AG1157

Food Manufacturing, Processing and Storage Pest Control

Classification 7

Training Manual

UofA
UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE
Cooperative Extension Service

University of Arkansas, U.S. Department of Agriculture, and County Governments Cooperating

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Preface

This manual provides information for the Arkansas commercial pesticide applicator wishing to become certified in Food Manufacturing, Processing and Storage Pest Control – Classification 7. To become a certified applicator in this category, a candidate must pass both a general standards exam and pass an examination based primarily on the material presented in this manual and (Circular 6) Arkansas Pest Control Law (Act 488 of 1975, as amended). Information covered in the general standards examination is contained in *A Guide for Private and Commercial Applicators: Applying Pesticides Correctly*. Refer to (Circular 6) Arkansas Pest Control Law (Act 488 of 1975, as amended) for specific requirements. The Arkansas State Plant Board administers the examinations. Up-to-date study materials can be obtained from the Arkansas State Plant Board, #1 Natural Resources Drive (P.O. Box 1069), Little Rock, AR 72203-1069, phone (501) 225-1598. Additional study information may be obtained from the University of Arkansas Cooperative Extension Service, the pesticide label, current publications on the subject, pesticide distributors and manufacturers.

Acknowledgments

Information accumulates from direct observations, scientific literature and anecdotes from others. Information from these sources blurs together quickly, and consequently, unique ideas are rare in society. Credit for sources of information on urban pest control and management must go to Land Grant University Extension and research workers, most of whom are entomologists, who pioneered this work, those who kept training and research alive during the period when the success of synthetic organic pesticides preempted nearly all but control evaluations from the 1940s to the 1960s, and those who persist today; Pest Control Industry workers who held training sessions nationally, regionally and locally where information was disseminated among the experienced and provided to the inexperienced; Environmental Protection Agency personnel who molded modern training and influenced the need for national uniformity in training requirements; state regulatory personnel who cooperated with universities and industry and who strongly emphasized the importance of training; and the few textbook authors in the United States and England who compiled the reference data in the understandable and usable form that allows urban pest management practitioners to be professionals.

Portions of this manual have been adapted from commercial applicator certification training manuals for general pest control developed by the Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University; Texas Agricultural Extension Service, the Texas A&M University System; and University of Nebraska Cooperative Extension, University of Nebraska-Lincoln. Also, special thanks go to Dr. Jim T. Criswell and Dr. Melinda Crockett, Oklahoma State University, Oklahoma Cooperative Extensive Service; Dr. Don L. Renchie (Texas Cooperative Extension); Dr. Grady J. Glenn (Center for Urban and Structural Entomology), Texas A&M University System; and Dr. Clyde L. Ogg, Extension Educator-Pesticide Education, University of Nebraska Cooperative Extension.

Specific acknowledgments should go to the anonymous biological illustrators who graphically render pest and beneficial animals where photographs fail.

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Food Manufacturing, Processing and Storage

Overview of Managing Pest Problems in Food Related Facilities

Management of pests in food processing facilities requires a high degree of professional knowledge combined with experience. Pest management includes many items in addition to pesticides. A good definition for pest management: IPM is the integration of chemical, physical, cultural and biological controls into a system that minimizes health, economic and environmental hazards. Some have stated pesticides are to be used as the last resort or as a method to correct a serious problem.

One of the first steps in managing pests in food plants is a well-constructed building. Preventive design and maintenance is an extremely valuable tool and first step in pest control. When preventive design/construction is not possible, then steps must be taken to apply preventive measures to existing facilities to decrease pest problems.

Food plants must employ daily, ongoing pest management programs including record keeping to monitor both effectiveness and legality of pest management.

The pest management program must be directed against the threat of pests not only in the facility but also from surrounding areas. Pests may be introduced to the facilities via incoming ingredients, materials and transportation vehicles. Pest management must be directed at preventing favorable environments for the pest to develop.

The first step in pest management for a food processing facility is design and construction to eliminate pest entry and harborage. Without this step, the pesticide applicator is working from a deficit situation in which the applicator is on a continuous treadmill of trying to catch up with the problem.

The applicator must also be very aware of federal and state regulations regarding the use of pesticides in a food processing facility. This can include the Food and Drug Administration (FDA), United States Department of Agriculture's Food Safety Inspection Service (USDA-FSIS), Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and Department of Transportation (DOT). There may be more than one state agency that will be inspecting the food plant also. In Arkansas, the Arkansas State Plant Board, the Arkansas Department of Health (ADH) and the Arkansas Department of Environmental Quality (ADEQ) will either be inspecting the plant or affecting pesticide selection and/or application.

Many food plants also have strict guidelines for which pesticides can be used in the plant and where the pesticide(s) can be used. In addition, the food plant's contractors may have further restrictions on pesticide use regarding the processing of the contractor's product. The applicator must be aware and follow all of these requirements.

Building Design

Through the engineering design of the building, pest prevention will be made easier. The design includes not only the building, walls and interior but also the exterior landscaping, drainage and where usable materials will be stored and, very importantly, where unusable (trash) materials will be stored outside. The location of property lines can be very important if a food plant's neighbor does not practice sanitation or is a business which will provide harborage for pests.

Short grass, neatly trimmed shrubs, paved access ways and proper drainage are some of the environmental management strategies that help reduce or eliminate shelter areas for most pests. Rodents are further discouraged by surrounding the building foundation with an 18- to 24-inch strip of 1-inch gravel in a trench six (6) inches deep. This also makes an excellent area for traps and bait stations. If the bottom of the trench is lined with roofing paper, weed growth is reduced. A soil sterilant may be used as a surface treatment.

Building design or remodeling for pest prevention involves building framing, construction materials and building services. It is important to keep framing four inches or

more away from walls so that inaccessible voids are not designed into the building. Where voids cannot be prevented, the voids should be filled with polyurethane foams coated with epoxy filler or similar materials. Steel column floor junctions should be grouped and sloped 60° to facilitate cleaning. Reinforced concrete framing should not leave ledges for dust, should be free of pits, crack and crevices and sealed and painted where necessary.

Concrete is suitable for floors, but if not properly poured, concrete will crack and hold dust. Coating the floor will help aid in sanitation. The concrete must be cured and the surface must be sandblasted, ground or acid-etched and primed with the recommended bonding material before the coating is applied. The type of service needed will determine the coating required.

Wet processing areas require acid-proof or brick floors for easy cleaning and resistance to erosion. If the floor will be exposed to large quantities of running water or harsh chemicals, the concrete substrate should be protected from erosion with an asphalt membrane over which the tile cement is applied before laying tiles and grouting. Good epoxy or acid-proof grouts must be carefully and smoothly applied to the joints, which should be no more than 1/4 inch wide to reduce water penetration and pest shelter.

Nonproduction zones of food plants may be covered with asphalt or straight vinyl tiles. However, these tiles may have cracks or void areas due to incomplete bonding, which will harbor insects, so they should not be used in areas where there is a high potential for insect infestation. Tiles may also be discolored by pesticides. Old wood floors offer many pest harborages. Store the new flooring materials for several days in the same area where it is to be used. This preconditioning reduces shrinkage and cracks that can develop later.

There should be a floor drain every 400 square feet of floor in a wet processing area. Floors should be sloped toward the drain at 3/16 inch per foot into a four (4) inch or larger sanitary line which should be equipped with check valves to prevent the entrance of insects and rodents.

Wall materials include precast or poured concrete, concrete block, brick, tile and metal curtain. Whatever the material, it should be sealed or repainted and sealed so that it will be easy to clean and so that pores, cracks and joints will not offer insect shelter. Be sure that when purchasing hollow, sandwich panel-type metal curtain walls, they are well sealed. Do not drill or punch holes in these walls because holes provide access to the interior of the wall, which makes excellent insect quarters.

Roofs should be smooth, built-up paper and pitch type and free of spills and standing water. Pitch and gravel roofs are difficult to clean, and corrugated metal roofs can support insect life in the voids.

It is desirable to have as few windows as possible in a food production zone. Windows are hard to clean and allow many pests to enter when left open. Transparent glass block windows should be considered when outside light is necessary.

Doors should be made of metal and have tight-fitting seams. Use of air curtains on delivery doors or other large entries could also prevent certain pest entry. Any night-lights should be located 30 feet or more away from exterior doors so insects will be attracted away from the doors. Train shed doors are particularly difficult to rodent proof, but by use of a channel threshold and proper locations of the track splice, an acceptable seal can be obtained.

Good lighting with dust-tight fixtures leads to easy inspection, better housekeeping and improved pest management. Wall-suspended lockers, urinals and shower partitions and ceiling-suspended toilet partitions allow wet cleaning of floors. Likewise, water fountains should be wall mounted.

Electrical and plumbing services should be installed so there is adequate access for cleaning behind and through the wall. Pipe insulation should be dense, tough and well sealed and electrical control panels should be either sealed to or held away from the wall. All such panels should be insect proof.

Equipment layout and design should be roomy, easily accessible for cleaning and should not have rolled edges, ledges, dead ends or pockets in which insect-attracting dirt, dust or waste products can accumulate. Equipment should either be raised at least six (6) inches off the floor or sealed to the floor with a pliable material that will resist vibration.

There are five distinct general areas of activity in food plants in which various pests must be managed. In addition to understanding the life cycles and habits of pests, you should consider management in three successive steps:

1. Preventive maintenance
2. Other non-chemical management options
3. Pesticide management options

The following are procedural guides for each area of activity.

Grounds

1. Preventive Maintenance

- Eliminate improperly stored equipment, litter, waste, refuse and uncut weeds or grass within the immediate vicinity of buildings or structures to reduce pest harborages.
- Eliminate excessively dusty roads, yards or parking lots. Pave where necessary and establish well-maintained lawns. This reduces the possibility of food contamination from dirt, microbes and other airborne particles that may drift into the plant.
- Properly slope and adequately drain the grounds to avoid contamination of food products through seepage of foot-borne filth. Poor drainage also provides a breeding place for insects, micro-organisms and water source for rodents.
- Position outside lighting away from buildings and focus the lights toward buildings to attract night-flying insects away from doors and windows. Low sodium lights attract fewer insects and should be used when possible.
- Reduce potential bird harborage by screening off harborage areas. Reduce any waste food product or raw product spillage outside to reduce food potential for birds, insects or rodents.
- Eliminate food that may accumulate near dust collection or exhaust systems.

2. Nonchemical Management

- Consider various types of rodent, insect and bird traps.
- Maintain adequate housekeeping programs.
- Implement pest monitoring programs including pheromone(s) and sticky traps.

3. Pesticide Management

(Rodents)

- Maintain and inspect bait stations. Install bait stations at adequate intervals and inspect often for signs of activity. Be aware of rodent migration seasons or nearby construction that may cause rodent migration. Rodenticides must be kept fresh. Consider solid baits in wet weather and liquid baits in dry weather.

(Insects)

- Install solid insecticidal baits in and around breeding sites that cannot be removed.
- Treat as needed with approved insecticides, especially near potential insect breeding sites.

(Birds)

- Use chemical bird repellents where possible on bird harborage and nesting sites.
- Avicides may be selectively used in many ways.

Buildings

Effective grounds management is beneficial in preventing pest entry, but it cannot stop all pests or prevent pest entry from incoming ingredients and/or materials.

Some general preventive maintenance and non-chemical control guidelines that apply to all areas of operations within the buildings are:

1. Preventive Maintenance

- Rodent proof all doors, walls, windows and roofs.
- Screen all windows that can be opened.
- Eliminate cracks, crevices, recesses and ledges for ease of cleaning and elimination of potential pest harborages.
- Eliminate access to ledges and roofing areas for birds.
- Locate equipment off the floor and away from walls or seal equipment to walls and floors.

2. Nonchemical Management

- Housekeeping – Keep all areas free of loose materials such as cardboard, rags, processing waste and equipment.
- Clean structure frequently with brooms and vacuum, paying particular attention to out-of-the-way places.
- Clean both the interior and exterior of all equipment (electrical and mechanical) often.
- Inside buildings, utilize electrified grids for attracting insects. However, outside buildings electrified grids may do more harm than good.

Incoming Ingredients and Material Storage Warehouse

1. Preventive Maintenance

- Inspection of all incoming vehicles as well as ingredients and materials is essential to determine that pests are not brought into storage areas.

2. Nonchemical Controls

- Store ingredients and materials away from walls far enough to permit access for inspection and sanitation.

(Rodents)
- Place rodent traps (windup and snap) at or near all doors and at intervals along walls and maintain a map of trap locations. Record catches for each trap.

(Insects)
- Utilize air curtains at dock and pedestrian doors

(Birds)
- Selectively use revolving bird lights. Add wires, prongs or other deterrents to rooftops or roosting sites. Note: all mechanical and electrical units require frequent inspection to ensure proper functioning.

3. Pesticide Management

- Use rodent bait stations containing anticoagulants to supplement rodent traps (where company policy permits).
- Space treatment with nonresiduals.
- Crack and crevice treatment with residual insecticides.
- Spot treat with residual insecticides.
- Fumigate raw bulk commodities when infested during receiving and, if possible, before entering the processing plant.

Frequent inspections are necessary to determine that all controls are functioning correctly.

Processing Area

1. Preventive Maintenance

- Detailed monitoring program
- Total facility IPM program

2. Nonchemical Management

- Place rodent traps near doors if situation warrants and monitor for activity.
- Ensure proper sanitation and elimination of harborages.

3. Pesticide Management

- Space treatment withnon-residuals.
- Spot treatment with nonresiduals.
- Crack and crevice treatment with residuals.
- Contact treatment with nonresiduals.

Frequent inspections of all programs are necessary.

Packaging Areas

This is the most critical area of the entire facility since foods are most likely to be exposed in their finished form. Contamination resulting from human contact can also be a significant problem in this area. Packaging materials must be considered as a source of and home for pests.

Records for chain of custody can be very important for packaging material to document proper care and protection from pests.

Preventive maintenance, nonchemical management and pesticide management are the same here as stated earlier.

Finished Products Warehouse

The probability that rodents, insects and birds might gain entry into the finished product warehouse is just as great as with receiving materials and storage. The management requirements are similar. However, the possibility of rodents and insects being introduced into warehouses via carriers is less likely unless all operations are housed together and there are lapses in the pest management program.

Vehicles

The need for an effective vehicle inspection program cannot be overemphasized. If pest-free finished products are placed on a pest-contaminated carrier, the pest control manager has not fulfilled their obligations. Carrier inspection of boxcars and trucks with false walls is difficult at best since it is impossible to closely examine behind walls. Vehicles must be clean and free of infestation prior to loading final product.

(Vehicles before loading)

- Space treatment.
- Crack and crevice treatment.

Creation of In-Plant Sanitation Program

For in-plant sanitation programs to be successful, the program must be supported and followed by all plant personnel including upper management. Inspections of any facility consume a considerable quantity of executive and supervisory time. Therefore, it is important that inspections are organized and efficient, and provisions made to utilize the information gained. Inspections should be given the same careful attention as any other production maintenance activity. Keeping this in mind, the following comments are aimed primarily at the establishment of an in-plant sanitation inspection program.

The procedure in setting up an inspection program can be broken down into five basic steps. These are:

1. Organization
2. Goal
3. Inspection
4. Utilization
5. Follow-up

Organization

The need for in-plant inspections for any food plant operation is quite obvious. In nearly all instances, the motivation to operate a clean, orderly, complaint-free plant surpasses the fear of enforcement activity. Protection of the consumer and maintenance of a respected trade name are strong motives for proper sanitation pest management programs. In this interest, it is obvious that a complete review of the sanitation effort is needed on a periodic and scheduled basis.

As there will be many decisions to make as the program progresses, in matters of finance, policy and personnel, it is best to have the highest company official fully support the program. When the group meets, the highest company official present should act as chairman of the committee. In addition to the chairman, all department heads should be involved, plus an office manager, a safety officer, a personnel director and similar department heads as applicable. The reason for this large group is pest management affects all departments and all departments affect the plant's pest management program. Also, the more persons looking, the more apt the committee is to see and correct any problems.

Goal

The main goal of in-plant sanitation is to review existing activities. After seeing what is being neglected or performed improperly, it is the prime duty of the committee to compile a list of these deficiencies by category. A suggested routine is to precede each item recorded, possibly on a sample inspection sheet, with the categorical classification of the item.

Generally, all defects will fall under five main headings:

1. Pest Control
2. Operational Methods
3. Personnel Practices
4. Maintenance for Sanitation
5. Cleaning Practices

Preceding each deficient item, single or multiple notations of PC, OM, PP, M or C will serve to categorize the problem.

The reason for identification categorically of deficiencies observed by the committee is the violation becomes more obvious when a critical situation starts to appear within a given category. If 50% of the items concern maintenance, it can be assured the plant manager will have some answers from the maintenance department. It could also be the plant superintendent does not like the engineer and is loading the report. In which case, another problem area has been brought to the committee's attention.

The true goal of the in-plant sanitation committee is to recognize weaknesses in the program, to find missed areas in all phases of the effort if these exist and to solve sanitation problems beyond the scope or authority of the individual in charge of the in-plant sanitation program or individual departments.

Inspection

A poorly equipped sanitation committee will do a poor job. Rank-and-file employees know where problems exist and how corrections can best be made. The inspection committee should utilize this information source. The inspection committee should start with clean, spotless outer clothing; a white or green smock would be minimum. A suitable and identifiable uniform is better. A white uniform with a jacket identified as Sanitation Inspection Team, or other such marking, is suggested.

Often when equipment is poorly cleaned, faulty lighting is to blame. The same applies to

inspections. See to it that each member of the inspection carries a halogen flashlight. Some members may prefer having halogen flashlights attached to their bump caps in order to allow free use of their hands. A scraper or spatula is often helpful.

Generally, the engineer will carry a screwdriver and pliers that will be needed tools. The recorder should bring a suitable note pad and pencil and use them.

The committee should assemble on time at a selected site. Determine at this time where an inspection will be made. Proceed to the selected area and begin with the inspection. Try not to look into all the places you examined on the previous inspection unless that location has a history of pest problems. It is a fallacy of inspectors that if an insect was found at a specific location, that person tends to return to and look at the same location.

Discussions during the course of the inspection should be brief and confined to matters within the scope of observations in that specific area. If a unit appears to need cleaning, question the cleaning cycle and when the unit was and is to be cleaned. If the same unit is soiled every time it is viewed, it is likely that the cleaning cycle should be changed unless the inspection is occurring during the "dirty" phase of the day for that unit.

