flea development are temperatures

Figure 10-1. The flea life cycle.



between 65 and 80°F with a relative humidity of 70 percent or more. Dry conditions and temperatures over 95°F are fatal to larvae because they lose excessive moisture.

The larvae develop within 8 to 21 days in the cracks and crevices where the eggs have fallen. In unfavorable conditions, the larvae develop slowly and take up to 200 days. The larvae feed on organic debris such as food particles and dried blood excreted by adult fleas.

The fully grown larvae prepare a cocoon using debris and saliva, and pupates within the cocoon. When conditions are favorable, the pupal stage lasts 1 to 2 weeks, but when it is cool and moist and no host is present,

this stage can last nearly a year. Adult fleas emerge from pupae in response to the warmth, vibrations, and carbon dioxide coming from an animal or human. This ability of adult fleas to remain in a cocoon to wait until a host arrives can result in a sudden increase of adult fleas when they emerge simultaneously from many accumulated pupae.

As soon as the adult fleas emerge from the pupae, they look for a host for their first blood meal. Adults can live 1 to 2 months without a meal and can survive 7 or 8 months with one.

These variations in flea development time account for the sudden appearance of large numbers of adult fleas in "flea season," usually in the late

summer and early fall. The flea population has been building up all year long in the form of eggs, larvae, and pupae, but rapid development into biting adults cannot be completed until the temperature and humidity are right, and a host appears.

Damage

Flea bites cause irritation but also serious allergies in animals and humans. Cat fleas (Figure 10-2) can carry or transmit various disease organisms, such as *Yersinia pestis*, which causes bubonic plague; *Rickettsia typhi*, which causes murine typhus; and *Dipylidium caninum*, the double-pored dog tapeworm, which can live in dogs, cats, or humans.

Detection



Photo: Jim Kalisch

Figure 10-2. Cat flea

and Monitoring

Fleas can be a problem even when no pets are kept in the buildings. Adult fleas can be brought in on the clothing of staff, children, or visitors. Other possible sources include urban wildlife such as rats, raccoons, opossums, chipmunks, squirrels, feral cats, or birds that may live in unused parts of the buildings.

Areas to Monitor

- In and around the cages of pets kept in school or child care classrooms (also check the pets themselves for signs of fleas, Figure 10-3)



Photo: Vicki Jedlicka

Figure 10-3. Flea on a cat

- Places where animals might find harborage, such as basements, crawl spaces, attics, eaves, roof top structures, and secluded shrubbery near buildings

Monitoring Traps

Flea Sock Traps

These are homemade, knee-high, white flannel booties that fit over the shoes and lower pant legs. When you walk through a flea-infested area, fleas will jump onto the flannel and become temporarily entangled in the nap where you can easily see and count them. Long, white athletic socks worn over the shoes and trouser legs will also work, as well as wide strips of sticky-backed paper wrapped around the lower legs (sticky side out). Socks can also provide protection from bites if a person must enter a severely flea-infested area for a short period of time.

Light Traps

These compact (roughly 4x6-inch) traps are composed of a small electric light and a sheet of sticky paper. Fleas attracted to the warmth and light get stuck to the paper. According to research data, fleas are most sensitive to green light and are more attracted to light traps if the light is turned off for 10 seconds every 5 to 10 minutes; therefore, it is important to choose a

trap with a green light that can flicker on and off.

Light traps are especially useful for monitoring in office situations where no animals are present and the flea population is likely to be small. Check the traps once a week. If no fleas are caught by the second week, move the trap to another location or remove it. If the traps catch only a few fleas, the infestation is very small and can probably be controlled by the traps alone. In this case, leave the traps in place until no additional fleas have been caught for a week. If 20 or more fleas are caught per trap in a week, this probably indicates a more serious infestation, and time must be devoted to finding the source of the infestation (such as an animal living in or under the building).

Persistent Flea Problems

Persistent flea problems in buildings where there are no pets may indicate the presence of rodents or other wildlife. In this case it can be useful to have the fleas identified by a professional. When the flea species is not the cat flea, its identity can help determine the host animal and where to search to find the animal or its nest.

Box 10-A. Sample IPM Program for an Indoor Flea Emergency

If monitoring has confirmed a high indoor flea population that requires an immediate response, the following IPM program can be used to bring the emergency under control. A significant reduction of flea numbers should occur within one to two days.

1. **Protect yourself.** Wear long pants tucked into boots or socks. For added protection, you may want to apply an insect repellent to pant legs and footwear.
2. **Vacuum and/or steam-clean infested areas.** Since most fleas reside in carpeting, it should be thoroughly cleaned. In uncarpeted areas, or where carpeting cannot be steam-cleaned, concentrate vacuuming along baseboards, under furniture, behind doors, or in other areas where dust collects and flea eggs are protected from foot traffic. See Physical Controls for more details.
3. **Apply an insect growth regulator (IGR).** After completing steps 1 and 2 above, spray carpets and floor with an IGR such as methoprene (see Chemical Controls). The IGR will prevent pre-adult fleas that survive vacuuming or steam-cleaning from maturing to biting adults.
4. **Apply an insecticide if needed.** The first three steps described above should reduce the flea population to a very low level and keep it there while long-term measures (e.g., locating and removing wild animal flea hosts from the building) are undertaken. If sufficient control has not been achieved, apply a borate insecticide to carpeting or spot-treat infested areas with insecticidal soap or pyrethrin (see Chemical Controls). If adequate control has still not been achieved, apply a stronger insecticide, such as a synthetic pyrethroid. Follow all label directions to the letter and wear appropriate protective clothing.
5. **Remove any wildlife nesting in or under the building.** If flea problems persist but no pet is present, check for wildlife in the vicinity of the building and remove the animal.

Management Options

An integrated management program for fleas can be designed by selecting from the following strategies and tactics. See Box 10-A for a sample emergency flea control plan.

Non-Chemical or Physical Controls

Wild Animal Removal

Wild animals can be removed with traps by trained animal control tech-

nicians. Consult your Yellow Pages or talk to your local Extension office for a recommendation. Make appropriate repairs to the building to exclude animals. For plans for controlling rats and mice, see Chapter 13.

Vacuuming

- Vacuuming on a regular basis throughout the year will keep developing flea populations low by picking up adult and egg-stage fleas.
- Vibrations caused by vacuum cleaners will stimulate pupal stage fleas to emerge, and the new adults can be captured in the next vacuuming.
- Vacuuming is not very effective at capturing flea larvae in carpeting because they coil themselves around the fibers. Vacuuming does, however, pick up the food particles and dried fecal blood that larvae feed on.
- Use vacuum attachments to clean cracks and crevices. Caulk or seal these openings permanently.
- Most fleas will be killed when dust in the vacuum bag blocks their breathing apparatus, but to be sure, you can vacuum up a tablespoon of cornstarch.
- Vacuum badly infested areas thoroughly every day until the infestation is controlled.
- When infestations are severe, you may need to supplement vacuuming with steam-cleaning or other controls.
- Discard the vacuum bags by placing in separate tied plastic bags to prevent any escapes.

Steam-Cleaning

The services of a steam-cleaning firm may be warranted when flea populations are high. This process kills adult and larval fleas and probably some eggs as well; however, since the warmth and humidity from the steam also stimulates the remaining flea eggs to hatch a day or two after the cleaning, some fleas may reappear. If the other steps recommended in this chapter are followed — regular vacuuming, washing, etc. — the few fleas that emerge after steam-cleaning should represent the last of the flea population.

Flea Combs

Classroom pets in a flea-infested room should be combed regularly with a special flea comb that can be purchased at a pet store. Fleas and eggs removed from the animal should be dropped into container with soapy water.

Cleaning and Laundry

Wash removable floor coverings, such as rugs, located in areas where there are known infestations. Any bedding for classroom pets should be washed regularly.

Drying or Flooding Infested Areas Outdoors

Outdoors, organic matter can temporarily harbor flea larvae. Either drying out these areas or saturating them with water will kill the eggs and larvae. You can also treat these areas with insect-attacking nematodes (see “Biological Controls”) or with an insecticidal soap (see “Chemical Controls”).

Biological Controls

Insect-Attacking Nematodes

These microscopic, worm-like organisms live in the soil and kill insects by entering their bodies, feeding on tissue, and releasing harmful bacteria. These bacteria do not affect humans or other vertebrates. When they have eaten all they can of the insect, the nematodes leave to search for other prey. They cannot move far (only an inch or two) and die if they find no other insects. The nematodes sold for flea control are native to the United States and are found naturally in the soil all over the country; they will not adversely affect beneficial soil organisms, including earthworms.

Tips for Using Nematodes

- Use the number of nematodes recommended by the manufacturer.
- Treat areas outside where you have found evidence of animals sleeping or areas that you know are regular travel routes for animals.
- Moisture is critical to the effective use of nematodes so water the area before and after the application.

Chemical Controls

If non-chemical methods alone prove ineffective in solving the problem, then integrating a pesticide into your management program may be warranted. Pesticides must be used in accordance with their EPA-approved label directions. Applicators hired by the facility must be certified to apply pesticides and should always wear protective clothing during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the

IPM program should be maintained on file. Do not apply these materials when buildings are occupied and never apply them where they might wash into the sanitary sewer or into outside storm drains.

Insecticidal Soap

The insecticidal properties of naturally occurring fatty acids used to make soaps have been refined into a number of useful flea-control products. These insecticidal soap products can be found in pet stores and sometimes hardware stores.

Insecticidal soap can be used on pets, rugs, floors, and other places where flea eggs or young fleas may have collected. Outdoor areas can also be treated with insecticidal soap to reduce adult flea populations. Since this soap can kill a wide variety of insects, mites, and other arthropods (many of which are beneficial), it should be used outdoors only in spot treatments where wild animals nest and only during periods of large flea infestations. Routine or random outside treatment or cover spraying is not advised. To locate areas with adult fleas, wear the flea socks described earlier (under “Detection and Monitoring”) and walk around the areas suspected of harboring fleas. If adult fleas are present, they will hop onto the socks where you can easily see them and evaluate the severity of the infestation.

Diatomaceous Earth and Silica Aerogel

These are insecticidal dusts that can be used for flea control. Diatomaceous earth is from fossilized diatoms, and silica gel is an inorganic

compound. Both of these products kill insects by desiccation; they abrade the wax and oil from the insect's exoskeleton, which causes dehydration and death. Although these materials are not poisonous to humans directly, the fine dust travels freely through the air and can be irritating to the eyes and lungs; therefore, use a respirator or dust filter mask and goggles during application. Silica gel and diatomaceous earth are also formulated with pyrethrins.

How to Use Diatomaceous Earth and Silica Aerogel

- Be sure to get dust into the cracks and crevices.
- Apply a light dusting to rugs used for pets bedding and other bedding materials.
- Apply to infested carpeting, leave for a couple of days, and then vacuum up.
- Dust into crawl spaces, wall voids, attics, and other similar spaces where you suspect animals of nesting or resting.
- Do not use in moist environments; neither material works well when wet.

Citrus Oil Extracts (D-Limonene/ Linalool)

D-limonene and linalool are citrus-peel extracts that have been used for years as food additives. Products that contain d-limonene kill larval and adult fleas, while those containing both ingredients kill all flea stages by direct contact. EPA-registered citrus products can be used directly on pets, but veterinarians caution that some cats may suffer if the material is applied in excessive concentrations. These materials can also be applied to animal bedding but should not be used to spray entire rooms, nor should they be used outdoors.

Borates

Sodium polyborate can be used in carpets to control flea larvae. The powder is worked into the nap of the carpet and then thoroughly vacuumed. This treatment will continue to kill flea larvae for as long as a year.

Insect Growth Regulators

Insect growth regulators (IGRs) arrest the growth of the flea at or before the pupal stage, but they do not kill fleas that have reached the adult stage before the material was applied. IGR products containing

methoprene should be used before fleas reach the adult stage and only inside where severe infestations were previously located. Use liquid solutions and apply as spot treatments. Do not use aerosol foggers because much of the material falls on areas that will have no contact with fleas.

Pyrethrins and Pyrethroids

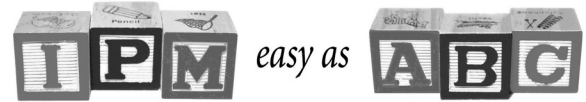
There are a number of flea control products containing pyrethrins and pyrethroids. These products can be used in areas where flea problems are severe. Apply as a spot treatment — do not use aerosol foggers.

Resources

For management practices and pesticide recommendations on flea control, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Educational resource guides on fleas are available at <http://lancaster.unl.edu/pest/Fleas.shtml>.

IPM for Flies



Introduction

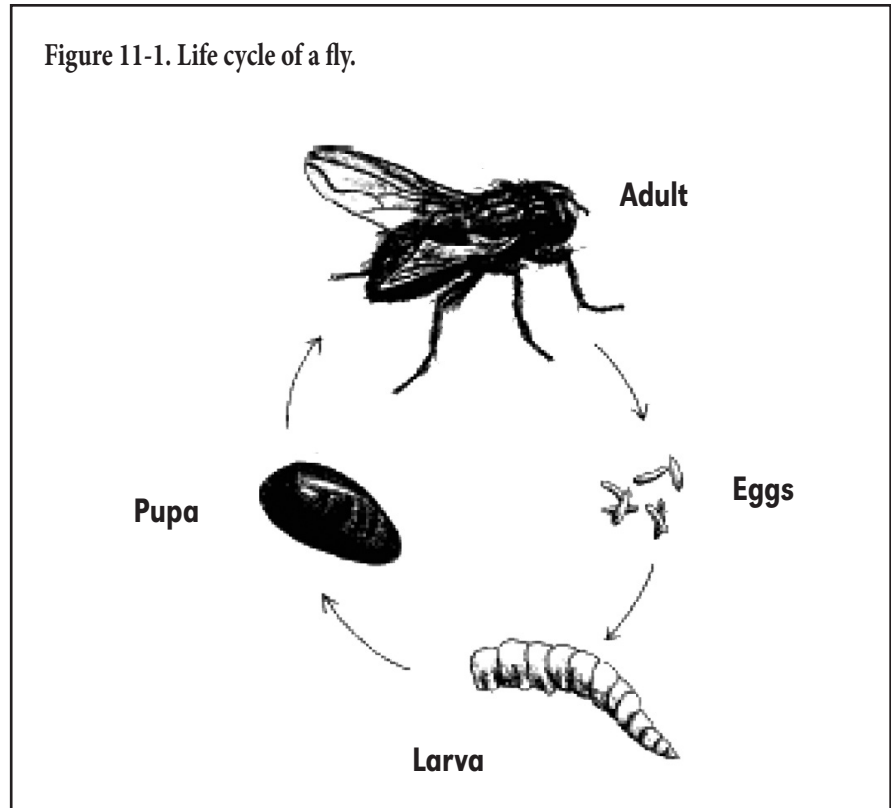
Many species of flies can be problems in buildings. Each kind of fly has a distinct breeding site inside or outside the structure. In order to control pest flies, it is necessary to know which fly is causing the problem and where it is breeding.

Garbage- and Manure-Breeding Flies

Identification and Biology

Flies such as house flies, dump flies, blow flies, and blue and green bottle flies that breed in food wastes (garbage) and/or animal feces are generally referred to as “filth flies.”

Sometimes flies are confused with wasps. But, flies have two wings, while wasps and all other winged insects have four wings arranged in two pairs, although sometimes the second set are hidden by the first. Wasps, unlike flies, fold their wings alongside their bodies when at rest. Most pest wasps are colorfully marked with yellow, red, black, and white. These wasps are less likely to come indoors, they are aggressive in their flight around foods, particularly sweets, and they are larger than filth flies. Filth flies do not act aggressively. The cluster fly, which is also larger than the filth flies, can be identified by its stout body with crinkled yellow hairs.



Filth flies pass through four distinct stages in their life cycle: egg, larva (maggot), pupa, and adult (see Figure 11-1). Adult female filth flies look for a moist place with the right smell to lay their eggs. This can be in food waste in a garbage can or dumpster, in dog or cat feces, in dead animals, in grass clippings allowed to rot in a pile, and even in moist soil mixed with garbage. The larva hatches from the egg and grows until it is ready to form a pupae from which an adult fly will emerge. Once the adult fly emerges, it doesn't grow any larger; small flies do not grow into larger flies.

Damage

Filth flies that invade cafeterias and kitchens carry bacteria and other microbes that contaminate food, utensils, and surfaces. It is good hygienic practice to prevent this exposure.

Detection and Monitoring

It is important to correctly identify the problem flies and pinpoint their breeding sites. Table 11-1 can help you with identification, or you can take several specimens to a specialist. The

Table 11-1. Common Flies Found in and around Structures

Common Name	Scientific Name	Description	Sources
House Fly	<i>Musca domestica</i>	medium-sized, gray; 4 stripes on thorax	garbage, human and animal manure
Stable Fly “biting house fly”	<i>Stomoxys calcitrans</i>	medium-sized, gray, 4 stripes on thorax, spots on abdomen; stylet-like mouthparts used to bite ankles.	animal waste mixed with vegetation
Black Blow Fly	<i>Phormia regina</i>	large; dark blue	garbage, animal carcasses; most abundant in early spring
Green Bottle Fly	<i>Phaenicia sericata</i>	medium-sized; shiny green to bronze	garbage containing mixtures of animal and vegetable matter, dead animals, animal feces, enters buildings less frequently than house flies
Blue Bottle Fly	<i>Calliphora vomitoria</i>	medium-sized; thorax dull, abdomen metallic blue	exposed meat, feces, garbage, enters buildings in cool seasons
Little House Fly	<i>Fannia canicularis</i>	small, dull gray, yellow on upper abdomen; males circle in the air	decaying vegetable and animal matter, animal and human excrement, leaks from sewer pipes,
Cluster Fly	<i>Pollenia rudis</i>	larger than house fly; dark gray with distinctive yellow hairs; adults sluggish	larvae parasitic on earthworms; adults enter houses in fall
Face Fly	<i>Musca autumnalis</i>	Very similar to house fly	larvae breed in very fresh animal manure; More common in rural areas
Fruit Fly	<i>Drosophila</i> spp.	very small; yellow-brown	fermenting fruit and vegetables, other moist organic matter
Phorid Fly (Scuttle Fly, Humpback Fly)	<i>Megaselia scalaris</i>	similar to fruit fly, but more humpbacked in appearance. Scoot along surfaces before flying	decomposing organic matter, especially leaks below garbage disposal, toilets or floor drains.
Drain Fly (Moth Fly)	<i>F. Psychodidae</i>	look like tiny moths, but have two wings	larvae feed on the gelatinous gunk that lines drain pipes

specialist should be able to tell you what kind of breeding site to look for after an identification has been made.

To collect specimens inside, use sticky flypaper or gather dead specimens from windowsills and light fixtures. Outside, trapping is one of the easiest methods of catching flies for identification (see the discussion below for trap construction, placement, and baits). If adult flies consistently avoid baited traps, it may indicate that the pest fly is not a filth fly. In this case, you can try using a butterfly net to catch one of the flies.

Management Options

To manage flies, you must find and reduce breeding sites, install and maintain screens to keep flies out of buildings, kill those flies that do get inside with a fly swatter or flypaper, and reduce or eliminate the odors that attract flies.

In a facility with frequent garbage pickup, it is unlikely that filth breeding flies are breeding on the premises. It is more likely that odors from dumpsters, garbage cans, kitchens, and cafeterias are attracting flies to the building from the surrounding neighborhood. House flies and blow flies, the species that most commonly invade buildings, usually develop outside and follow odors into the structure. In facilities where waste removal is infrequent, fly populations can be breeding at the waste collection site.

Habitat Modification

This is one of the most important aspects of fly control. Without controlling wastes and odors, it is impossible to control filth flies.

Food Waste

- All food waste from the kitchen, cafeteria, and other areas should be separated from other garbage, drained so it will be as dry as possible, and then stored in sealed plastic bags before discarding.
- Place containers with small amounts of food waste, such as milk or yogurt cartons, into sealed plastic bags before disposal
- Promptly fix drains or electric garbage disposal units that leak, or drains that allow food waste to accumulate under sinks or floors. Leaky drains can attract many species of flies. Remove any food waste that has accumulated under sinks or floors or in crawl spaces or basements at the site of the broken drain and then clean the area thoroughly.

Other Garbage

- In food preparation areas, rinse all cans, bottles, and plastic containers before recycling or discarding.

Exterior Garbage Cans and Dumpsters

- To avoid attracting flies into the building, place dumpsters and recycling containers upwind and well away from the outside doors of the facility, particularly doors to the kitchen or cafeteria. When dumpsters are downwind, flies are attracted to the waste odors and then find the odor trails that the breeze blows down from the doorways. Following these odor trails, they find their way into the building.
- Wastes should be collected and moved off site at least once a week. In hot months, garbage collection twice a week will significantly reduce fly problems.

- Make sure garbage can and dumpster lids seal tightly when closed and remain closed when not in use. Do not leave lids open at night; garbage can attract other pests, such as rodents. Repair or replace garbage cans with holes or with lids that do not close tightly. For more information on rodent-proof garbage containers, see Chapter 13, IPM for Rats and Mice.
- Regularly clean garbage cans and dumpsters to prevent the build-up of food waste, an ideal place for flies to lay eggs. Use a high-pressure stream of water or a brush and soapy water, if necessary. A solution of borax and water will eliminate odors. Do not allow soured milk to collect in trash receptacles; it is a powerful attractant to flies. If possible, dumpsters should be fitted with drains so they can be hosed or scrubbed out as needed. Another option is to require the refuse company to clean the dumpster or replace it with a clean one more frequently.
- Do not store extra garbage outside of dumpsters or garbage cans in cardboard, plastic, or paper; this provides easy access for rats, dogs, raccoons, or other animals.
- Inspect dumpsters and other outdoor trash receptacles at the end of the day and remove any wastes lying on the ground.
- Garbage cans should have removable domed tops with self-closing, spring-loaded swinging doors. Cans should be lined with plastic bags that can be tightly sealed and removed daily.
- Remind everyone of the importance of placing garbage inside proper containers. Garbage should not be left lying on the ground.

Animal Feces

Remove droppings promptly and put them into plastic bags that are sealed before disposal. Dog feces that dry quickly may attract adult flies with their odor but are unlikely to host many maggots. Droppings that remain damp because of humidity or rain can breed a number of maggots.

Odors

Flies can detect odors over long distances. Smells of souring milk from hundreds of containers thrown in dumpsters can attract thousands of flies from the surrounding neighborhood. Storing garbage in sealed plastic bags and having cans and dumpsters cleaned and emptied frequently to eliminate odors is very important. Removing pet feces also helps reduce attractive odors.

Flies attracted to open kitchen or cafeteria doors, or to dumpsters or garbage, will rest on nearby walls, eaves, and rafters. While resting, they leave fly specks, which have a strong fly-attracting odor. These brown- to cream-colored specks should be washed off with an odor-eliminating cleaner (a mild solution of borax and water can be particularly effective); otherwise they will continue to attract flies.

Physical Controls

Screens

Install screens over windows, doors, and vent holes to prevent flies from entering buildings. Weather-stripping or silicone caulk can be used to ensure a tight fit. Torn screens can be repaired with clear silicone caulk.

Screen doors should be fitted with springs or automatic-closing devices that close the screen door firmly after

it is opened. External doors that cannot be screened should be fitted with automatic closing devices, and/or vertical strips of overlapping plastic that allow human access but prevent fly entry. “Air walls” that force air across openings are another alternative to screen doors.

Fly Swatters

In many instances, the old-fashioned fly swatter is the safest and quickest way to kill flies that have found their way into a room. Aim the fly swatter about 1 1/2 inches behind the fly, rather than directly at it, because research has shown that when a house fly takes off from a horizontal surface, it jumps upward and backward. Stiff plastic swatters seem to work better than wire mesh ones. The fly’s unblurred range of vision is about 1.5 feet, and the swatter can be moved to this distance before striking.

Flypaper

Sticky flypaper is effective at catching flies because it takes advantage of their natural habit of moving up to the ceiling to rest. It will take several days for a new strip of flypaper to start catching flies. Use a number of strips at a time and replace them when they are covered with flies or when they begin to dry out. Flypaper can be very useful in areas where there are too many flies to kill with a fly swatter, and where aesthetic appeal is not of primary importance. Flypaper is also a useful monitoring tool.

Fly Traps

Fly traps can be used to reduce adult fly populations, capture specimens for identification, and monitor the effectiveness of control programs. Fly traps are not toxic and are more

selective than using insecticide.

Traps need to be serviced regularly, appropriately placed, and repaired or replaced when damaged.

Trapping Flies Indoors

Ultraviolet light traps (Figure 11-2) are preferred for indoor use and can be used in food preparation and storage areas. These traps sometimes combine the use of pheromones and ultraviolet light to attract flies. After flies are drawn to the light, they are caught in sticky pads or liquid traps. Fly zappers (traps that electrocute bugs) should not be used. Light traps will not work well in a room with many and/or large windows because the bright light coming in the windows is a much more powerful attractant than the comparatively weak light coming from the trap.

Contrary to the advice provided in some promotional literature for ultraviolet light traps, these traps should not be used outdoors. They are relatively non-selective in the insects they attract and will kill many more beneficial and innocuous insects than pests.

The following are key points to remember when using UV light traps for indoor flies.

- Use the number of traps recommended by the manufacturer, or, as a general rule, one trap for every 30 feet of wall.

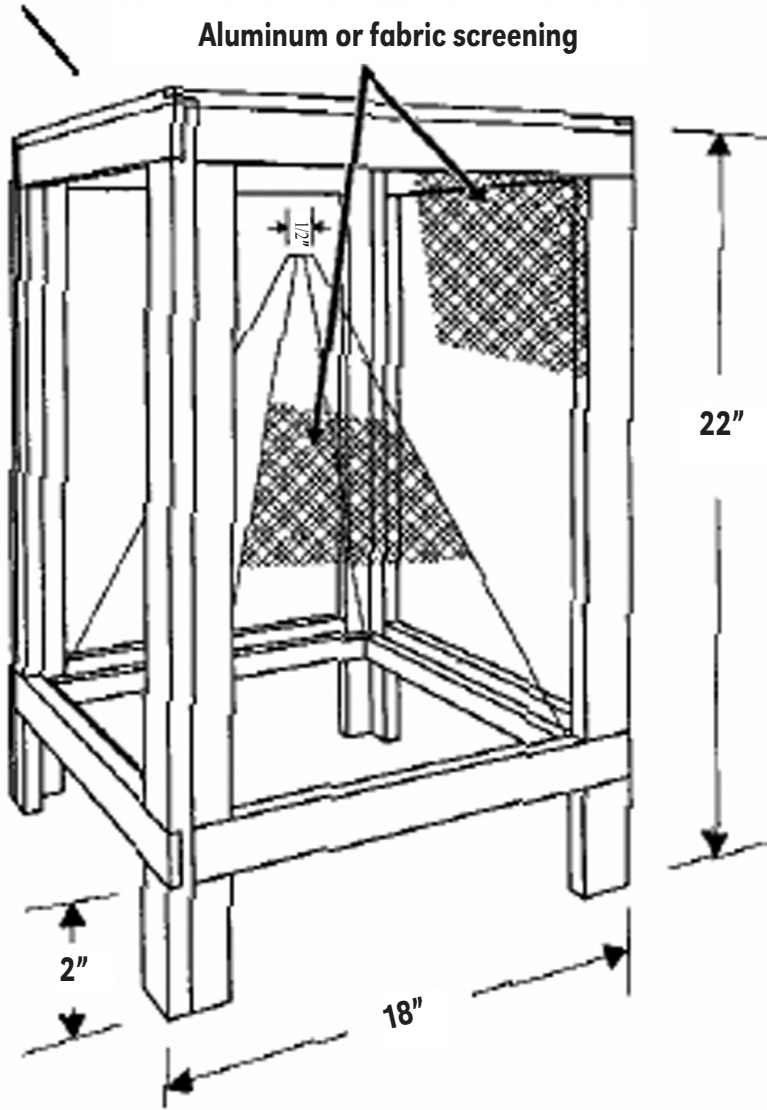


Photo: Erin Bauer

Figure 11-2. Light trap for flies

Figure 11-3. Cone Trap. Bait pan is placed beneath of the cone. Make sure the top edge of the bait pan is above the bottom edge of the trap.

Top is also made of screening. Top should be hinged (to empty the trap) and closed with a hook and eye. Weather-stripping or a strip of foam or cloth glued to all 4 sides of the underside of the lid will prevent flies from squeezing out.



cans, restrooms) since odors will be more attractive (especially from a distance) than the light.

Trapping Flies Outdoors

To capture flies outside, use traps with a screen cone suspended above the bait. These cone-type traps take advantage of the fly's habit of flying or walking toward light. Cone traps can be easily made from wood together with aluminum or plastic screening; use the dimensions in Figure 11-3. Flies are attracted to the bait in the pan under the trap. Once the flies are under the trap, the brightest spot they see is the hole in the cone above them. They walk up through the hole and are trapped in the outer screen cage. Since flies are attracted to the light and it is always lighter above them, they do not find their way back out through the hole in the cone.

The following are key points to remember when trapping flies outdoors.

Trap placement is important.

- If an area has a small or moderate fly problem, traps placed close to buildings can attract flies from all over the neighborhood and make the problem worse. It is better to set the traps close to fly breeding sites with any prevailing breeze blowing from the trap toward the breeding area.
- Since most bait odors are heavier than air, place traps so odors flow over the area where flies are developing.
- Do not set traps near doorways or entrances to buildings.
- Place traps away from outdoor areas that are used for eating or recreation.

- Mount traps 3 feet (no higher than 5 feet) from the floor on the perimeter walls of the room because hungry flies circle the perimeter of a room close to the floor when looking for food.
- Mount traps 5 feet away from any open food and 25 feet from any doors or windows. Traps work best in rooms without windows.

- Empty and clean the traps weekly to prevent dermestid beetles from developing in dead flies.
- Replace lamps at least once a year.
- Do not place traps where flies that are outside can see the light bulb. This may attract more flies.
- Place traps near odor sources (such as cooking areas, garbage

- Generally, traps are most effective when placed on the ground, but they can be hung over the openings of dumpsters and from buildings or fences as well. Traps hung in these areas must not interfere with the opening and closing of the dumpster and should be placed in areas where people will not tamper with them and will not be offended by the bait odors.
- Place traps in sunlight. Flies are more active in sunlight, both outside and inside the trap. Flies buzz more in the sunlight, and the noise coming from the trap will attract additional flies from a distance. Yellowjackets are also attracted to the buzzing and will enter the cone trap in search of food.

Empty the trap to maintain performance.

Empty the trap when dead flies cover about one quarter of the cone. Do not release live flies that are in the trap. Kill them by enclosing the trap in a plastic bag and placing it in the sun. After the flies are dead, the contents of the trap should be poured into the plastic bag, sealed, and discarded in a dumpster or garbage can.

Do not clean the trap between uses. The smell of the millions of fly specks deposited on the screen is very attractive to flies.

Bait is important to the performance of the trap.

- Liquid bait, either the Yeast Bait or the Beltsville Bait (see Box 11-A for recipes), is a superior attractant that will not breed flies unless it is allowed to dry to a sludge. If either of these baits contaminate clothing and hands, use baking soda and water to remove the odors.

- Yeast Bait has a foul odor that is particularly attractive to female flies because it smells like a good place to lay eggs. This bait will lure flies even from the most attractive breeding sites.
- Beltsville Bait will attract all flies because it contains sugar. This sweet bait can be used in cool weather when the main aim of trapping is to reduce the total number of flies rather than to suppress breeding.
- Baits such as decaying meat or fish scraps will attract mainly blow flies and flesh flies. These baits should always be put inside a rolled down plastic bag and then placed in the bait pan. Watch the bait so that it does not become a breeding site for flies. The larvae feeding on the bait can crawl out of the plastic bag and away from the trap to pupate. If larvae are found in the bait, the plastic bag should be sealed, thrown away, and replaced with a new bag and bait.
- Do not add poison to the bait. Flies are more attracted to the live flies in the trap than they are to dead ones.
- The top edge of the bait pan must be at least 1/2 inch above the bottom edge of the trap. If flies can sit on the top edge of the bait pan and look out under the trap, trap catches will be poor.

Prevent excessive amounts of water from getting into the trap.

If dead flies in the trap get wet and begin to rot, they will attract blow flies that will lay their eggs on the outside of the screen. When the tiny blow fly larvae hatch, they crawl through the screen to feast on the rotting mass of flies. This turns the trap into a messy breeding site for flies.

- Do not place traps where sprinklers will get them wet.
- In areas where there are frequent rainstorms during the trapping season, it may be necessary to fit the trap with a clear Plexiglas™ top.

Chemical Controls

Except for odor-eliminating chemicals such as borax, pesticides are not recommended for fly control.

Borates

Low concentrations of borax in water can be used to eliminate fly odors. This solution is particularly effective for removing fly specks from walls and eaves, and for rinsing out garbage cans and dumpsters. These solutions should not be used near ponds, streams, lakes, or other bodies of water and should not be poured onto plants.