Be constructive, but watch details. Note missing electrical box covers and knockouts. Open boxes present possible insect harborage. Surplus lubricant and chipped paint over or in the vicinity of a product zone is a product hazard and should be noted. It is far better to have too many items on the list than to miss even one item that is critical.

Recording of defects is important because this information will be a work list and must be treated as such. The record sheet should carry the date, area or area number and names of persons participating in the inspection. Consecutive numbering is suggested, starting with item 1 and continuing on to the final item at the end of the series of inspections that comprise one complete in-plant inspection cycle.

Be complete when identifying and describing recorded deficiencies, but be as specific as possible and brief. Get the meaning down on paper so recall on a given item is simple and appropriate measures can be taken to correct the deficiency.

At the conclusion of each inspection, the recorder should comply and distribute inspection notes to each department head so immediate action can be taken on items that can be corrected readily.

As the routine of inspections is established, there may be temptation to consider making up a sanitation checklist or form. This may be helpful as a rough guide. A checklist becomes a problem if it becomes routine, and constructive "digging" is forgotten.

There will be times when it is necessary to look for and to catalog specific things. Surplus lubricant conditions, chipped or peeling paint on structures or equipment and similar product hazard defects are to be considered here. The emphasis of enforcement inspections is shifting to conditions whereby a product may become violative. This means if a condition exists where condensate is dripping off a pipe into a product zone, a violation already exists.

These are of initial and primary concern and should be given priority over all else. Rodent evidence in a warehouse should not be tolerated and could bring about undesirable comment or serious action from enforcement personnel.

Utilization

Each department should be given a clear, written copy of the inspection notes within a day after the inspection. Correction of defects that are within the scope of activities of a department head should be carried out at once. Depending on the seriousness of the condition, a decision must be made by the committee on the action to be taken. When such a condition is observed by the sanitation committee or reported to the sanitation committee, immediate action should be taken. If product contamination or a potential product contamination situation is involved, immediate steps must be taken.

Usually, the sanitation committee will identify items of a less significant nature that can be handled as a matter of routine. At the end of an inspection cycle, when the entire operation including inspection of the roof and grounds has been completed, the sanitation committee should hold a meeting and review the notes compiled during the survey.

Uncorrected items left over from previous inspections should be addressed first. To address repeat situations, the committee head should go down the list, item by item, to determine if a correction has been made. If a correction has not been made, the department head responsible for the condition should give a realistic correction date.

Not infrequently an item will continue to reappear on the inspection notes in spite of

having been marked as corrected. For example, it is a violation of the current Good Manufacturing Practices to have personal clothing lying about in a food production area. In a mill packing area in very hot or very cold weather, personal clothing is often where it does not belong. The packing superintendent's comment may be about having told someone something. This is not correction, however. Providing a site to place clothing, even just a specific peg on a specific post, and enforcing its use is correction.

Both the inspection and meeting should be conducted in a businesslike format, allowing discussion and problem solving.

There is one facet of this type of inspection and meeting that must be carefully watched, and that is to avoid criticism of each other or departments. Finger pointing leads to distraction from the original purpose and does not meet the goal of providing a safe plant to work or to produce a quality product.

Follow-up

Sanitation responsibility does not rest with just the plant sanitarian, the plant manager or any other single plant person. Responsibility for the sanitation program rests on everyone in the plant including plant administrators.

Inspection Observation Routine

The first detailed look should start with obscure places, such as areas where pipes pass through the wall. Usually, if insect trails are present on a pipe, even ten or more feet off the floor, they become quite obvious as a flashlight beam is played slowly along the pipe. When such a situation is found, have the inspection team confirm it. This not only gets a second opinion, but also, quite often, is an educational moment for those of the inspection team who are not familiar with the situation.

Pay particular attention to any highly dust-coated surface, especially on a fairly flat piece of structure. By holding a flashlight at a flat angle to the surface, minor disruptions of the dust coating are elongated and become more obvious. Insect trails or mouse footprints usually stand out well in such situations. Light colored dust on a dark surface is best for this type of observation. Such trails, as those made by mites, are almost microscopic, but readily stand out on such a surface because the mite trails are generally disproportionately large in comparison to the mite itself.

Individual insects, such as the flat grain beetle, are often difficult to see in stock of the same color as the insect. One method of observation is to lay a handful of suspect stock on a flat surface and smooth it out with a spatula. By holding the flashlight at about a 20 or 30-degree angle to the surface carefully for a minute or two, movement can be noted if there is live infestation. Cereal-type insects will usually come to the surface of the stock and can be seen. Mites will start to move, and although the mite itself may not be viewed, mites will move flakes of stock, such as bran or chaff, and this movement can be observed. Insects such as the saw-toothed grain beetle will sometimes remain motionless for up to a minute or so, and only then is movement detected. Again, this is a lesson in seeing, not haste.

In looking for insect or rodent activity, inspect areas most likely to produce results.

It is general opinion of enforcement agencies that a plant will be clean and free of contaminants regardless of what must be done to prevent them. No system is permitted to be insect infested, even a raw grain handling system. While a court case may not evolve from such an infestation, this will appear on an "I Observe" form (Form FDA 483, Inspectional Observations) for which the operation can be held accountable.

Concepts in the amount of allowable filth in any food operation have changed drastically in the past few years. This had diminished from a shovelful to a teaspoonful, and now even a potential contaminated situation must be looked upon with alarm.

Grease and paint should be of prime concern in the inspection along with insects, rodents or any other potential source of contamination. However, it is infrequent that these situations are obvious. Pests are observable in hoppers, under equipment and inside of equipment framework, and it is the task of the inspection team to get in, under and behind such areas to make the necessary observations. This is another reason to carry a good light. Places missed in cleaning are generally dark and inaccessible or else they would not have been missed.

A lesson in equipment framework examination is to determine from which side a piece of equipment is cleaned. The problem, if

one exists, will usually be on the reverse side of the framework, or the one nearer the person cleaning but on the interior.

A void, for the purpose of inspection routine, is any space that cannot be accounted for or access gained for routine check. These are potential danger spots. More often than not, a single insect trail on the floor will point the way to an adverse condition. Remember, suspect everything that cannot be accounted for in false spaces in equipment and structure.

Know what previous inspections reports have stated. If no mice have been reported on the plant trapping record, and hair is observed on a snaptrap, something is wrong. Perhaps this is just a failure to clean the trap, perhaps not.

A portion of each inspection should be devoted to watching employee actions and in-plant practices in general. This observation should be done in a manner as to see the operation, as it would normally be done – not as it may be done with plant supervisors present.

A routine daily inspection of each area is the responsibility of that area's supervisor. These daily inspections should be included in the plant inspection reports.

Good sanitation should be rewarded and recognition should be made to the area and personnel working in that area. This is an important part of total plant cooperation.

Often a periodic inspection by an outside firm will provide insight into the plant's operations. An outside inspection can help identify strengths and weaknesses in a sanitation program.

Specialized Plant Inspections

Persons responsible for sanitation inspections for specific areas of the plant need to be given the authority to implement and enforce sanitation programs.

Warehouse: The person in charge of sanitation needs to be able to require leaving an 18-inch space between pallets and walls and 14-inch space between double rows of pallets. This extra space allows for inspection of the warehouse for insects and rodents. The 18-inch space between the wall and pallets is not attractive for rodents.

Raw Product Receiving: The law (FD&C Act, Title 21, Code of Federal Regulations) requires inspection of raw product received at a food processing plant; however, this often is not done. Each plant needs a written inspection procedure for receiving and inspecting incoming raw product. Not only is the raw product vital for processing, but often either the product or the receiving area is the source of most pest problems. These problems can be eliminated or greatly reduced by a good inspection and sanitation program at receiving.

Items to include for a receiving procedure include:

1. Guidelines for acceptance level of rail cars and trucks as per insects (live or dead), odors, rodent contamination and physical condition of the car. Insects may be either in the raw product or the transportation vehicle.
2. Guidelines for checks and visual examinations of both bagged and bulk products. Included in this are methods to be used and the number of samples and how to take samples for inspection of insects or for quality control analysis.
3. A recording form that is used to provide direct and quick communication when a problem is detected.
4. Set housekeeping standards for receiving area.
5. A pallet-cleaning program coupled with a cleaning code and frequent checks.
6. Specifications as to height, storage and location of stocks in relation to each other. One purpose is to isolate slow-moving stock away from dusty areas or raw product.
7. A reliable method of ensuring stock rotation.

A very critical item at the receiving area is the quick removal of spilled raw commodity, broken packaging and other garbage type material. Removal means not only getting the material into a trash receptacle but having the trash removed frequently and the trash container kept clean.

A pest manager must know which pests cause product damage and those that occur due to some management situation but do not damage the final product. The pest manager must know why a pest occurs, that is, what conditions must be present for the pests to survive and how to remove those conditions. The pest manager must also be aware of the federal and state regulations relating to his/her plant.

Food Manufacturing, Processing and Storage Integrated Pest Management

When people discuss food processing pest management, discussion usually concerns a crisis point or another area where a problem has erupted and people are trying to solve the problem. Most concerns revolve around concern from governmental and regulatory enforcement actions or consumer complaints. The biggest impediment to improved management and implementation of IPM systems is the prevailing attitude of eradication. While managers of other commodities such as fresh market produce have accepted IPM principles, the food processing and distribution system has not yet accepted the philosophy behind this system.

What is IPM?

IPM is defined as a systematic approach to commodity protection emphasizing increased information for improved decision making to reduce purchased inputs and optimize social, economic and environmental consequences. The IPM concept emphasizes integration of disciplines and control measures into a total management system. Control or management measures include natural enemies, cultural management, temperature and other physical controls, sanitation and pesticides. This system anticipates and prevents pests from reaching damaging levels and improves overall economic and social outcomes. From an economic and ecological standpoint, IPM is based on the "economic threshold" concept that management action is taken only when potential losses due to pest populations exceed costs of controls available to reduce the populations.

Basic changes in management decision-making processes are required to implement an effective IPM program. Food processors and distributors must realize most decisions have consequences far beyond a particular time period and location. Excessive use of management practices such as pesticides may reduce profitability, create potential worker hazards and stimulate pesticide resistance. Keys to implementing IPM include understanding factors that regulate systems, monitoring, maintaining good records and using this information to make sound management decisions.

What regulates storability?

Postharvest systems are regulated by moisture content, temperature, pest access and time that the product is in a susceptible state. Within biological limits, the greater the temperature, moisture content and the time products are in a susceptible condition, the higher the resultant pest population. Management systems must be built around these biological and management factors and their influence on population dynamics.

Moisture Content: Different insect and mold species have different requirements for grain moisture. The rice weevil is limited by its requirements for high grain moisture (>13%), whereas the lesser grain borer can tolerate dry grain. Within limits, the greater the moisture content, the higher population growth. Mold growth normally requires high grain moisture greater than 14-15%. Most processed goods are low in moisture content, and this helps reduce population development.

Temperature: Temperature is the most important regulatory property in processed food storage. Temperatures below 65°F are unfavorable for insects and molds. Likewise, grain temperatures above 95°F are unfavorable for insects. Insects are especially sensitive to high temperature, and high temperatures have been used as a disinfestation and management practices for centuries. From a stored product management viewpoint, keeping insects at sub-optimal temperatures is important to reduce population development and minimize damage and cosmetic concerns. **Table 1** shows the general response to high and low temperature. The interaction of both temperature and time to achieve mortality are obvious. Even relatively low temperatures can be very effective in suppressing insect populations.

Table 1. Response of stored-product insects to temperatures (Fields 1992)

Zone	Temperature (ºF)	Effect
Lethal	122-140 113	Death in minutes Death in hours
Sub-optimum	95 90-95	Development stops Development slows
Optimum	77-90	Maximum rate of development
Sub-optimum	60-77 60-55	Development slows Development stops
Lethal	41-60 0	Death in days Death in minutes

How long will packages have to be in a cool temperature controlled climate? **Table 2** shows several packages and time to get the temperatures to a level where insect mortality will occur.

Table 2. Times for selected commodities to reach 32ºF to ensure insect mortality. All commodities were exposed in a 27 ft^2 freezer filled to capacity.

Commodity	Temperature Setting (ºF)	Time to 32ºF (hrs)	Time to equilibrium
Cornflakes	-14 -5	7 6	30 30
Flour (100 lb)	-14 -5	55 29	160 130
Macaroni (24 lb)	-14 -5	29 18	130 95

A key component is that insects are very durable creatures and, if insects are given time to adjust to changing temperatures, insects will modify their physiology to survive extended periods of harsh temperatures. This is primarily true for cold temperatures. However, if the temperature change is rapid and dramatic (e.g., taking insects from 90°F to 60°F), very high mortality will occur (**Table 3**).

Different insect species have differing tolerances and temperatures that are optimal. Insects most sensitive to cold are red and confused flour beetles. The most cold tolerant are the weevils and the Indianmeal moth. The stage of development can also help insects survive harsh climates. For example, larvae of the lesser grain borer and rice weevil are very cold tolerant, whereas adults of the rusty and red flour beetles are the most cold tolerant.

Table 3. Mean percent mortality of lesser grain borer and rusty grain beetle populations in instantaneous temperature drop from 86°F.

Temperature	Lesser Grain Borer	Rusty Grain Beetle
86°F	10	19
77°F	6	17
68°F	2	2
59°F	2	1
50°F	10	96
43°F	98	95
32°F	100	99

Surrounding conditions have a significant influence on insects. Earlier discussion demonstrated the significant impact commodity moisture could have on population development. Likewise, relative humidity has a significant impact on insect mortality in different temperatures.

Time: Stored grain insects and molds are very predictable and have an exponential growth curve after the product is processed. Managers have the ability to shift this population curve to the right or to the left and the magnitude of the height depending on their sanitation program and the ability to aerate to control temperature.

Access: Most stored product insects can fly and move within and between storage structures. Maintenance sanitation and residual sprays are keys to minimizing residual populations in storage facilities and reducing the population growth of insects. Food warehouse facilities are very attractive to stored product insects and insects will find these facilities. Keeping insect movement to a minimum is a key component to sound management.

Keys to Reduce Access

Carefully inspect all materials entering a warehouse area. This should include raw products, paper materials, packaging or any other material that could transport insects.

Building design: Design storage and processing areas to minimize open areas, unscreened vents and other areas of access.

Screens: Screen all vents, doors and other areas to minimize access. Use fine mesh screens to minimize penetration.

Make sure doors are not left open, and it is preferable to have double doors to minimize migration.

If a significant infestation is found, eliminate the population to prevent spread and modify microclimate to prevent insects from developing significant populations.

Monitoring Tools

The backbone of any management system is effectively sampling pest populations and monitoring grain/product quality. There has been a great deal of excitement regarding new sampling tools that have become available for insect sampling in grains, warehouses and processing facilities. These tools can be pheromone baited or used unbaited. These sampling tools have not been accepted because they are presently uncalibrated and there is no implementation work demonstrating these in commercial situations. In processing industries, trapping systems are of great assistance in detection to maintain low populations of insects.

Key Monitoring Tools

Visual – Visual inspection can be a key to maintain a low population in food processing and food warehouses. Key areas to watch are foods that are high risk:

- Longest in the warehouses
- From a high risk firm
- In an area that is the warmest
- Near access points
- Poor packaging

Visual inspections also have another added benefit – they force personnel to walk through a facility and notice any open packages, improper sanitation and other areas that will attract and allow a population of insects to develop.

Lights – Lights are often an excellent place to begin a facility inspection. Most stored product insects are attracted to lights. If Indianmeal moths or other insects are noticed flying around lights, there is likely a population within the warehouse. Indianmeal moths were often thought to avoid light; however, they are significantly attracted to light and this is a good way to initially sample for Indianmeal moth adults. Replacing incandescent or mercury vapor light with yellow or sodium arc lights at outdoor areas can be effective in reducing the attraction of insects from outside services.

Trap Design and Attractants

For each insect and sampling requirement, the user must decide what kind of trap and if there are needs for attractants.

A pheromone is a chemical attractant released by an insect to affect the behavior of the same species of insect. Two commonly used pheromones for insects are sex and aggregation pheromones.

Sex pheromones are used to facilitate mate location and mating. There are several commercially available sex pheromones for use in traps to improve sampling. Most commonly used is the Indianmeal moth pheromone.

Aggregation pheromones are chemical substances released to attract members of the same species. The most commonly used is the confused flour beetle pheromone.

Food attractants are often used in corrugated traps and have significant advantages because the food attracts all species of food-processing insects. An obvious limitation to the use of food attractant in a food warehouse is the competition with food odors surrounding the traps.

Trap Placement

Trap placement is a key component in managing food processing insects. Placement of traps is dependent upon:

Time of Year – Different times of the year have different temperature profiles within the processing area and warehouse. When temperatures are 90ºF, extensive movement within and around the facility will occur.

Outdoor Use – If outdoor traps are used to measure movement into a facility, the traps should be placed in areas that will not collect extensive amounts of dust but are close to areas of entry.

Number of Traps Per Square Feet – The number of traps required depends on the risk the manager is willing to take, personnel time available and pest level at which the manager wants to maintain the population. A rule of thumb may be one trap per 4,000 to 5,000 square feet. A key part is putting traps in high-risk areas where there have been insect problems before. This practice can prevent buildup and the requirement for extensive insecticide application or fumigation and/or product removal.

Interpreting Trap Catch

There are no hard and fast rules for interpreting trap catch. A better practice may be examining the trends in trap catch and attempting to modify management practices to reduce populations. Insect population grow exponentially, and when outbreaks occur, they are often easy to measure.

Future Applications

With decreased pesticide alternatives and increased regulations, the processing industry will have to begin looking for alternatives to pesticides. These alternatives will have to be based on the ecology of the system with an emphasis on system regulatory mechanisms. Many flourmills are beginning to use heat treatments to manage insect populations. Management options should emphasize available tools such as hot or cold temperature manipulation, improved monitoring systems in processing, increased awareness of sanitation and housekeeping and having well trained personnel throughout the system from acquisition to marketing.

How to Use Insect Traps in a Warehouse

A tool to determine the presence or absence of potentially harmful pest insects is needed where stored commodities are held for extended lengths of time. Pheromone-baited traps are excellent tools for this purpose.

Trapping systems are significant tools to use in an integrated pest management program in warehouses. Pheromone-baited traps can be used in a variety of ways to assist in a warehouse pest management program:

1. Inspection of bagged commodities.
2. Identification of pests or the potential for pest infestation.
3. Determination of the extent of the problem.
4. Evaluation of a particular treatment or control method.

All pheromone-baited traps were not created equal. Traps for moths may act differently than beetle traps (**Figure 1**). One cannot treat all stored-product pests the same when it comes to recommending an effective trapping program. Long-lived insect adults (e.g., flour beetles) tend to be less attracted to pheromone-baited traps than short-lived insect adults. A flour beetle adult that lives for 12 to 18 months does not react as dramatically as an Indianmeal moth adult that may only live in this stage for one to two weeks.

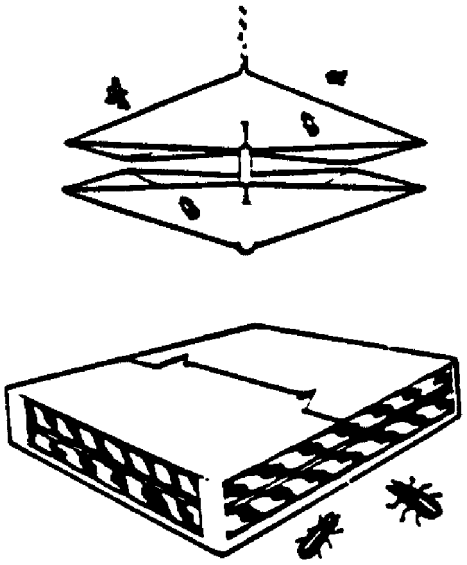

Figure 1. Moth trap (top), beetle trap (bottom).

Know the Pest

Knowing the pest is half the battle in controlling it when establishing and managing a grain, bulk commodity or bagged product pest management program. This holds true when one tries to interpret the results and data from such a trapping program.

Common Insect Pests in Grain and Processed Food

Tables 4 and 5 summarize the results of surveys conducted in 1980 and in 1988 and show the frequency at which stored-product insects were found in raw grain and processed food.

Table 4. Most frequently found stored-product insects in raw grain in the United States.

Rank	Species	Number of States Responding	
		1980	1988
1	Indianmeal moth *	27	30
2	Sawtoothed grain beetle	20	23
3	Red flour beetle*	16	26
4	Rice weevil	19	19
5	Confused flour beetle	17	11
6	Flat grain beetle	7	18
7	Granary weevil	8	13
8	Foreign grain beetle	7	11
9	Lesser grain borer*	8	10
10	Angoumois grain moth*	10	3

* A pheromone lure is commercially available for this stored-product insect pest.

Table 5. Most frequently found insects in processed food in the United States.

Rank	Species	Number of States Responding	
		1980	1988
1	Indianmeal moth *	29	40
2	Sawtoothed grain beetle	33	38
3	Red flour beetle*	24	24
4	Dermestids*	24	23
5	Confused flour beetle*	15	20
6	Cigarette beetle*	13	15
7	Drugstore beetle*	6	11
8	Flat grain beetle	0	3
9	Rice weevil	0	2
10	Granary weevil	0	2
11	Warehouse beetle	0	0

* A pheromone lure is commercially available for this stored-product insect pest.

Traps

It is important to recognize that there is not always one type of trap that is best to use in a pest-monitoring program in warehouses. It is important to match the specific trap to the environmental conditions in each particular situation. Some examples of this would be: 1) dusty areas vs. areas that are not dusty, 2) hot vs. cold temperatures and 3) outdoors vs. indoor use.

Too much dust can cause sticky traps to be ineffective. In this situation, alterations to the sticky trap can prevent an excessive build-up of dust or a pitfall-type trap could be incorporated.

Dusty warehouses offer challenges for conventional sticky glue traps. In these extreme conditions, a sticky trap may become useless after several days, or even after several hours. The selection of a trap that can deflect the dust, or a pitfall-type trap that does not include glue as the entrapment mechanism, will need to be implemented.

Placement of traps will depend on the temperature in the warehouse. In the spring, the ceiling of the unheated warehouse offers optimum conditions for the growth and development of stored-product insects. As the temperature gradients in the warehouse change during the summer months, the harsh conditions near the top of these facilities may hinder the capture of insects in a monitoring program.

Outdoor Trapping

Trapping for stored-product insects around the outside of a stored-product warehouse can offer several advantages in an overall pest management strategy. The trap selected for outdoor trapping must be able to withstand the weather (e.g., plastic construction) and should not be prone to becoming saturated with insects quickly.

By placing pheromone-baited traps on the outer perimeter of a storage facility, potentially destructive insects can be intercepted or lured away from stored food and grain. A feral population of many of the most common stored-product insect pests is available outdoors throughout the United States and Canada. Thus, the outdoor pheromone trapping technique can help the modern pest manager predict the arrival of indoor populations of insects and prevent many from causing an infestation.

Trap Placement

There is no exact number of traps that should be placed in a warehouse to detect the presence or absence of pest insects. The number of traps needed may change according to several factors determined by the trained person implementing and reevaluating a trapping program. Some factors to consider are:

1. Quality assurance standards by management

2. Seed vs. finished goods
3. Pharmaceutical vs. raw intermediate products
4. Popcorn vs. field corn

Important questions to ask are:

1. What is the goal of a sanitation program? Is the goal zero insect tolerance?
2. Is an attempt being made to mass trap out a population, or to just monitor a pest population?

Figure 2 illustrates a situation where one trap per 100,000 cubic feet is placed in a finished grocery product warehouse. The pest management inspector checks each trap weekly. A record of the results is kept in a separate log away from the physical trap itself. A map should be made of each trapping location. Each trap in this practical example contains two lures: (1) *Plodia* complex (Indianmeal moth), and (2) *Trogoderma* complex (warehouse beetle, *T. galbrium,* furniture cabinet beetle, khapra beetle). An optional lure for the cigarette beetle could be placed in each trap in some situations.

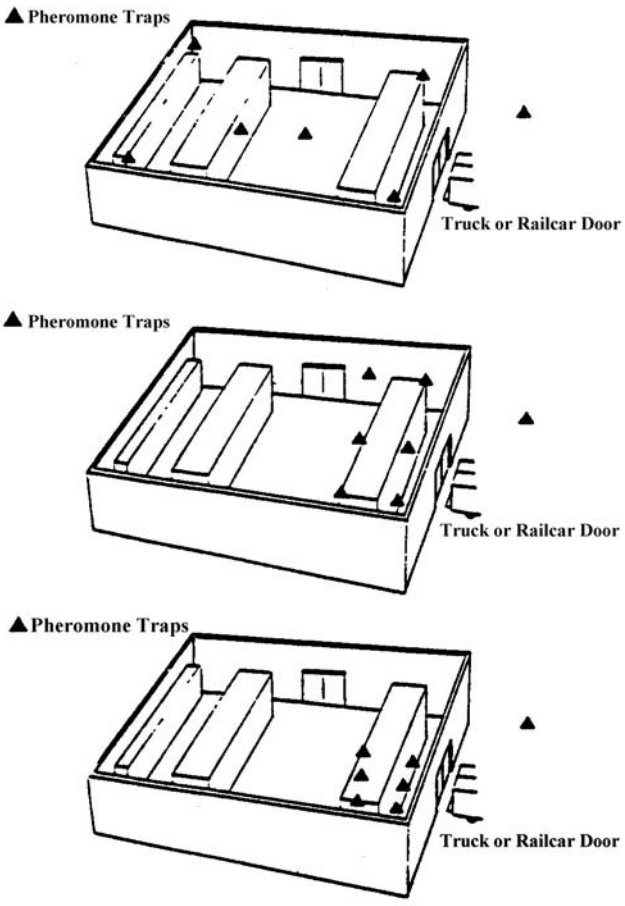

Figure 2. Monitoring for stored-product insects in a finished foods warehouse.

After determining that his warehouse contained little or no detectable target pests in half of the facility, the traps were moved to the half of the warehouse where insects were found in the pheromone-baited traps. Another approach that can be used instead of moving the traps is to employ more traps in a uniform grid pattern in the suspect areas of the warehouse. After several days or a week, these traps are checked and recorded again. At this point, there is one trap per 50,000 cubic feet. If the pest management inspector has more time, he/she can tighten the grid even further to pinpoint this infestation (one trap per 10,000 cubic feet). The inspector can then start visually searching for signs of an active infestation in the areas where the most insects were captured. This could be cast skins of *Trogoderma* larva; odor distinctive to certain insects (e.g., flour beetles and roaches); webbing on bags, flaps of the bags or the surface/side-walls of a grain bin; pupa casing in corrugated cardboard; or actual live insects on finished product.

In this actual warehouse, old code-dated rolled oats were found to be infested with Indianmeal moths, sawtoothed grain beetles and flour beetles. Some nearby dog food also contained large stored-product insects that could have entered this warehouse from the often-opened dock door. The cost of this program for pheromone-baited traps/lures would typically run about $250 to $300 per year. The time needed to count and record seven traps each week would be about 30 minutes.

Interpreting Trap Catch

A common misconception in a strategy used to manage grain, bulk commodities and bagged products using pheromone-baited traps is that there is a set numerical threshold for action or reaction. There is no magic number for determining action. A trained pest management inspector must weigh all factors before making a decision. The key to interpreting trap catch is to look for increases in numbers of insects from one trapping period to the next (e.g., 1 - 5 - 30).

It is often easy to see when an outbreak occurs. At this time, the pest management inspector can recommend appropriate corrective action (e.g., chemical, nonchemical, sanitation, discarding product).

A Plan for Pest Management for the Popcorn and Seed Industry

Purpose: To establish an on-going, year round pest management program to eliminate any damage incurred by insects, rodents or birds. This would include both physical damage to the seed and the defacing of the packaging that contains the seed.

History of the Problem

The popcorn and seed industries in the United States are making rapid advances in the manipulation of the genetic structure of plants in order to create varieties that are more productive. However, even with the amount of technology available, most seed companies are years behind other processed food disciplines in the protection of their stored commodities from stored-product insect pests and rodents.

I. Monitoring and Inspection
- A. Pheromone traps
  1. Indianmeal moth traps
  2. Angoumois grain moth traps
  3. Grain probes in bulk bins
  4. Recordkeeping is essential
  5. Replacement of traps and lures
- B. Glue boards and Ketch-alls/rodent inspection
  1. Dock and loading areas
  2. Critical points in the operation
- C. Visual inspection
  1. Insects
     a. Inbound packaging materials
     b. Webbing from moths
  2. Rodents
     a. Black-light inspections/inbound
     b. Fecal pellets
  3. Birds
     a. Nests
     b. Feces

II. Building to Keep Out Pests
- A. Insects
- B. Rodents
- C. Birds

III. Non-chemical Control
- A. Cold storage
  1. 50ºF with 50 percent R.H.
  2. Insect activity in cold temperatures
     a. Reduces activity
     b. No reproduction
- B. Anticipation of winter storage/fumigate before winter
- C. Mice in cold storage
  1. Insulation, be aware
- D. Lighting/placement is critical
  1. Indoors
  2. Outdoors
- E. Beneficial insects (non-food areas)

IV. Chemical Control of Bulk Seed Storage
- A. Timed pyrethrin dispensers *replacing vapona strips
  1. 32-day aerosol cans of two percent natural pyrethrin
  2. Labeled insecticides
- B. Pheromone traps
  1. Moth trap/every fourth bin (outside the bins)
  2. Grain probes in the bins (one per 5,000 bushels)
  3. Check every two weeks/ July-November
  4. Critical check before processing
- C. Routine fumigation of bulk bins
  1. Aluminum phosphine tablets
  2. Aluminum phosphine pellets
  3. New Degesch Mini-Ropes *retains the dust in the rope
- D. Empty bin treatment
  1. Beneficial insects
  2. Residual insecticides
  3. Fumigation: Chloropicrin
- E. Perimeter control
  1. Weeds
  2. Bare ground herbicides
  3. Gravel or blacktop
  4. Insecticides
     a. Where to spray/one foot upside and two feet away from bin
     b. How to use/see label instructions
     c. How often to spray/twice a summer
  5. Spillage clean-up/important

V. Chemical Control in Seed Warehouses and Processing Areas
- A. ULD Treatments (Ultra Low Dosage); *replace vapona
  1. Check pheromone traps/once per week and record catch
  2. Minor threshold: if total catch exceeds 10 moths per week
     a. Apply remotely if possible (timer)
     b. Particle size: 15 to 30 micron
  3. Three percent Pyrethrin

4. Types of ULD equipment: Micro-Gen
5. Safety equipment to use
    a. Proper respirators
    b. Draeger detection tubes before re-entry

B. Fumigation with aluminum or magnesium phosphide
1. Trained, certified and experienced
2. Safety
3. Proper storage/cool, dry, well ventilated, locked
4. Cold temperature fumigation
    a. Magnesium phosphide
        (1) Degesch Fumi-Strip
        (2) Degesch Fumi-Cel
5. Inert gases
6. Aerate to safe level
7. Proper safety equipment available
8. Draeger detection equipment

VI. Rodent Control Program

A. Outdoor
1. Bait stations/tamper proof
2. Rodenticide
    a. Grain based/Talon Weatherbloc, Vengence
    b. Liquid bait, summer
    c. Safety
3. Building them out

B. Outdoor perimeter control
1. Weed abatement
2. Bait stations, every 60 feet
3. Ditches and standing water
4. Rats need water every day
5. Gravel 24 inches perimeter
6. All doors should fit tightly

VII. Bird Control

A. Cooperative venture with surrounding groups
1. City
2. Grain companies

B. Farm machinery sheds

C. Warehouses
1. Close doors
2. Plastic strips
3. Rid-A-Bird perches (restricted use pesticide)
4. Avicides
5. Bird netting
6. Sticky Bird Repellent

Limitations

Pheromone-baited traps have some limitations in management of grain, bulk commodities and bagged products. These traps are very sensitive to the target insects being monitored. However, other insects often are present and go undetected because of a lack of effective or efficient trapping systems. In one field situation, cigarette beetles were extensively monitored and managed with limited applications of chemical insecticides only to find that several pallets of oats were highly infested with a hidden population of flour beetles.

The entomologists' and chemists' inabilities to duplicate the exact chemical messenger or messengers have not given us a complete choice of effective pheromones with which to work. The beetle pheromones seem to be much harder to identify than the moths. However, results demonstrated by the lesser grain borer aggregation pheromone hint that when the components are discovered and mixed in commercial pheromones in the correct combinations, they can work well to detect the presence or absence of a target insect pest. Advances in biotechnology and the potential cloning of these precise chemical messengers will overcome some of these limitations.

Conclusions

The use of pheromone-baited traps to determine the presence or absence of a pest population in storage facilities is an exciting new step toward a total pest management program. The interest in pheromones in recent years has been fueled by their potential to modify the behavior of pests and to attract them to traps. By monitoring the change in trap catch over time in warehouses containing stored products, action levels can be decided and the judicious use of control methods can be prescribed when population growth is observed in one or more areas of a facility.

The practical application of pheromone-baited traps to alter insect behavior and prevent reproduction is helping provide the grain, bulk commodity and bagged product industries with the option of a total pest management strategy.

Pesticide Labels, Applications and Regulations

The pesticide applicator should be thoroughly trained in the uses and hazards of the materials being used. The applicators are responsible for preventing adverse effects to the public, to pets and domestic animals, to property, to the environment and to himself and other applicators. In addition, the application must achieve effective results on the pest problem being treated.

Labels

By definition the label is the information printed on or attached to the pesticide container. Labeling includes the label and all other written, printed or graphic material accompanying the pesticide.

The importance of reading the label cannot be stressed too much. The information that appears on the label represents some of the most expensive literature available. The research and development that lead to the wording on a label frequently costs millions of dollars and takes many years to complete. The information on the label is the best literature available on the safe and proper use of the chemical. The most important moments in pest control are the time spent in reading the label.

Please refer to the chapter on Labels and Labeling in the manual entitled *Applying Pesticides Correctly* for a discussion of the basic information that appears on every pesticide label. The following is a discussion of terms that are found on labels frequently used by the pest control industry.

Some information appears on the labels of the insecticides used by pest control operators that is rather specific to the industry. This information is extremely important since the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) states it is illegal to use any pesticide in a manner inconsistent with its labeling. A specific example where this information is important to the pest control industry involves the use of pesticides in food-handling establishments. You can only use those insecticides that bear directions on their labels for use in food-processing establishments. Typical labels have wording such as “Food Areas: limited to crack and crevice treatment only. Application of this product in the food areas of food-handling establishments other than as a crack and crevice treatment is not permitted.” Some important definitions of terms that appear in labeling with respect to use on food-processing areas are as follows.

Applications

Food

Food is considered as:

(1) Articles used for food or drink for man or other animals (includes pet food, bird seed and feed for cattle, horses, swine, poultry, etc.)
(2) Chewing gum
(3) Articles used for components of any such articles

Food Processing Facilities

An area or place other than a private residence in which food is held, processed, packaged, stored and distributed in bulk. These places can include dairies, meat processing facilities, bakeries, grain storage facilities and food product warehouses. A comprehensive listing of food processing facilities is found later in the chapter. (Restaurants, school lunchrooms, bars, hospitals, etc., are **not** included under food processing facilities.)

Nonfood Areas

Include garbage rooms, lavatories, floor drains (to sewers), entries and vestibules, offices, locker rooms, machine rooms, boiler rooms, garages, mop closets and storage (after canning or bottling).

Food areas include areas for receiving, serving, storage, packaging (canning, bottling, wrapping, boxing), preparing (cleaning, slicing, cooking, grinding), edible waste storage and enclosed processing systems (oils, dairies, edible oils, syrups).

Residual Insecticides

Include products applied to obtain insecticidal effects lasting several hours or longer and which are applied as general, spot or crack and crevice treatments. Residuals include the common insecticides such as Baygon, Diazinon and Dursban. Also included are pyrethrins and DDVP. These are usually thought of as nonresidual materials; however, certain formulations with higher than normal concentration, applied as coarse sprays, provide insecticidal effects lasting several hours or longer and are therefore considered residual by EPA.

There are three types of residual applications recognized by EPA: general, spot and crack and crevice. Each may be used in certain areas of food-handling establishments, and they are defined as follows.

General

Application to broad expanses of surfaces such as walls, floors and ceilings or as an outside treatment. This is permitted only in nonfood areas using only those insecticides so registered.

Spot

Application to limited areas on which insects are likely to occur, but which will not be in contact with food or utensils, and will not ordinarily be contacted by workers. These areas may occur on floors, walls and bases or undersides of equipment. For this purpose, a "spot" will not exceed two square feet. In order for spot treatments to be justified, there must be a surface on which insects are likely to occur. A "spot" may be round or long and narrow. This indicates that a considerable area could be treated, but in practice the area must be limited to places where insects are present or are likely to occur.