Fruit Flies, Cluster Flies, and Phorid Flies

Identification and Biology

Fruit Flies

These small flies are commonly seen flying around ripe fruit, especially bananas. They are about 1/8 inch long and usually have red eyes. They lay their eggs near the surface of fermenting fruits and vegetables and other moist organic materials (including damp mops and cleaning rags as well as residues in bottles, cans, garbage disposals, and drains). Their life cycle, from egg through maggot and pupa to adult, takes little more than a week, and the number of flies that can be produced by a single piece of fruit is enormous. These flies are most often a problem in late summer and early fall so careful storage

Box 11-A. Fly Bait Recipes

Liquid Yeast Bait

This recipe makes 7-9 portions of liquid bait for use with a cone trap. It can be stored 20-30 days once it is ready for use.

Ingredients:

2 quarts tepid (not hot) water (95-105° F)
1 cup + 3 oz. active dry yeast (baking yeast)
2 tablespoons ammonium carbonate (optional*)

Mixing the bait:

Use a plastic (not glass) narrow-necked gallon jug with a screw cap for mixing, ripening, and storing bait. Bleach or milk jugs work well. Wide-mouth containers will not produce effective bait.

Mix all the above ingredients in the jug. Important: With cap lightly sealed, allow mixture to begin to ripen (see ripening instructions below). It will foam up at first. After it subsides (1-2 days), tighten the lid and continue ripening till very smelly (2-9 additional days). Gases must escape while bait is foaming up (loose cap), but bait must finish ripening without air (tight cap) to attract flies.

Ripening the bait:

Allow bait to ripen 4-10 days in a place where temperatures remain above 60° F during the night and day. Bait is ripe when it is very smelly, with a musky, penetrating odor. Warm daytime temperatures will make up for slightly cooler (less than 60°F) nights, but in general, the warmer the average temperature, the faster the bait will ripen. Because of its heavy odor, the bait should be ripened in a well-ventilated area where it will not offend people. Do not ripen or store the bait in direct sunlight. Extreme temperatures can build within the jug, kill the yeast, and cause gases to expand enough to pop off the lid or break the jug.

Storing the bait:

To maintain potency, store bait with the cap kept tight. Open the jug only when necessary to refill the bait pan. Do not store in direct sunlight.

*Ammonium carbonate is available from chemical supply houses and will improve the odor of the bait.

Note: Ripened bait should be treated as a decaying food material. It can cause gastro-intestinal disturbances if ingested.

Using the bait:

Stir or shake the bait supply each time before adding to the bait pan. Pour about 1 cup (8 ounces) of bait in a wide pan on a level surface under the trap. Be sure the edge of the pan is higher than the bottom edge of the trap frame.

The bait is effective in the pan for at least 3 to 5 days. It attracts more flies on the first day and then gradually declines thereafter. Don't let the bait dry out.

Beltsville Bait

This makes a dry bait that can be easily stored for a considerable time. It must be mixed with water before using.

Ingredients:

1 pound granulated sugar
1 pound baking powder (double-acting type)
2 ounces dry active yeast (baking yeast)
6 ounces air-dried blood or freeze-dried fish meal
1/4 cup honey
2 tablespoons* water

Procedure:

Mix ingredients thoroughly. Press mixture into a plastic ice-cube tray to form cubes. Invert the tray to dump the cubes, and let them dry to form hard blocks. To use the bait, add 2 cubes of bait to 2 quarts of water. Place bait in a wide-mouth pan beneath a cone-type trap. Flies are attracted to this bait from only a short distance so traps should be placed within 6 feet of areas where flies are active. Bait pans should be cleaned and baited every 1 to 2 weeks and should be kept filled with water.

*Quantity of water needed may vary with humidity of air when mixing. Use only sufficient water to bind dry ingredients together when they are compressed.

of fruit and vegetables is necessary at these times of the year.

Cluster Flies

Cluster flies are larger and darker than house flies and have a distinctive yellowish color caused by the crinkled yellow hairs on their bodies. In the summer, cluster flies lay their eggs in soil where the maggots parasitize earthworms. Soil containing many earthworms — for example, large lawn areas or in nearby parks — is a common source of these flies. In the fall, the adults can be seen clustering on the south and west sides of buildings. As the weather gets cooler, these flies begin looking for sheltered places to spend the winter and often enter buildings.

Phorid Flies

The most common phorid fly, *Megaselia scalaris*, is small (1/16 to 1/8 inch) with a yellowish-brown body and light brown wings. The adults seem reluctant to fly, and they run around on walls, windows, and tables with a characteristic quick, jerky motion. The females are strongly attracted to odors and lay their eggs on or next to decaying material, both plant and animal. Food sources for the larvae are highly varied, from decomposing fruit, vegetables, and meat to open wounds in animals and people, and human and animal feces. Infestations may be associated with leaks from toilets or garbage disposals. The life cycle from egg to adult takes from 14 to 37 days.

Management Options

Fruit Flies

Fruit flies are most active from late summer through early fall. Problems with these flies can be avoided by

ripening fruit in paper bags. Seal the bags by folding the top over several times and closing it with a paper clip or clothes pin. Once fruit is ripe, it should be stored in the refrigerator. Because fruit flies will also breed in rotting potatoes and onions, check your pantry for these vegetables.

If an infestation is discovered, look for and remove the material that is breeding the flies. Begin by searching for the obvious sources, such as ripe fruit and vegetables, and then look at water from refrigerators, humidifiers, or sink drains that may be fermenting; spoiled animal food; or even

damp, sour mops or rags. Areas outside the building near windows and doors should be checked for rotting vegetable matter. All breeding sources should be removed and disposed of in a sealed plastic bag. Make sure that screens and windows near food preparation areas are in good repair.

A simple trap can be made to help reduce fruit fly numbers (Box 11-B.)

Cluster Flies

Cluster flies are not as strong fliers as house flies and can easily be killed with a fly swatter or removed

Box 11-B. Fruit Fly Trap

To make a simple trap for fruit flies, combine 1/3 cup warm water, 1 package active dry yeast and one teaspoon sugar in a 1-pint jar. Swirl the mixture to dissolve the yeast and sugar. This mixture will begin to froth as the yeast becomes activated. Make a plastic funnel with a sandwich baggie or food storage bag and snip a small hole in the point of the bag to allow flies to enter the trap. Place the funnel at the top of the jar with the funnel pointing into the jar. Secure the funnel with a jar ring or heavy duty rubber bands. Place the bottle on a countertop. This trap will attract fruit flies for 4-5 days. After that, its contents should be dumped down the drain and flushed well with water. If you neglect to do this, after about 10 days, the trap may begin producing its own flies. This trap will only work with fruit flies.



Photo: Barbara Ogg

with a vacuum. Cluster flies can also be allowed to exit by opening the window. They can find their way into buildings through unscreened doors and windows, openings under siding and around roofs, unscreened ventilating spaces, cracks around windows, and holes where wires penetrate the walls of the building. During warm winter periods, cluster flies hidden in buildings become active and are attracted to windows. Sealing cracks is the best method of prevention.

Phorid Flies

Phorid flies breed in diverse sources of organic matter so it may take considerable sleuthing to find their breeding sites. Large infestations of these flies are often the result of broken drains or garbage disposals that allow organic matter to accumulate in out of the way places such as wall voids, under floors, in basements, or in the soil of crawl spaces.

Fiber optic devices to check pipes for leaks may be extremely helpful in diagnosing phorid fly infestations associated with leaky pipes. If the infestation is associated with a leaky pipe or broken floor drain, the plumbing must be fixed and the wet area dried to prevent further breeding.

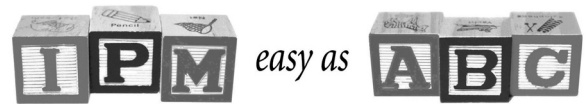
Resources

For management practices and pesticide recommendations on fly control, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Educational resource guides on flies are available at <http://lancaster.unl.edu/pest/flies.shtml>.

Chapter 12

IPM for Head Lice



Introduction

Today, the management of head lice continues to be a major task for parents, child care and school personnel, and health care professionals worldwide. The growing resistance of lice to pediculicides (lice-killing insecticides), combined with a surprising willingness of many parents to tolerate head lice, is turning a manageable problem into a major nuisance.

Head lice are most often found on school children between the ages of three and ten, less often on older children or adults. The eggs, or nits, of head lice are glued tightly to hairs, most often around the back of the ears and at the nape of the neck. The adults are found in these and other areas of the head, including the eyelashes, and more rarely on other body hairs.

Since there is increased resistance to some of the most common over-the-counter (OTC) insecticidal products, sole reliance on a chemical approach is often not effective and not recommended. Sound management of head lice involves prompt diagnosis and the use of non-chemical physical treatments (i.e., combing with a nit comb). Insecticidal treatments may be used, but combing is still the key to successful treatment of head lice.

Identification and Biology

The head louse, *Pediculus humanus capitis*, (Figure 12-1) is dependent on



Photo: UNL Extension in Lancaster County

Figure 12-1. Head Louse

human blood for survival and spends its entire life on the human head. If it is accidentally displaced onto other surfaces, it must return to the head within a few hours to survive. At room temperature, lice survive less than 24 hours without blood, and they cannot complete their life cycle on pets.

Head lice can move fairly rapidly but cannot jump or fly. The adult head louse is 1/16 inch to 1/8 inch long, and ranges from tan to grayish-white in color. Insecticide resistant lice may be darker in color. Each of its six legs ends in a claw that is used to grasp the hair shaft. The nits are laid about 1/4-inch from the scalp. The eggs are oval-shaped and are glued to the hair shaft. The glue is so strong the egg cannot be easily dislodged, even after it has hatched. Each female produces about 6 to 8 eggs in a 24-hour period, and these are laid mostly at night.

The eggs hatch within 7 to 11 days. Once hatched, developing lice take 8 or 9 days to become adults; after an additional day, the adult female can start laying eggs. Only about 16 days are required for an egg to give rise to a female capable of laying more eggs. Adults live for up to 30 days.

Transmission of Head Lice

Experts believe most head lice are transmitted when an infested person comes into close contact with a non-infested person. For example, when children or family members sleep or sit closely together, lice may transfer from one person to another. Older literature says lice can also be transferred via infested brushes, combs, caps, hats, scarves, coats, and bedding, but studies have not been able to find significant numbers of lice on intermediate objects, so experts believe head-to-head contact is the most frequent way lice are transmitted. Parents or health care workers who understand this can focus their energies on removal of lice from the infested person's head and not spend excessive amounts of time vacuuming and laundering.

Damage

Although the symptoms of head lice are irritating, medical personnel have generally considered head lice to be little more than a nuisance. While a

louse bite itself is painless, the louse's saliva usually causes an allergic reaction that produces itching (although some people may not experience the itching for several weeks). If itching is severe, the lice probably have been present for some weeks. Scratching scabs create entryways for germs and lice feces and can lead to swollen glands and secondary infections such as impetigo. Severely infested individuals may experience fever and feel tired and irritable.

Detection and Monitoring

Frequent head scratching may be the first sign of lice. Under close examination, parents will see lice close to the scalp or in the eyebrows and eyelashes, and with careful observation, the eggs can be seen. A magnifying glass will help in distinguishing between nits and dandruff. Eggs are oval-shaped and attached only to one side of the hair shaft. The eggs themselves stay glued to the hair even after they hatch and cannot be removed as easily as a piece of dandruff or other debris. Since eggs stay attached to the hair, it is also important to determine whether or not the egg has hatched. Nits start out as a yellowish to gray color and darken to a tan or coffee color before they hatch. Hatched eggs are white. Eggs that are shrunken or indented will not hatch.

Management Options

Lice can be controlled without resorting to insecticidal treatments with the use of a nit comb (Figure 12-2) to remove lice and eggs. Because lice are resistant to OTC (over-the-counter) products, combing of the hair must be used to eliminate the lice infestation even if these products are used.

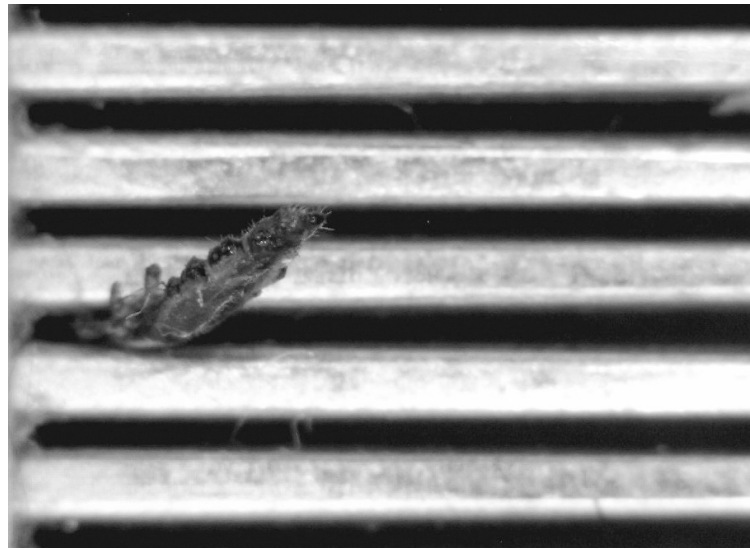


Photo: UNL Extension in Lancaster County

Figure 12-2. Head louse caught in a comb

There are two reasons for children to become reinfested. The first, and most likely scenario, is because the lice were not successfully eliminated after initial treatments. The first stage lice are extremely small and hard to see. An electronic comb, used on dry hair, can be helpful in detecting live lice to double-check the effectiveness of treatments and combing. Even the smallest lice will get caught in the tines of the electronic comb. The second scenario is when infested playmates or other family members continue to transfer lice to the child. When children continue to have lice, parents may wrongly assume that the first treatment wasn't strong enough and turn to something more toxic, not realizing combing is an effective non-chemical approach.

Education

Most people view lice with disgust. Panicked parents who would not normally expose their children to potentially hazardous materials may apply pesticides in haste, sometimes well beyond the recommended frequency and dosages. Education can help to overcome these obstacles to non-toxic lice control.

It is crucial that child care directors, school administrators, nurses, teachers, children, and parents have some rudimentary information about head lice before an outbreak occurs. A school or child care center can send an information sheet home with children when school begins in the fall and after long vacations. The sheet can include some facts about lice and information on how to detect them. See the "Head Lice Information Packet" section in this chapter for a sample. Encourage parents to look for head lice weekly as just another part of personal hygiene. Have teachers in the lower grades or child care centers talk to students about head lice at the beginning of the school year. Young children generally are not hesitant to talk about head lice—for them, it's just another learning experience. Remind them repeatedly not to share combs, brushes, caps, hats, scarves, head pieces from costumes, etc.

When an outbreak occurs, the child care center or school can send home a packet that includes information on how to control lice and a note alerting parents that children will not be allowed back into school until their hair is free of nits — the "No Nit"

policy. It is our experience that sometimes only a small group of families is responsible for the frequent reinfestation of an entire class. It is important to understand that there are some parents who do not regard head lice as a serious problem at all. Many cultures outside the United States accept head lice as a minor, constant inconvenience and do not assume that head lice can be eliminated when infestations occur. Families with this attitude may need to be convinced of the importance of cooperation.

“No Nit” Policy

The National Pediculosis Association (P.O. Box 610189, Newton, MA 02161; 617/449-NITS), a nonprofit organization that provides education on safe ways to manage head lice, recommends that schools establish a “No Nit” policy, which means that children are denied re-admission to the classroom until their heads are free of lice eggs. This recommendation is based on the fact that most parents and teachers cannot easily tell the difference between an egg that is viable and one already hatched. By tolerating nits, children are allowed to return to school and unwittingly spread head lice to others.

When a “No Nit” policy is adopted, each principal or child care director should designate at least one member of the staff to receive training from the school nurse or other public health official in the detection of lice and nits.

Store Garments Separately

Transmission can be reduced through proper storage of hats and other garments that may carry stray female lice. Head lice are a particular problem among children in child care programs, kindergarten, and the early

grades of grammar school. Facilities should be equipped with separate lockers or “cubbies” for each child. Headgear, scarves, and other outer clothing that comes into contact with the hair should be stored separately, one cubbyhole for each child. It is crucial that the parent or teacher explain the importance of this behavior clearly. If separate lockers or cubbies are impossible, cloth bags that close at the top with a drawstring are another alternative. At the very least, children should be assigned a hook on the wall to use throughout the year. There is evidence that assigned hooks can reduce the spread of lice through a classroom.

If, during head lice outbreaks, cubbies or lockers are unavailable, sturdy plastic bags can be used. Place identifying decals on individual bags so children know which is theirs. Bags containing clothing should be doubled over and wrapped with a twist tie. This process should be supervised to make sure the children are doing it properly. Torn bags should be replaced immediately.

Housekeeping

The rugs and upholstered furniture in classrooms with lice outbreaks should be thoroughly vacuumed. If lost and found articles are stored in the classroom, they can be separated by placing them in individual plastic bags and then sealed.

Treatments

This must be left to the parents, but the school or child care facility can provide them with accurate information on how to comb for lice and nits, and on the proper use of insecticidal shampoos. The Sample Information Packet later in this chapter provides this information.

Physical Controls

It is possible to eliminate a lice problem using the following physical controls without resorting to more toxic chemicals. Success depends on several factors, including the determination of parents, existence of good relations between the parent and child, and the length and texture of the child’s hair.

Combing

Combing is the most important aspect of head lice control. Combing removes nits from the hair and helps to find adult lice. Unfortunately, there is no safe solvent for the powerful glue that holds the nits to the hair. The “How to Comb For Head Lice” section of this chapter provides detailed instructions on combing that should be followed carefully, using a comb with specially tooled metal teeth designed to remove head lice and their eggs from the hair. Metal lice combs are available from pharmacists. Fine-toothed plastic combs may be too flexible to be effective, even though they may be sold along with various insecticides for the control of head lice.

There is no denying that the combing process demands time and patience from parents and children; however, many parents tell us that their children grow to enjoy the process and even look forward to it because it feels good, and the child is the center of the parent’s attention.

If there is a lice outbreak at school or child care, parent should check their child’s hair every day or two. An electronic comb is ideal for lice detection. If the child is reinfested, the combing must to be done and repeated as needed to remove lice and nits.

Salad Oil or Hair Conditioner

The use of salad oil is sometimes recommended to smother lice, but studies have shown that lice can survive in hair covered with oil even when it is left on overnight. Do not count on oil to kill adults or nits. Oil can be very useful in combing, however. Oil or conditioner prevents the hair from tangling and makes combing much easier. Washing the hair twice with any ordinary shampoo will remove all traces of the oil.

Washing Clothing and Bedding

Since lice may wander from the head to the pillow or to headwear, washing these items at the time the child is first diagnosed and treated is a good idea. Putting clothing or bedding through a wash cycle with hot water and ordinary detergent in a washing machine and then drying in a hot dryer is sufficient. Anything that cannot be washed can be stored in large, sealed plastic bags for 2 weeks.

Vacuuming

Clothing can also be vacuumed to remove stray nits and wandering lice. Upholstered furniture and rugs can be vacuumed, too, but, in general, head lice do not leave the head, and there is no need to go into a frenzy of laundering and cleaning. The time and energy spent in washing clothes and cleaning the home environment would be far better spent combing out lice and nits.

Chemical Controls

Ordinary shampoo

Certain fatty acids in soaps have insecticidal properties, but shampoos are detergents, and you cannot count on shampoo to kill young or adult lice. Although it might seem possible

to drown lice while shampooing the hair, adult lice can survive through two consecutive shampooings even when the hair is not rinsed for an hour after the second shampooing.

Shampoos with Pediculicides

We do not recommend the use of insecticides except in extreme cases. The scalp has many blood vessels that are close to the skin, making it easy for toxic substances to be absorbed directly into the bloodstream. Absorption is greater when the skin is warm, and the blood vessels are dilated.

For many years, lindane (commonly referred to as Kwell®), an organophosphate insecticide, was the treatment of choice; it is still recommended by medical personnel who have not taken the time to acquaint themselves with its potential health hazards to humans. Lindane is absorbed through the skin into the bloodstream; once absorbed, it can be carried throughout the body to tissues and organs. In pregnant women, it can travel across the placenta to the developing fetus. Lindane is available only by prescription. We do not recommend its use at any time. The chronic overuse of lindane has resulted in lice resistant to Kwell so it is not only hazardous but also somewhat ineffective.

The over-the-counter insecticides include pyrethrum, pyrethrins, and permethrin. A few years ago, scientists reported that lice in the US have developed resistance to these most readily available products. This is another reason to use combing as the primary control method.

Ovide® is a product that has been available in the U.S. for several years. The active ingredient in this

lotion is 0.5 percent malathion, an organophosphate insecticide. This product is available in the US only by prescription. Head lice resistance to malathion was reported several years ago in Britain where this product has been used for a number of years, but this product may be more effective against lice until it has been used extensively over a number of years. Problems with this product include an unpleasant odor and its flammability (the carrier is isopropyl alcohol). Another big problem is that the label mandates that the child's hair must be allowed to air dry for 8-12 hours before shampooing.

Insecticidal products must be used in accordance with their EPA-approved label directions. Never re-treat with the chemical more frequently than the label allows. The following cautions should be added to those already on the label:

- Never treat pregnant or nursing women, infants, or children under two with pediculicides.
- Minimize body exposure. Confine the exposed area to the head hair. Do not treat the eyebrows or get the pediculicide near the eyes. Do not use in the bathtub or shower stall; use a basin or sink so pesticide residues do not reach other parts of the body. Wear rubber gloves to protect yourself if you shampoo yourself or someone else.
- Minimize frequency of use. Frequent, repeated use of pediculicides, especially lindane, is dangerous. Never use insecticides at higher doses or at a greater frequency than listed on the label. If insecticides are not working, it can mean either product failure or lice resistance. Return to combing.

- Never treat anyone with open cuts, scratches, or head or neck inflammations. Check for cuts, scratches, or inflammation before treatment; do not use insecticides if such conditions are found.
- Store insecticides out of reach of young children, ideally in a locked cabinet. Treat insecticides as you would any other poison.
- Do not use any head lice insecticide preventively. Before any head lice treatment is used, make sure live head lice or viable eggs are present. Studies have shown that even health professionals often misdiagnose head lice cases. Since the first stage lice and nits are so small, lice and nits can easily be missed by inspections. In addition, children are sometimes identified as being infested when lice or nits are not present. Nits can be confused with dried hair gel, dandruff, hair casts and dust particles. Remember, viable nits are gray when laid and turn coffee colored before they hatch. A white nit is usually dead. A magnifying glass may be helpful. An electronic comb, the Robi Comb®, may be useful in monitoring. It detects live lice but will not detect nits.

Lice Sprays

Never, under any circumstances, should lice sprays be used. Lice cannot live in the environment, and lice sprays unnecessarily expose everyone to harmful pesticides. Use a vacuum cleaner if you are concerned about lice on furniture or on floors.

Resources

For management practices and pesticide recommendations on head lice control, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Educational resource guides, *Quick Guide to Removing Head Lice Safely* and video, *Removing Head Lice Safely* are available in English, Spanish, Arabic and Russian; and a head lice picture gallery are available at: <http://lancaster.unl.edu/pest/lice/>.

Head Lice Information Packet for Schools and Child Care Centers

This Sample Information Packet contains the following:

1. Facts about Head Lice
2. Recommendations for How to Treat Head Lice
3. How to Comb for Head Lice
4. Sample Letter from School or Child Care to Parents

These materials may be reproduced by any school or child care center in part or as a whole and may be modified to suit particular situations.

Facts about Head Lice (Pediculosis)

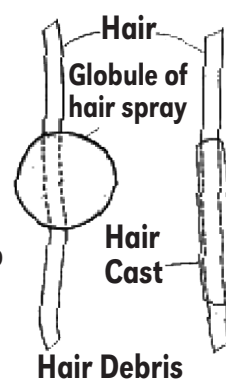
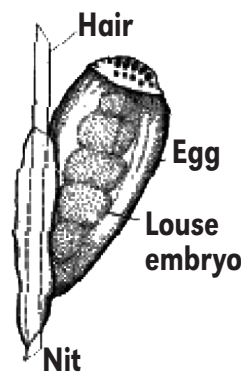
People have many false ideas about head lice.

1. Head lice are not a reason for panic or extreme measures.
2. Head lice are not a sign of uncleanliness.
3. Head lice do not favor any particular socio-economic level —they attack rich and poor alike.
4. Head lice are not something to be ashamed of.
5. Head lice do not carry serious diseases.
6. Head lice cannot jump or fly.
7. Head lice cannot live on pets.

Head lice infest the hair, suck blood from the scalp, lay their eggs (commonly known as nits) on the hair shafts, and cause itching and some additional discomfort when present in large numbers.

Lice are usually transmitted from one person to another by head-to-head contact. It is possible, but less likely, that they may also be transmitted by sharing personal items like combs, hair brushes, hats, or other articles of clothing on which infested strands of hair or adult lice are present.

Below are drawings of an adult louse (1/8" long, yellowish-grey), a nit (1/3" long), and hair debris that can be mistaken for nits. The eggs are white when they are first laid and darken to a coffee color before they hatch.



Notice that nits are always oval-shaped and attached to only one side of the hair shaft, usually close to the scalp.

They are attached with very strong glue and cannot be as easily removed as dandruff and other hair debris. There is no safe solvent for this glue.

The female lays 6-8 eggs/day. It takes 7 to 11 days for the eggs to hatch and another two weeks to develop into reproducing adults. Adults live for up to 30 days and spend their entire life on the human head. If they do move to other surfaces, they must return to the head within a few hours to survive.

In order to prevent multiplication and spread, the adults and the nits must be killed.

We encourage you to add a quick, weekly inspection for head lice to your regular personal hygiene routine for children between the ages of 6 and 10 (younger if the child is attending pre-school or a child care center). If lice are reported at a school or child care center, increase lice inspections to once every two or three days. A magnifying glass can help you to see the nits. An electronic comb, the Robi Comb®, can be helpful to monitor children. This comb detects live lice, even very tiny ones. It will not detect nits.

Recommendations for Treating Head Lice

In order to bring the current head lice problem under control, the following procedures are recommended:

1. Inspect your child's head. If you find lice or eggs (commonly called nits), continue reading. If you find no lice or nits, you don't need to do anything; however, continue to check your child's head weekly and more often if friends or school mates have lice.
 - (a) Separate the hair with a rat-tailed comb.
 - (b) Check all areas of your child's scalp, especially at the back of the neck and behind the ears — these seem to be the favorite spots for lice.
 - (c) Adult lice are found close to the scalp. Nits are attached to the hair 1/2 to 1 inch away from the scalp. Nits may be found farther out on the hair strands in long-standing cases. There may be anywhere from a few to several hundred nits in a child's hair.
2. If you find lice or nits, coat the hair with salad oil and comb out the lice and nits with a special metal lice comb. You can buy these combs in a pharmacy. Do not use the plastic combs provided with some pesticidal shampoos; they can allow nits and lice to slip through unnoticed (if you cannot find a metal lice comb, ask your pharmacist to order one).

Refer to the section entitled "How to Comb for Head Lice" for combing instructions.

You can get rid of lice just by combing. It is not necessary to use pesticidal products. In fact, these shampoos are recommended only as a last resort in extreme cases. And, because head lice are resistant to most over-the-counter products, these readily available products, used alone, will probably not solve a head lice problem.

- Do not use shampoos with pesticides on infants or children under 2 years, or on pregnant or nursing women.
- Do not use these shampoos on anyone with open cuts, scratches, or head or neck inflammations.
- Do not use in the shower or bath; use over a basin or sink. Expose only the scalp to the pesticide.
- Never use lice shampoos to prevent lice infestations. Check the child's head first. If there are no lice, don't treat.
- Do not use extra shampoo or leave the shampoo on the hair for longer than the directions specify, and do not use on the eyebrows or allow any shampoo to get into the eyes.
- Store these products out of the reach of children, ideally in a locked cabinet.

3. Comb, Comb, Comb! *This is the only way to remove the nits.* Repeat the combing every week until you find no more lice or nits. Be forewarned that if the child has very long or very curly hair this process will be time consuming. You may want to consider cutting the hair.
4. Examine all members in the household. If lice are found, treat other members of the family.
5. Do not use the lice spray included in some of the lice shampoos. Lice cannot live very long, (probably less than 24 hours) in the environment and sprays unnecessarily expose everyone to pesticides.
6. Wash bed linens and recently worn clothes in hot, soapy water in a washing machine and dry in a hot dryer. This does not have to be repeated daily. The washing is only necessary when you treat the child or when he/she is re-infested. Articles that cannot be washed can be vacuumed or placed in a plastic bag and sealed for 2 weeks. This will kill all lice and nits.
7. Clean combs and brushes by soaking them in 1 teaspoon of ammonia and 2 cups of hot water or heating them in a pan of hot water for 5-10 minutes.
8. If your time is limited, it is much more important to comb the child's hair than to spend time washing clothes and linens and vacuuming your house.
9. Check hair the morning following treatment to be sure it is nit-free before allowing your child to return to school.
10. Until the lice epidemic has passed, school personnel will be examining children's heads frequently. Any child with nits or lice will not be allowed to attend school.
11. If your child is re-infested, comb the hair again with the lice comb rather than applying pesticidal shampoo. Use these products only as a last resort.
12. Instruct children and adults not to share combs, brushes, hats, and other articles of clothing that might be contaminated with strands of hair.

REMEMBER:

It takes time to comb all the nits out of the hair, BUT this must be done, and done frequently, until the hair is free of evidence of lice and nits.

- Combing is an inconvenience, but remains a parental responsibility and only total parent cooperation and follow-through will stop the spread of lice.
- You will probably find that your child actually enjoys the combing.

How to Comb for Head Lice

NOTE: We do not recommend shampooing with a lice shampoo that contains a pesticide except in extreme cases and as a last resort.

A. You will need:

- Salad oil.
- A special metal lice comb. These are available in drugstores (ask your pharmacist to order one if you cannot find a metal comb). Do not use the plastic combs that are included in some lice treatment packages. These are not effective.
- A wide bowl of water with a squirt of dishwashing detergent added. This water is used to kill nits (eggs) and lice combed from the head.
- A box of facial tissue.
- A strong lamp with a flexible arm that allows you to rotate it to direct the light wherever you are working. (If it is possible to do the combing in the daylight near a window, it will be much easier to see the adult lice and the nits.)
- If the hair is long, many large bobby pins or hair clips, to pin up sections of hair that have been combed.
- A large towel to place around the child's shoulders during combing.
- Two comfortable seats, one for the child and one for you. You want the child to be just below your eye level.
- Something entertaining for the child to do that does not require much physical activity, such as reading, drawing, playing with plastic clay, or watching videos.
- If the child has very long hair, which takes more time and tries the patience of the child, two people can work together on different parts of the head.

B. Preparing the Hair

Cover the child's hair with salad oil (any kind will do). This will prevent the hair from tangling and make it very easy to use the lice comb. (The oil may also smother some of the young and adult lice, but you cannot count on it.) Oil has the advantage of not drying out if the combing takes a long time. To remove oil after you finish combing, shampoo the hair twice.

C. The Combing

1. Seat the child so that his or her head is just slightly below your eye level.
2. Brush or comb the hair (use a large-toothed regular comb) to remove snarls.
3. Separate a mass of hair that is slightly wider than the width of your lice comb and about 1/2 to 3/4 inch in the other direction. Separating the hair into such small sections is important so that you can more easily see nits and adult lice.
4. Hold the mass of hair with one hand. With the other hand, hold the lice comb in a slanting position with the curved side of the teeth toward the head.
5. Insert the comb into the hair as close to the scalp as possible, since the eggs are first laid within 1/2 inch of the scalp. Pull the comb slowly through the hair several times.

6. Comb one section at a time and check each section to make sure it is clean, then pin it out of the way, curling it flat against the head.
7. Whenever you comb out nits or live lice, dunk the comb in the soapy water. Make sure the lice and nits are off the comb before you use it on the hair again. Frequently remove the hair and other debris from the comb with a tissue. When the tissue becomes soiled, place it in the bowl of soapy water. When the bowl is full, flush its contents down the toilet and refill the bowl with soapy water.
8. When all the hair has been combed, wash out the oil by shampooing twice.
9. Once the hair is completely dry, check the entire head for stray nits and remove those hairs individually with a pair of small, pointed scissors (like nail scissors).

D. Cleaning up

1. Soak the lice comb in hot ammonia water (1 teaspoon of ammonia in two cups of hot water) for 15 minutes. Metal combs can also be boiled in plain water for 15 minutes. A comb can be cleaned either way
2. Scrub the teeth of the comb with a nail brush or an old toothbrush to remove debris. Remove dirt lodged between the teeth of the comb with dental floss or a small stiff brush.
3. Wash towels in a washing machine in hot, soapy water, followed by drying in a hot dryer.

Note: There is no safe solvent for the glue that the female louse uses to attach her eggs to the hair even though there are products that make such claims.

Combing is the only sure way to remove nits from hair.

WARNING: *If you must use a shampoo with a pesticide,*

- **Do not** leave the shampoo on any longer than the time specified, and do not use it more frequently than indicated on the label. Follow the directions exactly.
- **Do not** use on the eyebrows or allow any shampoo to get into the eyes.
- **Do not** use on pregnant women or nursing mothers.
- **Do not** use on children under 2 years.
- **Do not use** on anyone with open cuts or scratches or with head or neck inflammations.
- **Use gloves** to do the shampooing.
- **Do not** count on lice shampoos to kill nits. You must comb to get them out.
- **Never use** any head lice shampoos preventively. Before you treat, make sure that live lice or eggs are present.
- **Return to** combing if the lice shampoo is not working; it may mean product failure or that the lice have become resistant to the pesticide.
- **Store these shampoos** out of the reach of children, ideally in a locked cabinet.