Crack and Crevice

A crack and crevice treatments is the application of small amounts of insecticides into cracks and crevices in which insects hide or through which they may enter a building. Such openings commonly occur at expansion joints, between different elements of construction and between equipment and floors. These openings may lead to voids such as hollow walls, equipment legs and bases, conduits, motor housing, junction or switch boxes. The crack and crevice treatment includes the use of sprays, dusts or baits. It permits the use of products in food areas as long as the insecticide is placed only into cracks and crevices. It does not permit treatment of surfaces. In some cases, a pin-stream spray may be an acceptable application method, but a better approach may be to make application with an insertion tube directly into cracks and crevices.

Pesticide Regulations

Pesticides are regulated nationally by EPA through the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Within Arkansas the Arkansas State Plant Board has responsibility for regulating all pesticide applications.

If pesticides are misused, then other state agencies can become involved. These agencies include the Departments of Health, Environmental Quality, Labor, Transportation, etc. The responding agency depends on the exact misuse that occurs. Therefore, proper application is critical to both food worker and business safety.

Pesticide Residues

For a pesticide to be used on or in a food or feed product it must either have a tolerance or be exempt from a tolerance. Excessive residues can cause both food and worker safety problems. Residues can occur from direct application to the product in the processing area, application to equipment, direct application to product being held in a storage area, space sprays which contaminate the product and application to the product before it arrives at the processing facility. The latter can occur either in production or in transit.

EPA is becoming increasingly concerned about residue detection – not the level but the fact that residue can be detected. Part of the concern is a result of EPA shifting policy to consider human exposure from sources of exposure to a pesticide. Thus, a pesticide which has a wide use will have a higher potential for greater exposure to humans. This exposure includes food, air, water, etc. Therefore, any

insect management program in a food processing area must include more than just the use of pesticides.

Pesticide Tolerances

Pesticide tolerances are set by EPA but they are authorized by the Federal Food, Drug and Cosmetic Act (FFDCA). Pesticide tolerances can be "in or on" raw agricultural products or in processed products. In 1996, Congress passed the Food Quality and Protection Act (FQPA) which did away with the Delaney clause and redefined how pesticide tolerances would be established. Two major changes were the requirement that EPA consider all exposures (air, water, food, etc.) from a pesticide and the requirement EPA consider aggregate effects from pesticides. The latter means all risks from cholinesterase-inhibiting insecticides would be considered when establishing a tolerance for one cholinesterase-inhibiting insecticide.

Although EPA sets tolerances, the Food and Drug Administration (FDA) enforces tolerances for food and feed while USDA enforces tolerances for meat and meat by-products. Therefore, pesticide applications in a food processing facility must be done with great care to minimize potential for food contamination or excess pesticide residues which may lead to illegal tolerances in the finished product. If the food contains any poisonous substance (pesticide) which is not approved or exists above the approved level, then the product is adulterated and must be destroyed.

Site Names

Pesticide labels are the law and must be followed to obtain proper use of the pesticide. One of the pieces of information on a pesticide label is where the pesticide can be used. These use areas are called "sites." Sites have various names, with some being specific and others general. A specific site would be "flour warehouse" compared to a general site as "warehouses." If a pesticide label has specific sites, that pesticide can only be used for those sites even if other pesticides, with the same ingredients, have other sites listed on their labels. You must use a pesticide according to the label from which you obtained the pesticide. If you make a spray from two pesticide containers, you will use the restrictive portion from each label.

Use of a pesticide on sites that are not listed on the label is considered misuse of the pesticide and is a violation of the label and law. Such use could result in illegal residues and/or food safety concerns.

Even though a site name is on the label, the user must read further into the label to ensure that the pesticide can still be used on that site in a manner that will control the pest. At times the site name will be on the label, but the pesticide use will be restricted to a certain type of application.

A listing of EPA sites which one may run into for food processing areas is provided below under the heading "Pesticide Use Site Groups." These are names EPA considers when registering a pesticide. You are likely to see such wording or similar wording on pesticide labels. You must understand what the site wording means or misapplication can occur.

Pesticide Use Site Groups

The following use sites are from the Code of Federal Register 40 Part 158 Appendix A. These site listings are used by companies and EPA to determine specific tests required for registering a pesticide. Therefore, similar site names are used on pesticide labels. These site names on labels are both restrictive and broad. For example, the site name "fruits" would include all fruits, whereas the site name "flour mill machinery" would limit the pesticides use to only flour mill machinery and not other machinery in food processing plants.

Processed or Manufactured Products, and Food or Feed Containers or Dispensers

Food and feed containers, dispensers and processing equipment

Airtight storages – large (empty/full)
Airtight storages – small (empty/full)
Fumigation chambers
Bins
Elevators
Storage areas – (empty/full)
Processing or handling equipment and machinery (other than food processing)

Commercial and Industrial Uses

Food and feed processing plants
- Bakeries
- Bottlers
- Canneries
- Dairies, creameries, milk processing plants
- Feed mills, feed stores
- Fresh fruit packing and processing
- Meat processing
- Poultry processing
- Wineries, wine cellars
- Flour mills, machinery, warehouses, bins and elevators
- Egg processing
- Candy and confectionery plants
- Sugar processing, cane mills, etc.
- Cider mills
- Dry food products plants
- Tobacco processing
- Air treatment for processing and transportation of foods
- Beverage processing
- Nut processing
- Cereal processing
- Seafood processing
- Vegetable oil processing
- Spice mills
- Vinegar processing
- Farinaceous processing (noodles, etc.)
- Mushroom processing
- Dried fruit processing
- Pickle processing
- Ice plants
- Chocolate processing
- Fruit juice processing

Eating establishments (all)
- Food handling areas
- Food serving areas
- Eating establishment nonfood areas
- Air treatment for eating establishments
- Food storage equipment (coolers, refrigerators, etc.)
- Eating and serving utensils (spoons, etc.)
- Food marketing, storage and distribution
- Food dispensing and vending equipment
- Food stores, markets, stands
- Meat and fish markets
- Food catering facilities
- Food marketing, storage and distribution equipment and utensils

When selecting a pesticide for use in a food use area, one needs to assess whether the site is on the label and if the food area is under USDA inspection service. If the site is under USDA inspection, then the applicator must follow USDA requirements as well as EPA label requirements. If the USDA requirements are not followed, both the applicator and facility can be in big trouble.

There are other regulations that may affect where you can use a particular pesticide. These include state regulations, USDA regulations and company policy.

State regulations may prohibit use of certain pesticides or restrict their use in certain areas. It is the applicators responsibility to obtain information on any such state requirements. Such regulations can vary from more stringent use requirements to prohibiting the use of certain pesticides. Remember, state requirements often vary between states. Questions regarding regulations specific to Arkansas should be addressed to the Arkansas State Plant Board, #1 Natural Resources Drive (P.O. Box 1069), Little Rock, AR 72203-1069, phone (501) 225-1598.

USDA regulations can come in various forms, but they mainly are associated with USDA inspection services such as the Federal Meat Inspection, Federal Equipment and Sanitation Division (FESD), Federal Grain Inspection Service (FGIS), Food Safety and Inspection Service (FSIS) and others. Any pesticide used in federally inspected meat processing plants must be on USDA's FESD list and approved by the plant's federal inspector. Be certain you understand the regulations of each USDA section and how it applies to the facility you are working.

Company policy is an aspect an applicator needs to determine before signing a contract. Some companies do not allow use of certain registered pesticides. If this would be the case, you need to be aware of the situation and determine beforehand if you can service the account without the use of those pesticides. Examples could include not allowing any pesticide that EPA has classified as a B1, B2 or C carcinogen.

USDA Meat Plants

For USDA meat processing plants, the Pest Management Professional (PMP) must go through the USDA inspector to obtain a list of pesticides that can be used within that plant. This list changes every year.

The USDA inspector will provide the PMP with the list. The plant will have an approved

pest control plan and will provide the PMP with a list of materials to use. The PMP will provide the plant with a list of pesticides, from the approved list, the PMP will use. The PMP's list will be filled out on the plant's forms.

Residuals cannot be used in production areas. Production areas are defined as areas where the product is being handled and is exposed.

Residuals cannot be used where they may be "carried" into the production area. "Carried" can include transported on shoes, hands or through air currents. Thus, this may include restrooms and offices.

Residuals **can** be used in production areas **if** they are (1) used as a crack and crevice treatment **and** the crack and crevice is sealed after application. The Arkansas State Plant Board, (501) 225-1598, and the Arkansas Department of Health, (501) 661-2000, are contacts for further information.

You may obtain the list of chemicals from the Government Printing Office by purchasing *List of Proprietary Substances and Nonfood Compounds, Authorized for Use Under USDA Inspection and Grading Programs,* Miscellaneous Publication Number 1419.

When selecting a pesticide for use in a food use area, one needs to assess whether the site is on the label and if the food area is under USDA inspection service. If the facility is under USDA inspection, then the applicator must follow USDA requirements as well as EPA label requirements. If the USDA requirements are not followed, both the applicator and facility can be in big trouble.

Safety

Pesticide safety is the responsibility of the employer and the applicator. The applicator is responsible for the safety of other applicators, employees of the food processing facility and the safety of the food product.

Safety information can be obtained from the pesticide label, pesticide Material Safety Data Sheet (MSDS), technical information received from the company and other sources. Other sources of safety information include applicator association material such as the National Pest Control Association, American Institute of Baking, Pest Control Technology, etc.

It is the applicator's responsibility to ensure the safe application of any pesticide. This includes making a survey of the facility before conducting an application. During the inspection, the applicator should consider all possibilities that may occur before, during and after the application. You should consider practices the facility is undertaking which may affect the pesticide. This would include use of detergents and cleaning materials, pesticide applications the facility is doing itself, sanitation, etc. When treating food-serving areas, you should consider if the pesticide will be present on the tables and in the air when food is served. If so, you may need to select another pesticide. When treating storage areas, the applicator should insure that the application will not leave residue on containers in which food may be placed. Determine the facilities cleanup procedures to ensure that the cleanup will not negate the pesticide application. It is best to develop both a safety checklist and an inspection checklist. This will help ensure a safer application.

Insect Pests and Control

Insects are among the most important and numerous of the pests plaguing the food processing industry. Although only a portion of the many hundreds of insects that are found in the plants cause serious damage to the final product, no insects are allowed in the final product.

One important aspect in managing insects is knowing about the insect. Where the insect likes to spend its time, what foods the insect prefers, what conditions the insect does not like, how the insect develops, etc., are vital pieces of information necessary for a good management program. Without these pieces of information the pest management program is really nothing but responding to problems and not solving the problem.

Food processing insects can be divided into three broad groups: the beetles, the moths and others that include roaches, mites, silverfish, etc.

Beetles and Moths

Beetles and moths have one thing in common. They both have four life stages: egg, larva, pupa and adult. The pupa is the stage in which the larva changes into the adult. Although the adults of beetles and moths do not look alike, the other stages do have some similarities. Basically, the larva is the "grub or worm" stage and does not look like the adult. Larva of both beetles and adults may feed on raw food or processed food. Both beetle and moth larva have chewing mouthparts. When an inspection finds an insect larva, it will either be a beetle or moth. They can be separated by looking at the back half of the larva. If there are legs present, the larva is a moth larva. If legs are missing they are beetle larva. There are some exceptions, but for the major beetles and moths found in food processing plants, this rule will hold. The pupa is the stage in which the larva changes into an adult. There is no feeding during the pupa stage. Adult beetles are raw and processed food feeders. They have chewing mouthparts. Adult moths do not feed on raw or processed food because they have sucking mouthparts. However, moths can contaminate the final product by being "packaged" if the moths are in the packaging area. Not all beetles or moths present in a food processing facility are insects that will feed off raw or processed food. Some are just there. Somehow they got into the plant. During the summer, this may apply to ground beetles which wander into buildings. Some may be attracted to problem areas in the facility such as a wet area in which mold is growing. There are many mold-feeding insects that can be a nuisance in food plants.

Others

Most insects in "others" undergo what is called gradual metamorphosis. This means they have basically three life stages: egg, nymph and adult. The nymph looks similar to the adults, and has similar habits, ecological preferences and food choices as the adult stage. In most groups, the difference is nymphs do not have wings whereas the adults do have wings.

Moths

Moths and butterflies are familiar four-winged insects characterized by the flat, overlapping scales and hairs that, in most cases, completely clothe the body, wings and other appendages. These insects develop by complete metamorphosis with four stages in their life cycle: egg, larva (or caterpillar), pupa and adult. They have chewing mouthparts in the larval stage and coiled sucking mouthparts as adults. The larvae, unlike the beetle larvae, have abdominal legs. Moths are most active during dawn, dusk and at night.

Most larvae are important pests of stored products. Although the adults are important for reproduction, the larvae consume and contaminate our food. They often leave the infested products and move about inside the structures, leading to other problems. Excessive populations can spread bacteria and molds. Moths will also attack fabrics and other material of animal origin such as woolens (clothing, carpets, upholstery, tapestry, etc.), fur and feathers. Such damage usually occurs when clothes are stored for an extended period of time. Some of the more common and important moths are discussed below.

Almond Moth *(Cadra cautella)*

The adult almond moth has 4 wings, with about 5/8-inch wing spread. The forewings are brown to gray with a pale wavy band near the tip and darker band across the middle. Larvae of the almond moth are dirty white, with brown or black spots along their back. Larvae increase to about 1/2 inch long when fully grown. Almond moths can produce five to six generations per year.

Although they can be found in dried fruits, nuts and pet foods, they are most frequently found infesting various candies composed of chocolate and nuts.

Indianmeal Moth *(Plodia interpunctella)*

The adult Indianmeal moths have four wings with a spread of 3/4 inch. Their forewings are gray near their body and reddish near the tip. Both their head and thorax have a reddish color. When fully grown, the larvae of the Indianmeal moth leave a silken thread behind wherever they crawl. This webbing can be found on or near the surface of the food where they feed. Indianmeal moths can produce five to six generations per year.

Figure 3. Indianmeal Moth, Spread (l), Resting (r).

Indianmeal moth larvae feed on as wide a range of foods as any food-infesting insect. They prefer the coarse grades of flour and milled products and are commonly found in packaged cornmeal, whole-wheat flour and various prepared flours. They also feed on many types of grains and grain products, garden seeds, oil seeds, nuts, peas and beans and their products, spices, powdered milk, chocolate, dried fruits and vegetables, drugs, dried pet foods and many others. In large, crowded populations, they are cannibalistic, especially on larvae in cocoons and pupae.

Control Considerations

1. The prime consideration should be avoidance. All products entering the premises should be carefully examined and rejected or heat-treated or fumigated.
2. Sanitation is a must! Remove pockets of infested foods in machinery, buildings and warehouses. Remove accumulations of dust, flour and other materials in which the insects can feed and breed.
3. Infested material can be heat-treated, 140 degrees F for one hour or 120 degrees F for two hours. Cold treatment (cooling) has been shown to be a viable suppression technique but has not been advocated as an elimination process because some strains of Indian meal moths can undergo extended resting periods (diapause) at reduced temperatures.
4. Properly labeled residual insecticides can be applied to grain; however, the webbing should be removed first.
5. Properly labeled space sprays can be used to kill moths. Evening applications are generally preferable since the moths tend to be most active during this period.
6. In some circumstance, spot or general fumigations are required.
7. Some studies have shown that a hymenopterous parasite, *Bracon hebetor* Say, provides control of the larvae.

Mediterranean Flour Moth *(Anagasta kuehniella)*

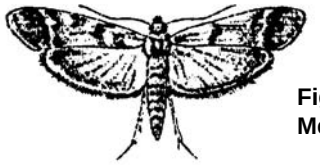

Figure 4. Mediterranean Flour Moth

The adult Mediterranean flour moth has four pale gray wings with a wing spread of 3/4 inch. Their forewings are a pale leaden gray with transverse, wavy, black markings. The adult moths rest with their head and thorax held high. Larvae have lateral dark spots on each segment of their abdomen distinguishing the Mediterranean flour moth from the Indianmeal moth. The larvae of the Mediterranean flour moth spin silken thread wherever they go and web and mat together particles of food on which they are feeding. The larvae will leave the feeding area to pupate.

The Mediterranean flour moth prefers flour but infests wheat, bran, nuts, chocolate, seeds, biscuits, beans and dried fruits.

Mealmoth *(Pyralis farenalis)*

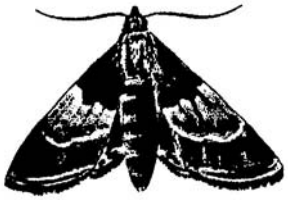

Figure 5. Mealmoth.

The forewing of the adult meal moth is light brown with dark-brown patches at the bases and tips. Also, each forewing has two wavy, transverse white lines. The larvae of the mealmoth are whitish, and about 1 inch long when fully grown. The larva shows a contrast between the black of the head and the first body segment and the white of the remainder of the body. The body of the larva is often tinged with orange toward each end. Mealmoths produce three to four generations per year.

Mealmoths are usually found feeding on damp or spoiled grain, bran or meal. To eliminate moth infestation of food and stored-grain products, you must find and destroy infested material; then treat the area where they were stored. Infested materials can be fumigated to eliminate the infestation. To keep areas or product from becoming reinfested, a thorough cleaning is essential. This begins by removing any spilled foods, then maintaining a good housekeeping program.

Beetles and Weevils

Worldwide, there are more than 250,000 species of beetles, some of which are found in homes and buildings where they feed upon our food, carpets and the building structure. Beetles and weevils are distinguished from other insects by the peculiar hardened forewings known as elytra that meet in a straight line over the middle of the abdomen. The primary difference between beetles and weevils is that weevils have a head with a beak or snout while beetles do not have this characteristic.

As noted earlier, these insects develop through complete metamorphosis with four stages in their life cycle: egg, larva, pupa and adult. The larvae may be slender and active, as with many stored-food beetle larvae, or clumsy, relatively inactive grubs. Beetle larvae have thoracic legs, whereas weevil larvae are legless.

Lesser Grain Borer *(Rhizoperth dominica)*

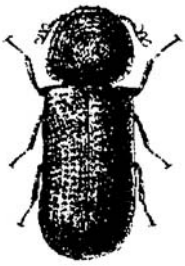

Figure 6. Lesser Grain Borer.

The lesser grain borer is one of the smallest beetles injurious to grain in this country. The adult is readily distinguished from other grain pests by its slender cylindrical form and small size. It is polished dark brown or black, with a somewhat roughened surface. The dimensions of the lesser grain borer are about 1/8 of an inch long and 1/32 of an inch wide. This grain borer belongs to family of beetles that has the head turned down under the thorax and is armed with powerful jaws. Both the adults and larvae cause serious damage to a great variety of grains.

Each female lays 300 to 500 eggs and deposits them, singly or in clusters, upon the loose grain. The eggs hatch in a few days, and the small whitish grubs, or larvae, crawl actively about the grain, feeding on the flour produced by the boring adults, or they bore directly into kernels, especially those that have been slightly damaged. The larvae complete their growth within the kernel, transform into white pupae, and then change into adults. They then cut their way out of the kernel.

The lesser grain borer is primarily a pest in whole grains; however, it is capable of infesting other materials such as flours, dry dog food, edible legume seeds, wood, cork, macaroni, edible bulbs and tapioca roots. This insect commonly penetrates packages of foods in storage or in rail cars.

Control Considerations

1. For small infestations, locate the infested materials and destroy or use heat or freezing.
2. In stored grain, use approved fumigation procedures and/or protective chemicals, or use aeration with cool air to retard insect activity and development.

Cigarette Beetle *(Lasioderma serricorne)*

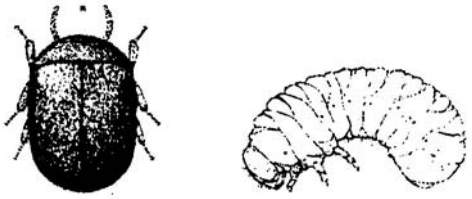

Figure 7. Cigarette Beetle adult (l), larva (r).

The cigarette beetle is a small stout, oval, reddish-yellow or brownish-red beetle, with the head bent down nearly at a right angle to the body. This gives the beetle a humped appearance when viewed from the side. It varies in size, but is usually about 1/10 of an inch long. Cigarette beetles breed in a variety of seeds and may occasionally be found attacking grains left in storage. The antennae of the cigarette beetle are saw-like and the head is somewhat retracted.

The adult cigarette beetle lives 2 to 4 weeks, during which time each female may lay as many as 100 eggs. The developmental period from egg to adult is quite variable but, under favorable conditions, is 6 to 8 weeks.

Cigarette beetles are primary pests of stored tobacco, yet they will occasionally attack stored grain and cereal products. Breeding can occur in rice risings, ginger, pepper, dried fish, seeds and cereal products.

Control Considerations

1. In food processing plants, managers must establish an inspection routine for all raw materials. Properly labeled chemicals can also be used for control of adults that are outside of foods/containers.
2. All infested articles must be located and destroyed.
3. Infested food materials in smaller containers can be destroyed by freezing (0 degrees F for 5 to 7 days) or by heating (as in an oven at 140 degrees F for 30 minutes).
4. Properly labeled insecticides can be used as sprays to provide some control of adults that are outside of foods/containers (sprays will not affect larvae and adults in foods or inside containers).
5. In warehouses/storage facilities, properly labeled fumigants, fogs and vapors can be used for control (however, there are significant limitations related to these types of products).

Drugstore Beetle (*Stegobium paniceum*)

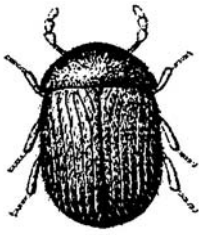

Figure 8. Drugstore Beetle.

The drugstore beetle and the cigarette beetle are similar in appearance. The adults are about 1/10 of an inch in length, cylindrical and uniform brown with fine silky hairs. The cigarette beetle adult has a stout, oval, reddish yellow or brownish-red body with the head bent down at right angles to the body. The adult drugstore beetle has a three-segmented, saw-like antennae that is pressed to the body when at rest.

This beetle lays eggs in almost any dry organic substance. The small white grubs or larvae emerge from the eggs and then tunnel through these substances. When fully grown, they pupate in small cocoons. The entire life cycle may be passed in less than two months. Note: This species is not reportedly encountered as frequently as the cigarette beetle, but control measures would be similar.

Confused Flour Beetle *(Tribolium confusum)*

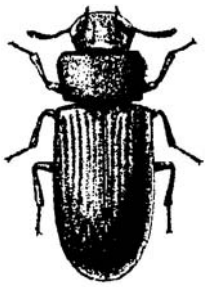

Figure 9.
Confused Flour Beetle.

The confused flour beetle is a shiny, flattened, oval, reddish-brown beetle about 1/7 of an inch long. The head and upper parts of the thorax are covered densely with minute punctures. The wing covers are ridged lengthwise and are sparsely punctured between the ridges.

The average life of these beetles is about one year, but some have been known to live almost four years. The female loosely lays an

average of about 450 small, white eggs in flour or other food material. Confused flour beetle eggs are covered with a sticky secretion and thus become covered with flour or meal. These eggs also readily adhere to the sides of sacks, boxes and other containers.

When fully grown, the larvae transform into small, naked pupae. Although they are white initially, the pupae gradually change to yellow and then to brown and, shortly afterwards, transform into adult beetles. Under favorable conditions, the period from egg to adult averages about 6 weeks.

Confused flour beetles are generally feeders of all cereal products. These flour beetles have been found feeding on more than 100 different foodstuffs. Common items infested include grain, seeds, flour, meal, cereal products, animal matter, wood, vegetables, drugs and spices. They have also been found to infest peas, beans, cottonseed, cracked nuts, dried fruits (especially raisins), grits, snuff, baking powder, milk chocolate, yeast, powdered milk, insect collections and eggs and larvae of their own species and of others.

Control Considerations

1. Inspect all new susceptible products (start with insect-free raw materials).
2. In mills, it is helpful to use impact machines (entoleters) as grain is taken in to destroy flour beetles in all life stages. Insects and their fragments may be removed by aspiration after impacting.
3. Use constant monitoring/inspection programs.
4. Fumigate infested products prior to acceptance/unloading.
5. Use all sanitation practices possible to insure plants are maintained in clean condition.
6. Apply approved residual pesticides where they are labeled for use (note, however, that resistance has been reported to several products).
7. Infested materials can be heated to 140 degrees for one hour or 120 degrees for four hours (as long as the maximum temperature reaches the center of the containers or mass). Also, infested products can be stored in subfreezing temperatures for a week for control of the flour beetles.

Red Flour Beetle *(Tribolium castaneum)*

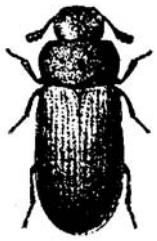

Figure 10. Red Flour Beetle.

The red flour beetle is almost identical in appearance to the closely related confused flour beetle. It can be distinguished from the confused flour beetle only with the aid of a magnifying glass. However, the red flour beetle can fly, while the confused flour beetle cannot fly. The segments of the confused flour beetle antennae gradually increase in size from the base to the tips, whereas the last few segments of the red flour beetle antennae are abruptly larger than the other segments, forming enlarged tips. The head margins of the confused flour beetle are expanded and notched at the eyes, with a ridge over the eye. The head margins of the red flour beetle are nearly continuous at the eyes and do not have a ridge over the eyes.

This insect is constantly associated with the confused flour beetle and has similar feeding and breeding habits.

Sawtoothed Grain Beetle *(Oryzaephilus surinamensis)*

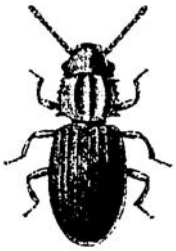

Figure 11.
Sawtoothed Grain Beetle.

The sawtoothed grain beetle is one of the best known of the cosmopolitan grain pests. It is a slender, flat, brown beetle about 1/10 of an inch long. It gains its name from the peculiar structure of the thorax, which bears six sawtooth-like projections on each side. It attacks, in both the larval and adult stages, all food of vegetable origin, especially grain and grain products such as flours, meals, breakfast foods, stock and poultry feeds, copra, nut meats, candies and dried fruits.

The sawtoothed grain beetle has been recorded from alfalfa seed, barley, breakfast cereals, cereal rat baits, corn, cornmeal, corn starch, flour, macaroni, milo, mixed feeds, oats, popcorn used as a packaging material, rice, shuffle board wax and powdered hand soap containing cornmeal, wheat and wheat bran. It has also been found in spices, herbs, nutmeats, dried fruits, birdseed, dog food, graham crackers and is very common in stored grain.

The adults live, on an average, six to ten months, but some adults may live as long as three years. The female beetle lays 43 to 285 eggs. She drops them loosely among the foodstuff or tucks them into a crevice in a kernel of grain. The small, slender, white eggs hatch in three to five days.

The emerging larvae do not stay within a single grain but crawl about actively and feed. During summer, they become fully grown in about two weeks. The mature larvae then construct delicate, cocoon-like coverings by joining together small grains or fragments of foodstuffs with a sticky secretion. Within these cells, the larvae change to the pupal stage, which lasts about one week. In the summer the developmental period from egg to adult is four weeks.

Control Considerations

1. In groceries or warehouses, locate infested materials and remove/destroy them.
2. For small amounts of infested products, you can use heat (140 degrees for 20 to 30 minutes) or cold (freezing the product for a few days).
3. Properly labeled residual insecticides may be of help in controlling adults that are outside of the infested food products.
4. Maintain product off the floor at cool temperatures below 65ºF.

Merchant Grain Beetle *(Oryzaephilus mercator)*

The merchant grain beetle is often confused with the sawtoothed grain beetle. It is less commonly found in grain than the sawtoothed grain beetle and appears to prefer oilseed products, including nuts. Cereal products are more likely to be infested with this insect than the grain itself.

In the merchant grain beetle, the eye diameter is larger than the temple region behind the eye and the head is rectangular. The sawtoothed grain beetle has smaller eyes and a more triangular head. The merchant grain beetle is also slightly larger and is a darker brown than the sawtoothed grain beetle. The habits and development of the two insect species are similar, but the merchant grain beetle lays only one-half to two-thirds as many eggs. In addition, the merchant grain beetle can fly, but the sawtoothed grain beetle cannot. Control of the merchant grain beetle would be the same as the sawtoothed grain beetle.

Foreign Grain Beetle *(Ahasverus advena)*

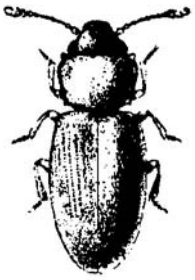

Figure 12. Foreign Grain Beetle.

This insect is placed in the same family as the sawtoothed and merchant grain beetles (but doesn't have the "saw teeth" along the margins of the thorax). Usually it is found in large numbers only when the infested product(s) is mildewed or moldy. In fact, they can feed on pure cultures of mold.

Females lay eggs singly or in clusters and under favorable conditions, the eggs hatch in about 4 days. The larvae may complete four or five molts, and the entire larval stage ranges from 11 to 19 days. Its pupation lasts three to five days, and the life cycle from egg lay to adult averages 22 1/2 days. The insect tends to do its best work and develop fastest and healthier at temperatures at 80 degrees or above and 75% relative humidity or above. Reports indicate that females lay virtually no eggs when the relative humidity is held at 58% or below.

The foreign grain beetle may be found associated with a wide variety of products: grains, cereal products, cocoa, peanuts and other oilseeds and their products, dried fruit, herbs, spices and various roots or their products. Although some of these may serve adequately as a food for this species, when found in large

numbers, the beetles probably are developing on molds. Thus, this indicates high moisture conditions conducive to mold growth.

Control Considerations

Because the occurrence of the foreign grain beetle usually indicates high moisture conditions with mold, the best control measures are to:

1. Find and remove moldy material(s).
2. Dispose of any product in poor condition as a result of the mold.
3. Correct conditions favoring mold (e.g., water leaks, entry points, etc.). Use fans and, where practical, heat to dry the infested area(s). Note: It may take 30 to 60 days for all adults to cycle out of the area after molded material is removed.
4. Use properly labeled insecticides to help control adults that are outside the infested products.

Rusty Grain Beetle *(Cryptolestes ferugineus)*

This insect is similar in appearance and biology to the flat grain beetle (*Cryptolestes pusillus*). It is more cold-tolerant than the flat gain beetle, but it infests the same kinds of materials that the flat grain beetle infests. The rusty grain beetle is normally a secondary pest and is reported to prefer high moisture conditions and decaying products. It is also commonly stated that they are found associated with fungi (mold growth). Researchers working with stored grains in Oklahoma have reported finding rusty grain beetles in grain and other products that contain less than 10% moisture. So there may be a preference for higher moisture conditions and mold growth, but apparently they can survive and develop under other conditions.

Management measures are the same as suggested for the foreign grain beetle.

Spider Beetles

These insects are occasionally associated with stored food products. They infest warehouses and households and occur rarely in mills or other food-processing plants. In general, they are considered more of a nuisance than destructive.

Spider beetles tend to be most active at night. During daylight hours or under bright light conditions, they usually hide in dark areas (cracks and cervices or under any available material). When food products are piled in stacks, the beetle population tends to be confined to the periphery. Activity is usually greatest during falling temperatures.

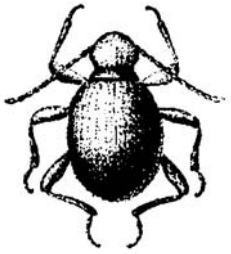

Figure 13. Spider Beetle.

Spider beetles develop slowly, the shortest life cycle being about eight weeks. The egg stage may extend from eight to 16 days. Normally there are three larval molts, and the larval development is highly variable. Under favorable conditions, spider beetle adults are long-lived (some reported for 6 months up to 2 years under moist conditions).

Temperature is the most critical factor that determines the extent of population increase. Maximum temperature is about 86 degrees F. but optimum is about 77 degrees. They usually die quickly as temperatures reach over 93 degrees F. Most species tend to reproduce and develop best between 50 and 90% R.H.

Spider beetles are mainly scavengers on plant and animal substances, but they can readily transfer their feeding to processed foods. Early studies found the beetles associated with nests of birds, insects or other animals where they were feeding on animal excrement, feathers, hairs and debris.

Generally, the most serious damage caused by spider beetles is not the amount of food consumed but in contamination from frass, body fragments and silk deposited as they wander about walls and ceiling. Larval feeding on grain is readily distinguished because the larvae eat the brancoat of the kernels unevenly. Feeding larvae secrete silken threads that incorporate fecal particles and tend to surround themselves. Older larvae tend to wander in search of a sites to form their cocoons in which to pupate. During this period, they may chew holes in textiles and

containers of linen, cellophane, plastic and cardboard. The adults do not cause this type of damage, but they may deposit their eggs through the meshes of bags. Food containers may become covered by masses of silk cocoons. The most common damage, from large populations, occurs to foods stored over long periods in dark, damp areas (68 to 73 degrees F).

Control Considerations

1. All foods should be inspected before their entry into a warehouse or household.
2. Insure that oldest products are moved first, as long storage encourages infestations.
3. Insure that are stock is piled or in racks that facilitate inspection and treatment.
4. Eliminate or seal all cracks and crevices that provide hiding places for beetles and pupation sites for larvae.
5. Search for and destroy all animal nests in or close to the premises (also eliminate animal excrement around the premises (e.g., pets, rodents, birds, etc.).
6. Apply approved residual insecticides to warehouse before stacking sacks or other food containers, and fumigate when necessary. Treat all cracks and crevices that are not sealed.

Warehouse Beetle *(Trogoderma variabile)*

Adult warehouse beetles are oval and black with variable patterns of reddish-brown blotches, and have a fine hairy covering. They range in size from 1/10 to 1/6 inch (2.4 to 4.4 mm), and the females are larger than the males. Warehouse beetles have the ability to fly.

Adults of the warehouse beetle have an average life span of 14 days. Females lay on average 38 eggs, but can lay as many as 94 eggs in one day. Most eggs are laid during the first three or four days of life. The life cycle of the warehouse beetle is about 45 days with egg incubation lasting seven (7) days, larval development 34 days and pupal development four (4) days.

The warehouse beetle is commonly found in such stored foods as almond meats, Austrian peas, barley, beans, breakfast cereals, cake mixes, dried chili pepper, cocoa, cookies, copra, corn, corn meal, powdered chicken soup, dried peaches, egg noodles, dried figs, flour, fudge mixes, garbanzos, hominy grits, macaroni, oats, peanuts, pecans, pistachio nuts, potato chips, powdered milk, powdered puddings, raisins, rice, rye, soybeans, spaghetti, spices, tapioca, tortillas, walnut meats, wheat, wild rice and numerous other kinds of stored seeds.

Control Considerations

1. Sanitation is important, especially the removal of food residues which may be nutritious and serve as a source of insects that can infest foods or grain.
2. For processed foods, dog food, cereals, etc., dispose of infested materials.
3. Freezing or heating may be used to disinfect materials.
4. Appropriate spray and fumigation treatments may be used.

Other Dermestid Beetles *(Trogoderma* species*)*

There are several different Dermestid spp. that have characteristic oval-shaped bodies, including the black carpet beetle and the Khapra beetle. Distinguishing characteristics between species are difficult to find. An expert is needed to tell the differences.

Dermestid spp. larvae are tapered with their head at the large end. Prominent bristles or hairs are often found at the pointed end of the larvae. They feed in waste grain, grain dust, flour, powdered milk, candy, dehydrated soup, cigarettes, woolen products, furs, feathers and hair. Infestations are common in old boxes of clothes, overstuffed furniture, woolen carpets and piano felt. When these insects are present their cast larval skins can usually be found in or nearby the commodity. Often the presence of adults in an area may be the first sign of an infestation.

Control of dermestids in food products should be the same for other food-infesting beetles. In fabrics, prevention by sealing fabrics correctly and storage in tight containers with moth crystals is an important part of control.

Cockroaches

Cockroaches are the most abundant and troublesome pests in many buildings. They contaminate product with their droppings, their bodies and the bacteria they carry. Cockroaches can carry organisms that can cause diarrhea, dysentery, cholera and many strains of *Salmonella* and *Staphylococcus* bacteria known to cause food poisoning.

Each species of cockroach varies somewhat in their appearance and habits. However, all cockroaches have the same basic characteristics. Their bodies are flattened from top to bottom and vary from tan to chestnut brown to black. When they are at rest, the head is flexed downward and backward under a shield like pronotum. They have one pair of long filamentous antennae or "feelers," large compound eyes and chewing mouthparts.

Cockroaches hide during the daylight hours in cracks and crevices in walls, doorframes, equipment, furniture, secure places in bathrooms, utility closets, steam tunnels, animal houses, basements and sewers. They are highly gregarious and nocturnal in habit. Because of their nighttime activity, their feeding habits are seldom observed.