Letter From School or Child Care Center To Parents

Dear Parents,

There have been a few cases of head lice detected in your child's class. Attached is information on head lice and their treatment. Your child will not be allowed to return to school/child care unless his/her head is free of nits (lice eggs).

Sincerely yours,

School Principal or Child Care Director



Introduction

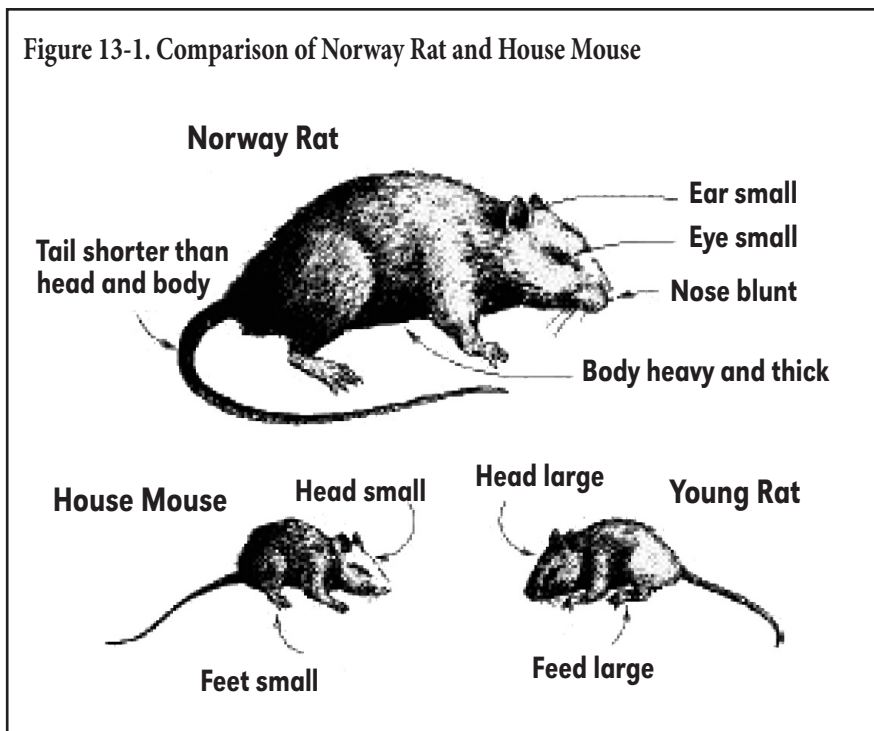
Although toxic baits are widely used to control rodents, their use can result in several problems. First, use of toxic baits creates the possibility that children or pet animals will inadvertently come in contact with the bait. Second, poisoned rodents frequently die in inaccessible places where their decomposing bodies create unpleasant odors and feed pest insects such as flesh flies and carpet beetles. Finally, inappropriate use of rodenticides raises the risk of rodents developing resistance and/or avoidance behaviors to toxic baits.

A better approach to effective rodent control combines careful inspection, regular monitoring, sanitation, garbage management, rodent-proofing, trapping, and, if necessary, baiting with toxicants. Unless the conditions that encouraged rodent presence are removed, new mice and rats will reoccupy the area vacated by the dead ones, and thereby continue the pest cycle.

Identification and Biology

Effective control of rodents requires knowledge of their biology, physical characteristics and abilities, and signs of their activities. Several tables and figures follow to provide you with a quick way to distinguish between the Norway rat (*Rattus norvegicus*) and the house mouse (*Mus musculus*) (Figure 13-1, Figure 13-2, Figure 13-3

Figure 13-1. Comparison of Norway Rat and House Mouse



and Table 13-1) and several species of native mice (Table 13-2).

Rats

We have included identification information on roof rats because their range is expanding. However, our discussion on the control of rats will focus on the Norway rat as it has the largest geographical distribution and

with some modifications, control of Norway rats would be very similar to the control of roof rats.

The Norway rat (*Rattus norvegicus*), also known as the brown, wharf, house, gray, or sewer rat, was brought to North America from Europe in the 1700s and today resides throughout the United States. Norway rats have a stocky build, with a blunt nose,

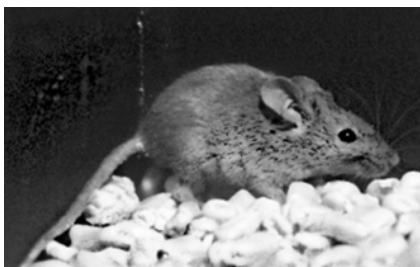


Figure 13-2. House Mouse



Figure 13-3. Norway Rat

Table 13-1. Differences Between the Roof Rat, Norway Rat, and House Mouse

	Roof Rat	Norway Rat	House Mouse
Scientific name	<i>Rattus rattus</i>	<i>Rattus norvegicus</i>	<i>Mus musculus</i>
Adult weight	6 to 12 ounces	3 to 16 ounces	1/2 ounce
Snout	pointed	blunt	pointed
Ears	Large enough to cover eyes	small and thick with short hairs	large, some hair
Tail coloration	uniform color	dark above, pale underneath	all dark
Fur	variable; black to brownish-gray	brown with black; shaggy	gray to light brown
Droppings	Capsule-shaped, pointed, 1/2-inch	capsule-shaped, pointed, 3/4-inch	1/4-inch rod-shaped, pointed
Food requirement	1/2 to 1 ounce/day	about 1 ounce/day	about 1/10 ounce/day
Water source	free water*	free water*	water from food; also need free water if diet is dry or high in protein
Climbing ability	excellent climber	can climb	good climber
Nest locations	mainly in elevated locations (e.g. trees, roofs,	mainly in burrows	walls, attics, basements near/in stored material
Swimming ability	Able but avoids water	excellent	can swim

*Water present by itself and not simply a constituent of the food eaten by the rodent. Free water is unnecessary when feeding on succulent foods but needed if diet is dry and/or high in protein.

Table 13-2. Distinguishing the House Mouse from Other Similar Species. Common Name Scientific Name Description

House Mouse	<i>Mus musculus</i>	small feet and head in proportion to body; long ears for body size; relatively small eyes; tail nearly hairless and equal or longer than the head and body combined; tail is uniformly dark
Deer Mouse or White-footed Mouse	<i>Peromyscus</i> spp.	same size or slightly larger than house mouse; distinctive bicolor coat, pale gray to reddish brown above white belly; tail brown or gray on top and white underneath; large eyes; invades buildings near fields or wooded areas
Vole or Meadow Mouse	<i>Microtus</i> spp.	large, robust body; weighs about twice as much as the house mouse; smaller, heavily furred ears; short tail; sometimes invades buildings, but commonly found outdoors under boards, boxes, etc.

Table 13-3. Reproductive Ability of Norway Rats

Breeding (estrous) cycle	polyestrous, every 4-5 days; in subtropical climates, rats can reproduce year around; in cooler climates, populations peak in spring & autumn
Litter size	average of 5 to 12
Litters per year	up to 9, depending on food availability (average - 4)
Age at weaning	around 30 days
Gestation period	20 to 25 day
Sexual Maturity	75-90 days
Life span in the wild	less than 1 year

hairless tail, and small ears. They weigh less than 16 ounces at maturity. They are prolific breeders (Table 13-3) and therefore, control must be aggressive or the remaining rats will simply repopulate.

Rats utilize a variety of nesting sites. Outdoor nests are typically ground burrows that are less than 18 inches deep and less than 3 feet long, but some can be quite complex. Burrow openings range from 2 to 4 inches in diameter and have smooth or worn openings when actively used. Rats also can take up residence in sewers and storm drains. Indoor nesting sites (usually in the lower floors of the building) are often found in wall voids and crawl spaces that have plenty of clutter and low human traffic.

Rats have diverse diets and research has shown their nutritional needs mirror those of humans except that rats only need 110 calories a day. They enjoy foods high in protein, such as fish, meat, nuts, grains, pet food, and insects. Rats do require free-standing water unless their diet is unusually succulent, such as ripe fruit. Rats usually search for food between dusk and dawn but when hungry or living under crowded

conditions may be seen in the daylight. They have been known to travel several hundred feet from their nests in search of food.

Rats have amazing sensory abilities. They have acute sense of taste, smell, and hearing. Interestingly, human odors do not frighten them. Their eye sight is poor but is able to see contrasts, patterns, and movement.

Norway rats also have exceptional physical prowess, including the ability to:

- pass through any opening as small as 3/4-inch in diameter
- walk along horizontal wires and climb vertical wires
- climb inside vertical pipes from 1 1/2 to 4 inches in diameter
- climb outside of vertical pipes that are up to 3 inches in diameter
- climb the outside of vertical pipes and conduits of any size if within 3 inches of a wall
- crawl horizontally on any type of pipe or conduit
- jump vertically (from a standstill) at least 24 inches above a flat surface and at least 4 feet horizontally

- reach about 13 inches above a flat surface
- fall more than 50 feet and survive
- dive and swim underwater for as long as 30 seconds and tread water for up to 3 days
- swim up through the water seal, or trap, of toilets
- swim as far as 1/2-mile in open water
- gnaw and leave marks on almost anything, including wood, chip board, lead pipes, cinder blocks, asbestos, aluminum, sheet metal, sun-dried adobe, and an exposed edge of a piece of glass.

Their secretive behavior also allows them to establish a residence in and around human dwellings. Often rats are only discovered when their numbers reach a level to leave significant signs. Given their reproductive capacity (Table 13-3), rats only need a few months to achieve abundant numbers.

Behaviors of rats that have impact on management:

- require access to free water or succulent foods like fruit.

Table 13-4. The Reproduction of the House Mouse

Breeding (estrous) cycle	polyestrous, every 4 days all year
Litter size	4 to 8
Litters per year	6 to 8, depending on food available
Age at weaning	21 to 28 days
Gestation period	18 to 21 days
Sexual Maturity	5 to 9 weeks
Life span in the wild	less than one year, perhaps up to 2 years under excellent conditions

Table 13-5. Zoonotic diseases of house mice and Norway rats

Disease	Agent	Transmission
bubonic plague (Black Death)	<i>Yersinia pestis</i>	bites of infective fleas
salmonellosis	<i>Salmonella</i> spp.	ingestion of feces-contaminated food and water
lymphocytic choriomeningitis urine, or saliva	LCM virus	ingestion of contaminated food; inhalation of dust from feces
rickettsialpox (or vesicular rickettsiosis)	<i>Rickettsia akaria</i>	bite of infective house mouse mite <i>Liponyssoides (Allodermanyssus) sanguineus</i>
leptospirosis or infectious jaundice	<i>Leptospira icterohaemorrhagiae</i>	ingestion of or contact with urine contaminated food, water, etc.
rat bite fever (Haverhill fever, Sodoku)	<i>Streptobacillus moniliformis</i>	rat bite, ingestion of contaminated food
tapeworms	<i>Hymenolepis nana</i> , <i>H. diminuta</i>	ingestion of droppings, contaminated food
murine typhus or endemic typhus	<i>Rickettsia typhi</i>	infective flea feces that contaminate broken skin, or are inhaled, or eaten
Hantavirus Pulmonary Syndrome (HPS)	Sin Nombre Virus (SNV)	most common route of transmission is through breathing in the virus on/in aerosolized, infective rodent urine, saliva, and feces; mucous membranes can also be infected after one handles infective/ contaminated materials (dirt, dust, rodent excreta, etc.); a rodent bite is another, though less common route

- prefer to travel along edges, e.g., the edge of the floor next to the wall or along the outside or inside of a foundation so their whiskers can maintain contact with surfaces. It is rare for rats to venture into the middle of rooms or fields as this exposes them to predation.
- avoid new objects, a condition called neophobia. It is not unusual for rats to wait 2 weeks before approaching traps or bait stations.
- will follow the same travel routes established by urine trails.
- run up almost any vertical surface, including wood, brick, metal pipes and girders, wire mesh, and cables
- run along suspended electric wires and ropes of most common sizes
- squeeze through a 3/16-inch diameter hole
- travel upside down, clinging to 1/4-inch hardware mesh
- swim well but tend not to dive below the surface
- survive at 24°F for many generations.

Mice

The house mouse (*Mus musculus*) is the most common vertebrate species to invade structures, but native species of mice, such as meadow voles and deer mice, are occasionally found in buildings, especially when temperatures drop in the autumn. Usually native mice can be trapped easily and removed and rarely become chronic problems. Since deer mice are known vectors of hantavirus, consult Box 13-A before initiating any trapping or cleanup activities.

Invasions of the house mouse can occur at any time of the year, and once inside, they will continue to reproduce, generation after generation, without leaving the confines of the building. The reproductive potential of house mice is high (Table 13-4), and their physical abilities, like those of the Norway rat, are remarkable. They have the ability to:

- jump up to 10 inches from the floor, use vertical surfaces as a spring board to gain additional height, and jump downward 8 feet to the floor
- can generally obtain all the water they need from food; if dependent on dry food, they need some free water
- travel over their entire home range daily (about 33 feet), investigating changes and new objects
- prefer to travel along edges and are wary of crossing open spaces
- poor eyesight, but sensitive to motion; navigate using their whiskers
- indoors — often live in false ceilings, seek warmth in continuously operating appliances such as stoves, refrigerators, air conditioners, and coolers; in wall and floor voids; and in similar enclosed spaces
- outdoors — prefer thickly vegetated level areas

Indoors, populations of mice are limited by the availability of food, by competition from other animals, and by disease. The amount of available

shelter inside can limit the number of mice to a certain extent; however, in spring, summer, and fall, mice can establish themselves outdoors. They need to live inside only during the severe conditions of winter. Rats prey on mice and compete for the same food and shelter; therefore, removing the rats often results in higher and more visible populations of house mice.

Damage

Rodents damage food, clothing, documents, and structures through gnawing, urination, defecation, and nesting activities. Their activities can significantly reduce the value of structural insulation leading to increased energy bills. The damage to food from contamination is probably 10 times greater than the damage by direct feeding. Feces and urine raise the humidity of enclosed spaces, promote wood deterioration, and provide a medium for the proliferation of microorganisms. Mouse urine has also been implicated in causing allergies in 15% of children. Rodents cause fires by chewing through the insulation on electrical wires, and they are involved in spreading human pathogens (Table 13-5). Hantavirus is transmitted by mice and is a cause for cautionary measures when entering mouse contaminated areas (Box 13-A).

Detection and Monitoring

Inspection for the presence of rodents involves the careful and systematic investigation of an area searching for and identifying rodent habitat, signs, entry points, and damage in order to determine where control is needed.

Since rodents prefer dark, cramped, out of the way spaces, inspection requires proper illumination and personal protective equipment. Choose a flashlight with a powerful beam (at least 75,000 lumens). Ideally, flashlights with adjustable beams offer more flexibility. Other equipment needs include inspection mirror, binoculars (8x magnification), and personal protection equipment (PPE), such as gloves (preferably leather), work clothes, goggles, and NIOSH N100 or P100 rated respirator (depending on the environment). Respirators should be worn whenever entering an attic, crawl space, or other confined spaces not frequented by humans on a daily basis. Note that only individuals trained in fitting the respirator and who are medically cleared should wear a respirator. Finally, you will need a way to record findings.

Begin your inspection on the property surrounding the structure. Look for tall grass, water sources, bird feeders, debris, woodpiles, and other kinds of rodent harborage and sources of food.

Next, focus on the structure's exterior, inspecting as much of the structure you can without using a ladder. The following process will focus on inspection for mouse entry as their smaller size makes them more difficult to find. Check the foundation (particularly the sill plate), pipes, wires, and vents that enter a building for openings capable of allowing a mouse to enter (3/8-inch wide). Look carefully through ground ivy for the presence of rat holes.

While avoiding electrical lines, use a ladder rated for your weight to allow visual access of soffits, gables, vents (including ridge vents), gaps,

and other possible entry areas that were not easily investigated from the ground. Make notes on your findings. Fall protection equipment may be required when walking on the roof.

Interior inspections are more complicated as walls, construction practices, and furnishings all interfere with gaining access to signs. Access to a floor plan aids in documenting your findings. As you inspect, don't neglect to wear your PPE as conditions warrant. Respirators should always be worn when entering attics and investigating drop ceilings. Look for signs of droppings along walls, above drop ceilings, and underneath insulation. Trails and tracks may be seen in areas with a lot of dust or high rodent traffic.

The following tips will help improve the quality of your interior inspection.

1. Look for droppings along the edges of walls, especially walls behind objects that prevent easy view.
2. Rodents seek heat. Pay close attention to areas around hot water heaters, appliances with pilot lights, or compressors that are regularly working such as refrigerators and freezers.
3. Look under insulation.
4. Inspect pipes, particularly those that travel between floors as these can be highways for rodents.
5. Spend time in areas with food, including pet food.

Box 13-B, Box 13-C, and Box 13-D, highlight previously mentioned tips. Remember to inspect any outbuildings on the property.

- Collect fecal pellets and gnawed wood shavings and remove any nests. Re-inspect for new rodent signs in a day or two. The use of a vacuum is not advised because of the risks associated with Hantavirus (Box 13-A);
- Close suspected rodent burrows or holes temporarily with soil or crumpled paper. Inspect 24 hours later to see if the holes have been opened, or the paper chewed or moved.

Management Options

Ideally, rodent management should be performed simultaneously throughout the structure, employing all the techniques and strategies applicable to your situation. If resources (time, money, etc) are limited, concentrate control efforts in the high risk/high priority areas, such as the kitchen, the cafeteria, loading docks, and storage rooms. Your inspection will reveal the areas you must concentrate on in your own facility. After you have improved sanitation in these areas, worked on rodent exclusion, and trapped most of the offending animals, move on to the other areas noted in your inspection, being mindful that rodents can reinvade controlled areas and migrate to new ones.

Habitat Modification

It is very important to change the physical environment that is supporting rodents. As mentioned before, killing rodents without removing the conditions that allowed them to thrive will simply result in rodents outside the zone of control to reinvade and replace the dead ones. Initially, the task of instituting the recommendations below can feel

Box 13-A. Hantavirus

Hantavirus pulmonary syndrome (HPS) is a serious, often deadly, respiratory disease that has been found mostly in the rural areas of the western United States where there is an abundant population of deer mice (*Peromyscus* spp.), the primary vector (see Table 13-2 for description). Other rodent vectors may be involved also.

The most common route of transmission is through breathing in the virus on or in aerosolized, infective rodent urine, saliva, and feces. Mucous membranes can also be infected by touching them with fingers that have been contaminated by handling infective or contaminated materials such as dirt, dust, and rodent excreta. Rodent bites also can spread the virus, but this is less common. Organisms such as ticks, lice, or fleas are not involved, and as of this writing, no human-to-human transmission has been observed.

Human exposures have been mostly associated with agricultural activities such as planting and harvesting field crops, but several exposures have come from contaminated dwellings. Infections have occurred from staying in previously vacant cabins, from cleaning barns and other outbuildings, and from hiking and camping. Any time the rodent population becomes large enough to incubate large quantities of the virus, disease outbreaks can result. At room temperatures, Hantavirus can remain infectious for up to 3 days. Sunlight will reduce its viability and freezing will extend it.

Symptoms of Hantavirus usually appear within 2 weeks of infection but can appear as early as 3 days to as late as 6 weeks after infection. The primary symptom of this disease is difficulty breathing, but other symptoms may include fever (101°-104°F), headache, abdominal and lower back pain, and sometimes nausea and vomiting. If any combination of these symptoms—especially difficulty in breathing—appear after direct or indirect exposure to rodents, contact your doctor immediately and be sure to mention your exposure to rodents.

In areas of known infection, a trained health department representative or pest control operator should do trapping and cleanup.

At present, the best means of protection against the virus is by excluding deer mice from buildings. Since the types of mice that carry Hantavirus are difficult to identify, all wild rodents should be considered potentially infectious and should be avoided. Methods for excluding deer mice are identical for the house mouse. See the section on excluding rodents under Management Options for directions on rodent-proofing your sensitive environment building.

When cleaning, you can minimize contamination by following these precautions:

- Thoroughly air out crawl spaces and infrequently used areas where rodents have likely resided prior to entry. Avoid disturbing materials or stirring up dust before treating with disinfectant. Wear protective equipment described below.
- Since the virus can enter by breathing contaminated air or through broken skin and conjunctive tissues, wearing protective clothing is imperative. Minimum protective equipment no matter how slight the contamination includes gloves (e.g. latex, rubber, vinyl, or nitrile). Eye protection and a dust mask are recommended. For cleanup in heavily contaminated areas, one should wear a Tyvek® suit and a full-face particulate respirator rated N100 (if oil is not present) and P100 (if oil is present). Medical evaluation and fit-training is required to use respirators safely and correctly.
- Mix a solution of 1 1/2 cups of bleach to 1 gallon of water or use a household disinfectant and spray contaminated areas until damp BEFORE cleaning. In particular, spray or soak any dead mice, droppings, traps with captured mice, or nesting areas with disinfectant or the 10 percent bleach solution.
- Wipe down counter tops, cabinets, and drawers. Mop floors and baseboards.
- Do not vacuum, sweep, or dust as this may spread the virus throughout the air. Use rags, sponges, and mops that have been soaked in the disinfectant solution.
- Steam-clean carpets, rugs, and upholstered furniture.
- Wash clothes and bedding in hot water and detergent. Transfer to a dryer set on high.
- Wrap contaminated items, including dead mice, in double-plastic bags before disposal.
- Disinfect gloves before taking them off and throw them away.
- When you are done, thoroughly wash your hands with soap and hot water.
- If you develop flu-like symptoms within 6 weeks of your cleaning activities, inform your doctor that you were working in a rodent contaminated area.

overwhelming. Avoid the trap of thinking that small habitat modifications will not help. The fact is every reduction in rodent friendly habitat, no matter how small, increases the stress of the remaining rodents. Rodents under stress have lower reproductive rates and are more susceptible to other control techniques.

Reducing Food Availability

- Store foods such as grains, pet foods, snacks, etc. in metal, glass, or heavy plastic containers with tight fitting lids.
- Food stored in classrooms, meeting rooms, or worker lounges should be in tightly closed containers. Do not leave food out overnight.
- Do not allow students or staff to store food in their lockers overnight unless it is in rodent-proof containers.
- Explain to them why this is important to help improve compliance.
- Store fresh fruits and vegetables in refrigerators or in open-air coolers that are screened with 1/4-inch, heavy wire mesh.

Box 13-B. Signs of Rodent Presence

Live or Dead Rodents

- Seeing live rodents is the most obvious and certain sign of their presence. Observation of live rodents in the daytime frequently suggests a heavy infestation, that their harborage has been disturbed, or that new rodents are moving into the area and have not found any harborage yet.
- Discovery of intact dead rodents signifies an active infestation, but this is not necessarily true with an old, dried body, which may merely indicate a previous infestation.

Droppings

- Most droppings will be in feeding areas, travel routes, and near harborage.
- Rat droppings may be up to 3/4-inch long and 1/4-inch in diameter. Mouse droppings are much smaller, about 1/4-inch long but can reach 1/2-inch. To distinguish from cockroach droppings, look for longitudinal ridges; rodent droppings will be smooth.
- Fresh droppings are moist, soft, black or nearly black, and they glisten or look wet. After a few days to a week, the droppings dry, become hard, and appear dull rather than shiny. In warm, dry atmospheres, the droppings can lose their shine after only a few hours. After a few weeks, rat droppings become gray, dusty and crumbly, and mouse dropping become hard, dry, and dull or whitish.
- If very old droppings are moistened, they may look like new ones, but they will still be crumbly instead of soft.
- Sometimes bat droppings can be confused with rodent droppings. But bat droppings contain insect fragments that can easily be seen with a hand magnifying glass (look for sparkles) when the droppings are crushed.
- Monitor for current rodent activity by removing droppings so that fresh droppings are apparent during future inspections.

Damage to Goods and Structures

- Rodents gnaw to get at food in packaging or containers and to obtain nesting material.

- When rodents gnaw, their front teeth leave two parallel marks, about 1/8-inch across for rats and about 1/16-inch across for mice.
- Gnaw marks on doors or ledges, in corners, in wall material, or on stored materials as well as bits of gnawed wood, paper, cloth, and packaging materials are good indications of the presence of rodents.
- Rats can gnaw through rusty sheet metal and sheet aluminum.

Grease Marks or Rub Marks

- Smudge marks on beams, rafters, walls, pipes, and other fixtures are the result of oil and dirt rubbing off rodents' fur along frequently traveled routes.

Runs or Burrows

- Trails or burrows of rats may be found outside along foundations, walls, fences, and under bushes or debris. Runs will look like tiny paths and burrows are open holes.

Tracks

- Look for tracks in dust, mud, or snow. Rats and mice have 4 toes on the front feet and 5 on the hind. Rat tracks range in size from 3/4 to 1 1/4 inch in length versus 3/8 to 3/4-inch of mice. Sign of tail dragging is rare but when found may suggest an older rodent.

Noises

- Rats make noise as they gnaw, claw, fight, and scramble around inside walls, which is particularly audible at night when they are most active. A stethoscope may be used to pinpoint the activity. Mice are harder to hear, but you can sometimes hear them scurrying and skittering around. Squirrels and other animals can make similar noises so you should confirm the presence of rats and mice with other signs.

Urine

- Fresh rodent urine will fluoresce blue-white under ultraviolet light, but many other substances also fluoresce so recognizing rodent urine takes skill. Since droppings are more easily recognized and just as effective in identifying rodent activity, we do not recommend the use of ultraviolet (UV) lights for inspections.

- Store bags of grass seed, dry pet food, and other similar items in rodent-proof containers.
- If birdfeeders are not removed, reduce seed waste by using one seed per feeder. Install a new feeder for each seed type you wish to use. Install catch-plates under bird feeder to reduce the volume

of seed reaching the ground. Promptly clean up any spilled bird seed around feeders. Make sure the feeders are squirrel proofed (Information can be found at <http://icwdm.org>).

Limiting Areas for Eating

If you expect to contain and limit pest problems (cockroaches and ants

as well as rodents), it is very important to designate appropriate areas for eating and to enforce these rules. The fewer designated areas, the easier it will be to limit pests.

Managing Garbage Properly

In most areas, garbage is the main source of food for rats. An electric garbage disposal unit in the sink can

Box 13-C. How to Conduct a Rodent Inspection Outside

- Try to identify as many of the areas as possible that provide rodents with harborage, food, water, and access to buildings.
- Make detailed notes on your map of the exterior of the building and the sensitive environment grounds.
- Take note of how garbage is dealt with, what condition dumpsters and garbage cans are in, and whether rodents have easy access to garbage.
- Check doorways for gaps or holes and note windows without screens or glass.
- Look for other openings in the structure — holes, vents without screens, holes around plumbing, and electrical wire entry points.
- Note any power lines that run into the upper portions of buildings and any trees that brush up against the structure; these give rodents access to the roof.
- Note any bird or bat problems because rats may not be far behind. Rodents will feed on bird eggs, chicks, and young bats.
- What kind of vegetation is growing near the building? Does it give rodents cover for runways or nesting sites? Are there any fruit- or nut-bearing trees?
- Inspect all planters, piles of waste wood, portable storage containers, and outbuildings. Are there signs of rodent infestation in or around any of these areas?
- Take into account any adjacent field or lot, as well as any supermarket or fast food establishment that may attract rodents. Rodents that start to invade a structure may be an overflow from adjacent properties. If a vacant building next door to a sensitive environment is going to be renovated or an empty field or lot prepared for construction, the rodent population will be displaced to the surrounding areas.
- Pay attention to seasonal occurrences. For example, field mice often migrate to the nearest structure when corn or wheat fields are harvested in the fall.
- Check for irrigation leaks and any standing water such as irrigation or drainage ditches, stagnant pools, ornamental ponds, and fountains.
- Check air conditioning units that might provide water and harborage for rats.

Box 13-D. How to Conduct a Rodent Inspection Inside

- Begin in the basement or substructure. Remember that you are trying to find as many areas as you can that might provide harborage, food, water, or access to the building.
- Make detailed notes on your schematic of the building.
- Try to locate all entry points and nesting areas. “Starter holes” for rodents to enlarge can be openings as small as 1/4-inch in diameter in walls, around pipe entries, sewer outlets, and under doors. Unscreened sewer outlets and even toilets can give rats access to buildings. Nests are often composed of shredded paper, pieces of plastic, and bits of fabric gathered together into a 5-inch diameter mass for mice and 8 to 12 inch diameter for rats. If you find clothing or paper that looks torn or shredded but doesn't look like a nest, you will most likely find the nest nearby.
- Look for water leaks and rooms where water condenses on the walls.
- Always be on the lookout for piles of trash, clutter, or other debris.
- Note where the custodians, staff, residents, and students take their breaks or eat lunch. These areas can present a sanitation problem.
- Rodents like to follow edges; inspect these areas for feces, rub marks, urine, or other indications of activity.
- Move to the main floors of the building and inspect locker rooms, home economics rooms, art rooms, child care facilities, lower-grade areas, cafeteria, kitchen, and teachers' lounges. Think broadly as some rooms (like Science classrooms) can have food for rodents.
- Continue into the attic to look for holes, nests, feces, and rub marks. Inspect vents, especially those you were not able to inspect properly during your outside inspection.

make rat problems worse by providing them with food in the sewer system. Proper disposal of organic garbage (food waste, garden waste, pet waste) is essential.

- All food waste from the kitchen, cafeteria, and other areas should be separated from other garbage, drained so it will be as dry as possible, and then stored in sealed

plastic bags. These bags must be placed in rodent-proof containers at the end of each day because plastic bags are not rodent-proof.

- In food preparation areas, thoroughly rinse all cans, bottles, and plastic containers before recycling or discarding.
- Make sure garbage cans and dumpster lids seal tightly when

closed and remain closed when not in use, especially at night. Repair or replace garbage cans with holes or with lids that do not close tightly. Use stretchy fasteners over garbage can lids, if necessary.

- Clean garbage cans and dumpsters frequently to prevent the build-up of food waste. Dirty garbage cans not only attract pests but also

repel people who want to use the garbage cans so that trash ends up outside the can. Use a high-pressure stream of water or a brush and soapy water if necessary. If possible, dumpsters should be fitted with drains so dirty water can be drained. The plug should be snugly in place, except when hosing out the dumpster; otherwise, rodents can enter the dumpster, and it becomes a huge feeding station. Another option is to require the refuse company to clean the dumpster or replace it with a clean one more frequently.

- Do not store extra garbage in cardboard, plastic, or paper outside the garbage cans because they can be torn open by rats, dogs, raccoons, or other animals.
- Inspect dumpsters and other outdoor trash receptacles at the end of the day and pick up any wastes lying on the ground.
- Garbage cans on the facility's grounds should have removable, domed tops with vertical, spring-loaded swinging doors. Line these cans with plastic bags that can be tightly sealed and emptied into rat-proof garbage containers every evening.
- Inform students, residents, and staff of the importance of placing garbage inside the proper containers.
- Pick up cat and dog feces daily (rats will feed on these).
- Shovel, rake, or sweep up fallen fruit, nuts, and similar foods that may be feeding rats in the yard. Dispose of the foods in rat-proof garbage containers. Sometimes it may be necessary to strip trees of their fruits or nuts to get a rat problem under control.

- Store excess garden produce away from rats or dispose of it in rat-proof garbage containers.

Removing Vegetation

- Create a plant-free perimeter at least 12- to 18-inches around the building to decrease cover for rodent burrows and runways and prevent hidden access to buildings. Trim trees branches 6 feet from structures. Prune vines, bushes, grass, and weeds away from the structure.
- Break up dense plantings with pathways, stretches of lawn, or very low groundcover. Rodents don't like to move across barren areas where they can be easily seen.
- Avoid large plantings of a single groundcover that provide cover for rodents to move for long distances without being noticed.
- Thin out dense bushes, cut long grass, and trim weeds to reduce rodent cover and food sources.

Excluding Rodents

Exclusion is the basis of any reliable management program. Since rodent-proofing takes time, begin simultaneously with population control techniques. The following procedures are recommended.

Large Openings in the Exterior of the Structure

- Seal holes larger than 3 inches in diameter with 1/4-inch hardware cloth, 19-gauge or thicker sheet metal, plaster, or mortar. Attach supports or frames for the screen solidly to the building. Never seal holes unless you are certain they are no longer being used by rodents. If in doubt, cork the hole

with crumpled newspaper and monitor for several days.

- If access to the opening is needed, install a lockable door with a heavy-duty spring hinge that will close the door automatically.
- Look for holes in the building not only in the first 3 feet above the ground but also at the roof line, in the eaves, and in attic and roof vents.
- Install 1/4-inch hardware cloth over all vents and ensure that no existing door and window screens are ripped. Note that 1/4-inch mesh will reduce airflow. Separate control measures should be used with dryer exhaust vents. Consider using floating shuttle type dryer vent covers such as Lambro Ultraseal Dryer Vent. Louvered vents frequently become jammed with lint so unless they are regularly cleaned, they will not provide significant protection.
- Cover vent pipes with manufactured covers and screens that meet building codes. Installation of 1/4-inch hardware cloth over exhaust could be a safety hazard if moisture freezes and blocks escaping vapors and gasses.

Small Openings in the Structure, Inside or Out

- Seal all holes less than 1/2 inch in diameter with caulk or other sealant (be sure to choose the type suitable for the substrate and setting).
- Holes 1/2-inch or larger should be filled with backing, such as wool made of stainless steel (e.g. Xcluder™) or copper mesh to provide backing for the caulk or sealant.
- Check for gaps around exterior doors and seal with metal-clad weather stripping. Metal kick

plates can be used to prevent rodent entry. Use raised metal door sills when necessary.

- Some doors have vents or louvers in them as part of the ventilation system. It may be necessary to screen these. Sometimes pipes have been installed through the vents or louvers; make sure to seal any gaps around the pipes.
- Check areas where pipes and wiring enter buildings and close any gaps with wire mesh, sheet metal, or mortar.

Air Conditioners

- Cooling units can provide rodents with water, harborage, and access to the structure. Seal each unit to eliminate access.

Overhead Cables and Electrical Lines

- Rodents sometimes use overhead lines. In these situations, consult your electrical company. NEVER tamper with or work in proximity of electrical lines. CritterGuard® is a product employed by power companies to prevent rodents from climbing wires. Non-electrical lines can be protected by installing 18-inch discs and PVC pipe overlays.

Sewer Pipes

- Repair broken sewer pipes. Rats can dig into broken sewer lines and swim up the toilet trap and enter the building.
- Toilet drains can be rat-proofed by installing a toilet flap or feeding the pipe from the toilet bowl into a pipe with an internal diameter greater than 4 inches.

Drains

- Install 1/2-inch galvanized wire mesh in the drains in basement floors so rats cannot enter through them.
- Install a brass drain cover or perforated metal cap held in place by a hinge so it can be opened for cleaning. The unhinged type of cover should be threaded so it screws in place; otherwise, a rat can push it open.
- Place 1/4-inch galvanized hardware cloth under existing drain covers with holes larger than 1/2-inch.

Debris and Clutter

- Clean up and organize storage rooms to eliminate as much clutter as possible. It is more difficult to detect the presence of rodents in such rooms, and the clutter is attractive harborage.
- Outside, remove heaps of debris, wood piles, or construction debris. Cut grass frequently enough to prevent seeding to remove a food source for mice.

Water

- Free-standing water in stagnant pools, ditches, ornamental pools, or fountains can provide rats with their daily ration of water. Drain or eliminate these sources where possible. Fountains and ornamental pools will pose a problem, but during severe rat infestations, they may need to be temporarily drained. Do not neglect standing water that may be present on the roof of the building.
- Fix leaking pipes, faucets, or broken irrigation systems.
- Eliminate condensation in places like boiler rooms or under air conditioner units.

Installing Barriers

- Install rodent-proof barriers to separate landscaping from the foundations of buildings by digging a small trench at least 12 inches wide, 8 inches deep, adjacent to the foundation and as long as the building. Place 1/4-inch galvanized hardware cloth along the structural and floor sides of the trench. Secure top of mesh to building. Then fill with gravel. These weed-free zones discourage rodents from digging and approaching the structure.
- Place barriers between and within walls to prevent rodent travel (Figure 13-4). An open space between floor joists (as shown at A) gives rats free access to wall voids. Wood 2x4 stops (shown at B) are sometimes used on upper floors, but noncombustible materials should be employed on lower floors. In old buildings, galvanized sheet metal (shown at C) can be cut to fit and nailed between studs, joists, floor, and sill. In new construction, noncombustible stops of cement are recommended (shown at D).
- Vertical barriers of galvanized sheet metal 18 to 24 inches high placed around stored flour or grain will exclude mice. Pallets containing stored food and paper supplies can be mouse-proofed by elevating the pallet on 12-inch cinder blocks, then covering the pallet with a layer of sheet metal so that the edges of the sheet metal extend 4 to 6 inches beyond the edges of the pallet. The edges should then be bent down toward the floor at a 45° angle.

Methods of Direct Population Reduction

Trapping Rodents

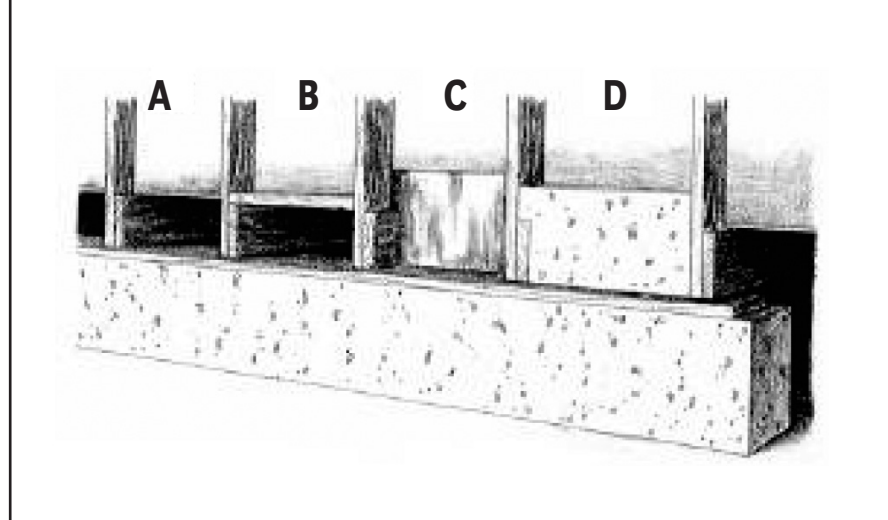
Rodent trapping, especially for mice, is an important component of an integrated pest management program in sensitive environments. Some people have concerns about the ethical implications of killing rodents by trapping. Remember that house mice and Norway rats are invasive species and do not belong in the United States. Relocation is not necessarily humane (and in some areas is illegal) because you will have separated the animal from its familiar surroundings and forced it to find food and shelter while avoiding predators in an unfamiliar environment. Some research shows that rodents released into the backyard simply reenter the structure from which they were evicted.

The following are direct population control methods in descending order of humaneness to the animal; electric shock traps, anti-coagulant toxicants, non-anti-coagulant toxicants, specially designed snap traps (e.g. Victor® Quick Kill Mouse Trap) traditional snap traps, multiple catch traps, and glue boards. Animal welfare concerns can be turned into motivation for habitat modification and other strategies that exclude rodents and eliminate their food supply, thus reducing the numbers that have to be directly killed. Inspect traps daily to remove and humanely kill any rodents that have been caught.

Killing trapped rodents

- Mice found alive in traps should be killed by a swift blow to the head or by asphyxiation with carbon dioxide gas. Insert a hose attached to a regulator connected to a cylinder of CO₂ (available

Figure 13-4. Barriers between and within walls



at bottled gas companies) into a 5-gallon pail. Place the traps in the pail, rest the cover on the pail. The cover does not need to seal because CO₂ is heavier than air. As the CO₂ enters the pail, it will push out the oxygenated air. Turn on the gas for 15-20 seconds at a rate of 10 liters/minute, turn down the flow to 1 liter/minute and leave the pail for 5 minutes. Upon returning, carefully lift the lid and check the trapped mice for signs of life. If you notice respiration or movement, replace the lid and continue the gas flow at the 1 liter/minute rate for another 5 minutes.

- Place the dead mice in two plastic bags (double-wrapped) and dispose of them in a sealed dumpster or garbage can.

Tips for a successful trapping program

- Place baited but unset traps in areas where rodent activity has been noted and/or is likely. Check and rebait (if needed) for 3 consecutive days. Set traps on the third day. Check traps daily, removing captures and rebaiting as neces-

sary. As captures begin to decline, checks can be extended to every other day or every few days.

- Use the map of the building and/or grounds to record the precise location of each trap and the date it was set. This recordkeeping is the key to preventing lost and forgotten traps. If dead and decomposing rodents are left in the traps, the results can be very unpleasant.
- Always wear gloves when handling traps for protection from diseases.
- Trapped rodents provide you with the opportunity to identify the species. Take the opportunity to confirm the species of rodent you are controlling.
- For mice, set a large number of traps for a few days (1 every 6-10 feet). One of the greatest errors in mouse trapping is the failure to use enough traps. Continue to monitor.
- If trapping success ends, set snap traps and leave them in place. Reset traps two weeks later to ensure that mice too small for capture during the first trapping are caught in the second round.

- If catches are poor, try moving the traps to new locations or place new traps in new locations.
- Most rats are trap-shy and have been known to avoid traps for up to two weeks. Rat traps can be pre-baited in the unsprung position to improve their effectiveness. You also can leave out food in shallow pans until the rats readily eat it, and then camouflage the trap by burying it under the food in the pan.

Trap choices

Rodent traps fall into four general categories: electric shock traps, snap traps, box traps (a.k.a. live) traps, and glue boards. Each kind of trap is better suited to some situations than others. The information below will help you decide where to best use each of the traps.

Electric Shock Traps. These traps use battery power to kill rodents when they complete the electrical circuit.

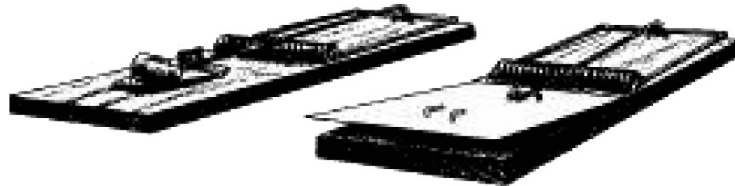
Snap Traps. Snap traps are widely available and fall into two types. The first is the traditional snap trap that uses a striking bar to kill the rodent. Those lacking wide triggers can be made more effective by expanding the trigger (see Figure 13-5) so they can be tripped by a mouse or rat that is running over the trap. Do not place them where human toes might accidentally get caught unless the traps are protected inside a tamper proof bait station (Figure 13-6). Clamshell type is the second trap variety. It uses jaws to kill the rodent. While more expensive, the design of the trap allows for easy (one hand) removal of the rodent.

Box Traps. Box traps (a.k.a. Live traps, Figure 13-7) are available for rats and mice, but the rodents must

Figure 13-5. Rat traps

Making an Expanded Rat Trap Trigger

Rat traps with expanded triggers are available commercially, but you can also make your own. Cut a 1 1/2 in (3.8 cm) square piece of stiff cardboard or 1/8 in (0.3 cm) thick wood and attach it to the existing trap trigger with wire or strong glue. Expanded triggers often catch rats without bait if the traps are placed well and are moved when necessary.



be killed once they are trapped. When mouse populations are high, multiple-catch live traps may be more efficient than snap traps. They are not as effective on rats.

Multiple catch traps can capture several mice at a time without needing to be reset. Some models have windup mechanisms that “kick” the mice into another compartment. Others use a treadle door. Although these traps can work without baits because mice are curious and attracted to the small entrances designed into the traps, they are more effective when baited.

Glue Boards. Glue boards are covered with a sticky material that will catch mice and rats. Glue boards provide the advantage of catching and retaining rodent hairs, droppings, and ectoparasites coming from the trapped animal. Glue board traps should be inspected daily to prevent unnecessary suffering by the trapped animals.

If glue boards are used in areas where they might fall and get stuck to something, secure the traps with a staple or wire. Glue boards should always

be secured when trapping rats so that the rats cannot drag the traps away. Baiting glue boards is not necessary but will improve the chances of success. Never apply peanut butter or other greasy bait on the glue as the oils will decrease the glue’s effectiveness. Place baits in a plastic soda bottle cap and set in the middle of the board. Research suggests that glue boards are less effective in capturing rodents (particularly rats) than other capture methods. Dust will reduce the glue board’s stickiness over time.

Trap Placement

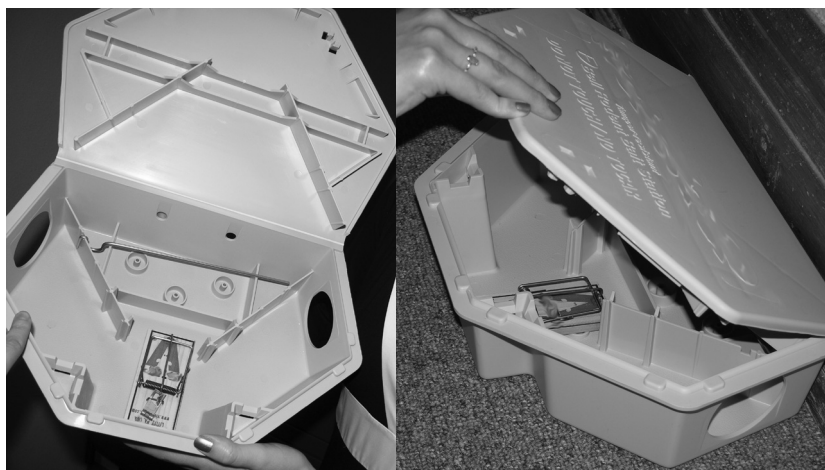
- Check the monitoring map to locate active rodent holes, and set traps along walls or other runways leading to the holes. Other good trap locations include areas near droppings, gnawing marks, or other signs of rodent damage; under and behind objects likely to harbor rats or mice; in dark corners; and along rafters or other protected areas where rodents are likely to travel.
- Changing the location of furnishings will produce new pathways

that mice will quickly investigate. Traps can be placed along these new pathways. For rats, move objects around to funnel them into the traps.

- Set traps at right angles to the wall with the trigger facing the wall (Figure 13-8).
- Place traps flush with the wall so that rodents traveling along the edge of the wall will encounter the traps.
- Two traps, side by side with their triggers facing the wall, can increase the chances of success. Alternatively, the two traps can be placed parallel to the wall, back to back with their triggers facing away from each other. Three traps in a row will make it difficult for a rat to jump over the traps without being caught.
- Traps can also be screwed to a wall or rafter or wired to a pipe. Make sure the trigger side of the trap is projecting into the rodents' runway.
- When trapping rats with snap traps, secure them to prevent rats from moving traps to inaccessible areas.
- Traps can be camouflaged on dirt surfaces by sinking it just below



Figure 13-7. Box trap



Photos: Erin Bauer

Figure 13-6. Snap trap in tamper proof bait station

ground level and covering it with a fine layer of sand or sawdust. Traps can also be set in shallow pans filled with sawdust, grain, or meal. It may be necessary to place a small piece of cloth over the trigger to keep it from jamming.

Baiting the Traps

- Peanut butter is attractive bait for rodents, particularly house mice. Given that some people are seriously allergic to peanut butter, it may be prudent to avoid its use at least in more public areas. Other baits include raisins, chocolate, gumdrops, chicken fat, caramel, rolled oats, or bacon grease. A small piece of cotton can be attached to the trigger instead of food. The cotton makes attractive

nesting material, does not spoil, and is less likely to attract new pests such as flies, ants, and cockroaches.

- Baits for Norway rats include pieces of chocolate, pepperoni, hot dog, bacon, liver, peanut butter, or nut meats. If rats are feeding on other foods, try them as baits also.
- Place the bait in the center of the trigger. Baits that do not stick to the trigger can be tied on with string or dental floss so the rodent cannot steal the bait without tripping the trigger.
- To catch rats, you will probably have to “pre-bait” the traps. Place the traps out with bait but do not set the traps. Check them daily to see if the bait has been taken and move them to a new location if the bait remains undisturbed for three or four days. Once you see signs of feeding on the bait, apply fresh bait and set the traps. Remember, snap and clam-style traps can be set in blind, meaning without bait. Simply placing traps the trigger end abutting the wall will be close enough to catch a rat walking along the wall.



Figure 13-8. Proper placement of traps

Number of Traps to Use

- For house mice, place one trap every 6 to 10 feet along a wall and more in areas where there are many signs of mice. Remember to think in three dimensions. Mice signs on one floor mean you should set traps not only on that floor but also the adjoining rooms/ areas beside, below, and above.

Protecting Snap Traps

- If safety or tampering is a concern, you can place a snap trap inside a rat bait station. Use only rat bait stations; a mouse station is not large enough to allow traps to fire. Place the bait station on its side against the wall with the entry holes closest to the floor. Set and insert a baited rat or mouse snap trap with its trigger facing the entry hole. By placing two of these bait station traps back to back, the rodent will be caught traveling in either direction.
- Mouse snap traps can also be placed inside PVC pipe. Use pipe that is at least 3 1/4 inches in diameter so the traps have room to fire. Place two traps end to end inside the pipe with the triggers facing the cut ends of the pipe.

PVC piping is available at plumbing supply stores and can easily be cut to the desired length.

Protecting Glue Boards

Glue boards should be placed inside professional rat or mouse bait stations to extend the life of the board by protecting it from dust, dirt, and tampering. This method also hides the catch from view. The following points will help you set up the traps:

- For mouse bait stations, you will need to cut or fold the glue board to fit inside the station before you remove the protective release paper from the board.
- Remove the glue board from the bait station to dispose of the rodent and replace with a new board. Glue boards can also be placed inside a length of PVC pipe along exterior foundations or indoor walls. Curl the glue board inside the pipe, making sure that the curve of the board matches the contour of the pipe.

Miscellaneous Points

- Do not spray insecticides on the traps and do not store them with insecticides, rodenticides, or application equipment. The traps

will smell of these substances, and rats will avoid them.

- To prepare snap traps for storage, treat with disinfectant, scrub them with a stiff brush, soak them in detergent and water, and dry them. Be sure to wear your PPE.

Repellent Sound Devices

A number of sonic, ultrasonic, magnetic, and electronic devices are marketed as effective tools in preventing and/or evicting rodents from structures. None of these products have been demonstrated to be effective in the long-term control of rodents in real-world situations. The reasons for their lack of efficacy are quite simple. Rodents exploit the inevitable sound shadows that arise from their use or simply tolerate the noise while foraging.

Biological Controls

Some institutions maintain cats for protection against rodents. While cats can and do kill rodents, they typically only “prune” the population. Rodents in areas with cats quickly learn to avoid their presence. It should also be apparent that no matter how good a cat is at catching rodents, they cannot enter walls where rodents live. Free-ranging cats also can transmit diseases acquired outdoors to their owners, such as toxoplasmosis.

Rodenticides

If non-chemical methods alone prove insufficient to solve the problem, then integrating rodenticides into your management program may be warranted. However, rodents weakened by toxicants can poison the animals that eat them, such as owls and snakes. This phenomenon is known as secondary poisoning. So when considering the use of chemical

control techniques, remember that depending on the toxicant used, these predators can be killed by consuming poisoned rodents.

Rodenticides must be used in accordance with their EPA-approved label directions. Applicators that are hired by an institution must be certified to apply rodenticides and should always wear protective clothing during applications. Copies of all labels and Material Safety Data Sheets (MSDS) for the rodenticide products authorized for use in the IPM program should be maintained on file.

Patience is necessary when using rodenticides. Baits and bait stations will be avoided for a few hours to several days after initial placement. Even after this period, rats will be very cautious about approaching them. Depending on the type and amount of rodenticide eaten, rodents will begin dying in 3 days but have been known to live up to 3 weeks before succumbing to the poison.

When to Use Rodenticides

It is appropriate to use rodenticides when trapping and physical changes to the building and to food and waste storage have been clearly documented to be insufficient to meet control requirements. In emergency situations when there are very high numbers of rodents or when rodent ectoparasites have been identified as a concern (e.g. bubonic plague), it may be appropriate to use toxicants, but trapping and habitat modification should be used at the same time. Understand, however, that control of rodents does not automatically constitute control of ectoparasites.

Safety Precautions

- Before purchasing a rodenticide, carefully read the instructions on

the label. Consider whether the label allows its use in the area where rodents need to be controlled. Remember, “The label is the law.” Different rodenticides may have different restrictions. So choose the one best suited for your situation.

- All rodenticide baits should be placed inside Tier 1 tamper-resistant bait stations. Tier 1 stations are resistant to weather and tampering by children and dogs. Bait stations should always be secured to the floor, a wall, or other surface. We also suggest that they be positioned out of the reach or access of children whenever possible. Bait stations should be clearly labeled with a warning.
- Use rodenticides over long holidays when residents, workers, and students are not in the building.
- Use only in locked storerooms, basements, attics, or other areas not accessible to children.
- Only use formulations of toxicants that cannot be moved by rats or mice, such as secured paraffin blocks.
- Handle rodent carcasses with gloves.
- Keep unused bait in its original container in a locked cabinet with appropriate warnings on the outside of the cabinet door. If baits are stored with other chemicals, put the original container into an airtight container so the bait will not absorb odors that may impair its effectiveness.

Types of Rodenticides

Rodenticides fall into two broad categories, anticoagulants and non-anticoagulants. Anticoagulants kill rodents by disrupting their capillaries and preventing the clotting of

their blood. Non-anticoagulants kill by disruption of the nervous system or other means. Rodents usually eat small amounts of the toxicant over several days and eventually die from internal bleeding. Anticoagulants present minimal hazards to humans because of the small amount of toxicant in the baits and an antidote (vitamin K) that is readily available. Anticoagulants are further categorized as first or second generation. First generation anticoagulants require multi-feedings before the rodent receives enough poison to reach lethal levels. Second generation anticoagulants can kill rodents in a single feeding, but rodents typically begin dying by the third day. The delay in the toxicant’s lethality is to prevent rodents from “learning” that the bait is actually dangerous. If rodents got sick immediately after a feeding, the few that survive would avoid the bait thereafter.

Three non-anticoagulant rodenticides are available: bromethalin, cholecalciferol, and zinc phosphide. All three can kill rodents with a single dose, but no antidote is available. Non-anticoagulants are recommended only if there is a need for a quick reduction of the rodent population and if access to the baits is completely restricted.

Recent changes in EPA regulations now designate second generation anticoagulants and above ground use of non-anticoagulants as Restricted Use Pesticides. This categorization means you must have a pesticide license in order to purchase and use these toxicants. First generation anticoagulants, however, are still considered General Use Pesticides and are available at supermarkets, hardware, and farm supply stores.

Rodenticide Formulations

- Parafinized and extruded bait blocks are useful in wet situations where dampness could spoil other baits. These blocks must be wired to the bait station so they cannot be dragged away. This formulation is available to the public.

Restricted Use Pesticide Formulations

- Liquid formulations are dispensed in special bait stations made especially for liquids and are most useful for rats in situations where water is very restricted and food is plentiful. Liquid bait must always be used where non-target animals and children have no access.
- Loose grain or meal formulations, e.g., cornmeal or oatmeal mixed with a toxicant, are extremely attractive to rodents. But rodents sometimes make caches of the bait to eat at another time.
- Tracking powders are used in wall voids and other locations inaccessible to humans. As rodents walk through the powder, they ingest the toxicant during their grooming.

Use of Toxic Baits

Before beginning a baiting program, inspect to determine the locations where rodents are most likely to accept poison bait.

Points to consider when instituting a baiting program include the following:

- bait stations (Use Tier 1 bait stations) should be secured in place and clearly labeled “RODENT BAIT — POISON — DO NOT TOUCH”

- place bait stations where rodents are most active. Place bait stations along walls and, whenever possible, between shelter and the source of food
- use one color of toxicant for indoor stations and another for outdoor stations. These colors will persist in rodent droppings and will tell you whether the rodent was feeding indoors or out.
- bait stations should be placed 15 to 30 feet apart in areas with high densities of rodents (but check toxicant label)
- number your bait stations and mark the location of each on your building map when beginning, check each bait station every 3 to 5 days ensure there is enough bait (this is extremely important in the early stages of a control program), the bait is in good condition (not moldy or wet), and the bait station is not being disturbed. Leave bait stations in place for the number of days recommended on the label. Mice will readily investigate new things in their territory, but it may take 2 weeks for rats to try the bait. Anticoagulants, whether first or second generation, require 5 days or more to kill rodents. Maintain bait stations by checking them at least monthly. Dispose of old bait according to the label. When cleaning stations wear protective clothing as suggested by CDC.gov. If you must use a cleaning agent, swap the station out with a new one
- remove and securely store all bait stations when the baiting program is over.

Vigilance

You cannot relax after finding and treating a rodent infestation. Mice and rats are always a potential problem. Designate areas of high and low risk and continue to monitor the high risk areas perhaps every other week. Use monitoring blocks to help detect the presence of rodents.

The low risk areas can be inspected once every quarter. It is important to pay attention to seasonal and other changes. Is there a vacant lot, or agricultural area adjacent to the sensitive environment? If so, the property will be regularly invaded by surplus or evicted rodents seeking shelter on your property. Is new construction or demolition starting next door to the sensitive environment? Rats will be displaced and could invade your facility's yard and/or buildings. These are times for renewed vigilance.

Monitoring Blocks/Monitoring Stations

Monitoring blocks provide an effective, convenient, and non-toxic way to maintain a vigilant outlook for rodents. Monitoring stations require several steps, including the following:

- make a site plan of the sensitive environment with separate drawings of each floor so you can accurately record information.
- Non-toxic, food attractant blocks are commercially available for monitoring rodents. You can also use bait stations filled with non-toxic baits such as rabbit food or grains. These monitoring blocks or stations can be placed anywhere indoors or out to locate or monitor a rodent population simply by noting whether animals have fed on the bait. Monitoring blocks or

stations can also help you gauge the effectiveness of your treatment efforts. The blocks or bait stations should be wired, staked, or glued down with caulk so they cannot be dragged away. Clearly mark the blocks or stations with a tag, alerting people that a non-toxic, rodent monitoring program is underway.

Number each block or station and note its location on your map. In 2 to 7 days, check for signs of rodent feeding and record the amount on a monitoring form.

The following are some of the best locations to place monitoring stations:

- food storage areas
- kitchens — in closets and food storage areas
- locker rooms, break rooms, and teachers' lounges
- attics
- basements
- under and behind cabinets, appliances, computers, and electrical boxes
- in storage sheds, especially any containing grass seed or bird seed
- outdoors in dense vegetation and along buildings and fences

Conclusion

While rats and mice will continue to thrive in and around human environments, the extent of their success depends entirely on us. Implementation of an integrated management program, involving habitat modification, exclusion, lethal control, and regular monitoring, will result in a rodent-free environment.

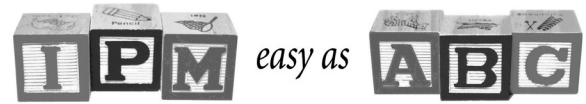
Resources

For Norway Rat, House Mouse and other pest vertebrate management practices, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Hygnstrom, S.E., R.M. Timm, and G.E. Larson, eds. 1994. *Prevention and Control of Wildlife Damage*. (<http://icwdm.org/handbook/index.asp>) University of Nebraska–Lincoln Extension, Lincoln. 250 pp.

Internet Center for Wildlife Damage Management (<http://icwdm.org>). University of Nebraska–Lincoln Extension.

IPM for Silverfish, Firebrats, and Booklice



Introduction

The presence of silverfish, firebrats, or booklice is an indicator of excessive humidity. These insects can damage paper and book bindings, starched fabrics, cotton, linen, silk, rayon, cereals, and wallpaper. They also feed on the molds growing on various surfaces.

Silverfish, firebrats, and booklice (Figure 14-1) are frequently introduced into a building with boxes of materials that have been stored in damp basements or attics, but they can also wander in from outdoors. They are fast-moving and can travel throughout buildings in ventilators or heating ducts originating in damp basements. Once these insects find a good source of food, however, they stay close to it. In general, they do very little damage, but they may be seriously upsetting to people who are afraid of insects. They may also attract spiders that prey on these insects.

Identification and Biology

Silverfish and Firebrats

Silverfish are about 1/2 inch long when fully grown and are covered with silvery scales. They are grayish to greenish in color, have two long antennae, and have a flattened-carrot shape. There are three long append-

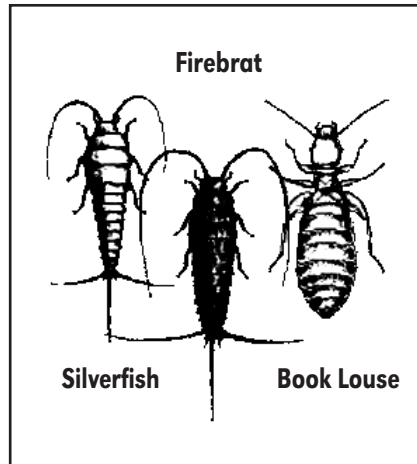


Figure 14-1. Firebrat, Silverfish and Book Louse

ages attached to the tapered posterior end, each about as long as the body. They do not have wings. Firebrats have a mottled appearance with patches of white and black and are shaped similarly to silverfish.

Characteristics of Silverfish

- lay eggs in any season, usually in secluded places
- life cycle is 3 to 4 months
- prefer moist areas (75 to 97 percent humidity) and moderate temperatures (70 to 80°F)
- active at night or in dark places and rarely seen unless disturbed during cleaning
- indoors, may be found throughout the building— sometimes in boxes and books, or in glass utensils and sinks into which they have fallen

- leave yellowish stains on fabric
- outdoors, live in nests of insects, birds (especially pigeons), and mammals, and under the bark of trees

Characteristics of Firebrats

- lay eggs in cracks and crevices
- life cycle is a few weeks
- prefer moist areas with temperatures above 90°F
- active at night or in dark places
- found where heat and starches are present (for example, in bakeries); also found in furnace rooms, steam pipe tunnels, and partition walls of water heater rooms.

Booklice (Psocids)

The common booklouse is a small, grayish, soft-bodied insect whose shape superficially resembles that of a head louse. Booklice are wingless and have chewing mouthparts. The size of an adult is approximately 1/25 to 1/12 inch. Relatives of the booklouse live outside under the bark of trees where they feed on molds.

Characteristics of Booklice

- life cycle is around 110 days
- prefer warm, moist conditions that are conducive to the growth of the mold and mildew they feed on; require humidity of at least 60 percent.

- found in books and paper products
- sometimes found on houseplants where they may be feeding on honeydew (a protein-rich substance excreted by plant-eating insects such as aphids), or more likely, on the sooty mold that grows on the honeydew

Damage

The mouthparts of silverfish and firebrats are used for biting off small particles or for scraping away at surfaces. Silverfish and firebrats eat material high in protein, sugar, or starch, including cereals, moist wheat flour, starch in book bindings, sizing in paper, and paper on which there is glue or paste. These insects often attack wallpaper, eating irregular holes through the paper to get to the paste. Silverfish may bite very small holes in various fabrics, including cotton, linen, and silk, even though they cannot digest either linen or cotton. Firebrats will feed extensively on rayon, whereas silverfish usually damage it only slightly.

Booklice cause little direct damage to plants and wood because they feed chiefly on mold. Damage to books may be more direct since they eat the starch sizing in the bindings and along the edges of pages.

Detection and Monitoring

Silverfish are found in bookcases, on closet shelves, behind baseboards, wallpaper, window or door frames, and in wall voids, attics, and subfloor areas. They prefer bathrooms and kitchens because of the moisture.

Firebrats will be found in similar but warmer areas. If you suspect that damage to books, carpets, curtains, art prints, or other materials is due to silverfish or firebrats, confirm your suspicions using the following test.

- Mix flour and water to the consistency of house paint.
- Coat one or more 3x5 index cards with the paste.
- Let the cards dry and place them where you have spotted damage.
- If silverfish or firebrats are in the vicinity, they will be attracted to the card within a week and will feed on the paste. Characteristic feeding marks are minute scrapings in irregular patterns, and the edge of the card may be notched.

If you see groups of small whitish insects in damp areas, suspect booklice, particularly if mold is present or the area smells moldy. Remember that booklice are considerably smaller than silverfish and lack the telltale three long bristles at the tail end.

Silverfish, firebrats, and booklice can also be detected by placing sticky cockroach traps in the area where damage is occurring. These traps, along with other homemade ones, can also be used for control purposes (see the discussion on Physical Controls). When the insects are caught, they should be preserved in alcohol for professional identification.

Management Options

Management of booklice, silverfish, and firebrats is essentially the same. All three are living indicators of excessive moisture. An occasional individual is not a pest and is usually tolerated by most people. Nonethe-

less, its presence should be taken as a sign to investigate moisture problems.

Physical Controls

Dehumidifying

If moisture is not eliminated, it may bring more serious problems, such as termites, carpenter ants, and wood rot (see Chapter 18, IPM for Wood-Damaging Pests). Libraries and paper supply storage rooms could have independent dehumidification systems in areas where high humidity is a concern.

You can do the following to decrease humidity.

- Mend leaking pipes.
- Ventilate closed rooms and attics.
- Eliminate standing water.
- Replace any single-glazed window that repeatedly accumulates condensation with a double-glazed window.
- Use a dehumidifier in rooms such as bathrooms that are regularly moist.
- Use anhydrous calcium carbonate, a dehydrating agent that is available from chemical supply companies, or silica gel, available from camera stores, to absorb free moisture, particularly in enclosed areas. Silica gel is often packaged in small cloth bags that can be dried out in an oven and then reused. Do not use these agents in areas to which children have access.

Vacuuming

Regularly vacuum accumulations of lint in cracks and crevices. Wherever possible, such potential hiding and

feeding areas should then be sealed with patching plaster and/or caulk.

Exposure to Heat and Cold

Firebrats die when exposed to a temperature of 120°F for one hour. Below freezing and above 112°F, nymphs are killed quickly. Thus, in areas of the building where temperatures can be elevated, use hot air as a lethal treatment. After a general effort has been made to reduce the source of the humidity, a small heater can be used to warm and dry the problem area. The heat should be turned off before the wood surface gets too hot to touch. Books and similar materials that are suspected sources of infestations should be placed inside a plastic bag with a dehydrating agent (anhydrous calcium carbonate) and placed in the freezer for a week to kill all life stages of the insect.