Cockroaches are general feeders, consuming most of the food man eats, especially the carbohydrates. They discharge liquids from their mouth and thoracic glands, implanting a musky odor to food and heavily infested rooms. Their appetite includes a taste for glue, paste, the sizing in book covers and pages, excrement and sputum. A high level of sanitation will reduce the number of cockroaches, but not eradicate them.

Cockroaches have gradual metamorphosis and lay their eggs in a case called an *ootheca.* Each cockroach type has a different shaped ootheca that can be used for identifying the type of cockroach present

When the nymphs hatch, they are white but quickly turn brownish or black depending on the type of cockroach. The nymphs will not have wings but look like small cockroaches. As the nymphs grow they will shed their *exoskeleton* or skin. The shed skin is called a *cast skin.* This shedding will be done at each nymphal growth stage until the nymph is an adult. Once an adult, the cockroach has reached its largest size. Males mature quicker than females.

When cockroaches of various sizes of the same species are seen during an inspection, this is an indication of a well-established cockroach colony. When making surveys, trained inspectors frequently note these three signs of cockroach infestation: cast cockroach skins, egg cases and stains or excretion of cockroaches. Excreta of the larger adults are almost as large as small mouse droppings but differ in having six lengthwise ridges. When cockroach infestations are heavy, people can detect a characteristic must odor.

Identification of Cockroaches

There are about 57 species of cockroaches in the United States. However, only two small and two large species are commonly found in buildings and homes in Arkansas. These are the German cockroach, the Brown-banded cockroach, the Oriental cockroach and the American cockroach. Characteristics that distinguish these four species are discussed below.

German Cockroach (*Blattella germanica*)

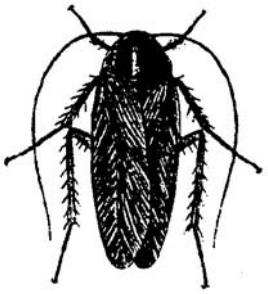

Figure 14.
German Cockroach.

German cockroaches are light brown (tawny) and easily identified by having two parallel black streaks on their back just behind their head. They are about 1/2 inch long when mature adults. Considered the most common household insect pest, they usually thrive in cooking areas, as they prefer heat and moisture. Females carry their egg capsule until hatching time. Four to six egg capsules are produced per female cockroach with 30 to 40 eggs per capsule.

American Cockroach *(Periplaneta americana)*

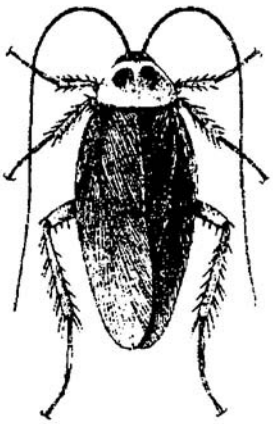

Figure 15. American Cockroach.

When mature the American cockroach is large (1 1/2 inches) and reddish brown. These cosmopolitan cockroaches have fully developed wings that extend to or beyond their abdomen. The shield like band behind the head has a yellowish edge. Females produce reddish-brown to black capsules containing 14 to 16 eggs. They prefer basements (near pipes and plumbing fixtures) and steam heat tunnels or warm sewers. They feed on a variety of foods, but can survive without food for 2 to 3 months as adults.

Oriental Cockroach *(Blatta orientalis)*

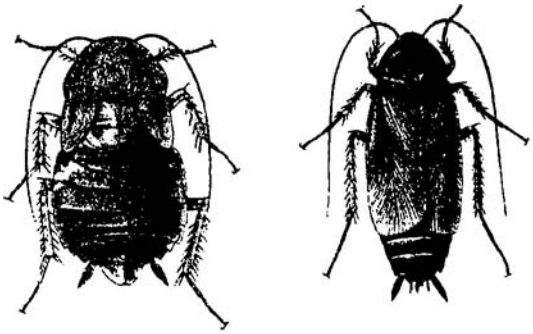

Figure 16. Oriental Cockroach, Female (l), Male (r).

The Oriental cockroach is dark brown to black and about 1 inch long when an adult. Females have small rudimentary wings while those of the male cover 3/4 of the abdomen. Each female produces eight capsules containing about 16 eggs. They feed on all kinds of filth, rubbish and other decaying matter and prefer to congregate in dark secluded areas, such as crawl spaces, basements and water drains. Note: many lay people call this roach a “waterbug.”

Brown-banded Cockroach *(Supella longipalpa)*

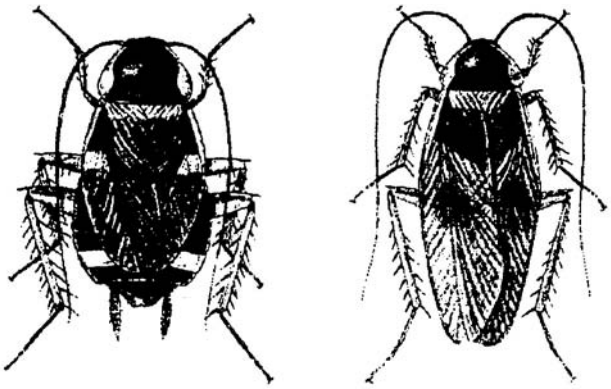

Figure 17. Brown-banded Cockroach, Female (l), Male (r).

Brown-banded cockroaches are small (1/2 inch) adults. They are light brown and readily distinguished by two lighter-colored transverse bands across the base of the wings and abdomen. It is important to identify them correctly since they are generally found high on walls or on ceilings in protected areas. They also frequent electrical appliances. Although they feed on almost anything, they seem to prefer starchy foods. Female brown-banded cockroaches produce an average of 15 egg capsules with each containing 10 to 18 yellow to red-brown eggs.

Other cockroach species infest buildings in other areas of the country. Some of these are very similar in appearance to those described above but differ in their habits. As a result, proper identification is essential to control. Contact local experts for information on other species that may be important in your area.

Apply insecticides as crack and crevice or spot treatments to places where the cockroaches hide. Label directions of residual pesticides permit only crack and crevice treatment to be used in commercial food handling areas. Dusts can sometimes be blown into places difficult to reach with spray. Use ULV (ultra low volume) and aerosol application of contact sprays and flushing agents to supplement residual sprays and dusts. Use them alone where the label prohibits use of residual insecticides.

The removal of food and water sources and destruction of breeding places is essential in obtaining satisfactory cockroach control.

Flies

Flies have one pair of wings (two wings) as adults. Flies feed by lapping and sucking up food with their sponge-like mouth. Flies actually release enzymes onto their food and the enzymes dissolve the food to the point where the fly can "sop" the food up with its mouthparts. Most any organic matter can be a food source for flies. Flies undergo complete metamorphosis: egg, larva, pupa and adult. Like the larvae of weevils, fly larvae have no legs; however, fly larvae differ in that their head is located at the small, pointed end. Fly larvae are called maggots.

The main flies that food-processing facilities may experience include the house fly, fruit fly and the green bottle fly. The house fly likes any warm moist, organic material such as garbage, manure, packinghouse wastes and other such material for egg laying. Fruit flies cause a high percentage of insect contamination of fruit and fruit products. They are especially attracted to decaying fruit and garbage. The green bottle fly prefers garbage. The blue bottle fly is similar to the green bottle fly, but prefers decaying animals for egg laying. Flies are quite prolific and can quickly become a nuisance when ample food and breeding locations are available.

Management of flies starts with sanitation in the removal of breeding locations and a good cleaning program followed by various mechanical and insecticidal controls. Wind curtains can prevent many flies from entering areas of the plant and all windows should be screened.

Ants

Normally only adult ants are seen. These ants eat many foods, but sweets and grease are preferred by the food pest ants. Most species have a winged stage once a year, and these are often mistaken for termites. They may come in from the outside where they have built their chambered nests in the ground. Their life cycle is a complete metamorphosis: egg, larva, pupa and adult.

Control of indoor or outdoor nesting ants can be accomplished by direct treatment of the nest. Locate the entries of the carpenter ant, then blow an insecticide into the nesting area. Control of other ant species is accomplished with sprays, dusts or granular insecticides directed at the nest and surrounding area. Baits may be effective as well. If you cannot locate the nest site, apply insecticides where the ants gain entry or hide (along foundation walls, doorways, window sills, baseboards, behind built-in cabinets and furniture or beneath refrigerators and other heavy appliances).

Bees and Wasps

Bees and wasps present problems to food processing facilities when they build their nests near or on buildings, equipment or when they inhabit the surrounding areas. They pose threats to workers in plants because of their annoying threats and stings. Although they may not sting employees, they can cause employees to be injured by attempting to avoid bees or wasps.

Adult bees and wasps are robust four-winged insects that may nest in attics or between walls, or may enter buildings in the fall to hibernate. Nesting colonies build one of two main types of nest, either exposed comb or comb enclosed in a paper envelope. Honey bees present a special problem due to the risk of honey seeping through walls when the wax comb is weakened by heat. Carpenter bees may burrow a 1/2 inch diameter opening in face boards at eaves, porches and near entrances. Some species of bees and wasps will have a brood emerge continually during the warmer part of the year. These insects present a particular risk to people who are hypersensitive to stings.

Special protective clothing is needed when controlling wasps and desirable when controlling bees to protect against stings. Insecticide sprays directed into the nests work well, particularly with wasps and hornets. The sprays must be applied at night with an applicator large enough to do the job quickly without getting too close to the nest. Dusts may be blown into the nest openings of hornets and yellow jackets. For some species, baits may be available.

Other Occasional Insect Pests

Booklice/Psocids *(Lepenotus and Liposceles* Species*)*

Booklice are very short (1/16 inch) and soft bodied. Depending on the species, some psocids have wings while others are wingless. Certain psocids are called "booklice" because they are very small and resemble lice, plus they are found around books and papers stored in damp locations.

Figure 18. Booklouse.

These insects feed on microscopic molds, fungi, dead insect fragments, pollen and other starchy foods found in humid environments such as houses, warehouses, libraries and structures where green lumber is stored or used in construction. Sweating and high humidity may form in wall voids when new lumber becomes enclosed (i.e., from uncured green lumber) or in/around newly plastered areas.

Damp basements, crawl spaces, leaky and sweating plumbing, cereal, flour, bird nests, furniture stuffing of natural plant fiber, paste on book bindings, grains and similar sites/materials are areas where booklice infestations are common. They do not normally actually damage grain, but they can contaminate grains and stored food products. Although they can be a major contamination problem for mills, processing plants, storage facilities and other locations, they are considered more a nuisance and annoyance pest.

Control Considerations

1. The primary method for avoiding problems with psocids is good sanitation. Keep spillage cleaned up and store food, boxes, books and papers off the floor and in dry areas.
2. Lowering the relative humidity (R.H.) hinders development or causes death due to desiccation (drying out). Effort should be made to reduce the R.H. in rooms and buildings to less than 50 percent. Drying of infested materials and reducing the R.H. also eliminates the primary food sources such as molds and mildews.
3. All efforts should be made to prevent infestations. Infested cereals or stored foods can be discarded or supercooled in a deep freeze (up to 7 days). Books, papers or upholstered furniture can be dried in sunlight.
4. Fix all leaky plumbing, insure that the outside grade is away from the building, install a vapor barrier in the crawl space or add additional ventilation in crawl space.
5. Seal cracks in interior and exterior foundation walls and repair leaking rain gutters, downspouts, root vents and roofs.
6. Avoid accumulations of paper, books or magazines.
7. When infestations occur, ventilate and dry areas with a dehumidifier and/or fans.
8. Insecticides should only be used as a supplement to sanitation, heat/cold and drying techniques and never as the primary control procedure. Residual and space spray treatments with properly labeled materials can be employed once all other control considerations listed above have been employed if a few booklice are still found in the area.

Silverfish and Firebrats

Silverfish and firebrats are wingless insects with a characteristic flat shape, widest before the middle, and tapering to the rear. They have long antennae and three long antennae and three long tails at the end of the abdomen, giving rise to the common name “bristle tails”. They are silvery, brownish or blackish. Development from egg to adult is competed in about 12 weeks.

Often found in warehouses, silverfish or firebrats primarily cause damage to paper, book bindings, wallpaper, labels and stored foods. Silverfish are nocturnal in habit and are most frequently found in dust, label and box storage areas, file cabinets and in sinks where they have become trapped searching for water. Firebrats prefer hot, dry situations and are found more often in bakeries, boiler rooms or behind heating units.

To control this insect problem, direct sprays into cracks and crevices, dusts and bait insecticides prove to be effective.

Crickets

The house cricket is a shiny, black insect that is fond of warmth and may become a pest in processing plants, although it ordinarily lives out-of-doors. This insect develops by gradual metamorphosis. It has chewing mouthparts, long legs fitted for jumping and two pairs of wings when fully grown. The adult male produces the familiar chirping sound by scraping his outer wings together. Crickets sometimes feed upon

book bindings and labels. The cave and camel crickets often invade basements if openings are available. They are large humpbacked insects, usually with no wings, and with antennae much longer than the body. They are plant feeders and are considered nuisance pests in processing facilities. Crickets can become very numerous in the fall and are attracted to lights. Proper management of lighting will discourage them from entering buildings as the adults are active at night and readily move toward lights.

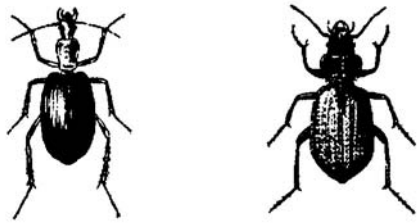

Figure 19. Slender Ground Beetle (l), Ground Beetle (r).

Ground Beetles

These nimble, soil inhabiting species occur in a wide range of sizes and colors. The smaller forms may be about 1/8 of an inch long, while the larger can be up to an inch in length. Colors vary from brown and black to red and green. Ground beetles prey upon other insects and related animals in the soil.

They may invade processing facilities, usually at windows and doors.

Ground beetles do no damage but can become a persistent nuisance where moisture is difficult to control. Removal of debris around foundations is helpful in controlling this insect. Proper management of lighting will discourage them from entering buildings, as the adults are active at night and readily fly toward lights.

Other Arthropods

Sowbugs and Pillbugs

Sowbugs and pillbugs are arthropods but not insects. They are very much alike in appearance ranging from gray to brown. Their bodies are oval in shape, about 1/2 inch in length, with the upper surface of their bodies covered by heavy segmented plates. They have seven pairs of legs and no wings.

These insects can be a pest in greenhouses, flower beds and sometimes potted plants. They can become a nuisance in damp areas (under fiber mats, pallets, rugs, etc.) sometimes feeding on improperly stored paper boxes and corrugated cartons. Removal of leaves, decaying vegetation, peat or composting materials next to or adjacent to foundations and buildings will generally aid in preventing infestation of buildings. The same control measures used for centipedes and millipedes are usually effective. A gravel barrier, as described in the section on rodent control, will assist in decreasing sowbugs and pillbugs.

Rodents and Their Control

Domestic rodents constitute a major pest problem in structures. There are three major domestic rodents in the United States: the house mouse, *Mus musculus*; the Norway (brown or sewer) rat, *Rattus norvegicus*; and the roof (black or ship) rat *Rattus rattus*. A field key that will aid you in identification of domestic rodents is presented in Figure 20. Rats and mice eat almost everything man or livestock use as food. Rats contaminate much more with their urine, hair, feces and other filth than they eat, with the result that such products must be destroyed. Before you can control rodents, it is important you know the behavior patterns and identify the correct species.

Senses, Agility and Reactions of Rodents

Touch

A rodent's sense of touch is well developed in highly sensitive whiskers or vibrissae, and certain guard (tactile) hairs. Rats and mice prefer to run along walls or between things where they can keep their whiskers in contact with side surfaces.

Vision

Their vision is not too well developed. Apparently they are colorblind, so any distinctive coloring of poison baits does not reduce their acceptance as long as the dye is tasteless.

Smell

A rodent's ability to smell is keen. Rodents apparently like the odors of most foods eaten by humans. They are accustomed to the smell of humans, so human odor on baits and traps does not repel them.

Taste

A rodent's tasting capabilities are highly developed. Rats associate sickness caused by poison bait with the bait and not the poison. They prefer fresh food to stale or spoiled food.

Hearing

Rodents have a keen sense of hearing. They can locate the source of a noise within 6 inches. Unusual noises cause rodents to attempt escape.

Balance

Their sense of balance is excellent. A falling rodent always lands on its feet. The roof rat even maintains its balance well while walking on suspended wires.

Reaction to Strange Objects

Rats may avoid a new sound or a strange object in their environment for three or more days, particularly if their associates are alarmed by it. Other objects are readily accepted by them (examples: food, garbage). As rodent population pressures build, all of the rats may develop a fright reaction to disturbances. Mice are more likely to explore new objects and to be caught in newly set traps.

Climbing

Roof rats and house mice are good climbers, and the Norway rat can climb quite well when necessary.

Jumping and Reaching

Rats can jump nearly 2 feet vertically and 3 feet with a running start; they can jump 4 feet horizontally and 8 feet from an elevation that is 15 feet above the finish point. Rats can reach upward about 13 inches.

Swimming

Rodents are good swimmers. They are able to swim up through floor drains and toilet bowl traps.

Recognizing Rat and Mouse Signs

Rats and mice are habitually nocturnal and secretive and are rarely seen during the day except when infestations are heavy. Therefore, it is necessary to interpret signs of their activities properly in order to plan control work. These signs are found in secluded places, such as along walls, under piles of rubbish and behind or under boxes, boards and thick vegetation. From the rodent signs, one can tell the species present and whether a rodent infestation is current or old, heavy or light. This information is critical for designing your rodent control plan.