Microwave Radiation

Books infested by silverfish and booklice can be placed in a kitchen microwave oven for 30 to 60 seconds. Most books can undergo this treatment without any damage. The glue on paperback book bindings may soften initially, causing the book to curl a little, but if the book is set on a flat table, it will soon straighten out. This treatment is not recommended for very old books made of parchment or other fragile paper, or for books with gilding or color illustrations that may contain metallic salts in their paints — metals and microwaves don't mix.

Trapping

Silverfish can be trapped very easily in small, clean glass jars. The outside of the jar should be wrapped with

masking tape so the insects have something to grip as they climb up. Tests have shown that adding bait does not enhance the trapping power of the glass jars — they work just as well completely empty. Set the jars upright in areas where silverfish have been seen. Silverfish can also be trapped in sticky cockroach traps. Remember that there is no point in trapping if the original moisture conditions are not corrected; pests will continue to migrate to the damp area.

Drying Stored Articles

Periodic airing and drying of articles stored in damp areas may help reduce the mold on which booklice feed. Disposing of moldy articles is often the simplest way of ridding an area of booklice infestations.

Consider Structural Changes

Condensation from wooden windows can cause mold to grow on and around windows. Sometimes the condensation can be eliminated by switching to aluminum windows with double panes. Other structural changes should be considered in order to reduce moisture accumulations that lead to pest presence.

Chemical Controls

It should not be necessary to use pesticides to control silverfish, firebrats, and booklice. Instead, focus on reducing humidity and on heating or freezing infested articles. When the pests are detected, they can be vacuumed up.

If non-chemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted.

Pesticides must be used in accordance with their EPA approved label directions. Applicators that are hired by the facility must be certified to apply pesticides and should always wear protective clothing during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials when buildings are occupied and never apply them where they might wash into the sanitary sewer or into outside storm drains.

Diatomaceous earth, borate-based insecticidal dust products, and silica aerogel can be used to kill these insects. Diatomaceous earth and borate-based products must be kept dry to be most effective, but silica aerogel will work under damp conditions.

Dusts should be applied only in cracks and crevices, attics, crawl spaces, and other areas that are relatively inaccessible to humans and pets. Wear a dust mask or a professional-quality respirator to provide proper lung protection when applying any dust.

Resources

For management practices and pesticide recommendations on silverfish, firebrats and booklice control, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Educational resource guides on silverfish and firebrats are available at <http://lancaster.unl.edu/enviro/pest/factsheets/005-94.htm>.

IPM for Spiders



Introduction

Although few organisms create as much hysteria as spiders, this fear is largely unwarranted. Most spiders are too small or have venom too weak to harm humans. Many bites for which people blame spiders are really inflicted by other organisms such as insects (fleas, bed bugs, mosquitoes) or mites (scabies, bird mites, etc.).

In Nebraska, the spiders that cause the most concern are the black widow and brown recluse (or violin) spider. Bites from these spiders can have medical consequences, but these spiders generally bite only if provoked and only under certain circumstances. The bite from some other Nebraska spiders can cause allergic reactions in sensitive people, including the parson spider and sac spider.

Spiders are beneficial to humans because they feed on insects and help to control a wide variety of insect pests. Unfortunately, the majority of spiders that are seen and killed by people pose no threat to us at all.

Removal of a Non-Dangerous Spider

Most spiders found in and around a school or child care center can be used as an educational opportunity to teach some interesting facts about these fascinating creatures. If any spider found in the classroom creates

anxiety on the part of the teacher or children and the teacher wishes to remove it, use the following procedure:

- Invert a wide-mouthed jar over the spider.
- Using a piece of stiff paper or thin cardboard large enough to cover the mouth of the container, slide it under the jar while keeping the jar pressed against the surface on which the spider is standing. Work slowly so the spider is not harmed.
- Keeping the card over the mouth of the jar, turn the jar over and tap the paper so the spider falls into the container.
- Holding the paper over the top as a cap, carry the jar outside and release the spider by shaking the container.

General Spider Management

You can control the number of spiders in an area by reducing their food supply. Study the situation to locate the source of their prey. Are too many flies getting in? If so, screens should be installed or repaired. Is security lighting attracting insects at night for spiders to feed on? Insects may also be attracted to poorly stored food or mishandled organic wastes. Don't forget about lounge areas and pop machines where food debris may accumulate. Eliminating the food source for these insects will reduce the food source for the spiders.

Unwanted spiders and their webs can be removed simply by vacuuming. In most cases, vacuuming and reducing the spiders' food source will be sufficient to control the problem. The black widow and brown recluse nest in undisturbed areas, often near the floor; therefore, thorough vacuuming from time to time in these areas can also help in their control.

Black Widow Spiders

Identification and Biology

Black widow spiders, *Lactrodectes* sp, are found in Nebraska, but are very uncommon. All the adult females of the three most common species of black widows in the United States are large (body size is 1/2 inch or larger), shiny black spiders with a red design on the underside of the abdomen that usually resembles an hourglass (see Figure 15-1). Since their webs are near the ground and the spiders hang upside down in the web, this distinctive marking is obvious. The adult male, which is not dangerous, is small and patterned with whitish streaks, bars, or dots on the top of the abdomen.

The black widow spins an irregular, tangled web with a tunnel in the center. The webs are spun in quiet, undisturbed locations that are usually, but not always, close to the ground.



Photo: UNL Department of Entomology

Figure 15-1. Black widow spider

The female spends her life in this web and retreats into the tunnel when disturbed. Her eggs are placed in spherical egg sacs within the web. After hatching, the spiderlings stay near the sac for a few hours to several days and then climb to a high point, wait for suitable air currents, and spin a silken thread so they can float on the breeze like a kite. This method of “ballooning” scatters them far and wide. Once they land, the spiderlings begin to construct their own webs. The abdomen of a young black widow is patterned with red, white, and yellow, but it has black legs and the general appearance of the adult.

Bites

Black widows are shy, retiring creatures that bite reluctantly and only in self-defense when threatened.

When a female is defending her egg sac, she can be more aggressive. Although the bite may not be felt at first, it soon becomes painful. Symptoms include headache and general body ache, nausea, shortness of breath, intense muscle pain, and rigidity of the abdomen and legs. An injection of calcium gluconate can

relieve the pain. Without treatment, these symptoms usually subside in 2 to 3 days. A black widow bite is more serious for a small child or an elderly person.

Detection and Monitoring

Monitor for black widows at night with a flashlight or head lamp. This is the time when they move to the center of their webs and will be most visible. When making your inspections, focus on areas that are dark during the day, undisturbed, but not necessarily close to the ground. Look in and around the following places:

- small crevices anywhere from the foundation to the eaves of buildings
- the undersides of outdoor wooden furniture (for example, beneath the seats in the corners where the legs are braced)
- piles of wood, bricks, stones, or similar materials
- the openings of rodent burrows
- water meters
- cellar doors
- outhouses
- storage rooms

Black widow webs have high tensile strength and, with a little experience, can be identified by the way they “pop” when broken. An experienced pest manager can use this information to find webs during the day.

Management Options

Physical Controls

To achieve some kind of permanent control of black widow spiders, you must try to eliminate not only the

spiders but also the habitats they prefer; otherwise a new black widow will soon find the same habitat and move in. If black widows regularly build their webs in certain locations indoors, try to modify these areas by increasing the light, caulking crevices, or reducing the insect population the spiders are feeding upon. As mentioned before, check window and door screens for holes that let in insects and make sure that foods and organic wastes are stored properly to prevent insect infestations. To reduce or eliminate possible web sites outdoors, debris piles and litter should be removed and discarded. All crevices in foundations and walls that are child-height and wide enough to stick a finger into should be caulked closed.

A black widow is easy to crush with a flat stick or similar tool. The spider can be pressed against one of the surfaces to which it has attached its web. You can also crush the spider with your fingers if you are wearing heavy gloves.

Brown Recluse or Violin Spiders

Identification and Biology

Brown recluse spiders (BRS) are identified by long thin legs, an oval-shaped abdomen, a light tan to dark brown color, and a very distinctive violin-shaped mark on the back (see Figure 15-2). This marking gives rise to another common name, the violin spider. Their overall size is 3/4 inch to 1 1/4 inches. The males are slightly smaller than the females.

There are many species of BRS in the United States. As the common name “recluse” suggests, these spiders are

shy and prefer dark, undisturbed locations.

Nebraska is at the north edge of the range of brown recluse spiders and this spider is rarely found outdoors here. Experts believe humans transport brown recluse spiders to Nebraska in boxes, especially from locations where BRSs are more common, like the southern part of the U.S. Brown recluse spiders have been found in boxes containing retail goods, as well as packed household goods. This is why recluse infestations are most common in warehouses and commercial stores that receive goods from other states. They are also found more frequently in apartments than in single family homes. Unlike the black widow, however, the brown recluse does not capture prey in webs but actively hunts its prey at night. They retreat during the day in undisturbed boxes in storage closets or piles of clothing or fabrics on the floor. They can also live above false ceilings and in wall voids, travelling between rooms or floors on electrical conduit or pipes. Care should be taken when cleaning out storage closets. Sticky traps placed in the corners of storage closets will capture brown recluse spiders and other crawling insects. Captured spiders can be compared with pictures on the internet or identified by experts.

Bites

- Brown recluse spiders avoid areas of human activity. Bites are rare and are usually the result of unused rooms suddenly being put to use, during cleaning activities, or accidental contact resulting from pressing the spider between the body and either clothing or sheets.
- The severity of a person's reaction to the bite depends on the amount



Figure 15-2. Brown recluse spider

of venom injected and individual sensitivity to it. Bite effects may be nothing at all, immediate, or delayed. Some may not be aware of the bite for 2 to 8 hours, whereas others feel a stinging sensation usually followed by intense pain if there is a severe reaction. A small white blister usually rises at the bite site surrounded by a large congested and swollen area.

- Within 24 to 36 hours, a systemic reaction may occur with the victim characterized by restlessness, fever, chills, nausea, weakness and joint pain. The affected area enlarges, becomes inflamed and the tissue is hard to the touch. The spider's venom contains an enzyme that destroys cell membranes in the wound area with affected tissue gradually sloughing away, exposing underlying tissues. Within 24 hours, the bite site can erupt into a "volcano lesion" (a hole in the flesh due to damaged, gangrenous tissue).
- This ulcerous wound takes a long time to heal. Young children, the elderly, and the infirm are most likely to be affected severely. Victims should seek medical attention

but should never allow a doctor to excise the affected tissue.

- From a legal liability standpoint, schools, child care centers, nursing homes, hospitals, and similar institutions should take measures using a pest control professional to control a brown recluse spider infestation. Because these spiders live in hidden locations, baseboard treatments are not always effective. Treatments with desiccant dusts, applied in wall voids and above false ceilings are generally more effective methods of control than are liquid treatments.

Detection and Monitoring

The brown recluse spider wanders at night searching for prey. It seeks dark, uninhabited areas for protection. Brown recluse spiders are usually found on floors and baseboards. Only rarely are they seen on desks and tables, and walls.

Searches for this spider should concentrate in uninhabited areas close to the floor, particularly in boxes; around piles of paper, clothing, and debris; in closets; and under

furniture. Periodic checks outdoors should focus on storage sheds, piles of debris or wood, cracks in the soil or in foundations and walls, and window wells, especially if small children play near those places.

Management Options

Physical Controls

Since these spiders prefer undisturbed places for nesting and hiding, periodic, thorough cleaning can help reduce their numbers. You should vacuum floors frequently. Boxes of paper and other items stored in closets or anywhere else that is dark and undisturbed should be handled carefully when first inspected. If brown recluse spiders are suspected, the boxes can be placed in a bin-type freezer for 48 hours to kill the spiders before the boxes are unpacked. A small hand-held, battery-powered vacuum can also be used while checking through stored items. If a spider is vacuumed up, the vacuum bag can be slipped into a plastic bag and then placed in a freezer to kill the spider. Outside, remove piles of debris, wood, and rock. Fill cracks in walls and foundations with mortar or caulk. Inside, clothing and other objects should be removed from floor areas in closets, locker rooms, and other storage spaces. Since most bites are received when putting on shoes or clothing that has lain on the floor, clothes normally stored near the floor should be moved to a higher location. Shake out clothes if they were on a floor overnight. Hang shoes or place them in sealed plastic bags to reduce the likelihood of being bitten. Wear leather gloves while searching through stored items to help prevent bites.



Photo: UNL Department of Entomology

Figure 15-3. Parson spider

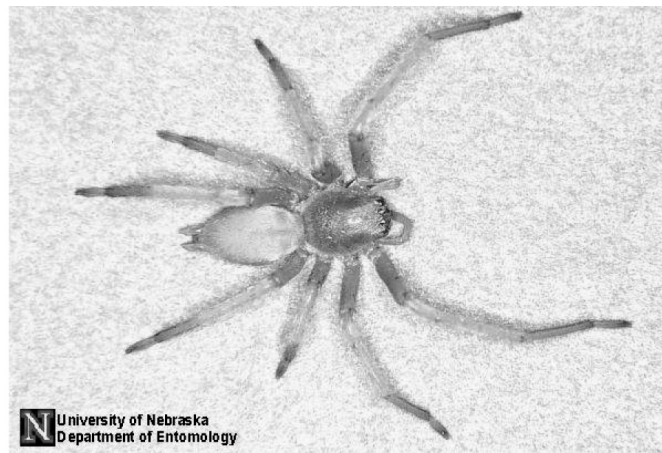


Photo: UNL Department of Entomology

Figure 15-4. Sac spider

Parson Spiders

The parson spider is generally non-toxic; although some people may experience allergic reactions to the bites. The parson spider is about 1/2 inch long and may vary in color from brown to black (see Figure 15-3). The front segment of the body tends to be a chestnut to black color, while the abdomen is grayish with a distinctive white or pink pattern along its middle. The body is covered with fine hairs, giving a velvety appearance. The parson spider is usually found outdoors under rocks or in piles of brush or firewood. This spider does

not spin a web but wanders on the ground in search of prey.

Indoors, this spider wanders about at night and conceals itself beneath objects or in clothing during the day. Most bites from this spider occur at night or when it is trapped in clothing. While the parson spider is not considered venomous, bite symptoms are variable in severity. Some people may experience localized allergic swelling and itching in addition to initial pain. A few individuals may experience excessive swelling, nervousness, nausea, sweating and elevated temperatures from the bites.

Sac Spiders

Some members of this group of spiders are quite common in homes. These spiders are light or dark-colored and have a darker coloration on the cephalic (head) region (see Figure 15-4). The body is covered with short hairs that give it a silky appearance.

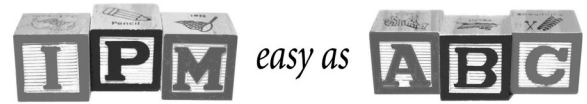
These spiders do not capture prey in webs but actively hunt at night. During the day, they hide in tubular silken capsules they construct, which gives them their common name. You may be able to find silken capsules on walls, ceiling, draperies and other locations. Bites from these spiders may result in localized allergic reactions in some individuals.

Resources

For management practices and pesticide recommendations on spider control, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Educational resource guides on spiders are available at <http://lancaster.unl.edu/pest/spiders.shtml>.

IPM for Trees and Shrubs



Introduction

Across the United States, landscapes vary so greatly that it would be impossible to provide specific management suggestions for all the pest problems on the many trees and shrubs that might be encountered. In this chapter, we will try to provide a basic framework that will enable you to solve your own problems using information from your specific site.

Plant Health Care Management

Plant health care management (PHC) is a relatively new concept in managing landscapes that was developed from the concept of integrated pest management (IPM). Many arborists, horticulturists, and landscape managers have long felt that IPM's focus on "pests" is too narrow when it is applied to landscape plants. Probably over half of the problems encountered in landscapes or gardens are not attributable to insects, mites, or disease; instead, they are the result of compacted soil, drought stress, over watering, frost damage, and many other factors. To effectively manage landscapes, plant health and the ecosystem in which the plant is growing must be taken into consideration. PHC takes just this kind of broad approach. PHC incorporates all the principles of IPM, including monitoring, recordkeeping, and integrating treatments, but PHC emphasizes plant health and proper management practices. PHC is plant

management, not just pest management. By focusing only on pests, we often overlook the horticultural or environmental factors that affect plant growth and health.

Components of a PHC Program

Van Bobbitt, Community Horticulture Coordinator for the Washington State University Cooperative Extension, lists the following 5 components of a PHC program:

- Know your plants.
- Determine key problems.
- Study your landscape ecosystem.
- Promote plant health.
- Consider a variety of strategies to manage pests.

Know Your Plants

Before you can properly care for the trees and shrubs on your grounds, you must know what they are. Make a map of the grounds and identify every tree and shrub. There are books that can help you with this, or you can take a specimen to a nursery, the local UNL Extension office, or to a landscaping professional.

Once you know the names of all of your plants, do some research on each one. Talk to nursery personnel and horticulturists and read about your plants in gardening books. From

your research, you should be able to answer the following questions:

- What kind of soil does the plant prefer?
- How much water does it need?
- If and when should it be fertilized?
- How should it be pruned?
- Does it prefer shade or sun?
- How much heat or cold can it tolerate?
- What are its most common pest problems?
- What environmental problems is it susceptible to (planting depth issues, stem girdling roots, soil compaction, air pollution, salt damage, etc.)?

Your research and your experience can help you to identify key plants that are prone to problems and will therefore need more of your time and attention than other plants. If there are many trees and shrubs on the grounds, this information can help you focus your maintenance activities. You may also want to use this information to remove plants that are not suited to their sites, that have too many problems, or that require too much care.

Determine Key Problems

Many things can affect the health of a tree or shrub, and they are generally divided into biotic factors and abiotic factors. Biotic factors are

living organisms such as diseases, insects, mites, deer, etc. Abiotic factors include planting issues (roots too deep in soil and stem girdling roots), maintenance practices (fertilizing, pruning, and over or under irrigation), weather, soil quality, amount of sunlight, and human activities such as grade changes over an existing root system, vandalism, or compaction of the soil caused by constant foot traffic. These abiotic factors are probably responsible for a majority of the landscape plant problems.

Determining key problems involves deciding which problems are most likely to affect the health of your plants. Ask yourself if the problem is a serious threat to plant health, a minor threat, or just an aesthetic problem. Again, your research and your experience will help you answer these questions. For instance, one plant disease may kill a tree, but another disease may cause premature leaf drop year after year without seriously affecting tree health.

It is likely that you will have not only key problems, but also key problem sites. For example, perhaps the heavy equipment used in remodeling the structure last year has severely compacted the soil in several areas, or perhaps drainage is poor in one corner of the site because of heavy clay soil. These sites will need special attention and most likely special plants.

Learn as much as you can about your key problems. If they are living organisms, learn about their life cycles, learn how to identify various stages of the pest and how to recognize symptoms of damage. Do enough research to help you decide which management options are both safe and effective.

If the problems are abiotic, you will need to research these also. Are there specific symptoms that you can learn to recognize? What techniques are available to you for solving the problem? Which solutions can you afford and which are best suited to the particular site? Are there specific well-adapted plants that can tolerate the problematic abiotic factors?

Hiring a nursery professional to walk through your landscape with you may be a good way to create your landscape inventory and assess plant health at the same time.

Study Your Landscape Ecosystem

Your landscape is an ecosystem with complex relationships among the plants, animals, water, soil, sunlight, weather, etc. Because of these complex relationships, there are many things you will need to pay attention to in order to promote plant health. Questions you will need to answer include the following:

- What is your climate? What are the maximum and minimum temperatures?
- Are there microclimates on site that might affect plant growth?
- Where do the prevailing winds come from? Are they unusually strong?
- What are your seasonal patterns of precipitation?
- Where are the sunny and shady parts of the yard? (These will change over time as plants grow and die during different times of the year and different times during the day.)
- What are the characteristics of the soil in each part of the yard?
- What are the drainage patterns?

- What is the history of each area on the grounds? What plants were grown there? (This can be an important factor for some plant diseases.) Was the area covered with asphalt or concrete at some point? Did a road or path go through the site?
- Are animals such as squirrels, deer, and dogs having an impact on the landscape? (The salts in dog urine can be very damaging to plants.)
- What human activities are having an impact on the landscape? Are children vandalizing plants? Is turfgrass growing right up to the trunks of trees so that mowers regularly damage the trees? Are city de-icing operations adding salt to the soil?
- What kind of irrigation system is installed in the landscape and is it in working order? Are plants getting too little or too much water?
- Is air pollution a problem in your area? (Air pollution affects plants as well as animals.)

Since landscapes are constantly changing, you will need to monitor frequently in order to detect problems early. Monitor at least every two weeks during the growing season. Focus your monitoring efforts on your key plants and your key problems. Be aware that plants growing in poor conditions are under stress and are often more likely to suffer from insects and disease. As you monitor, look for the kinds of damage symptoms you learned about in your research.

Promote Plant Health

Proper plant care is the foundation of a PHC program. Healthy plants mean healthy landscapes, and healthy landscapes have fewer problems and

require less special attention. The following points will help you to minimize cultural and environmental problems, as well as pest problems.

- Match the plant to the site. For example, you cannot grow a subtropical swamp plant in a cold dry site. Some plants cannot grow in full sun, and some plants are better adapted to salty or compacted soil or soil with poor drainage. For help with finding plants for your area or for problem sites, talk to local gardening clubs, nurseries, UNL Extension or Nebraska Forest Service personnel or consult books on regional gardening.
- Select pest and disease resistant species.
- Plant a diversity of species so that a single pest problem will not devastate your landscape.
- Know what kind of care each plant needs and pay special attention to how you water, prune, and fertilize it. If possible, group plants with similar growing requirements together. For example, place water-wise annuals and perennials together in beds separated from turf areas. This ensures all plants have their ideal growing conditions and helps create a low maintenance landscape.
- Include “insectary” plants in your landscapes. These are plants that attract and feed beneficial insects with their nectar and pollen, for example, sweet alyssum, flowering buckwheat, members of the parsley family such as fennel and yarrow, and members of the sunflower family such as sunflowers, asters, daisies, marigolds, zinnias, etc.
- Use proper planting techniques when installing vegetation (Figure 16-1).



Photo: Erin Bauer

Figure 16-1. Ensure tree health by planting at the proper depth.

- Improve the soil with organic matter and mulches.

Consider a Variety of Strategies

If you determine that a problem needs to be treated, it is important to consider a variety of strategies and to integrate those strategies into a comprehensive program. Treatment strategies can be divided into several general categories (each of these strategies is discussed in detail in Chapter 4, Treatment Strategies):

- **Education.** This can include educating students staff, and residents about respect for landscape plantings; for example, the more that children can be involved in the planting and care of various portions of the school yard, the less they will vandalize these areas. Education can also involve training maintenance staff in various aspects of plant care and plant selection.
- **Cultural Controls.** These techniques include modifying management practices to prevent plant problems or to improve plant

health, such as making sure plants are planted correctly or reducing water applications to overwatered plants.

- **Biological Controls.** Beneficial insects and other organisms can be used to combat pests. *Bacillus thurengiensis*, commonly sold as Dipel or Thuricide, is a biological insecticide used to control moth larvae. More and more beneficial organisms are becoming commercially available, and by planting “insectary” plants, you can attract beneficial insects already in your area.
- **Chemical Controls.** Pesticide applications not prohibited in a PHC program, but they are used as a last resort, and then they are used judiciously and in the least-toxic formulations. Always spot-treat to minimize the amount of active ingredient used.
- **No Action.** This can be a valid strategy in many situations where the problem does not seriously affect the health of the plant. Your research will help you understand

which problems are serious and which are minor or simply aesthetic problems.

Conclusion

PHC is an environmentally sound approach to managing landscapes and can result in healthier trees and shrubs that can better withstand the ravages of insects and disease. Although PHC requires time and work coupled with knowledge and experience, the reduction in the use of pesticide along with the long-term benefits to the landscape will far outweigh these expenditures of time and energy.

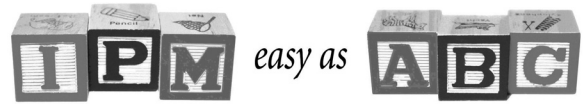
Resources

For management practices on trees, shrubs, and other plants, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Additional information on trees, shrubs and other plants is available at the following:

- **Backyard Farmer:**
<http://byf.unl.edu/>
- **Nebraska Statewide Arboretum:**
<http://arboretum.unl.edu/>

IPM for Turf and Grounds



Introduction

In many sensitive environments, turf often covers several acres and serves important roles as athletic fields, picnic lunch sites, outdoor classrooms, and general recreational areas for the community at large.

Heavy use of turf and athletic fields causes stress that predisposes grass to invasion by a variety of weeds, pest insects, pathogens, and vertebrates such as gophers and moles. Since the bodies of children and youths are often in direct contact with the grass, use of pesticides on lawns increasingly raises concerns among parents and health professionals. On the other hand, coaches and administrators are under pressure to ensure quality turf for use by students and by community athletic leagues.

In addition, the competence of landscape maintenance staff is often judged by the aesthetic appearance of the lawns that surround buildings. These various viewpoints often come into conflict when pests threaten lawns.

The key to turf IPM is the use of cultural practices that optimize growth of grasses and minimize conditions favorable to pest insects, weeds, or pathogens. The following discussion describes how to implement an IPM approach to lawn care. Since specific methods for managing all possible turf pests is beyond the scope of this chapter, a general IPM approach is described.

Detection and Monitoring

An IPM approach to turf management begins with a monitoring program. Monitoring entails making regular inspections of the lawn to gather and record site-specific information on which to base pest management decisions. Tools useful for monitoring turf are listed in Box 17-A.

Monitoring enables turf managers to do the following:

- identify the pest(s)
- identify any natural enemies of the pest(s)
- use preventive methods to reduce the occurrence of pest problems
- determine *if* any treatment is needed
- determine where, when, and what kind of treatments is needed
- evaluate and fine-tune treatments as the pest management program continues over the seasons

Developing Background on Local Pests

When beginning a monitoring program, some effort should be made to become familiar with the common pest insects, weeds, and lawn pathogens found in the local area. Learn about their life cycles and how to recognize them.

It is also important to learn to recognize the natural enemies of common turf pests and factor their presence into deciding if treatments are needed and which ones to use.

Gathering Background Data on the Site

The next step in a monitoring program is to map all turf areas, noting locations of existing pest problems or conditions that can produce pest problems (bare spots, broken sprinkler heads, etc.). Identify the turf grasses in each area and record the maintenance history of the turf and current management practices. Soil should be tested at representative sites to assess fertility status and requirements. If any pest organisms are present, be sure to get an accurate identification. Many unnecessary pesticide applications can be traced to mistaken identification of pests.

Next, give each major section of turf an identifying number and prepare a monitoring form for recording ongoing maintenance activities and information about pests and their management in each section of turf.

You will need to compile an inventory of existing turf maintenance equipment. In addition to mowers, is there an aerator, de-thatcher, and fertilizer spreader that can handle sludge or other organic materials? Is there a spring-tooth harrow for removing weeds from infields and running tracks? These are useful tools

in nonchemical lawn management. Prepare a list of equipment that is needed so it can be worked into the budget process. Inspect the condition of the equipment. Are mower blades kept sharp? Can mowing height be adjusted easily? Does the equipment have flotation tires to reduce soil compaction?

Developing Pest Tolerance Levels

Most turf can tolerate some pest presence without compromising appearance or function. The challenge for the turfgrass manager is to determine how much damage is tolerable and when action is needed to keep pest damage within tolerable levels. Since the competing interests in the turf mentioned earlier must be taken into account when deciding whether or not treatments are warranted, it is good practice to involve representatives of these interest groups in setting pest tolerance levels for turf areas.

One approach is to work with an IPM advisory committee (Chapter 5) to develop pest tolerance levels for turf at each site. Tolerance levels will differ, depending on location and uses of the turf. For example, tolerance for pest presence on turf at the front of a building in public view may be lower than tolerance on playing fields, such as behind school buildings. Tolerance levels may also differ depending on the particular pest. Tolerance levels can be quantified in a number of ways. A simple way to quantify the amount of weeds growing in a lawn is to measure off several 10 x 10 foot areas in the turf. Give a visual estimate of the percentage of weeds in a given 100 square foot area. The areas can be averaged to give an estimate for the large turf area. This permits expression of tolerance levels by percentage of weeds, for example, “up to 25 per-

BOX 17-A.

Tools Used to Monitor Turf

The following tools are useful for monitoring turf. They can be carried in a sturdy bag designed to transport baseball equipment (available at most sporting goods stores). The soil probe with its extension fits snugly in the bottom pocket designed for baseball bats, and everything else fits into an upper zippered area.

- soil probe
- pH meter
- soil thermometer
- 10-power hand lens (magnifying glass)
- watering can and bottle of detergent
- plastic bags for collecting specimens
- clip board and forms for recording data
- a ball of twine or clothesline for taking transects
- a small hand trowel and knife
- camera
- field guides for identifying pests and natural enemies
- pheromone traps for cutworms, sod webworms, etc.

cent weed growth is tolerable on the back turf at the child care center; only 10 percent is tolerable on the football field at the high school.”

Tolerance for insect damage can be correlated with numbers of insects present and amount of visible damage. For example, white grubs can be monitored by examining several areas of soil underneath the grass. A spade is used to cut three sides of a 1-foot square of grass. The grass is carefully folded back, using the uncut edge as a hinge. Dirt from the roots is removed, and the number of exposed grubs counted. Then the grass can be folded back into place, tamped, and watered in. In well-managed turf, up to 8-10 Annual White Grubs

(Masked Chafers) per square foot can be present without causing any appreciable damage to the turf. In stressed or poorly managed turf, however, 8-10 per square foot might seriously damage the grass.

By setting tolerance levels, turfgrass managers can gear their management efforts to keeping pest populations within tolerable levels, and apply treatments only if, when, and where necessary. By involving members of the community in setting treatment guidelines, confrontations can be minimized and broad support developed for the IPM program.



Photo: Erin Bauer

Figure 17-1. Monitor turf for signs of stress or damage.

Evaluating Pest Management Practices

When actions are taken to reduce pest presence, monitoring data should be used to evaluate the effectiveness of the treatment (Figure 17-1). Did pest numbers go down sufficiently to prevent intolerable damage? Were treatments cost effective? Is the problem likely to recur? Can conditions causing chronic pest problems be altered or removed? If not, can other ground covers better suited to conditions at the site replace the turf?

Management Options

When pest numbers threaten to exceed tolerance levels (i.e., the action level is reached), there is a wide variety of strategies and tactics available to solve any turf pest problem. The first approach is to address conditions causing stress to turf.

Stress and Pests

The pest problem of greatest concern on turf — and target of highest pesticide use — is growth of weeds,

such as dandelions or crabgrass. Presence of weeds is a symptom of turf undergoing stress — a common occurrence on the grounds of many structures. Turf stress can contribute to the development of insect and disease problems as well.

Sources of stress include levels of use unsuited to the grass species that has been planted, compacted soils, improper mowing heights, too much or too little irrigation or fertilization, and accumulation of thatch.

Knowing the identity of the pest and something about its biology often reveals the specific source of stress. By relieving the stress, the pest problem can be reduced or eliminated. For example, the weed yellow nutsedge grows best in wet soils — indicating a faulty or broken irrigation valve or a low spot in the turf. The presence of sod webworm damage, on the other hand, indicates high webworm populations and drought stress while brown patch disease suggests excessive fertilization with soluble nitrogen fertilizers.

Reducing Stress on Turf

The best method for reducing stress on turf is to employ good management practices during turf installation and maintenance. Even where budgets are limited, key sources of stress can be avoided or diminished by minor changes in maintenance practices such as raising the mowing height or changing fertilizer formulations. The following lawn care suggestions will help keep pest problems to a minimum.

Maintaining Healthy Soil

The most vigorous turf growth occurs in loose, loamy soils teeming with beneficial microorganisms, insects, worms, and other organisms. These organisms play critical roles in transforming thatch and grass clippings into humus. Humus slowly releases nutrients and buffers grass roots from extremes of drought or other stresses. Soil organisms also play an important role in biological pest control. For example, certain beneficial microorganisms (endophytes) protect grass roots from attack by soil pathogens or insects such as white grubs.

The presence of humus in the soil is key to a healthy soil ecosystem. The best way to improve poor soils and maintain healthy soils is to ensure that organic matter is routinely replenished by leaving grass clippings to decompose, and fertilizing or top-dressing with organic materials such as sludge, composted manure, etc.

Planting Appropriate Grass Species

Turf can be subject to high levels of use and wear, and maintenance budgets are usually low. Thus, select blends of grass species tolerant to such conditions and resistant to local pest problems. Check with the UNL Extension office closest to you for

recommendations suited to local climate and conditions.

Reducing Soil Compaction

When turf is heavily used or simply mowed on a regular basis, the soil eventually becomes compacted, and the pore spaces that allow water and air to pass through the soil become compressed, creating adverse conditions for root growth.

Compaction can be reduced through aeration, topdressing, and rotation of mowing patterns.

Aeration involves removing plugs of grass and soil to improve air exchange and water penetration into the soil. Ideally, heavily used turf should be aerated two to four times per year, although even a single aeration is better than none. Since aerating can provide a seedbed for problem weeds, you should time aeration operations to avoid periods when heavy seeders such as crabgrass are germinating or setting seed. Aeration should also be timed so that it is not done when the turf is under stress. For cool-season grasses such as tall fescue and Kentucky bluegrass, this means avoiding cultivation during the summer months.

Consider following aeration with a topdressing of compost along with seeds of the desired grass. If topdressing is not done after aerifying, the cores can be left on the turf and broken up by repeated mowings.

Mowers and other maintenance equipment compact the soil. By rotating the point of mower entry onto the turf from week to week, compaction at entry points can be minimized.

Raising the Mowing Height

Most temperate grasses used on turf planted near structures (tall fescues, perennial ryegrasses, bluegrasses, etc.) can be mowed at a height of 2 1/2 to 3 inches without sacrificing vigor or function as ball fields or recreational areas. Game fields may be mowed lower but never shorter than 1 1/2 inch. The taller the grass can be kept and the denser the canopy, the greater the interception of available sunlight. By keeping the soil shaded, weed seeds are less likely to germinate.

Adjust mowing frequency to changes in the growing season. Weekly intervals may be appropriate when grasses are growing vigorously, but when grasses are semi-dormant, 14 or 21 days may be more appropriate. The right interval between mowings allows grasses to recover from the previous cut and enter the second growth phase when new blades, called tillers, are produced from the growing points. "Tillering" keeps turf growing in a tight, dense manner that discourages weeds.

Careful Irrigation

Too much or too little water stimulates pest problems. For example, many turf diseases result from excessive irrigation. Development of a disease can often be arrested by letting the turf dry out, then keeping irrigation to a minimum.

The length of time needed to adequately water turf is determined by the time it takes to wet it to the depth of the root system. Most grass roots extend 4 to 6 inches in the soil, but because grasses and soil conditions differ, irrigation schedules must

be tailored to individual lawns and adjusted for seasonal changes. During most of the growing season, infrequent, deep irrigation is preferred since frequent, shallow watering promotes shallow rooting. A more frequent watering schedule (every 3 to 4 days) during the summer may be needed to keep the turf actively growing. Use a soil probe or a pointed tool such as a screwdriver to determine when soil is wet 4 to 6 inches below the soil. This will indicate how long to leave sprinklers on during each irrigation. Irrigation equipment should be checked to ensure that it is in good repair and that all areas of turf receive adequate coverage. Low spots should be leveled or drained to avoid waterlogged soils that favor weeds and pathogens.

Keeping Thatch to a Minimum

Thatch, common in Kentucky bluegrass, is the accumulation of dead but undecomposed roots and stems that collect in a layer at the soil surface. If the thatch becomes excessively deep—greater than 1/2 inch—water and nutrients do not penetrate the soil adequately. When water puddles on thatch, it enhances the habitat for disease organisms. Regular aeration keeps thatch at an acceptable level, and the use of organic fertilizers such as composted sewage sludge promotes thatch decomposition. Excessive layers of thatch can also be removed with de-thatching rakes or with power dethatchers available from equipment rental companies.

It is wise to seed the area with desired grasses wherever turf is thinned by de-thatching procedures. The seeds can be mixed into the topdressing (soil amendments or organic fertilizer) that is customarily applied to thinned turf.

Fertilizing with Restraint

Excessive nitrogen fertilizer produces weak grass blades with thin cell walls that are susceptible to pest attack. A soil test should be obtained every 3-5 years as needed. Only the levels of nutrients needed should be applied. Two fall fertilizer applications are important for turf growth. The first fall application should occur around Labor Day and the second at the time of the last mowing. The grass should still be green when making the last application. A spring fertilizer application may be made, if necessary. Avoid heavy fertilization in the summer. Use slow-release fertilizer to prolong the availability of nutrients throughout the growing season. When feasible, organic materials such as compost are preferable because they provide organic matter to support soil microorganisms and improve soil health.

Direct Pest Suppression

When the management practices listed above are not sufficient to solve the pest problem, direct suppression methods including physical, biological, and chemical controls can be integrated into the program. Physical controls include using a flamer to spot-treat weeds or using a bamboo pole to flick off dew from grass blades in the early morning to deny nourishment to turf pathogens. Biological controls include topdressing lawns with microbially enhanced soil

amendments to kill turf pathogens. Chemical controls include insecticides, herbicides, and fungicides.

Resources

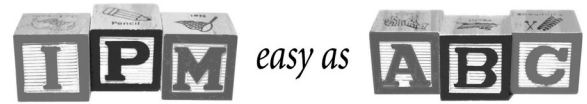
For management practices and pesticide recommendations on diseases, weeds, and insects of turfgrass, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

For detailed information on IPM in turfgrass for Nebraska, see *Integrated Turf Management for the Northern Great Plains* (EC1557, available from Educational Media, Box 830918, University of Nebraska-Lincoln, Lincoln, NE 68583-0918, or on-line at: <http://www.ianrpubs.unl.edu/sendIt/ec1557.html>).

Turf iNfo for the North Central US: <http://turf.unl.edu>

UNL Turfgrass Entomology at <http://entomology.unl.edu/turfent/>

IPM for Wood-Damaging Pests



Introduction

The job of maintaining a building includes detecting structural pest problems before they become severe. Early detection means less costly repairs. Although the discovery of wood-destroying insects often generates panic and premature decisions, these pests are slow to cause new damage, and there is ample time to accurately identify the pest and decide on an appropriate IPM program. Some of the work can be done by facility personnel, and the rest contracted out to a professional, or the entire job can be contracted out to professionals. This chapter will discuss wood-attacking fungi, termites, and wood-boring beetles.

Identification and Biology

Wood-Attaching Fungi

Fungi reproduce from seed-like spores present in the air and soil. Thread-like structures called hyphae grow from the spore and penetrate directly into wood. A mass of hyphae, called a mycelium, is frequently visible on the surface of the wood. A mycelium often takes the shape of a fan or a fluffy mat. Optimal growth occurs at temperatures between 50°F and 95°F on wood containing at least 20 percent moisture.

The three major groups of wood-attacking fungi are surface-staining fungi (molds and mildews), sap-

staining fungi (wood-stains), and decay fungi (wood rots). Surface-staining and sap-staining fungi do not cause loss of structural strength and will not be discussed here; however, they are evidence of moisture problems needing correction. The third group, decay fungi, attack the cellulose and lignin in wood and cause structural weakness. They are hard to detect in their early stages; however, advanced stages are quite evident from the changes in the wood's appearance.

Brown Rot

- characterized by white mycelial mats
- causes wood to crack into small cubical pieces perpendicular to the wood grain
- wood rapidly loses its strength and eventually crumbles to powder
- changes the color of the wood to a distinctive brown

Dry Rot or Water-Conducting Rot

- relatively rare problem
- a special kind of brown rot most often found in new construction
- can disperse rapidly throughout wood, destroying large amounts in one to two years
- characterized by large, papery, white-yellow mycelial fans

- forms large tubes called rhizomorphs that are up to an inch in diameter and can conduct water to 25 feet
- rhizomorphs are dirty white to black, and grow out and away from the moisture source
- rhizomorphs allow the fungus to extend its growth into dry wood containing less than 20 percent moisture
- wood surface may appear sound but wavy, even while the interior is heavily decayed

White Rot

- makes wood look bleached
- affected wood feels spongy when probed and is stringy when broken
- no abnormal shrinkage
- strength of the wood gradually diminishes

Soft Rot

- seldom encountered in buildings, except where wood is in contact with constantly wet soil
- develops in marine habitats in wood that is too wet for other decay fungi
- attacks surfaces of wood and produces a gradual softening inward

Termites

Although there are a number of groups of termites in the United

States (including subterranean, dry-wood, dampwood, and powderpost termites), only subterranean termites are found in Nebraska. They are social insects and form colonies that contain several castes — reproductives (queen and king), workers, and soldiers. These castes differ greatly in their form and function.

The total number of eggs deposited by subterranean queens number in the tens of thousands. Nymphs hatch in 6 to 12 weeks and are tended by the worker caste, except when a new colony is becoming established. As the nymphs increase in size and number, castes are formed. The worker caste maintains and feeds the colony, and the soldier caste defends the colony. The darkly pigmented, winged reproductive caste (kings and queens) serves only to reproduce and start new colonies. Reproductives “swarm” (fly away from their original colony) only at certain times of the year.

Subterranean Termites

Subterranean termites (Figure 18-1) require specific ecological conditions. Knowing these requirements is critical to their successful detection and management.



Figure 18-1. Subterranean termite workers.

- Subterranean termites must be in regular contact with moisture, which, in most cases, means they must stay in contact with the soil.
- In rare cases, they live in the wood above the soil, getting their moisture from a leaky air-conditioner, regular condensation, or some other constant moisture source.
- They construct distinctive earthen tubes to bridge the distance between the soil and wood.
- The passageways protect them from predators and help prevent desiccation as they travel. These tubes are important visible clues to subterranean termite presence.
- Initially, subterranean termites tunnel into soft spring wood, but as the infestation grows, they remove more and more wood until most of it is gone.
- They reinforce their excavations with “carton,” a mixture of wood fragments and fecal material held together by saliva.
- Subterranean termite galleries are coated with a carton-like substance that gives the interior of the galleries a rough and uneven appearance.

Wood-Boring Beetles

Although some wood-boring beetles can cause serious damage, there is always time to identify the type of beetle present before taking action. When dealing with wood-boring beetles, it is important to know whether or not they will reinfest a piece of wood. Some beetles cannot, and seeing their holes in wood means they have done their damage and left. See Table 18-1 for more information to help you identify some of the most important beetles. Listed here are three examples of wood-boring beetles.

Lyctid Powderpost Beetles

These are small (1/8-1/4 inch), slender beetles that vary from reddish brown to black (Figure 18-2). Lyctids attack only the sapwood (outer wood) of hardwoods and are the most common and widespread of the beetles that reinfest wood in the United States.

Females lay an average of 20 to 50 eggs in exposed areas of partially seasoned lumber with a high starch content. The hatched larvae bore down the vessels of the wood making straight tunnels that then turn and become irregular. Most species complete their life cycle in 9 to 12 months, but they can develop more quickly if the temperature and starch content of the wood are favorable. The larvae pupate near the surface of the wood, and the emerging adults drill a hole through the wood to get out.

You are unlikely to see adult beetles during an inspection, and the larvae are always inside the wood. There is no outside evidence of infestation on wood that has been attacked for only a short time; however, once adult beetles emerge, you will see their

small exit holes in the wood. You may also see piles of the fine, flour-like frass (beetle excrement) that sifts from the holes.

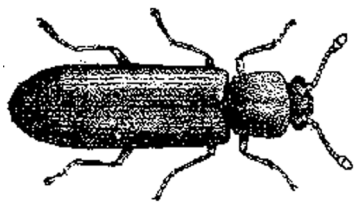


Figure 18-2. Lyctic powderpost beetle

Anobiid Beetles (sometimes called deathwatch or furniture beetles)

These beetles are small (1/8-1/4 inch), reddish brown to black, and elongate with a very rounded back (Figure 18-3). In general, beetles in the family *Anobiidae* are more frequently a problem in unheated dwellings or wherever the humidity is high. Furniture kept in centrally-heated living spaces is usually too dry for them to infest.

Anobiids attack both hardwoods and softwoods and will feed on either newly seasoned or older wood. Although they feed mainly on the sapwood, they can also damage heartwood that is close to the sapwood. In the wild, they live in dead tree limbs or in bark-free scars on the trunks.

The females lay their eggs in small cracks or crevices on the surface of the wood. When the larvae hatch, they bore a short distance into the wood, then turn at a right angle and tunnel with the grain. Their tunnels get larger as the larvae grow, and eventually, become so numerous that they intersect, and the wood becomes a mass of fragments. Tunnels are packed with fecal pellets from the

larvae. It may take two to three years for larvae to complete their development.

Larvae usually pupate in the spring. The newly emerged adults bore holes straight out of the wood, and a large proportion of the females lay eggs in the same wood from which they emerged.

Old House Borer (*Hylotrupes bajulus*)

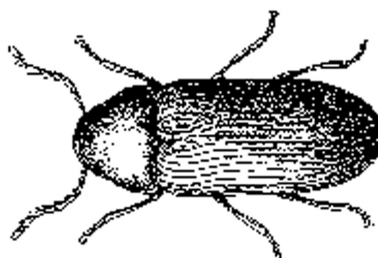


Figure 18-3. Anobiid beetle

These beetles are brownish black, slightly flattened, and about 5/8 to 1 inch long. The segment just behind the head is marked by a shiny ridge and two shiny knobs that suggest a face with two eyes. These beetles are very common in some parts of the country, but because they can be moved around in infested wood, they can become established anywhere.

Despite being called the “old” house borer, this insect is also very common in new construction. This beetle attacks coniferous wood, such as pine, spruce, hemlock, and fir, but it will also feed on hardwoods. The female lays her eggs in cracks and crevices on the surface of wood, and the hatched larvae sometimes crawl around before finding a place through which they can bore into the wood. They remain near the surface, feeding on the sapwood and only gradually penetrating deeper as they grow. They do not feed on heartwood.

The larval period may be completed in two to three years, but it can take as long as 12 or 15 years in dry wood, such as that found in attics. Old house borer tunnels have a distinctive rippled appearance on the inside. Unless the moisture content is high, the tunneling proceeds slowly.

Although this beetle can reinfest wood, the likelihood of this happening in buildings that are occupied, heated, and well ventilated is small.

Detection and Monitoring

It is important to determine exactly which organisms are present and causing damage before deciding on treatment strategies. The actual damage caused by structural pests occurs slowly over a period of months or years so there is time to study the situation and make a decision. Correct identification of the pest is critical to determining appropriate management strategies. The diagnostic key in Table 18-1 will help you identify the pest that is causing the problem. Figure 18-4 illustrates some of the major differences between ants and termites, which are often confused with each other. Note that in some cases more than one kind of wood-damaging pest may be present.

Table 18-2 describes the major groups of wood-boring beetles and the damage they cause. Wood-boring beetles can be distinguished from one another by the type of frass they produce and the size and shape of the holes they create. It is important to distinguish between those species of beetles that can reinfest wood, causing extensive damage, and those beetles whose damage is limited to one generation.

If you are uncertain about which pest is present, get help making an identification from the local Extension office or a pest management professional. The time and potential expense needed to correctly identify the pest will be compensated by the fact that you will be able to develop an effective management program.

Regular Monitoring

Monitoring involves looking for signs of damage, on a regular basis, to the wooden parts of the structure. Information gathered from these regular site inspections should be written down. Include a map of the site with notes about problem areas. Monitoring should show whether a pest problem is getting worse and requires treatment and whether the treatment has been effective.

Monitoring for structural pests should be regarded as an ongoing responsibility, repeated every one to five years depending on the kind of problems in your area. Early detection of structural pest activity will result in considerably less expensive treatment later.

Box 18-A. Tools and Safety Equipment for Monitoring Termites

- Flashlight with spare batteries and bulbs
- Screwdriver or ice pick for probing wood suspected of being infested
- Hammer or similar instrument for hitting wood and listening for indications of hollowness
- Ladder for inspecting roof trim and other off-ground areas
- Moisture meter with a range of at least 15 percent to 24 percent moisture
- Pencil, clipboard, graph paper, and measuring tape; with these, records can be made precisely on the floor plan or elevation of the building where moisture is evident or wood is damaged
- Tools for opening access entrances into crawl spaces
- Hacksaw blade for checking earth filled porches adjacent to crawl spaces; when inserted under the sill, the thin portion of the blade should not penetrate beyond the sill or headers
- Good-quality caulk, such as silicone seal, and a caulking gun to plug suspicious exterior cracks and crevices; silicone seal is also available in a thinner consistency that can be applied with a brush

Personnel Responsibilities for Monitoring

All staff responsible for maintaining wooden structures should be trained to identify the conditions that can lead to infestation by wood damaging pests. Box 18-A provides a list of

equipment needed for monitoring. If monitoring by personnel indicates signs of termite or wood-boring beetle activity, a more thorough inspection should be made by a pest management professional. These staff members should also be trained to recognize obvious signs of damage, such as those listed under Symptoms in Table 18-1. Although major structural pest management decisions should be based on the recommendations of a trained inspector, having someone on the staff who is knowledgeable about structural pests and who can supervise outside contractors can improve the quality of pest control and contain costs.

Using a Pest Management Service

When contracting for structural pest control services, the choice of a company should be based partially on their willingness to provide

Figure 18-4. Differences between ants and termites

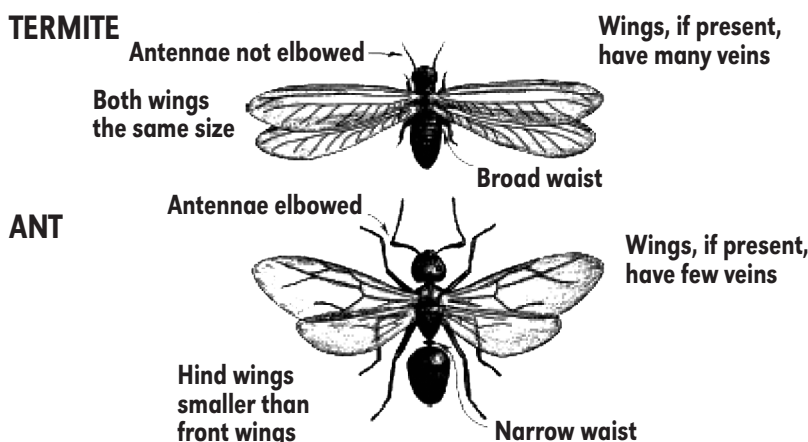


Table 18-1. Diagnostic Key to Wood-Attacking Organisms Based on Symptoms

Fungi: Wood damaged and discolored with shrinkage and/or loss of structural strength. Colored stains or dusty coating on underside of floor, on walls, or on ceilings.	
Specific Symptoms	Probable Cause
Fan-shaped white fungal mat with large 1 inch wide dirty white, brown or black threadlike strands (mycelia)	Poria fungus, or 'dry rot.'
Soft decayed wood with mycelia and checking (cracking) at right angles to the grain of the wood, particularly on floor or perimeter joists. Wood looks brown and crumbles to a powder when touched.	Brown rot.
Insects: Holes, tunnels, galleries or chambers on or beneath the surface of the wood.	
Specific Symptoms	Probable Cause
Holes greater than 1/2 inch in diameter.	Carpenter bees.
Holes less than 1/2 inch in diameter	Wood boring beetles.
Galleries or chambers found in wood. The wood surface is easily penetrated with a screwdriver or ice pick.	Subterranean termites.
Surface earthen tubes or tunnels running from soil to wood	Subterranean termites
Swarming winged insects at base of fence post, foundation, or indoors, or a collection of wings but no insect specimens.	Ants or termites (refer to Figure 18-4 to distinguish).
Large bumble bee-like insects flying around exterior near the eaves of the house. Some enter large holes. Damage mostly confined to siding or outer boards.	Carpenter bees.
Sawdust or tiny wood scraps on floor	Carpenter ants

monitoring services for a fee separate and distinct from treatments. It is still common for pest management professionals in Nebraska to offer free termite inspections with the expectation that the inspection cost will be covered by the fees for the treatments that follow. Since there is a potential conflict of interest in having the inspection and treatments performed by the same company, inspection services should be purchased separately. Separate payment increases the likelihood of an unbiased inspection, especially if the inspection and treatment companies are different.

A compromise that can save money might involve personnel checking the relatively accessible areas once or

twice a year and hiring a professional to check the harder-to-see places less frequently. Inspect both the inside and the outside of the building. If a professional is hired to do the inspection, ask to see examples of sites that were found to have damaged wood. Discovering subterranean termite tubes or beetle damage is not necessarily evidence of an active infestation. Termite tubes or beetle exit holes or frass indicate only that termites or beetles were there at one time. In the case of beetles, the adults that made the exit holes may have been the last beetles that will ever emerge if they are from a species that does not reinfest wood. Treatment of inactive infestations would be an

unnecessary expense. Ask for confirmation that living termites or beetles are present as some companies do not make this confirmation normal practice.

Detection Techniques for Termites

There are several ways to identify termite activity. The observation of swarming reproductives is an indication of a current termite infestation in the area but simply finding a pile of discarded wings can be misleading.

Winged termites are attracted to light and so could come from other areas. If only swarming insects are seen, a distinction must be made between ants and termites (see Figure 18-4).

Table 18-2. Characteristics of Damage Caused by Common Wood-Boring Beetles

TYPE OF BORER	WOOD ATTACKED		RECOGNIZING DAMAGE			Reinfest?
	Part and type	Condition	Exit Holes	Galleries (tunnels)	Frass	
Anobiid powderpost beetles	Sapwood of hardwoods and softwoods; rarely in heartwood	Seasoned	Circular, 1/16 to 1/8 inch diameter	Circular, up to 1/8 inch diameter; numerous; random	Fine powder with elongate pellets conspicuous; loosely packed in isolated clumps of different sizes; tends to stick together a	Yes
Bostrichid Powderpost Beetles	Sapwood or hardwoods primarily; minor in softwoods	Seasoning and newly seasoned	Circular, 3/32 to 9/32 inch diameter	Circular, 1/16 to 3/8 inch diameter; numerous; random	Fine to coarse powder; tightly packed, tends to stick together	Rarely
Lyctid Powderpost Beetles	Sapwood of ring- and diffuse-porous hardwoods only	Newly seasoned with high starch content	Circular, 1/32 to 1/16 inch diameter	Circular, 1/16 inch diameter; numerous; random	Fine, flour-like, loose in tunnels	Yes
Roundheaded Borers (general)	Sapwood of softwoods and hardwoods; some in heartwood	Unseasoned, logs and lumber	Oval to circular 1/8 to 3/8 inch long diameter	Oval, up to 1/2 inch long diameter, size varies with species	Coarse to fibrous; may be mostly absent	No
Old house Borer	Sapwood of softwoods, primarily pine	Seasoning to seasoned	Oval, 1/4 to 3/8 inch long diameter	Oval, up to 3/8 inch long diameter; numerous in outer sapwood, ripple marks on walls	Very fine powder and tiny pellets; tightly packed in tunnels	Yes
Flat-headed Borers	Sapwood and heartwood of softwoods and Hardwoods	Seasoning	Oval, 1/18 to 1/2 inch long diameter	Flat oval, up to 3/8 inch long diameter; winding	Sawdust-like, may contain light and dark portions if under bark; tightly packed	No
Bark beetles	Inner bark and surface of sapwood only	Unseasoned, under bark only	Circular, 1/16 to 3/32 inch diameter	Circular, up to 3/32 inch diameter; random	Coarse to fine powder, bark-colored, tightly packed in some tunnels	No
Ambrosia Beetles	Sapwood and heartwood of hardwoods and Softwoods	Unseasoned, logs and lumber	Circular, 1/50 to 1/8 inch diameter	Circular, same diameter as holes; across grain, walls stained	None present	No

^aIn hardwood, pellets may be absent and frass packed tightly.

Wood-boring beetles make holes in wood and, in some species, fine sawdust-like fecal pellets sift from the holes. Table 18-2 can be used to help identify the pest based on the kind of fecal pellets (frass) left and the kind of hole and tunnels produced by the pest.

The discovery of a mud tube extending from the soil up to the wood is an indication of probable subterranean termite infestation. If only one tube is located, monitoring for other tubes should begin immediately. Break open tubes to see if the termites are active or if the tubes are deserted; an active tube will be rebuilt within a few days. Finding soil in cracks and crevices can also be an indication of subterranean termites.

It isn't always possible to detect damaged wood by looking at the surface. An ice pick can help you probe the wood, and listening for sound differences while pounding on the wood surface can help you find the hollow areas (see Box 18-B).

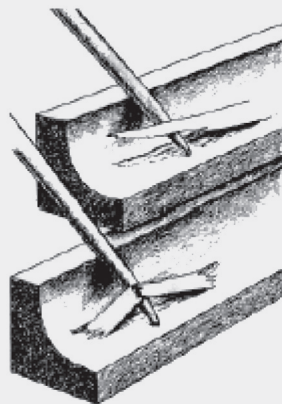
For many years, the only structural pest detection method available was visual observation by trained, experienced pest control inspectors. This method has been further improved by inspection tools such as moisture sensors.

Moisture Meters

A moisture meter will help determine whether or not the moisture content of the wood is high enough to support the growth of wood-inhabiting fungi, wood-boring beetles, or subterranean termites. The needles of the meter should be inserted along the grain of wood to give the most accurate readings. Temperature corrections should be applied to readings taken below 70°F and above

Box 18-B. The Pick Test

When monitoring your building, use an ice pick or screwdriver to probe wood you feel might be decayed based on its color or other changes you detect. Insert the pick about 1/4 inch into the wood and press sharply downward perpendicular to the grain. If the wood is sound, a long splinter will pull out of the wood along the grain (as shown in the figure below). If the wood is decayed, the splinter will be brittle and break into short pieces across the grain, especially at the point where the pick enters the wood and acts as a lever. You can also detect decayed wood by its lack of resistance relative to sound wood.



Mudsills (wood installed on footings) can be pick-tested without producing excessive visual or structural damage since they are not visible from outside the crawl space. Sometimes wood treated with a preservative on the surface is decayed inside. The pick test can help reveal these hidden pockets of decay.

90°F (correction tables are supplied with meters). The meters should not be used in wood treated with water-borne wood preservatives or fire retardants.

Monitoring for Beetle Infestations

When wood-boring beetle larvae mature into adults inside the wood, they bore exit holes to the surface to get out. Table 18-1 can help you determine what kind of insect created the holes you find. If it is a beetle, the information in Table 18-2 will help to identify the kind of beetle and whether or not it is capable of reinfesting. Consultation with a professional is also advised.

Discovering beetle damage is not necessarily evidence of an active infestation. Signs that the infestation is still active include fresh frass the color of new-sawn wood and live larvae or adults in the wood. Where you suspect an infestation of the kind of beetles that do not emerge for several years (such as old house borers), you can confirm their presence by listening for the chewing sounds they make inside the wood. To amplify the sounds, use a doctor's stethoscope or the cardboard tube from a roll of paper towels. You can also place a cloth or piece of paper underneath the suspicious area for a week or two to monitor for the fresh debris and frass that are indications of activity for some beetles.

Management Options

Habitat Modification (All Wood-Damaging Pests)

No structural pest control program is complete unless the conditions that favor the survival of the pest are modified. Moisture in or on wood is the single most important predisposing condition for wood damage and structural failure.

Reduce the moisture level of the wood

The investment in installing, fixing, or relocating gutters, siding, roofing, vents, drains, downspouts, and vapor barriers will pay for itself in long-term protection against termites, wood-boring beetles, and fungi. Leaking pipes, drains, sinks, showers, or toilets should be repaired. For wood-boring beetles and fungi, often the only control measures necessary are fixing leaks, installing vapor barriers, and using central heating to dry out wood and keep it dry. The most common wood-boring beetles cannot establish themselves in wood with a moisture content below 10-15 percent, and the old house borer probably needs more than 10 percent moisture. Wood must contain at least 20 percent moisture before it will support the growth of fungi. Few species of fungi can extend their growth into dry wood, and these fungi are relatively rare.

Ensure proper drainage under buildings

If the soil under buildings is constantly wet or becomes wet after it rains, this problem should be corrected. Equip downspouts with plastic extensions to direct water away from foundations. Grade the soil around the building to slope gently away from the structure. Installation of a

vapor barrier under the building will correct many situations, but more serious moisture accumulations need other measures. Coat foundation walls with rubberized asphalt membranes to reduce moisture under the building. Extreme cases may require the installation of a sump pump or French drains. French drains are lengths of perforated pipe placed under the soil below the outside foundation footings to catch and drain water away from the building.

Improve irrigation or landscape practices to decrease water collection near buildings

Remember that water that falls on the sides of buildings from sprinklers can cause as many problems as natural rainfall.

Eliminate direct contact between wood and soil

Ideally, wood should be at least 8 inches above the soil to prevent direct access by subterranean termites and to prevent wood from absorbing excessive moisture. Wood in contact with the soil must be replaced with concrete. If wood is too close to the soil, remove some of the soil and grade it so that it slopes away from the building.

Replace damaged wood with treated wood

When wood must be replaced, especially wood in vulnerable areas, it can be treated with borates (see discussion under "Chemical Controls") to protect it from termites and fungal decay. Whenever wood will be exposed to the weather, it is important to paint a water repellent on the bare wood before it is stained or painted. Depending on the product, water sealed wood must dry for a few days to over a month before being painted. Studies show that wood treated in

this manner resists weathering and decay many years longer than wood that is only painted or stained.

Replace moisture-prone wood with aluminum, concrete, or vinyl

Sometimes it is more cost-effective to eliminate wood altogether from the most vulnerable areas of the building.

Remove tree stumps and wood debris

Decaying stumps, construction debris, and wood scraps near or under the building can be a source of termite infestation. Remove all wood debris within 10 feet of foundations. To kill stumps, make a new cut horizontally across the top and a number of cuts vertically into the stump. Immediately rub handfuls of soil into the vertical cuts and cover the stump with a tarp to block out all light. Leave for several months until the stump has decomposed. Never bury wood pieces; they can become termite nesting areas. Wood debris containing live termites should be taken to a landfill.

Store wood piles properly

Firewood or lumber piles should be constructed so that no wood rests directly on the ground. Use cinder blocks or concrete as a base on which to pile lumber or firewood and inspect the pile periodically. Large piles should be as far from the building as is practical; smaller amounts of wood can be moved closer to the building as they are needed but do not store logs inside or in a place where they can touch the building or a wooden deck.

Plant trees away from buildings

Since trees and shrubs used in landscaping are often planted when young, a common mistake is to site them too close to a structure. Roots,

branches and eventually decaying stumps provide avenues for termite, carpenter ant, and wood-boring beetle infestations. Trees and large shrubs may also provide squirrels and other animals nesting places and access to the upper portions of the building. Leaves clog gutters and can lead to water damage.

Maintain buildings in good repair

The most effective indirect strategy for controlling structural pests is keeping buildings in good repair. Keep the skin of the structure sealed using paint, putty, and caulk. Repair cracked foundations by injecting cracks with various materials (patching compounds). Cracks should be chiseled out to a 1/2 inch depth and 3/4 inch width before patching. Injectable bonding materials have some elasticity to resist cracking, whereas cement mixes are likely to crack if soil heaving or settlement is causing ongoing foundation movement.

Inspect lumber

Lumber and other wood items should be carefully examined for wood-boring beetle damage, such as small holes, sawdust, or fine wood fragments, before using or storing. Wooden furniture should be examined carefully for current beetle infestations before placement in the building.

Use kiln-dried or air-dried lumber

Although close visual inspection of wood is essential, it is not a guarantee against beetle infestation. Some infestations can go undiscovered for years before damage is seen. Kiln-dried or air-dried lumber should be used in all construction projects.

Physical Controls

For termites, heavily damaged wood should be replaced with sound wood. Wherever possible, use lumber treated with wood preservatives such as borates (see “Chemical Controls”). Dispose of wood as described above under “Remove tree stumps and wood debris”.

For wood-boring beetles, simply removing and replacing infested wood should be the first treatment option you consider. Carefully inspect wood in contact with the pieces that are removed to see if there is further infestation. In some situations, this may not be practical because of inaccessibility of the wood or prohibitive labor costs. If any wood has been damaged to the point of structural weakness, it must be replaced or reinforced no matter what treatment is used.

Chemical Controls

If non-chemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted. Pesticides must be used in accordance with their EPA approved label directions. Applicators that are hired by the facility must be certified to apply pesticides and should always wear protective clothing during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials when buildings are occupied and never apply them where they might wash into the sanitary sewer or into outside storm drains.

Always post durable signs where pesticides have been used in attics and crawl spaces so that future inspectors

and repair technicians can identify and avoid the materials if necessary.

Borate-based wood treatments (Subterranean Termites, and Wood-Attacking Fungi)

Borates are fungicides and slow-acting insecticides. They are not repellent to insects (termites will construct tubes over borate-treated wood) but do act as antifeedants, which means that pests prefer not to feed on wood treated with borates. When insects feed on wood treated with borate or, in the case of wood-boring beetles, chew emergence holes through treated wood, the borate acts as a stomach poison to kill the insects over a number of days. As fungicides, borates act by inhibiting the growth of wood-attacking fungi.

Borates are used both in the pre-treatment of lumber for the construction industry and in remedial treatment of lumber in existing buildings. Pre-treated lumber can be used to replace existing lumber to prevent reinfestation in areas of potential termite activity or in areas vulnerable to rot. Crawl spaces and attics can be treated by a professional by spraying or painting liquid solutions directly on the wood or by pressure injecting the solution into the wood. Borates can sometimes be effective as an insecticide to eliminate small termite and wood-boring beetle infestations.

Since borates are water soluble, they cannot be used to treat exterior wood unless a finish (paint or stain) or sealant is subsequently applied to the wood. Since borates can move easily through the soil and leach away from the area of application, they should not be used in close proximity to lakes, streams, ponds, or areas where there is standing water. High concentrations of borates are toxic to

plants so treatments of the perimeter of buildings can result in inadvertent poisoning of plants and shrubs near the building.