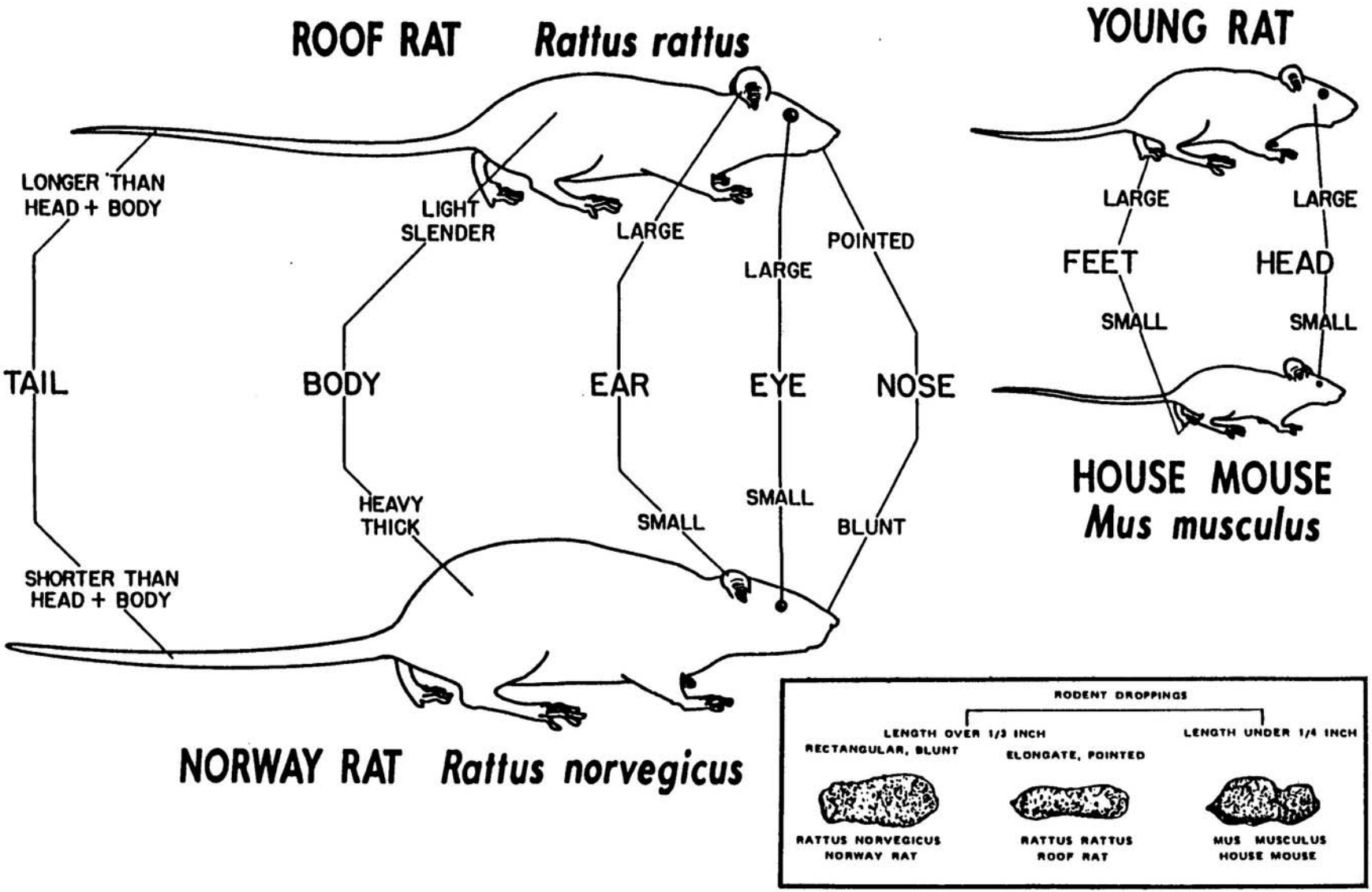

Figure 20. Field key to domestic rodents.

Droppings

Fresh fecal droppings are usually moist, soft, shiny and dark, but in a few days they become dry and hard. Old droppings are dull and grayish and crumble when pressed with a stick.

Runways

Rats habitually use the same runways between food, water and harborage. Because of the keenly developed sense of touch in their vibrissae (whiskers) and in specialized hairs along the body, rats prefer continual body contact with at least one vertical surface, such as a fence or wall. Rats also follow "odor trails." Outdoors, their runways are narrow pathways of beaten earth swept clear of debris. Indoors, greasy runways are found along walls, steps and rafters. Undisturbed cobwebs and dust in a runway indicate that it is not in use.

Rubmarks

Along regularly traveled runways, a dark, greasy mark forms from contact with the rodent's body. Fresh marks are soft and will smear if rubbed. As the grease ages, it dries and gathers dust and will flake off when scratched with a fingernail. The rubmarks of the Norway rat are most commonly found along runways near ground or floor level, while those made by the roof rat are most commonly seen overhead as swing marks beneath beams or rafters at the point where they connect to the walls. Mice do not leave detectable rubmarks except when the infestation is heavy.

Burrows

The Norway rat prefers burrows for nesting and harborage; the roof rat burrows only occasionally. Burrows are found in earth banks, along walls, under rubbish or concrete slabs and in similar places. If a burrow is in use, its entrance will be free of cobwebs and dust. Fresh rubmarks on hard-packed soil and the openings indicate a well established and presently used burrow. The presence of fresh fragments of food or freshly dug earth at these burrow entrances also indicates current use by rats.

Tracks

Fresh tracks are sharp and distinct, whereas old tracks are covered with dust and are therefore less distinct. The tracks of the five-toed rear paws are more commonly observed than are those of the four-toed front paws, but both may be present. To detect rodent activity, place patches of any dust material, such as flour or talc, along runways and check for tracks. To see tracks in the dust, hold a flashlight at an angle that causes the tracks to cast distinct shadows. Tail marks, too, are often visible in dust or tracking patches.

Urine

Dried rodent urine will fluoresce bluish white to yellowish white when illuminated with a blacklight. Be aware, however, that numerous items will fluoresce under a blacklight including optical bleaches found in many detergents and lubricating oils. For positive identification, use a Brom Thymol Blue Urease Test. Place the suspected material on Urease-Brom Thymol-Blue test paper. Moisten with water and place a cover glass over the testing area. If a bluish spot appears after three to five minutes, it is urine.

Rodent Management

Commensal rodents can cause considerable damage to stored grain and structures. If rats or mice are present in and around such facilities, it is because they are able to find food, water (in the case of rats), places to hide and places to nest and rear their young. Good sanitation practices, combined with steps to prevent rodent entry into structures and the elimination of rodent harborage, will reduce rodent problems. While sanitation and rodent-proofing may not eliminate rodents, they will limit the size of rat or mice populations the premise can support.

Sanitation and Habitat Modification

Clean, orderly facilities will not support large numbers of rodents. Attention to key elements that rodents require for survival, **food** and **shelter**, is important in limiting the habitat's carrying capacity for these species. Sanitation involves good housekeeping, including proper storage and handling of food materials. Warehouses, processing areas, packaging areas and similar structures may provide excellent habitat for commensal rodents. Finished products should be stored in rodent-proof structures whenever possible.

Shelter is an invitation for a rodent problem (especially when shelter is near a food source). Particularly when structures are not rodent-proof, it may be difficult to prevent rodents from feeding on food products; however, it is possible to achieve good rodent control by taking away their shelter. When mice and rats are unable to hide or rest, they cannot remain in any location for long. Regular removal of debris and weed control around structures will reduce the amount of shelter available to rodents. In some instances a strip of heavy gravel placed adjacent to building foundations or other structures will reduce rodent burrowing, especially burrowing by Norway rats. Gravel should be at least 1 inch (2.5 cm) in diameter and laid in a band at least 2 feet (0.6 m) wide and 6 inches (15 cm) deep. In any event, keeping the periphery of buildings and other structures clean of weeds and debris (including stacked lumber, firewood and other stored materials) will discourage rodent activity and allow easier detection of rodent signs. Cleaning up also puts rodents under stress. This makes it more likely they will accept lethal quantities of baits (rodenticides) if these are used as part of a control program.

Water sources should be eliminated wherever possible. Rats require water daily for their survival, unless feeding on very moist foods. While house mice can survive without water (obtaining it from their food), they will drink when water is available. Drainage ditches and water runoff areas must allow water to flow quickly away from structures so no standing water accumulates. Where no sources of water are present, rats cannot thrive. Further, reduction of water sources enhances the effectiveness of liquid rodent baits.

Storage

Food products must be stored properly on commercial premises. Where possible, these materials should be kept in rodent-proof containers or rooms. Sacked foods should be kept in orderly piles, preferably on pallets so they can be readily moved. An 18-inch (45 cm) strip of light-colored paint should be painted on the floor around the base of the walls in the warehouse. Warehouse personnel should not pile supplies against the walls on top of these strips. This permits easier inspection and treatment in rodent control work. Intersecting stored products with frequent aisles and daily sweeping or vacuuming of spilled foods should be routine. Promoting these practices is the only chance of achieving some degree of control in a warehouse that cannot be economically rodent-proofed and is under constant rodent pressure from the surrounding area.

Nonfood supplies such as boxes, machinery, sacked goods, lumber, building supplies, etc., should be stacked away from the walls and kept off the ground to aid access to the area. These need to be inspected for rodent infestation as frequently as the food stores.

Reduction of outdoor harborage around the premises will assist in relieving the constant pressure from outside rodent populations. Racks should hold stacked lumber, building supplies, rubbish, etc,. at least 18 inches (45 cm) off the ground. Other outdoor harborage such as weeds, brush and junk piles should be trimmed or removed.

Sources of water should be dried up and the cause eliminated by repairing leaky faucets and plumbing, draining standing water or covering open water supplies that cannot be handled any other way.

Rodent-Proof Construction

Where rodents cannot enter structures, they cannot cause damage to products stored inside them or damage the structures themselves. Ideally, all structures where food products are stored or processed should be rodent-proof. To prevent rodent entry, the physical capabilities of rats and mice must be understood. For example, rats and mice can:

- Run along or climb electrical wires, ropes, cables, vines, shrubs and trees to gain entry to a building.
- Climb almost any rough vertical surface such as wood, brick, concrete and weathered sheet metal.
- Crawl horizontally along pipes, augers, conveyors or conduit.
- Gnaw through a wide variety of materials including lead and aluminum sheeting, wood, rubber, vinyl and cinder block.

In addition, rats can:

- Climb the outside of vertical pipes and conduits up to 3 inches in diameter; climb the outside of larger pipes attached to buildings by bracing themselves against the wall; climb the inside of vertical pipes between 1 1/2 and 4 inches (3.8 and 10.2 cm) in diameter.
- Jump from a flat surface up to 36 inches (91 cm) vertically and as far as 48 inches horizontally.

- Drop 50 feet (15 m) without being seriously injured.
- Burrow straight down into the soil for at least 36 inches (91 cm).
- Reach as high as 13 inches (33 cm) along vertical walls.
- Swim as far as 1/2 mile (800 m) in open water, dive through water traps in plumbing and travel in sewer lines against a substantial water current.

House mice can:

- Jump as high as 18 inches (46 cm) from a floor onto an elevated surface
- Travel considerable distances hanging upside down from screen wire.

As mentioned above, rats can enter openings larger than 1/2 inch (1.27 cm) while mice can penetrate openings over 1/4 inch (6 mm). Although these are small openings, any place a young animal can squeeze its skull through, the rest of the body can generally follow.

The location of the openings is equally important. A rule of thumb for rats is that all openings 39 inches (1 m) **above and below** grade level should be blocked. Grade level means not only the height above ground line but also above any objects such as sheds or stored materials the animals can easily climb on to reach an opening. Norway rats have been known to get into upper storage, particularly where vines, fire escapes and other vertical "ladders" are available. Roof rats tend to inhabit attics and the upper levels of structures. Additional measures may be necessary to block entry near pipes or electric wire openings.

The next consideration is the use of rodent-resistant materials. Stuffing a wooden block in a hole is about as effective as newspaper. The following materials are rodent-resistant.

Stainless steel wool	No specific weight or density.
Sheet metal	26-gauge or heavier, galvanized.
Perforated metal	24-gauge or heavier of rust-resistant materials with openings no more than 1/4 inch (6 mm).
Hardware cloth	19-gauge or heavier with rust-resistant coating and openings no more than 1/2 inch (13 mm) for rats and 24-gauge with 1/4 inch (6 mm) for mice.
Brick	Regular size 3 3/4 inches (10 cm) with mortared joints.
Cement mortar	Should be 1:3 mixture or richer.
Concrete	Should be 1:2:4 mixture or richer and 4 inches (10 cm) thick.

Hardness is not the only consideration, however. The shape and position of the material is also important in determining if a material will be attacked. Rodents cannot work on smooth surfaces, seeking instead a "gnawing edge" such as a joint, butt, small hole or other irregularity where they can get a better bite.

There are a multitude of devices and situations encountered in rodent-proofing a given structure. The main points to consider are listed on the following pages.

Doors

Like humans, rats find the easiest entrances are doors. Tight-fitting doors with a sill clearance of less than 3/8 inch (1 cm) prevent most rats from entering if doors are kept closed. Self-closing devices may be useful in preventing human carelessness. Doors with higher clearances should have metal channels or butt plates installed.

Windows

The next logical openings are windows that are within reach of rats. Windows left open at night are particularly vulnerable. Mosquito screens will probably prevent entry, but heavier screening with 1/4-inch (6mm) hardware cloth is recommended. When attached to wooden framing, the metal wire should be wrapped around the edge of the frame. Windows that swing out horizontally need be protected with a basket device. Windows that do not need to be opened should be nailed shut and any broken glass repaired.

Vents and Drainpipes

Vents that are accessible to rats should be screened in the same manner as windows. Be aware that 1/4-inch mesh hardware cloth reduces ventilation efficiency and may even freeze completely over in severe winter storms. This could create a potentially dangerous situation leading to a lack of air circulation and suffocation in some structures (for example, livestock or poultry confinement structures). Roof vents do not normally need rat-proofing except where roof rat invasions are a threat. All utility and service openings into the basement should be

inspected and closed. Drainpipes in particular should be screened and kept in good repair, as this is a favorite entryway. Where rats climb up sewer pipes and into toilet bowls, a rat guard can be installed. A piece of pipe 8 inches (20 cm) in diameter and approximately 30 inches (76 cm) long is placed into a vertical sewer pipe to prevent rats from entering.

It seems to be part of the steam fitters' code that a one-foot hole must be knocked in the wall to place a one-inch pipe, a two foot hole for a two-inch pipe, etc., and to leave these open for when they are called back for repairs. These openings must be sealed with cement or sheet metal. Small holes can be tightly packed with coarse steel wool.

Foundations and Basements

Norway rats generally enter through basements. Holes and cracks in foundation walls and basement floors must be blocked. In rat-infested locations, put hardware cloth, sheet metal or broken glass in large openings before sealing with concrete. This gives the concrete time to harden before rats chew through the uncured concrete.

Where foundation entries cannot be completely blocked or a dirt floor exists, a curtain wall can be built. A rat that burrows down to the bottom of the "L" will travel along the base rather than digging outside the leg of the "L." While "L" type is recommended, some authorities recommend a straight 36 inch (1 m) wall can be just as effective in keeping out rodents and is cheaper to install.

Outside Utility Lines

Roof rats travel along utility lines where they can gain entry into structures. Guards with a 18-inch (45 cm) radius are needed to interrupt the free passage of these expert wirewalkers. They should be placed away from the building so the rats cannot jump over the guard and onto the building. Guards should be constructed of at least 24-gauge metal. Nails should be spaced far enough apart so as not to provide footing for the rats.

Loading Docks

These areas may offer harborage for rodents, plus provide very easy access to a building. Keep docks clean of all debris and other shelter for rodents.

Interior Rodent-Proofing

Double walls are attractive rat passageways. Eliminate them wherever possible, or place stops of galvanized sheet metal or concrete. Cement floors are recommended, particularly in food-handling establishments. Other types of flooring should be inspected and rat-resistant flooring should be used to seal off openings in the floors. Stairwells should be blocked off completely or left wide open. In multiuse buildings, seal the interior passageways around any food-handling section.

Inspection

After installing rodent proofing in structures, keep close watch of these structures for about two weeks, as pressure to break through new rodent-proofing is particularly heavy following its installation. Also, begin a trapping or baiting program to completely eliminate rodents trapped inside by the proofing. The effectiveness of stoppage is only as good as its maintenance. Frequent inspections and prompt repair of any breaks is a necessary part of the overall rodent program. The following items should be checked on the exterior:

- Doors, windows and vents
- Weeds and other vegetative harborage
- Old equipment, pallets, boxes, etc., stored against the building
- Cracks and holes in building
- Loading docks
- Utility openings in exterior walls

The interior should be checked for:

- Floor and drain caps that are tightly sealed
- Pipe and other utility line openings in interior walls and floors
- Holes and cracks in expansion joints
- Sources of food, water and harborage

A repair kit for rodent-proofing and its maintenance should include hammer, pliers, tin snips, 1- and 1 1/2-inch masonry nails, assorted wood nails and staples, odd cuts of galvanized tin, odd cuts of 1/4-inch hardware cloth, screwdriver, assorted screws, keyhole or coping saw, ice pick or awl, staple gun, caulking compound, plastic wood, tape measure, concrete mix, bucket, trowel, plaster patching compound, 3M body caulking compound, contact glue, white, epoxy, stainless steel wool, short lengths of wire, wood blocks and dowels.

A building will remain rodent-proof only as long as the protective devices are maintained. Careless breaks in rodent-proofing devices,

thoughtless actions in propping doors or windows open and changes in building construction or plant operations may undo all the previous work. Constant inspection of rodent-proofing devices to prevent leaks is as necessary as plugging up all the holes in a sinking boat.

Tracking Powders

Tracking powder is a toxic dust placed where rodents travel. They pick up the chemical on their feet and fur and ingest the toxicant as they groom themselves or handle food with their forepaws. Tracking powders have been used for a long time. However, many, if not all, are Restricted Use pesticides.

The advantages of tracking powders are:

1. Useful when food is plentiful and bait acceptance is difficult to achieve. Tracking powders reportedly result in no bait shyness or awareness of the toxicant.
2. Usually added to the environment without arousing suspicion of rodents, though some individuals may avoid patches, at least initially.
3. Can increase the effectiveness of a rodent control program when used in combination with other methods, such as spreading around bait and water stations.

The disadvantages of tracking powders are:

1. They cannot be used where there is a hazard of the toxic powder being blown onto food, tracked on food by rodents or applied in areas with constant human traffic and air currents. Dusty and damp locations and scattered straw or other loose materials interfere with the effectiveness of powders.
2. They create a greater hazard than baits because the toxicants in tracking powders are 10 to 40 times the strength found in baits.
3. Powders are usually more expensive to apply.
4. The applicator must accurately locate areas traveled by rodents or the application will be wasted.
5. It is almost impossible to remove the tracking powder completely when cleaning up any premises.

Placement of Tracking Powders

Your choice of placement depends upon circumstances and personal experience, but the overriding consideration should be safety.