Desiccating dusts such as diatomaceous earth and silica gel (Wood-Boring Beetles)

Desiccating dusts can help in preventing future infestations of wood-boring beetles. They are particularly useful in confined spaces such as attics and wall voids where they can remain effective for the life of the building. Desiccating dusts alone are effective and safe. They act primarily as physical, not chemical, agents but are commonly combined with pyrethrins.

Desiccating dusts act by abrading the oily or waxy outer layer that coats the body of an insect. Water inside an insect is contained by this waterproof coating, and damage to the coating causes the insect to die from dehydration. Diatomaceous earth can be easier to handle because it is composed of larger particles than the silica gel. It is important to note that the product described here is not the glassified diatomaceous earth used for swimming pool filters but rather “amorphous” diatomaceous earth.

Conventional barrier soil-applied termiticides (Subterranean Termites)

Repellent or non-repellent termiticides are applied into the soil surrounding a structure. The termiticide must be applied so that the structure is completely protected. Drilling is often necessary in order to apply termiticide into the soil beneath concrete slabs and into the interior of concrete blocks. As long as the termiticide barrier remains intact and at a sufficient concentration and thickness, termites are prevented

from entering the structure. Non-repellent termiticides have emerged as the most effective when using the conventional barrier application method. Using insecticides as termite barriers in the soil relies on uniform distribution in the soil; however, in some cases, soil characteristics may prevent this, and barriers will fail.

Termiticides can also be applied as a foam to more effectively coat hard-to-reach surfaces. This can be particularly useful when treating a slab where the underlying soil has subsided or washed away. Injections of liquid pesticide may not coat all vulnerable surfaces, especially the underside of the slab. Since the foam fills the void, it leaves a residue on all surfaces.

Termite baits (Subterranean Termites)

The termite baiting strategy involves two steps: attracting termites and then exposing them to a slow-acting toxicant. The toxicant must be slow-acting so that termites have time to go back to the nest to spread the toxicant among their nest mates through food sharing and through mutual grooming. Since termites habitually wall off members of the community and/or galleries when they sense a problem with their food supply, the toxicant must work slowly enough that it goes undetected until a good portion of the colony has been exposed.

Baiting can eliminate a termite colony over a number of months (conventional chemical barrier treatments prevent termites from entering a structure), but elimination may not be practical.

Safety of Baits

Much smaller amounts of active ingredient are used in baits than are used in chemical barrier treatments so there is less of a risk of contamination by the poison. Most of the toxicants that are used in termite baits have low acute toxicity, and the concentrations in which they are used are generally low. Manufacturers are designing bait stations to be self-contained and tamper-resistant to protect children and animals from accidental exposure.

When to Bait

Since termite activity is seasonal, baiting is more effective at certain times of the year than other times. The best time to bait the eastern subterranean termite is in the late spring and early summer.

Two Types of Baiting Strategies

There are two general types of food baiting that can be used: perimeter baiting or interceptive baiting. If the whereabouts of the termites are unknown, perimeter baiting is used. Wooden stakes, bait blocks, or plastic monitoring stations are set around the perimeter of a structure either in a continuous circle or in a grid pattern. Perimeter baiting relies on the certainty that termites foraging will eventually discover the bait. Once termites have been located, either by perimeter baiting or by finding shelter tubes or active galleries, interceptive baiting can be used. Here, actively foraging termites are intercepted with toxic bait. Intercepting baiting of structures has the disadvantage that quite often termite damage has already been done, and even though the colony is eliminated, the wood may have to be replaced.

Resources

For management practices and pesticide recommendations on termite control, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

For detailed information on termites and their control, see *Subterranean Termites: A Handbook for Homeowners* available from the Lancaster County Extension office, 444 Cherrycreek Rd., Lincoln, NE 68528, (402) 441- 7180, or on-line at: <http://lancaster.unl.edu/pest/termite.shtm>.

Educational resource guides and a termite picture gallery are available at: <http://lancaster.unl.edu/pest/termite.shtml>.

IPM for Stinging Bees and Wasps



Introduction

Most stinging bees and wasps are beneficial and should be preserved unless they pose a direct hazard to humans. Wasps are predators and scavengers, helping to control pests and recycle organic materials. Some, including the honeybee, are important pollinators essential for the propagation of plants, including many agriculturally important crops.

Despite their many benefits, stinging insects can sometimes pose a hazard and it may become necessary to control them. Insect stings probably injure more people each year than all other venomous animals combined.

There are differences in the potential hazard posed by different species. In general, the species that are social and build large colonies and nests are much more aggressive than solitary species.

Since bee stingers are barbed, the bee is effectively eviscerated when it stings so bees can sting only once. It is important to recognize the differences between species in determining how dangerous the situation is and when taking steps to control the problem.



Photo: Jim Kalisch

Figure 19-1. Yellowjacket wasp

Biology and Identification of Specific Stinging Wasp and Bee Species

Wasps and bees can be classified as solitary or social depending on whether they live alone or in colonies. Solitary species such as cicada killers, carpenter bees, digger wasps, and mud daubers use their stingers to subdue the insects and spiders upon which they prey. These insects are normally quite docile and rarely attack people.

On the other hand, social bees and wasps such as yellowjackets, paper wasps, bumblebees and honeybees use their stingers and venom in a defensive manner. When forced to defend themselves or their nests, they often will attack the intruder in large numbers. To help distinguish between the various bee and wasp species, see Table 19-1.

Social Species

Yellowjackets

Yellowjackets feed on insects, spiders and a variety of food items. They are medium-sized, stout-bodied, and black with bright yellow bands (Figure 19-1). Yellowjackets construct globular paper nests, usually in underground cavities. Favorite nesting sites include rodent burrows, compost piles, wood piles and wall voids. Occasionally, these wasps will build aerial nests in garages, crawl spaces or other enclosed areas. Nests are built of paper made by stripping wood fibers from trees, fences, garden stakes and other wooden structures. The combs are built in tiers and are surrounded by an outer paper covering.

Yellowjackets are highly aggressive wasps and can be a serious threat to people because one wasp can sting a victim repeatedly. When

Table 19-1. Distinguishing Yellowjackets, Wasps, and Bees.

	Appearance	Habits	Nests	Feeding Behavior
Bees	Hairy, stout bodies with thick waists; adults are winged	Noisy flight; sting mainly while defending nest; foraging workers seldom sting	In hives, trees, or buildings	Collect pollen and nectar, feed pollen to young & share food with other adult bees
Wasps	Bodies vary; all winged	Colorful, rapid fliers; solitary & social varieties	Aerial or ground nests; can also be in structures	Scavengers and/or predators
Solitary wasps	Thin- or thick-waisted	Visit flowers & other vegetation; relatively docile	In mud or in holes in ground	Predators; provision nests with prey for young to feed on
Yellowjackets	Stout, colorful	Rapid fliers; aggressive; individuals capable of inflicting multiple stings; social in large vigorously defended colonies	Multi-layered, papery nests mostly in ground, although some aerial or in structures; nests have an outer papery covering called an “envelope”	Mostly beneficial predators but scavenger species can become pestiferous
Paper (umbrella) Wasps	Long bodies with thin waists, long dangling legs	Social; search vegetation for prey; visit flowers for nectar; not particularly aggressive	Single layered, papery nests without an envelope; attached to fences, eaves, boards, branches; shaped like an umbrella	Beneficial predators; feed prey to developing young in nest

Figure 19-2. Disposable yellowjacket trap made from a 2-liter pop bottle.

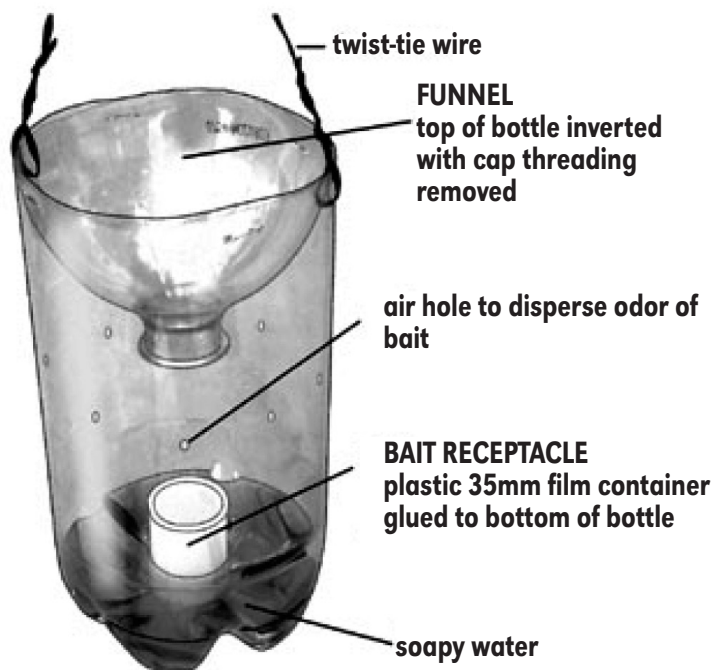




Photo: Jim Kalisch

Figure 19-3. Paper wasps on their nest



Photo: Jim Kalisch

Figure 19-4. Honeybee

yellowjackets are disturbed, give them plenty of room since they are capable of inflicting painful, multiple stings. If yellowjackets become excited and appear about to attack, do not panic. Do not make any sudden movements and retreat slowly and calmly from the area.

Yellowjackets are scavengers and are frequently found foraging in compost piles and garbage receptacles. Their activity can be discouraged in the vicinity of patios, parks, picnic and other recreational areas by covering all foods and disposing of wastes in covered containers. Turning compost piles regularly and placing insecticide-impregnated resin strips in the lids of garbage cans and dumpsters will help reduce the numbers of yellowjackets in these areas. Yellow jackets are highly attracted to over-

ripe fruit. Prompt removal of fallen fruit should help reduce the number of foraging insects.

One strategy to reduce the number of yellowjackets in an area is to employ baited yellowjacket traps (see Figure 19-2). Baits can be made from canned meats, tuna, or pet food, or can be purchased from most stores that carry insecticides. Traps should be hung in sunny locations around the periphery of the area to be protected.

Paper or Umbrella Wasps

Paper wasps are about 1 inch long, have a spindle-shaped body and are marked with a brown and yellow pattern (Figure 19-3). Paper wasps construct umbrella-shaped, single-layered nests with exposed cells. Nests may be built in trees and shrubs but

are frequently found under building overhangs, in attics, barns, garages, and sheds.

Nests are initiated by a single overwintered queen called the foundress. Other fertile females often join the colony later in the season. Colonies may produce up to 200 individuals by summer's end. These wasps are not overly aggressive and usually only pose a threat when their nests are disturbed; however, foraging wasps can cause considerable annoyance as they fly in and about building entrances. Knocking down a nest without an insecticide treatment is usually ineffective since these wasps will rebuild the nest in a short time.

Honeybees

Honeybees (Figure 19-4) may become troublesome when they swarm or build colonies near structures. Honeybees occasionally invade structures to establish a colony, building combs of wax containing honey, pollen and brood in wall spaces. Once established, a colony is difficult to remove because it usually requires structural modification of the building. To be effective, the honey, wax and bees must be removed or the site will remain attractive to other swarms. In addition, ants, carpet beetles, flies and cockroaches may find their way to the comb to feed and reproduce.

Several methods may be used to control honeybees once they are established in a building, but prevention is the best way to avoid the problem. Good maintenance, including painting, repairing or replacing rotted boards or broken brick and caulking, can prevent a colony from getting started. If a colony becomes established, call a local beekeeper who may be interested in remov-

ing the colony. Names of beekeepers can be obtained through your local UNL Extension Office or the Nebraska Department of Agriculture in Lincoln.

If the bees must be destroyed, apply an insecticide dust or spray in the evening when bees have returned to the colony and temperatures are cooler. Pyrethrins are particularly effective because they provide rapid knockdown. In many cases it is difficult to directly contact combs with the insecticide since they are often some distance from the building's point of entry. It is probably best to hire an experienced beekeeper or pest management professional to do the job. **CAUTION:** You should never use honey or wax from honeybee colonies that have been treated with an insecticide. Also, never attempt to kill bees in buildings with liquid petroleum, gasoline, or any other flammable material. The entire structure may be destroyed along with the bees.

Bumblebees

Bumblebees are large, robust bees covered with dense black and yellow hairs (Figure 19-5). They commonly reach 1 inch in length. Bumblebees usually are not overly aggressive, but they will sting if molested. Avoid flower beds where adult bumblebees are likely to forage. These bees most commonly become a problem when they establish nests close to a sidewalk or near building foundations.

Solitary Species

Cicada Killers

This is the largest wasp species in Nebraska. They are up to 2 inches long and are boldly marked with yellow stripes on a black body (Figure



Photo: Jim Kalisch

Figure 19-5. Bumblebee on a flower



University of Nebraska
Department of Entomology

Photo: Jim Kalisch

Figure 19-6. Cicada Killer

19-6). Cicada killers are most abundant during midsummer when their prey, the cicada, is active. Cicada killers attack, sting and carry paralyzed cicadas back to underground burrows. These burrows can be found near walks, driveways and retaining walls and can usually be identified by the presence of fresh soil around the 1/2-inch entrance hole.

Once the paralyzed cicada has been dragged underground, the wasp deposits an egg on it. Upon hatching, the wasp larva uses the cicada as a source of food. These wasps are normally quite docile and are unlikely to sting unless provoked; however, if nesting activities become a problem, infested areas can be treated with an insecticide.

Mud Daubers

Mud daubers are medium-sized (1-1.5 inches) wasps with the front portion of the abdomen being long and highly constricted, giving them a "thread-waisted" appearance (Figure 19-7). In Nebraska, two common species are the blue mud dauber and the yellow and black mud dauber. Both species feed almost exclusively on spiders. These wasps do not defend their nests and are unlikely to attack people. Mud dauber nests are constructed of mud or clay and often are found attached to the walls or under the eaves of buildings.

When emergence holes are present in nests, the wasps have completed their life cycle and are no longer present. These nests can simply be removed and discarded. Nests without holes should be removed and crushed.



Photo: Jim Kalisch

Figure 19-7. Mud Dauber

The destruction of nests discourages infestations by dermestid beetles and other insect scavengers that could move to other items.

Carpenter Bees

These large, dark-colored bees are similar in size and appearance to bumblebees. They can be distinguished from bumblebees by their hairless abdomen. Carpenter bees make their nests in beams, rafters and other wooden structures. Although extensive tunneling by carpenter bees can cause some damage to timbers, control is rarely necessary. If activity is unusually heavy, frequent painting of infested areas and/or application of insecticides to tunnels under construction will kill the adult bees and prevent further damage.

Digger Wasps

Digger wasps are beneficial. They appear in the morning and fly over turf in search of beetle grubs or the larvae of other insects. These wasps generally do not sting unless handled or molested. If control is desired, treat the lawn with a liquid or granular insecticide. These treatments will also reduce turf insect populations and, therefore, foraging by digger wasps.

Stings

Insect stings are the leading cause of human fatalities from venomous animals, and many of these stings are inflicted by yellowjackets. The people who die from yellowjacket or bee stings are normally individuals experiencing dozens to hundreds of stings, or those who suffer severe allergic reactions to the inflammatory substances in the insect venom. These allergic reactions include soreness and swelling, not only at the site of the sting, but also on other parts of the body that may be distant from the site. Other symptoms include fever, chills, hives, joint and muscle pain, and swelling of the lymph glands and air passageways. In severe cases, the individual may suffer a sudden drop in blood pressure and lose consciousness. Individuals who experience allergic reactions have become sensitized over time by previous stings so this hypersensitivity is found more often in adults than in children.

Ordinary reactions to stings include localized pain, redness, itching and swelling for hours to a day or two after the event.

See Box 19-A for first aid treatment for yellowjacket stings.

Nest Disturbance

Most bees and wasps that are foraging for food will not sting unless physically threatened in some way, such as being crushed or caught in a tight place. However, if social bees and wasps feel their nest is in danger, they will vigorously defend it. While most bees and wasps will defend their colonies, yellowjackets are more sensitive to nest disturbance and more aggressive in their defense. Disturbing the nests of these insects can result in multiple stings. This can occur when someone accidentally steps on an underground nest opening or disturbs a nest in a shrub or in a building. Sometimes merely coming near a nest, especially if it has been previously disturbed, can provoke an attack.

Bees and wasps nesting underground can detect vibrations of above-ground activities. Thus, mowing lawns or athletic fields can be hazardous, and operators may need to wear protective clothing when mowing during the late summer season when colonies are large. Appropriate clothing should include a bee suit with a protective bee veil or, at the very least, a veil and wrist and ankle cuffs taped or carefully tied to keep the insects out of sleeves and pant legs. A heavy sweatshirt can also be protective.

It can be very frightening to be the victim of multiple bee or wasp stings. The first response may be to run away, but since it is rarely possible to outrun the insects, running will only make the situation worse by exciting the insects even more. The best strategy is to back slowly away from the colony until you are at least 6 to 8 feet away.

Box 19-A. Avoiding and Treating Stings

Children should be taught to stay calm when confronted by a foraging yellowjacket. Impress upon them that sharp, jerky motions will frighten wasps and make them more likely to sting. Stillness or slow, gentle movements, which can be described to children as “moving like the swaying branches of a tree,” will greatly decrease the possibility of being stung. Slowly and carefully brushing off a wasp that has landed on someone or waiting until it flies off is better than hitting or constraining it since aroused wasps will sting. It is important to avoid smashing them because when crushed, they give off a scent that can cause other yellowjackets to attack.

If soft drinks or fruit juices are being consumed on the facility’s grounds where there are many yellowjackets, warn people to look into their cups or cans before each sip because someone can accidentally drink a wasp and get stung in the mouth or throat. Tell them not to panic if they find a wasp taking a drink. They should wait patiently until the wasp leaves by itself and place a napkin or similar barrier over the cup between sips. You can also use a straw for drinking or place the drink in a paper bag and poke a hole through it for the straw. Alternatively, eating and drinking outside can be prohibited during yellowjacket season.

Gardeners or custodians should wear protective clothing when mowing grass where underground nests are suspected.

First Aid for Stings

- If the sting is to the throat or mouth, medical attention must be sought immediately because swelling in these areas can cause suffocation. Dial 911 immediately and give the victim an ice cube to suck.

For hypersensitive individuals

- Anyone who is hypersensitive or is showing respiratory reactions, dizziness, or color changes should be taken to a doctor immediately. Some facilities may also have an emergency kit containing pre-loaded syringes of epinephrine for use with hypersensitive individuals. An antihistamine such as diphenhydramine (e.g., Benadryl) can stop or slow symptoms, but it must be given immediately.
- Keep the affected part down below the level of the victim’s heart.

For all others

- Wash the area around the sting with soap and water and apply an antiseptic. Washing can help remove the protein venom from the wound that will help reduce the pain and swelling from the sting.
- As soon as possible, treat the sting either with ice contained in a cloth or plastic bag, commercially available products for easing the pain of wasp or bee stings, or a paste of meat tenderizer mixed with water. Ice will help reduce the swelling, and the commercial products will relieve pain as well as swelling. Meat tenderizer works by breaking down the venom, thus reducing swelling and pain.
- Antihistamines given every few hours, according to label directions, can also prevent pain and swelling.
- Have the victim rest and do not administer sedatives such as alcohol.

It is important to educate children about the beneficial role of bees and wasps (they are important pollinators or feed on numerous pest insects) and to remind them of ways to avoid being stung. Since problems with bees and wasps, especially yellowjackets, are most common in late summer and fall, teachers should provide this information at the beginning of the fall term. See Box 19-A for tips on avoiding stings.

Detection and Monitoring

If there is a chronic problem with bees or wasps around places where people frequent, such as outdoor play areas, athletic fields, or parks, it is a good idea to inspect the area carefully to locate the nests. Nests can be found in the ground, under eaves, and in wall voids of buildings. Ground nests are frequently (but not

always) located under shrubs, logs, piles of rocks, and other protected sites. Entrance holes sometimes have bare earth around them. Watch for wasps and locate nest openings in the ground or in buildings. They will be most active on warm sunny days.

Management Options

Since yellowjackets are some of the most aggressive stinging insects,

Box 19-B. Tips on trapping yellowjackets and other wasps in a Homemade Cone-Type Fly Trap

Yellowjackets can be caught in a cone-type fly trap (Chapter 11, IPM for Flies, includes bait recipes and plans for making such a trap). The following tips will help improve yellowjacket trapping:

- Use this trapping method where no one can gain access to the traps. Mix the fly bait according to the instructions in Chapter 11 of this manual.
- Set up the flytrap with the fly bait in the area where the yellowjackets are a nuisance.
- If after a day or two in one spot the trap is still attracting only flies, move it to a new spot around the perimeter of the nuisance area.
- If your trap doesn't catch yellowjackets, try switching to a sweet bait such as fruit punch, jam, or grenadine. A recent study suggests Mountain Dew is attractive to yellowjackets.

NOTE: To avoid being stung, you should replenish the fly bait or move the trap in the cool parts of the day — early morning or late evening. To kill everything in the trap before emptying, put the trap into a large plastic garbage bag and seal the bag. Place the bag in direct sunlight for several hours or in a freezer overnight. You can also tie the bag loosely to the exhaust pipe of a gasoline engine and run the engine for a minute or two.

we will focus on their management here. The objective of a yellowjacket management program should be to reduce human encounters but not to eliminate them from the entire area since most are beneficial predators. The two most productive and least environmentally destructive ways to do this are to modify the habitat to reduce access to food in the vicinity of human activities and to use physical controls such as trapping and nest removal.

Area-wide poison-baiting should be used only as a last resort when other methods have failed, and stings are frequent.

Physical Controls

Habitat Modification

Garbage cans around structures should have removable domed tops with vertical spring-loaded swinging doors. The cans should be emptied frequently enough to prevent the contents from impeding the closure of the lid. The lids and cans should be periodically cleaned of food wastes. Disposable liners can be used and replaced when soiled or damaged.

When these practices are not followed, garbage cans become a food source for all the yellowjackets in the area. With a large number of wasps around the cans, people become afraid to get close enough to place

garbage all the way inside, and spilled food attracts more wasps.

Dumpsters should be cleaned frequently by washing them with a strong stream of water. If the dumpster service company has a cleaning clause in their contract, make sure it is enforced.

To limit yellowjacket infestations inside buildings, repair windows and screens and caulk holes in siding. Building inspections for wasps can be done at the same time as inspections for other pests such as rats, mice, termites, etc.

Trapping

Trapping with a sturdy trap and attractive bait can significantly reduce yellowjacket numbers if a sufficient number of traps are used. There is a variety of traps on the market. In general, cone-type traps are more useful for long-term (many weeks) trapping because it takes longer for the wasps to find their way out of the trap. In some places, unbaited yellow sticky traps (like those used to catch whiteflies) affixed to fences near underground nests have provided sufficient control to protect people from stings.

When traps are full, they can either be placed in a freezer for a day to kill the yellowjackets or enclosed in a heavy-duty plastic garbage bag and placed in the direct sun for several hours. A third way of killing the wasps is by submerging the traps in a bucket of soapy water until the wasps drown.

A homemade, cone-type flytrap can be used to catch yellowjackets simply by using the captured flies inside the trap as bait (see Chapter 11 for a discussion on how to catch flies). The

yellowjackets enter the trap to get the flies and become trapped themselves (see Box 19-B for tips for this kind of trapping). You can also try using baits such as dog food, ham, fish, and other meat scraps, or, toward the end of the warm weather, sugar syrups, fermenting fruit, and jelly.

Take care to place traps out of the everyone's reach as much as possible; however, the traps should be placed near the nest if it can be found, and/or near the area where the yellowjackets are troublesome. In schools or child care centers, teachers can be instructed to make a short presentation on the purpose of the traps to satisfy the curiosity that students will undoubtedly have. Show students the traps, explain how they work, and try to impress upon them the importance of the traps in maintaining the safety of the playground.

The traps should be out only during the period that wasps are a problem, usually late summer and early fall. When the traps are taken down for the year, they should be cleaned with soap and water and stored.

Nest Removal

A nest can be destroyed through physical removal (vacuuming) or by using a pesticide (see "Chemical Controls"). Either way, care is essential because any disturbance around a nest can cause multiple stings. It is best to have a professional pest management professional or other person experienced with these techniques remove the nest, and it should be done at night when wasps are in their nests. When illumination is needed, use a flashlight with the lens covered with red acetate film so it will not attract wasps. Adequate protective clothing (see Box 19-C) and proper procedure can minimize problems and stings. People who

Box 19-C. Protective Clothing for Nest Destruction

It is important to wear protective clothing when removing wasp nests. Complete body coverage is essential because yellowjackets and other wasps can find even the smallest exposed area. Use clothing made for beekeepers. This includes:

1. A bee veil or hood that either contains its own hat or can be fitted over a light-weight pith helmet or other brimmed hat that holds the veil away from the head. A metal-screen face plate that extends around the head is a desirable feature. Check the veil carefully for tears before each use.
2. A bee suit or loose-fitting, heavy-fabric coverall with long sleeves. This is worn over regular pants and a long-sleeved shirt to provide extra protection from stings.
3. Sturdy high-topped boots with pant legs secured over the boots with duct tape to prevent wasps from getting into trousers.
4. Gloves with extra-long arm coverings so sleeves can be taped over them to protect the wrists.

Box 19-D. How to Destroy Nests Using Pesticides

Application of pesticides to bee or wasp nests should be made in the evening or early in the morning, and the pest management professional should always wear protective clothing (see Box 19-C).

Aerial Nests

1. If necessary, use a pole-pruner to trim branches away from the nest. Be extremely careful if you do this.
2. Using a ladder, climb near enough to the nest to squirt a half-second blast (no more is necessary) of aerosol pyrethrins (0.3 percent or 0.5 percent) around the nest entrance hole to kill the guard wasps.
3. Cover the nest with a large, heavy-duty, black plastic garbage bag and cut off the branch from which the nest is hanging or cut the nest off the branch.
4. On a sunny day, twist the top of the plastic bag, fold the twist over and secure with a twist tie. Leave the bag in the sun for 2 or 3 hours to kill the wasps. On a cool or cloudy day, you may need to use insecticide to kill the wasps. Gather the top of the plastic bag together, insert the nozzle of the aerosol pyrethrins (0.3 percent or 0.5 percent), and squirt in another half-second blast. Do not over-treat. This small amount of pyrethrins is enough to kill the wasps.
5. Dispose of the bag in the garbage.

are sensitive to wasp stings should not attempt control procedures.

Vacuumping

We do not recommend vacuuming out entire nests unless it is done by a professional experienced in handling stinging insects.

Vacuumping can be particularly effective where nests occur in wall voids, in emergencies where nests have already been disturbed, and in environmentally sensitive areas where nests should not be treated with insecticides. Use a lightweight, powerful vacuum with a removable bag. Before the bag is completely full of wasps, vacuum up 2 tablespoons of cornstarch to incapacitate the insects. Leaving the motor running, detach the hose from the canister to reveal the opening in the vacuum bag. Stuff this opening with newspaper, paper towels, or a rag. With the motor still running, open the canister and tape over the bag opening with duct tape. With the motor off, take out the bag and place it inside a cardboard box. Seal the box and place it in a freezer at least overnight.

Before vacuuming an underground nest, check for secondary entrance holes (these can be identified by the wasps flying in and out) in a 40 to 50 foot area around the main opening. If these secondary entrances are not covered with a good quantity of soil before vacuuming begins, they will provide outlets for angry wasps.

Vacuumping the nest is a job for two people, both covered with protective clothing. While one person operates the vacuum, the other excavates the nest with a trowel. The vacuum operator does not actually insert the hose into the nest; instead, the wand is positioned 3 or 4 inches away from

the nest opening to suck in yellow-jackets as they fly in and out. When no more wasps are seen entering or leaving, the underground nest structure should be dug out, placed in a plastic garbage bag, and set in the sun for several hours.

Chemical Controls

If non-chemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted. Pesticides must be used in accordance with their EPA-approved label directions. Applicators that the facility hires must be certified to apply pesticides and should always wear protective clothing during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials when buildings are occupied. They should never be applied where they might wash into the sanitary sewer or into outside storm drains.

When an insecticide is considered necessary for the control of bees, yellowjackets, or other wasps, the best approach is to confine it to the nest itself. Anyone applying insecticides should use special clothing that protects against the chemical as well as against bees and wasps. This should include a respirator, goggles, coveralls, and rubber gloves, as well as a bee suit with a veil (see also Box 19-C). Apply insecticides in the evening or very early morning when bees or wasps are in their nests and cool temperatures reduce the insects' ability to move around. Of the main insecticides registered for use against bees or wasps, the following are most appropriate for use in sensitive environments.

Ground Nests

1. Check the area 40 to 50 feet around the nest before treating. If another entrance is found, use a half-second blast of aerosol pyrethrins (0.3 percent or 0.5 percent) to kill the guard wasps, stuff the hole with newspaper or paper towels, and cover it with soil.
2. Use a half-second blast of the aerosol pyrethrins to kill the guards at the main entrance.
3. Using a 4-way tip on the aerosol, spray inside the entrance hole for 5-10 seconds. Do not over-treat. Stuff the hole with newspaper or paper towels but do not cover it with soil.
4. After waiting a few minutes, remove the paper from the entrance hole. Use a bulb duster to apply silica aerogel plus pyrethrins to the interior of the cavity and the nest. A few pumps should apply sufficient material. If the nest is located some distance back from the ground opening, attach a length of PVC tubing to the bulb duster to extend its reach.
5. Insert a piece of coarse steel wool or copper mesh that has been treated with a light dusting of silica aerogel plus pyrethrins into the entrance hole. Any wasps trying to get in or out will chew on the steel wool and be killed by the insecticide.

Nests in Wall Voids

Wasp or bee colonies in wall voids can be eliminated using the same procedure detailed above for ground nests.

After removing the colony, make any necessary structural changes to prevent wasps from reinfesting the structure.

Pyrethrins Aerosol

Pyrethrins can be used to quickly knock down guard wasps at the nest entrance (See Figure 19-8) and to kill wasps in an aerial nest once the nest has been cut down and is inside a plastic bag. Only very small amounts of this material are necessary to kill the wasps and there is no need to use more (consult Box 19-D for the specific procedures for poisoning nests).

Silica Aerogel and Pyrethrins

Silica aerogel combined with pyrethrins is an effective insecticidal dust that can be used to destroy an underground nest or a nest in a wall void after the guard wasps have been killed (see Box 19-D). Silica aerogel is made essentially from sand and works by abrading the outer waxy coating on insect bodies. Once this coating is gone, the insects cannot retain water and die of dehydration.

Products with Components that “Freeze” Wasps

In emergency situations when nests must be destroyed in the daytime, it is helpful to carry one of these products as a safety precaution. These aerosol products are designed to project their spray a distance of 10 to 20 feet and contain highly evaporative substances that “freeze” or stun the wasps.



Figure 19-8. Pyrethrins can quickly knock down wasps at a nest entrance.

Do Not Use Gasoline

Many people pour gasoline into underground nest holes. This is a fire hazard, contaminates the soil, and prevents growth of vegetation for some time. It is a very dangerous procedure.

Avoid Area-Wide Poisoning

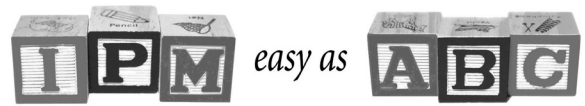
Mass poisoning is seldom, if ever, necessary, and is expensive due to the labor involved in the frequent mixing and replacement of bait. The effectiveness of bait mixtures is also questionable, since the baits experience considerable competition from other food sources attractive to scavenging yellowjackets.

Resources

For additional information on management practices and pesticide recommendations for controlling stinging wasps and bees, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

Educational resource guides on wasps and bees are available at: <http://lancaster.unl.edu/pest/bees.shtml>.

IPM for Indoor Air Quality: Molds and Other Asthma Triggers



Introduction

Concern about indoor exposure to mold has been increasing as the public becomes aware that exposure to mold can cause a variety of health effects and symptoms, including asthma and allergic reactions. The first part of this chapter presents guidelines for the prevention, remediation, and cleanup of mold and moisture problems in structures. The second part presents information about mold and other biological asthma triggers. The remediation/cleanup guidelines include measures designed to protect the health of building occupants and remediators.

The guidelines have been designed primarily for building managers, custodians, and others who are responsible for building maintenance as well as a reference for potential mold and moisture remediators. It will help those in charge of maintenance to evaluate an in-house remediation plan or a remediation plan submitted by an outside contractor. Contractors and other professionals who respond to mold and moisture situations in buildings should refer to these guidelines and to more in-depth resources.

Mold Basics

Molds need:

1. Moisture source

2. Food — organic materials
3. Oxygen

Molds are microscopic fungi that live on plant and animal matter as a part of the natural environment. Outdoors, molds play a part in nature by breaking down dead organic matter such as fallen leaves and dead trees. Molds are usually not a problem indoors unless mold spores land on a wet or damp spot and begin growing. However, mold should be handled with respect because of the potential health risk it poses if found indoors.

Molds can be found almost anywhere (Figure 20-1); they can grow on virtually any organic substance, as long as moisture and oxygen are present. Molds can grow on wood, wallboard, paper, carpet, foods, insulation, and more. When excessive moisture ac-

cumulates in buildings or on building materials, mold growth will often occur, particularly if the moisture problem remains undiscovered. It is impossible to eliminate all mold and mold spores in the indoor environment. However, mold growth can be controlled by controlling moisture indoors.

Sources of Moisture

Since mold requires water to grow, it is important to prevent moisture problems in buildings. Moisture problems can have many causes, including uncontrolled humidity. Some moisture problems in structures have been linked to changes in building construction practices over the last 30 years. Some of these changes have resulted in buildings that are sealed tightly but lack



Photo: Shirley Niemeyer

Figure 20-1. Mold on wall behind removed ceramic tiles

adequate ventilation, potentially leading to moisture buildup. Building materials, such as drywall, may not allow moisture to escape easily and serve as a good food source for mold. It is important that building materials be able to dry; moisture should not be trapped between two vapor barriers or mold may result.

Moisture problems may include roof leaks, landscaping or gutters that direct water into or under the building, and unvented combustion appliances. Delayed or insufficient maintenance is also associated with moisture problems. Moisture problems in temporary structures frequently have been associated with mold problems. Condensation on surfaces can lead to mold growth.

Mold and Health

Molds have the potential to cause health problems. When mold growth occurs in buildings, some building occupants, particularly those with allergies or respiratory problems, may report adverse health problems. Too much exposure to mold may cause or worsen conditions such as asthma, hay fever, or other allergies (see section on asthma). Depending on the amount of exposure and a person's individual vulnerability, more serious health problems can occur but are less common. However, most types of mold that are routinely encountered are not hazardous to healthy individuals.

Potential health concerns are an important reason to prevent mold growth and to remediate/clean up any existing indoor mold growth. Remediators should avoid exposing themselves and others to mold-laden dusts as they conduct their cleanup activities. Caution should be used to prevent mold and mold spores from

Box 20-A. Prevent mold by doing the following:

- Fix leaky plumbing and leaks in the building envelope as soon as possible.
- Watch for condensation and wet spots. Clean and dry wet or damp spots within 48 hours.
- Fix source(s) of moisture problem(s) as soon as possible.
- Prevent moisture due to condensation by increasing surface temperature or reducing the moisture level in air (humidity). To increase surface temperature, insulate and/or increase air circulation.
- Repair leaks and increase ventilation (if outside air is cold and dry) or dehumidify (if outdoor air is warm and humid) to reduce the moisture level in air.
- Vent moisture-generating appliances, such as dryers, bathroom and shower vents, and kitchen hood vents to the outside.
- Maintain low indoor humidity, below 50 percent to 60 percent relative humidity (RH), ideally 35-50 percent, if possible.
- Perform regular building/ heating, ventilation, and air conditioning (HVAC) inspections and maintenance as scheduled.
- Keep HVAC drip pans clean, flowing properly, and unobstructed.
- Clean out gutters and down spouts on a regular basis. Down spouts should extend 6 to 12 feet away from the foundation.
- Don't let foundations stay wet. Provide drainage and slope the ground (1" for every 12") away from the foundation.
- Seal foundation cracks.
- Avoid putting carpet on basement or slab floors that may wick moisture.
- Stop all unplanned moisture sources and leaks, keep all surfaces dry, and fix leaks.
- Don't allow water to stand or seep inside.
- Clean refrigerator drip pans, humidifiers and dehumidifiers often.
- Avoid letting outdoor watering systems spray on the exterior walls or near the foundation.

being dispersed throughout the air where they can be inhaled by building occupants.

Research on mold and health effects is ongoing. For more detailed information, consult a health professional. You may also wish to consult the Nebraska Department of Health and Human Services or your local health department.

Mold Prevention Tips

The key to mold control is moisture control. Solve moisture problems before they become mold problems. If mold is a problem in your facility, clean up the mold or have it professionally cleaned up promptly and *fix the water problem*. If the mold is cleaned up, but the water problem not fixed, most likely the mold problem will come back. See Box 20-A for some mold prevention tips.

It is important to dry water-damaged areas and items within 24-48 hours to prevent mold growth. The mold spores will not grow if moisture is not present. Indoor mold growth can and should be prevented or controlled by controlling moisture indoors.

Investigating and Evaluating Moisture and Mold Problems

Investigation

First, assess the extent of the damage, and then determine whether the remediation should be managed by in-house personnel or outside professionals. If you choose to use outside contractors, make sure they have experience cleaning up mold, check their references, and have them follow the complete recommendations found in U.S. EPA *Mold*



Photo: Shirley Niemeyer

Figure 20-2. Mold hidden inside a wall

Remediation in Schools and Commercial Buildings and the guidelines of the American Conference of Government Industrial Hygienists (ACGIH). The remediation manager can then use these guidelines to help design a remediation plan or to assess a plan submitted by outside professionals.

Molds are known allergens and may be toxic. Use personal protective equipment (PPE) while investigating a mold problem, as well as during remediation/clean-up situations. The minimum PPE includes an N-95 respirator, gloves, and eye protection (see Personal Protection Equipment section for more information).

Safety Tips While Investigating and Evaluating Mold and Moisture Problems

- Do not touch mold or moldy items with bare hands.
- Do not get mold or mold spores in your eyes.
- Do not breathe in mold or mold spores.
- Use PPE when disturbing mold.

Moldy Areas Encountered During an Investigation

Hidden Mold

In some cases, indoor mold growth may not be obvious (see Figure 20-2). It is possible that mold may be growing on hidden surfaces such as the:

- back side of dry wall, wallpaper, or paneling
- top of ceiling tiles
- underside of carpets and pads
- pipe chases and utility tunnels (with leaking or condensing pipes)
- walls behind furniture (where condensation forms)
- condensate drain pans inside air handling units
- porous thermal or acoustic liners inside ductwork
- roof materials above ceiling tiles (due to roof leaks or insufficient insulation)

Some building materials, such as dry wall with vinyl wallpaper over it or wood paneling, may act as vapor barriers or vapor retarders, trapping

moisture underneath their surfaces and thereby providing a moist environment where mold can grow. It is important that building materials be able to dry; moisture should not be trapped between two vapor barriers or mold may result.

You may suspect hidden mold if a building smells moldy but you cannot see the source, or if you know there has been water damage and building occupants are reporting health problems. Investigating hidden mold problems may be difficult and will require caution when the investigation involves disturbing potential sites of mold growth. For example, removal of wallpaper can lead to a massive release of spores from mold growing on the underside of the paper. If you suspect that you have a hidden mold problem, you may want to consider hiring an experienced professional. If you discover hidden mold, you should revise your remediation plan to account for the total area affected by mold growth.

Equipment to Aid Investigation

Moisture Meters: Moisture meters may be helpful for measuring the moisture content in a variety of building materials following water damage. They can also be used to monitor the process of drying damaged materials. These direct reading devices have a thin probe that can be inserted into the material to be tested or can be pressed directly against the surface of the material. Moisture meters can be used on materials such as carpet, wallboard, wood, brick, and concrete.

Humidity Gauges or Meters: A *humidity meter* or *hygrometer* can be used to monitor humidity indoors. Inexpensive (less than \$50) models

Box 20-B. Questions to Consider Before Remediating – Checklist

- Are there existing moisture problems in the building?
- Have building materials been wet more than 48 hours?
- Are there hidden sources of water or is the humidity too high (high enough to cause condensation)?
- Are building occupants reporting musty or moldy odors?
- Are building occupants reporting health problems?
- Are building materials or furnishings visibly damaged?
- Has maintenance been delayed or the maintenance plan been altered?
- Has the building been recently remodeled, or has building use changed?
- Is consultation with medical or health professionals indicated?

are available that monitor both temperature and humidity.

Humidistat: A *humidistat* is a control device that can be connected to the HVAC system and adjusted so that, if the humidity level rises above a set point, the HVAC system will automatically come on.

Remediating Moisture and Mold Problems

Remediation Plan

Plan the remediation before starting the work. Consider the questions listed in Box 20-B before beginning. Assess the size of the mold and/or moisture problem and the type of damaged materials before planning the remediation work. Select a remediation manager for medium or large jobs (or small jobs requiring more than one person). The remediation plan should include steps to fix the water or moisture problem, or the problem may reoccur. The plan

should cover the use of appropriate PPE and include steps to carefully contain and remove moldy building materials to avoid spreading the mold. A remediation plan may vary greatly depending on the size and complexity of the job and may require revision if circumstances change or new facts are discovered.

The remediation manager's highest priority must be to protect the health and safety of the building occupants and remediators. It is also important to communicate with building occupants when mold problems are identified. In some cases, especially those involving large areas of contamination, the remediation plan may include temporary relocation of some or all of the building occupants. The decision to relocate occupants should consider the size and type of the area affected by mold growth, the type and extent of health effects reported by the occupants, the potential health risks that could be associated with debris, and the amount of disruption

likely to be caused by remediation activities. If possible, remediation activities should be scheduled during off-hours when building occupants are less likely to be affected.

Remediators, particularly those with health-related concerns, may wish to check with their doctors or health care professionals before working on mold remediation or investigating potentially moldy areas. If you have any doubts or questions, you should consult a health professional before beginning a remediation project.

Basic Remediation Steps

1. Fix the water or humidity problem. Complete and carry out a repair plan. Revise and/or carry out a maintenance plan if necessary. Revise remediation plan as necessary if more damage is discovered during remediation.
2. Continue to communicate with building occupants, as appropriate to the situation. Be sure to address all concerns.
3. Completely clean up mold, and dry water-damaged areas. Select appropriate cleaning and drying methods for damaged/contaminated materials. Carefully contain and remove moldy building materials. Use appropriate PPE. Arrange for outside professional support if necessary.

Mold Remediation Guidelines

Mold Remediation in Schools and Commercial Buildings (http://www.epa.gov/mold/mold_remediation.html) presents remediation guidelines for building materials that have or are likely to have mold growth. The guidelines in Table 2 of the publication are designed to protect the health of occupants and cleanup personnel during remediation. These

guidelines are based on the area and type of material affected by water damage and/or mold growth. Please note that these are guidelines; some professionals may prefer other cleaning methods.

Although the level of personal protection suggested in these guidelines is based on the total surface area contaminated and the potential for remediator and/or occupant exposure, professional judgment should always play a part in remediation decisions. These remediation guidelines are based on the size of the affected area to make it easier for remediators to select appropriate techniques, not on the basis of health effects or research showing there is a specific method appropriate at a certain number of square feet. The guidelines have been designed to help construct a remediation plan. The remediation manager will then use professional judgment and experience to adapt the guidelines to particular situations. When in doubt, caution is advised. Consult an experienced mold remediator for more information. In cases in which a particularly toxic mold species has been identified or is suspected, when extensive hidden mold is expected (such as behind vinyl wallpaper or in the HVAC system), when the chances of the mold becoming airborne are estimated to be high, or sensitive individuals (e.g., those with severe allergies or asthma) are present, a more cautious or conservative approach to remediation is indicated. Always make sure to protect remediators and building occupants from exposure to mold.

Heating, Ventilation, and Air-Conditioning (HVAC) System

Do not run the HVAC system if you know or suspect that it is contaminat-

ed with mold. If you suspect that it may be contaminated (it is part of an identified moisture problem, for instance, or there is mold growth near the intake to the system), consult EPA's guide *Should You Have the Air Ducts in Your Home Cleaned?* (<http://www.epa.gov/iaq/pubs/airduct.html>) before taking further action.

If you are considering cleaning your ducts as part of your remediation plan, you should consult the above publication. Knowledge about the potential benefits and possible problems of air duct cleaning is limited. Since conditions in structures are different, it is impossible to generalize about whether or not air duct cleaning in your building would be beneficial. While the debate about the value of periodic duct cleaning continues, no evidence suggests that such cleaning would be detrimental, **provided that it is done properly.**

Use high-quality filters in your HVAC system during remediation. Consult an engineer for the appropriate efficiency for your specific HVAC system and consider upgrading your filters if appropriate. Conventional HVAC filters are typically not effective in filtering particles the size of mold spores. Consider upgrading to a filter with a minimum efficiency of 50 to 60 percent or a rating of MERV 8, as determined by Test Standard 52.2 of the American Society of Heating, Refrigerating, and Air Conditioning Engineers. Remember to change filters regularly and change them following any remediation activities.

Water Damage and Quick Cleanup to Prevent Mold

Strategies to respond to water damage within 24-48 hours are provided

in the EPA's *Mold Remediation in Schools and Commercial Buildings*. These guidelines are designed to help avoid the need for remediation of mold growth by taking quick action before growth starts. Depending on the size of the area involved and resources available, professional assistance may be needed to dry an area quickly and thoroughly.

Cleanup Methods

A variety of mold cleanup methods are available for remediating damage to building materials and furnishings caused by moisture control problems and mold growth. The specific method or group of methods used will depend on the type of material affected. Please note that professional remediators may use some methods not covered in these guidelines; absence of a method in the guidelines does not necessarily mean that it is not useful. Consult the EPA publication for more information.

Method 1: Wet Vacuum

Wet vacuums are vacuum cleaners designed to collect water. They can be used to remove water from floors, carpets, and hard surfaces where water has accumulated. They should not be used to vacuum porous materials, such as gypsum board. They should be used only when materials are still wet; wet vacuums may spread spores if sufficient liquid is not present. The tanks, hoses, and attachments of these vacuums should be cleaned thoroughly and dried after use since mold and mold spores may stick to the surfaces.

Method 2: Damp Wipe

Whether dead or alive, mold is allergenic, and some molds may be toxic. Mold can generally be removed from nonporous (hard) surfaces by wiping



Photo: Shirley Niemeyer

Figure 20-3. Ceiling tile damaged by moisture.

or scrubbing with water, or water and detergent. It is important to dry these surfaces quickly and thoroughly to discourage further mold growth. Instructions for cleaning surfaces, as listed on product labels, should always be read and followed. Porous materials that are wet (see Figure 20-3) and have mold growing on them are typically discarded. Since molds will infiltrate porous substances and grow on or fill in empty spaces or crevices, the mold can be difficult or impossible to remove completely.

Method 3: HEPA Vacuum

HEPA (High-Efficiency Particulate Air) vacuums are recommended for final cleanup of remediation areas after materials have been thoroughly dried and contaminated materials removed. HEPA vacuums are also recommended for cleanup of dust that may have settled on surfaces outside the remediation area. Care must be taken to ensure that the filter is properly seated in the vacuum so that all the air must pass through the filter. When changing the vacuum filter, remediators should wear PPE to prevent exposure to the mold that has been captured. The filter and contents

of the HEPA vacuum must be disposed of in well-sealed plastic bags.

Method 4: Discard — Remove Damaged Materials and Seal in Plastic Bags

Building materials and furnishings that are contaminated with mold growth and are not salvageable should be double-bagged using 6-mil polyethylene sheeting. These materials can then usually be discarded as ordinary construction waste. It is important to package mold-contaminated materials in sealed bags before removal from the containment area to minimize the dispersion of mold spores throughout the building. Large items that have heavy mold growth should be covered with polyethylene sheeting and sealed with duct tape before they are removed from the containment area.

Molds Can Damage Building Materials and Furnishings

Mold growth can eventually cause structural damage to a large building if a mold/moisture problem remains unaddressed for a long time (see Figure 20-4). In the case of a long-term roof leak, for example, molds can



Photo: Shirley Niemeyer

Figure 20-4. Wood damaged by moisture and mold.

weaken floors and walls as the molds feed on wet wood. If you suspect that mold has damaged building integrity, you should consult a structural engineer or other professional with expertise in this area.

Mold and Paint

Don't paint or caulk moldy surfaces; clean and dry surfaces before painting. Paint applied over moldy surfaces is likely to peel.

Mold Remediation/Cleanup and Disinfectants

The purpose of mold remediation is to remove the mold to prevent human exposure and damage to building materials and furnishings. It is necessary to clean up mold contamination, not just to kill the mold. **Dead mold is still allergenic, and some dead molds are potentially toxic.**

The use of a disinfectant, such as chlorine bleach, is not recommended as a routine practice during mold remediation although there may be instances where professional judgment may indicate its use (for example, when immune-compromised individuals are present or when the area

has been contaminated with sewage, etc.). In most cases, it is not possible or desirable to sterilize an area; a background level of mold spores will remain in the air (roughly equivalent to or lower than the level in outside air). These spores will not grow if the moisture problem in the building has been resolved. Spores may remain able to grow for years after they are produced.

If you choose to use disinfectants, always ventilate the area. Outdoor air may need to be brought in with fans. When using fans, take care not to distribute mold spores throughout an unaffected area. Disinfectants can be toxic to humans as well as to mold. You should also use appropriate PPE and read and follow label precautions. Never mix chlorine bleach solution with cleaning solutions or detergents that contain ammonia; toxic fumes could be produced.

Personal Safety

Use Personal Protective Equipment (PPE)

If the remediation job disturbs mold and mold spores become airborne,

then the risk of respiratory exposure goes up. Actions that are likely to stir up mold include the following: breakup of moldy porous materials such as wallboard; invasive procedures used to examine or remediate mold growth in a wall cavity; actively stripping or peeling wallpaper to remove it; and using fans to dry items.

The primary function of Personal Protective Equipment (PPE) is to avoid inhaling mold and mold spores and to avoid mold contact with the skin or eyes. The following sections discuss the different types of PPE that can be used during remediation activities. Please note that all individuals using certain PPE equipment, such as half-face or full-face respirators, must be trained, must have medical clearance, and must be fit-tested by a trained professional. In addition, the use of respirators must follow a complete respiratory protection program as specified by the Occupational Safety and Health Administration.

Skin and Eye Protection

Gloves are required to protect the skin from contact with mold allergens (and in some cases, mold toxins) and from potentially irritating cleaning solutions. Long gloves that extend to the middle of the forearm are recommended. The glove material should be selected based on the type of materials being handled. If you are using a disinfectant (such as chlorine bleach) or a strong cleaning solution, you should select gloves made from neoprene, nitrile, polyurethane, or PVC. If you are using a mild detergent or plain water, ordinary household rubber gloves may be used. To protect your eyes, use properly fitted goggles or a full-face respirator with HEPA filter. Goggles must be designed to prevent the entry of dust

and small particles. Safety glasses or goggles with open vent holes are not acceptable.

Respiratory Protection

Respirators protect cleanup workers from inhaling airborne mold, mold spores, and dust.

- **Minimum:** When cleaning up a small area affected by mold, use an N-95 respirator. This device covers the nose and mouth, filters out 95 percent of the particulates in the air, and is available in most hardware stores. In situations where a full-face respirator is in use, additional eye protection is not required.
- **Limited:** Limited PPE includes use of a half-face (see Figure 20-5) or full-face air purifying respirator (APR) equipped with a HEPA filter cartridge. These respirators contain both inhalation and exhalation valves that filter the air and ensure that it is free of mold particles. Note that half-face APRs do not provide eye protection. In addition, the HEPA filters do not remove vapors or gases. You should always use respirators approved by the National Institute for Occupational Safety and Health (see U.S. EPA *Mold Remediation in Schools and Commercial Buildings*).
- **Full:** In situations in which high levels of airborne dust or mold spores are likely or when intense or long-term exposures are expected (e.g., the cleanup of large areas of contamination), a full-face, powered air purifying respirator (PAPR) is recommended. Full-face PAPRs use a blower to force air through a HEPA filter. The HEPA-filtered air is supplied to a mask that covers the entire face or a hood that covers the entire head. The positive pressure within the



Figure 20-5. Half-face respirator equipped with a HEPA filter.

hood prevents unfiltered air from entering through penetrations or gaps. Individuals must be trained to use their respirators before they begin remediation. The use of these respirators must be in compliance with OSHA regulations.

Disposable Protective Clothing

Disposable clothing (see Figure 20-6) is recommended during a medium or large remediation project to prevent the transfer and spread of mold to clothing and to eliminate skin contact with mold.

- **Limited:** Disposable paper overalls can be used.
- **Full:** Mold-impervious disposable head and foot coverings, and a body suit made of a breathable material, such as TYVEK®, should be used. All gaps, such as those around ankles and wrists, should be sealed (many remediators use duct tape to seal clothing).

Containment

The purpose of containment during remediation activities is to limit release of mold into the air and surroundings, in order to minimize the exposure of remediators and build-

ing occupants to mold. Mold and moldy debris should not be allowed to spread to areas in the building beyond the contaminated site.

The two types of containment recommended are limited and full. The larger the area of moldy material, the greater the possibility of human exposure and the greater the need for containment. In general, the size of the area helps determine the level of containment. However, a heavy growth of mold in a relatively small area could release more spores than a lighter growth of mold in a relatively large area. Choice of containment should be based on professional judgment. The primary object of containment should be to prevent occupant and remediator exposure to mold.

Limited Containment

Limited containment is generally recommended for areas involving between **10 and 100 square feet (ft²) of mold** contamination (Figure 20-7). The enclosure around the moldy area should consist of a single layer of 6-mil, fire-retardant polyethylene sheeting. The containment should have a slit entry and covering flap on the outside of the containment area.



Photo: UNL

Figure 20-6. Disposable Tyvek® coverall.



Photo: Shirley Niemeyer

Figure 20-7. Containment area.

For small areas, the polyethylene sheeting can be affixed to floors and ceilings with duct tape. For larger areas, a steel or wooden stud frame can be erected and polyethylene sheeting attached to it. All supply and air vents, doors, chases, and risers within the containment area must be sealed with polyethylene sheeting to minimize the migration of contaminants

to other parts of the building. Heavy mold growth on ceiling tiles may impact HVAC systems if the space above the ceiling is used as a return air plenum. In this case, containment should be installed from the floor to the ceiling deck, and the filters in the air-handling units serving the affected area may have to be replaced once remediation is finished.

The containment area must be maintained under **negative pressure relative to surrounding areas**. This will ensure that contaminated air does not flow into adjacent areas. This can be done with a HEPA-filtered fan unit exhausted outside of the building. For small, easily contained areas, an exhaust fan ducted to the outdoors can also be used. The surfaces of all objects removed from the containment area should be remediated/cleaned prior to removal. The remediation guidelines outlined in Table 2 of EPA's *Mold Remediation in Schools and Commercial Buildings* can be implemented when the containment is completely sealed and is under negative pressure relative to the surrounding area.

Full Containment

Full containment is recommended for the cleanup of mold-contaminated surface areas greater than 100 ft² or in any situation in which it appears likely that the occupant space would be further contaminated without full containment.

Double layers of polyethylene should be used to create a barrier between the moldy area and other parts of the building. A decontamination chamber or airlock should be constructed for entry into and exit from the remediation area. The entryways to the airlock from the outside and from the airlock to the main containment area should consist of a slit entry with covering flaps on the outside surface of each slit entry. The chamber should be large enough to hold a waste container and allow a person to put on and remove PPE. All contaminated PPE, except respirators, should be placed in a sealed bag while in this chamber. Respirators should be worn until remediators are outside the decontamination chamber. PPE

must be worn throughout the final stages of HEPA vacuuming and damp-wiping of the contained area. PPE must also be worn during HEPA vacuum filter changes or cleanup of the HEPA vacuum.

Sampling

A visual inspection is the most important initial step in identifying a possible contamination problem. The extent of any water damage and mold growth should be visually assessed. This assessment is important in determining remedial strategies.

Is sampling for mold needed? In most cases, if visible mold growth is present, sampling is unnecessary. In specific instances, such as cases where litigation is involved, the source(s) of the mold contamination is unclear, or health concerns are a problem, you may consider sampling as part of your site evaluation. Surface sampling may also be useful in order to determine if an area has been adequately cleaned or remediated. Sampling should be done only after developing a sampling plan that includes a confirmable theory regarding suspected mold sources and routes of exposure. Figure out what you think is happening and how to prove or disprove it before you sample! See EPA's *Mold Remediation in Schools and Commercial Buildings* for more details.

Biologicals as Asthma Triggers

Biological air pollutants are found to some degree in every sensitive environment. Sources include outdoor air and human occupants who shed viruses and bacteria, animal occupants (insects and other arthropods, mammals) that shed allergens, and indoor surfaces and water reservoirs where fungi, mold and bacteria can grow, such as humidifiers. High

relative humidity encourages house dust mite populations to increase and allows mold and fungal growth on damp surfaces. Mite and fungus contamination can be caused by flooding, continually damp carpet, inadequate exhaust of bathrooms, or kitchen-generated moisture. Appliances, such as humidifiers, dehumidifiers, air conditioners, and drip pans under cooling coils, support the growth of bacteria, fungi, and mold.

Components of mechanical heating, ventilating, and air conditioning (HVAC) systems may also serve as reservoirs or sites of microbial amplification. These include air intakes near potential sources of contamination such as standing water, organic debris or bird droppings, or integral parts of the mechanical system itself, such as various humidification systems, cooling coils, or condensate drain pans. Dust and debris may be deposited in the duct work or mixing boxes of the air handler.

Biological agents in indoor air are known to cause three types of human disease: infections, where pathogens invade human tissues; hypersensitivity diseases, where specific activation of the immune system causes disease; and toxicosis, where biologically produced chemical toxins cause direct toxic effects. In addition, exposure to conditions conducive to biological contamination (e.g., dampness, water damage) has been related to non-specific upper and lower respiratory symptoms.

Asthma

Asthma, a chronic inflammatory disease of the airways, is a leading cause of long-term illness in children. It is one of the leading causes of school absenteeism. Asthma affects

more than 8 percent of the adult population in Nebraska.

The health consequences of asthma per year in the U.S. include over 5000 deaths, 479,000 hospitalizations, 100 million days of restricted activity, and \$14 billion in costs in 2002. Asthma is the number one cause of school absences attributed to chronic illnesses, leading to an average of 3.7 school days missed annually per child. Asthma accounts for a total of 14 million lost school days each year and is the third cause of hospitalization among children under age 15.

Asthma Triggers

The National Academy of Sciences has found that there is an association relationship or link between the development of asthma in children and indoor exposure to dust mites and environmental tobacco smoke (pre-school children). They also indicate that there is a causal relationship (or an association) between making asthma worse and pet (cat and dog) dander, cockroaches, dust mites, environmental tobacco smoke (second-hand smoke), fungi and molds, the common cold, and nitrogen dioxide and nitrogen oxides.

Note: Not all asthma triggers are listed here. Consult a health professional for more information about asthma, potential triggers, and management of specific problems. The following information is not a substitute for professional medical help and a doctor's recommendations and for information from parent(s) or guardians of children who are asthmatic.

Allergens and irritants in a building may trigger asthma attacks. By controlling the environment, people

may reduce their risk of an asthma attack, prevent asthma from getting worse, and perhaps avoid the onset of asthma. A discussion of triggers and potential management methods to reduce the triggers follows.

Note: Parents of children with asthma should work with their physician and health care professionals to determine specific pollutants that trigger asthma, how to reduce the triggers, and how to manage their asthma.

Management Techniques

Dust in Buildings

Dust contains more than 5,000 ingredients including molds, fibers, dander, soil, bacteria, smoke residues, dust mite allergens, skin flakes, insect body parts and more. Do the following to help manage dust:

- Prevent entry. Use quality commercial rugs or mats on the inside and outside of entrance doors (At least 6 to 12 walking steps inside and outside.)
- Use smooth, easy-to-clean surfaces and washable items in your facility.
- Damp clean to remove dust to avoid it becoming airborne.
- Use commercial high quality vacuums with filters that catch and retain the dust such as HEPA filters (High Efficiency Particle Air Filters).
- Use high efficiency filters in HVAC systems according to the manufacturer's directions. Consult with the manufacturer before changing filter types — provide the manufacturer with the HVAC model numbers.

- Change or clean heating and cooling system filters as directed by manufacturer.
- Remove old carpet and pads that may have deep imbedded dust, pollen, and dust mite parts.

Dust Mites

Dust mites are microscopic creatures and one of the principal irritants in dust. They live in warm humid places and in soft furnishings such as carpets, fabric-covered furniture, clothes, and stuffed toys, etc. If a school or child care center has rest areas for young children, the mats, beds, and covers may harbor dust mites as well as the first aid station rest area. Do the following to help manage dust mites:

- Reduce humidity to about 30 percent to 45 percent and use good cleaning strategies.
- Cover mattresses, box springs, and pillows with covers labeled for dust mite control.
- Wash all bedding and mats each week in hot water to reduce the dust mites and their deposits or parts.
- Avoid mats or furnishings that are more difficult to wash or clean.
- Replace pillows and quilts every year or two for particularly sensitive persons.
- Use hard surfaces in the rest areas and areas where children frequent such as classrooms. These include floors, furnishings, and window treatments.
- Remove clutter and stuffed toys. Keep toys out of rest areas. Select toys that can be washed or are hard surfaced. Some toys can be enclosed in plastic and put into the

freezer for several days to reduce dust mites.

- Clean and vacuum frequently used upholstered furniture on a regular basis.

Pets

Animal skin flakes, urine, and saliva can be asthma triggers. Cats and rodents are more likely to be triggers than dogs. If a particular animal or animals are triggers for some students, staff, or residents, keep it out of the facility. In schools, classroom science education may involve studies of live animals and tours to zoos and other places. This may expose individuals with asthma to asthma triggers. Do the following to help manage pet allergens:

- Keep pets away from fabric-covered furniture, carpets, and stuffed toys and in a confined area.
- Select animals that are not likely to be asthma triggers for the individual.

Insects and Rodents

Exposure to pests (such as cockroaches and rodents) can trigger asthma in some individuals. Many people with asthma are allergic to the dried droppings and cast off exoskeletons (skins) of cockroaches. Do the following to help manage insects and rodents:

- Keep all food and garbage in sealed air tight containers.
- Control and repair water leaks.
- Dispose of cardboard boxes and clutter.
- Seal openings around water pipes and other cracks where pests may enter around doors, windows, and cabinets.

- Use the least toxic product for pest control. Read the label! Limit the treatment area, provide plenty of ventilation, and keep asthmatic individuals out of the area.
- Clean up areas where food is stored, eaten, and prepared including student snack areas.

Pollen

Typical pollens to which people are allergic include grasses, ragweed, and pine, birch and oak trees. Pollens enter through doors, windows and other structural openings. Do the following to help manage pollen:

- Use quality doors, windows, and screens. Fix holes in screens and windows.
- Use caulk and weather strip to seal cracks around doors and windows.
- Keep doors and windows closed and the air conditioning on during peak pollen seasons.
- Place rugs at the outside and inside of all entrance doors (6 to 12 walking steps). Clean and wash weekly.
- Vacuum with an efficient vacuum that has a HEPA filter.
- Maintain and replace HVAC filters.
- Wet clean or damp mop surfaces.

Other Potential Asthma Triggers

Combustion Products

Combustion products, such as soot and smoke, and gases, such as sulfur dioxide and nitrogen dioxide, can cause breathing problems in children with asthma. Do the following to help manage combustion products:

- Have heating and cooking equipment, such as gas furnaces, water heaters, and ranges, serviced yearly.
- Provide adequate exhaust and intake ventilation to the combustion equipment.
- Use the hood ventilators in kitchens when cooking.
- Limit or avoid the use of wood-burning equipment, kerosene heaters, and candles.
- Do not burn yard or other waste near the building.

Secondhand Smoke

Environmental tobacco smoke or secondhand smoke may aggravate symptoms in asthmatic individuals and may be a risk factor for new cases of asthma in children. Children exposed to secondhand smoke are also more likely to suffer from pneumonia, bronchitis, and other lung diseases as well as ear infections. Children whose mothers smoked during pregnancy tend to be born with smaller airways, increasing their chances of developing asthma.

Smoke particles linger on walls and other surfaces and continue to give off particles and gases even after smoking has stopped. Smoking is prohibited while children are present in child care and school facilities.

Volatile Organic Compounds

Volatile organic compounds (VOCs) are gas pollutants and chemicals that can evaporate. They are found in such things as building materials, paints, glues, pesticides, solvents, and cleaners. Formaldehyde found in building materials is a VOC. Do the following to help manage VOCs:

- Avoid storing solvents or pesticides; buy only what is needed.
- Keep container lids on tight.
- Choose water-based products and non-aerosol products.
- Choose unscented products.
- Keep VOCs stored in detached storage if possible.

Sensitive environments that want more in depth information on assessing their facility for indoor air quality (IAQ) should go to the EPA website under the “Tools for Schools” program (<http://www.epa.gov/iaq/schools/>). The IAQ Tools for Schools Kit shows schools or anyone who manages indoor air quality how to carry out a practical plan of action to improve indoor air problems at little or no cost using straightforward activities and in-house staff.

Resources

For mold management practices, pesticide recommendations, indoor air quality, and asthma information, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

U.S. EPA Publications:

Mold Remediation in Schools and Commercial Buildings. (EPA 402-K-01-001) http://www.epa.gov/iaq/molds/mold_remediation.html or <http://www.epa.gov/iaq/molds/images/moldremediation.pdf>.

A Brief Guide on Mold, Moisture and Your Home. (EPA 402-K-02-003) <http://www.epa.gov/iaq/molds/moldguide.html>.

Indoor Air Quality Publications
<http://www.epa.gov/iaq/pubs/index.html> or 1-800-490-9198.

U.S. EPA Indoor Air Quality (IAQ) Sites:

Indoor Air Quality
<http://www.epa.gov/iaq/>

Asthma and Indoor Environments
<http://www.epa.gov/asthma/>

Indoor Air – Molds
<http://www.epa.gov/iaq/molds/>

Mold Resources List
<http://www.epa.gov/iaq/molds/moldresources.html>

IAQ “Tools for Schools”
<http://www.epa.gov/iaq/schools/>

Chapter 20 adapted by Shirley Niemeyer from:

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NOTES



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