Tracking powders can be placed in the following ways:

1. Spread in normal runways between food, water and shelter sources.
2. Placed on an apron and around feeding and watering bait stations in normal feeding areas.
3. Exposed in especially constructed tunnels, runways or stations constructed from round tubes such as the cardboard cores of carpets, PVC pipe or other rolled material. The tunnel should be at least 18 inches (45 cm) long and between 2 to 4 inches (4 to 10 cm) in diameter. It is advisable to place stops of 1/2 inch (1 cm) at the ends of the tunnels to keep the powder from being blown or tracked out. All tracking tunnels should be conspicuously marked with poison labels.
4. Blown into dry burrows or other enclosed spaces.

Different types of powders are available. The powder blown into burrows and double walls can be finer than that placed in the open. Powder should be placed at least 15 feet (5 meters) or more from food supplies. It is also more effective if placed near harborage. The further the animal travels before grooming itself, the less material will remain adhered to the feet and fur. Place powders only at floor level to minimize chances of being blown where they could cause contamination.

Application of Tracking Powders

Powder can be applied with a spoon, duster, salt-and-pepper type shaker, flour sifter or jar with holes punched in the lid. A spoon is used to place dust in tunnels. A duster is recommended for use on burrows or enclosed spaces. In open placements, apply carefully to keep the dust from becoming airborne.

Application should be confined to a given area. A uniform layer of powder should be applied to produce a layer at least 8/100 inch (2 mm) thick. Less powder is less effective, while a layer deeper than 16/100 in. (4 mm) is a waste of material. In all cases, follow label directions.

Powder must be replaced when it becomes caked or diluted with dust, dirt or other extraneous materials. Tracking powders may be used in connection with other controls such as solid or liquid baits. Some suggest scattering baits with powders in patches. Rodents may stop to investigate the food even if they do not eat it. The speed with which they travel across a patch of tracking powder affects the amount they will pick up. Light-colored or highly reflective powders arouse more suspicions than dark-colored dusts. It may be most efficient to lay down tracking patches of nontoxic materials (talc, flour, etc.) to check activity before applying toxic powders.

Tracking powders are most popular for use against house mice, particularly when other methods are not successful. Tracking powders are least effective against the roof rat, which walks with its legs extended and tail carried above the ground in comparison to other species. Furthermore, roof rats spend more time on vertical surfaces and upper structures where powders cannot be used.

Baits and Baiting

In controlling rodents with rodenticides, the selection of a proper bait material is of utmost importance. One reason for the success of commensal rodents is their ability to utilize foods available in a variety of environments. The type of environment as well as physiological requirements and individual preferences of a given rodent population determines the success or failure of a baiting program.

While certain baits are accepted more often than others, there is no "universal bait" that is consistently accepted in all circumstances. Thus, it is necessary to constantly assess baits and remain flexible in shifting techniques to suit a particular situation. Baits can be bought commercially or mixed on your own. Commercial formulations are recommended, as these are governed by regulations that require that operations are safe for their employees. Conversely, baits that you mix can be better accepted by rodents than commercial baits because they are fresher. However, poor quality bait material and inadequate mixing facilities may make it cheaper and more effective to rely on a variety of commercial baits than to mix one's own.

Baits are made of three components: toxicant, food or bait base and usually one or more additives to assist in compounding an acceptable bait. The choice of toxicant will be dictated by the target species, need for quick or long-term control and safety considerations.

The use of toxic baits, i.e., rodenticides, is recommended when there are large infestations of rodents and there is less concern about odors resulting from decomposing carcasses. Whenever a rodenticide is used, safety must be the first consideration. Toxic baits should be placed where they are inaccessible to children and pets. Rats and mice are colorblind; therefore, dyes that are tasteless to rodents can be used in baits to identify them for reasons of safety.

One classification of rodenticides is anticoagulants (Table 1), which are slow acting, chronic toxicants that require multiple feedings to be effective. Examples of first-generation anticoagulants are warfarin and chlorophacinone. Second-generation anticoagulants (brodifacoum, bromadiolone, and difethialone) can be effective after a single dose, though it may take up to 5 days before death ensues. Roof rats generally require a few more feedings of first-generation anticoagulants than Norway rats to produce death. However, little difference is evident when using second-generation anticoagulants.

Rodents poisoned with anticoagulants die from bleeding internally. A few cases of pet poisoning have been reported when pets feed on dead rodents. Dogs are more sensitive to anticoagulants than are cats, and pets accustomed to feeding on dry foods can easily ingest a toxic dose of rodenticide if these baits are accessible to them. Older, first-generation anticoagulants (e.g., warfarin, diphacinone, chlorophacinone) are considered less hazardous to pets because they typically require multiple feedings to achieve a lethal dose, and accidental poisoning can be treated with an antidote, Vitamin K1. However, the majority of anticoagulants being marketed today (including many d-CON products) contain brodifacoum or other second-generation materials than can be fatal in a single feeding.

Label directions on anticoagulants commonly instruct maintenance of a continuous supply of bait for 15 days or longer until feeding ceases. Anticoagulants are purposefully slow acting to prevent rats from becoming bait-shy. If the bait produces an ill effect in a rat but not death within a few hours, the bait will often

become associated with the illness. Bait shyness can persist for weeks or months and may be transferred to nontoxic foods of similar types.

Bromethalin, cholecalciferol and zinc phosphide are single-dose, nonanticoagulant rodenticides that can be effective for anticoagulant-resistant populations of rodents (Table 2). Although only a single dose is required, both bromethalin and cholecalciferol may take up to four days before death ensues. Because of this slow action, the rodent's subsequent illness is not associated with the bait even if a sublethal dose is consumed; thus, bait shyness does not usually occur. These baits, in effect, serve as their own prebait.

Zinc phosphide is relatively quick acting, with results evident one-half to 20 hours after ingestion. Because a rat or mouse could potentially ingest a small amount of zinc phosphide and survive, prebaiting is recommended. Prebaiting, that is, training rodents to feed repeatedly on nontoxic bait prior to applying the toxic bait, will encourage rats to feed subsequently on the toxic bait, thus largely preventing sublethal doses and thus bait shyness. As with any product mentioned, be

Table 1. Anticoagulant used for rodent control.

Common name and typical trade names	Chemical name	Usual types of formulations			Restricted Use Pesticide?
		Food bait	Liquid	Tracking powder	
Brodifacoum* (Talon®)	3-[3(4'-bromo[1,1' biphenyl]-4-yl-)-1,2,3,4-tetrahydro-1-naphthalenyl]-4-hydroxy-2H-1-benzopyran-2-one	X			
Bromadiolone* (Maki®, Contrac®)	3-[3-(4'-bromo [1,1'biphenyl]-4-yl)-3-hydroxy-1-phenylpropyl]-4-hydroxy-2H-1-benzopyran-2-one	X			No
Chlorophacinone (RoZol®)	2-[(r-chlorophenyl)phenylacetyl]-1,3-indandione	X		X	Yes for tracking powder
Difethialone* (Generation®)	[(bromo-4'-[biphenyl-1-1']-yl-4) 3-tetrahydro-1,2,3,4-nathyl-1] 3-hydroxy-4, 2H-1-benzo-thiopyran-2-one	X	X		No
Diphacinone (Ramik®, Ditrac®)	2-diphenylacetyl-1,3-indandione	X		X	
Warfarin	3- (a-acetonylbenzyl)-4-hydroxycoumarin	X	X		No

*This product is capable of being lethal in a single feeding.

Table 2. Single-dose, non-anticoagulant rodenticides used for rodent control.

Common name and typical trade names	Chemical name	Usual types of formulations			Restricted Use Pesticide?
		Food bait	Liquid	Tracking powder	
Bromethalin (Assault®, Vengeance®)	N-methyl-2,4-dinitro-N-(2,4,5-tribromophenyl)-6-(trifluoromethyl) benzenamine	X	X		No
Chloecalciferol (Vitamin D3, Quintox®, Rampage®)	9,10-Seocholesta-5,7,10 (19)-trein-3 betaol	X			No
Zinc phosphide (Ridall®)	Zinc phosphide	X		X	Yes for tracking powder and other formulations

sure to follow label recommendations to achieve best success. All single dose, non-anticoagulant baits should be removed and destroyed after the end of a poisoning program.

Single-dose, nonanticoagulant rodenticides work in a variety of ways. Bromethalin depresses the central nervous system and results in paralysis. Cholecalciferol, also called Vitamin D3, is a calcium releaser that causes too much calcium to be released into the blood, resulting in kidney, liver or heart failure. The advantage of Vitamin D3 is a minimal risk of secondary poisoning to pets or wildlife that eat poisoned rodents. Zinc phosphide causes gas to enter the circulatory system, resulting in heart paralysis, gastrointestinal damage and liver damage. Many formulations of zinc phosphide are Restricted Use and therefore require an applicator's license to be administered.

Selection of the food base depends upon many factors: species of rodents to be controlled, particle size, taste, texture, odor, caloric content and competitive foods available to the rodents. Rats normally prefer food bases they are accustomed to eating. Mice are nibblers and like to try new foods, but primarily are seed and grain feeders. Norway rats prefer meat and fish, though basically they are grain-eaters. Roof rats prefer seeds, nuts, fruits and vegetables.

Particle size is important. The optimum particle size for Norway and roof rats is about 0.04 inch (0.5 to 1.5 mm). Mice prefer a smaller size.

The effects of texture, taste and odor of bait foods on acceptance are intertwined. Whereas odor helps attract a rodent to bait, the final test of consumption is the palatability of the material determined by its taste and texture. Different varieties as well as different processing procedures of the same food will result in different rates of acceptance.

While rodents seek a stable caloric content in their food intake, this can be influenced by the quantity and quality of other foods available in a given environment.

Rodent food bases can be classified into meats, vegetables, fish, fruits, liquids and grains and seeds. The food preferences listed below are in the order of acceptance as determined by Harlan Shuyler in his studies on confined populations of Norway rats taken from Indiana sites. These represent only a portion of the 274 food substances tested. The limitations of applying this information to different circumstances should be very evident.

Norway Rat Food Preferences

Food Base	Preferences
Meats	Frozen horsemeat, beef hamburger, cooked horsemeat, pork shoulder, beef round, beef heart
Vegetables	Frozen sweet com, frozen green peas, canned sweet com, carrots, sweet potatoes, butternut or acorn squash
Fish	Sheepshead, smoked chubs, white-fish, channel catfish, smoked sable, silver salmon
Fruits	Honeydew melon, red delicious apples, dried shredded coconut, cantaloupe, bananas, Thompson seedless grapes
Liquids	Chocolate milk, whole eggs, prune juice, apple juice, lager beer, tap water
Grain and Seed	Breakfast rolled oats, freshly ground whole yellow field corn (only some samples rates this high), steel-cut oat groats, brown/white rice, degerminated yellow corn meal, hominy grits

Cereal grains are preferred for most bait materials as they are readily taken, easily mixed with most rodenticides, and conveniently stored because of their low moisture content. Combining several foods (for example, corn and oats), appeals to a larger number of individual rodents than reliance upon a single food base.

Additives

Additives are added to rodent baits for many different reasons, but some lower the bait's acceptance. Thus, it is necessary to determine if the advantages from their inclusion warrant a resultant lowering of bait intake. These additives include:

Attractants

Attractants are substances that presumably draw rodents to a bait. They are mainly odor producing and rarely add to the palatability of the bait. There is much mythology and little objective information on the effectiveness of attractants. Under objective analysis, many of the old favorites like anise oil have actually

proven to repel more than attract rodents, at least at certain concentrations. Further study of pheromones may eventually provide effective attractants. But attractive odors in commercial baits are probably more of a lure to the buyers than rats.

Binders

Liquids aid in formulating and holding the various bait particles together. Water is most commonly used. However, when it evaporates, the baits harden. Water also hastens molding, so oils are preferred.

Oils can enhance and help distribute the toxicant more evenly throughout the bait. Some binders in rodent baits include bacon grease, peanut oil, coconut oil, cod liver oil, syrup, cottonseed oil, lard, mineral oil, butter, safflower oil, soybean oil, corn oil and glycerin. However, the individual population's reaction to different oils makes it difficult to evaluate them universally. The British claim the best binders for mice are glycerin, corn oil, peanut oil and mineral oil. Studies in this country rated coconut, peanut and corn oils in that order for Norway rats. Animal fats tend to lead to rancidity, with resulting poor bait acceptance, much more quickly than vegetable oils.

Coloring Agents

It is advisable to use color baits as a safety precaution. This should alert human adults to the fact they are not food. Color can also repel birds that, unlike rodents, are color-conscious. However, coloring agents may add a taste factor and reduce acceptance. So select chemicals with care and use at the minimum amounts necessary to serve as a warning.

Enhancers

Compared to attractants, this component increases the palatability of a bait so that more will be consumed. The food base and binders can be considered enhancers. Sugar is the most widely used enhancer that has demonstrated ability to increase palatability. The percentage of sugar most often used in anticoagulant-cereal baits is about 5 percent. Some evidence indicates Dexide (MR-100), a carbohydrate with flavor, increases the acceptance and palatability of anticoagulant baits.

Preservatives

As rodents prefer baits that are not rancid, moldy, insect-ridden or otherwise spoiled, preservatives may be added to baits. Paraffin-treated baits with the addition of 0.25% paranitrophenol or 0.1% dehydroacetic acid inhibits mold and does not lower bait acceptance to rats. Sodium sulfite (0.1%) has been used to slow spoilage of meat and fish baits in warm weather.

Bait Formulation

When mixing baits, it is essential to follow directions on the label. Too heavy concentrations of toxicant may result in reduction of acceptance by rodents or increased hazards to nontarget animals. On the other hand, too low a concentration may not be sufficient to kill when not enough bait is taken. Thus, you must measure bait components accurately rather than by eye.

It is best to mix the dry ingredients separately. Mix the toxicant with liquid components and the coloring agent, if used, before adding the dry components. Mix thoroughly to get an even dispersion of the toxicant throughout the bait. An incompletely mixed bait is as bad as having incorrect proportions. Part of the batch will be too strong and the rest too weak. If the material is packaged in plastic bags, do some experimentation first. For example, the oil in the bait could leak through the plastic, making the ink run on the label.

If the mixed material is used in the field, provide service technicians with premeasured vials and graduated bait containers to minimize the possibility of incorrect proportions.

Figure 21.
Bait Station.

Figure 22.
Water Bait.

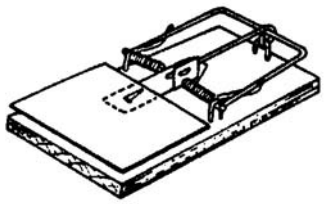

Figure 23.
Enlarged trigger trap.

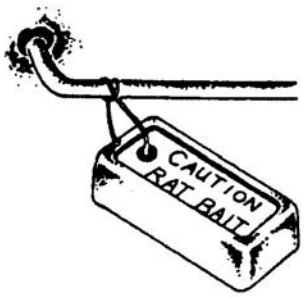

Figure 24.
Paraffin Bait Block.

Figure 25.
Place Packet.

Bait Placement

There are four methods of placing baits in the field.

1. Wrapped or packaged bait placement – Small amounts of bait are wrapped in paper or sealed in plastic packets. These reduce hazards to field crews placing the bait. There is more protection for the bait from the weather, thus keeping it fresher. Placements can be made from a distance by throwing packages over an open dump face or in a crawl space under a building. However, rodents sometimes fail to detect the bait materials inside the packet. Others have the tendency to haul them away to hoarding places that may transfer toxicant to the wrong environment.

2. Bait tray placement – Wet, dry or liquid baits are exposed in a container. There is no top to the container, and it offers little protection for the bait from the weather or protection from children or nontarget animals. Ideally, the lip of the container should be no more than 1/2 inch (1.25 mm) high for rats and 1/4 inch (0.6 mm) for mice. But, depending upon circumstances, higher sides will be investigated by the rodents.

   The smallest dimension of the base should be at least three times the height to cut down on the possibility of tipping. The tray should be large enough to hold at least 1/2 fluid ounce (15 cc) to 8 fluid ounces (200 cc) of liquid bait or 4 ounces (115 g) to 1 pound (450 g) of solid bait. Any waterproof material except metal is acceptable for liquid containers. Metal may react with the rodenticide solution and create an off-flavor. All trays designed to hold dry baits should be water repellent to prevent moisture seeping in from the bottom, causing the bait to mold.

3. Covered bait station placement – Bait stations or boxes are typically utilized for anticoagulant or other multiple-dose baits and in maintenance baiting programs. The bait is placed in covered containers to confine the bait, protect it from the weather and encourage rodents to feed under the protective shelter. They offer a minimal deterrent to children and pets from the baits. Size and shape may vary according to available materials and the amount of bait being placed. Bait stations should be made of waterproof materials to protect the bait from moisture.

   While one entry hole is acceptable, two entry holes in line with each other are much more effective, so the rodent can see an escape route as it enters the station. The holes should between 2 to 3 inches (5 to 8 cm) for rats, but may be as small as 1 inch (2.5 cm) for mice.

   There should be a provision for a tray, built-in hopper or other device for securing a water fount. The station should be large enough to contain 4 ounces (115 g) of dry bait or 8 ounces (234 cc) of liquid bait.

4. Tamper-proof bait station placement – This is a covered container that not only protects the bait, but also keeps children and pets from it. The following is the EPA definition:

   "A tamper-proof bait box is a structure made of material impervious to weather and strong enough to prohibit entry by nontarget species. The access panel must be

securely attached. The entrance must allow easy access for target species, yet prohibit access to bait by larger nontarget species. This can be accomplished by limiting entrance size, by using baffles and/or by incorporating a maze-like construction. The box must be capable of being anchored securely to resist the possible efforts of children, pets, domestic animals or wildlife to move it or displace its contents. It must not constitute an attractive nuisance; e.g., a container which clearly resembles a toy, such as a doll house or sand bucket. Proper precautionary statements must appear in a prominent location. The box must have some internal structure for containing the bait (i.e., a cup holder or raised lip) so that the toxicant will not be exposed on nontarget animals outside the box."

"Maze-like construction" as suggested above should be a modification of last resort. The obstructions generally decrease rodent acceptance of the station.

For perishable baits, set out bait in the late afternoon so the bait will be fresh when the rodents start feeding around dusk. Baits should be placed where rodents will find them.

Bait stations protect bait from weather, children, nontarget animals and irresponsible persons, as well as offer a place of security in which rodents can feed. Where protection of nontarget animals is not a serious consideration, a board nailed over a runway may be sufficient. Two openings, 2 x 2.5 inches (5 x 6 cm), on each end of the runway should face each other so the rodents can see a ready exit.

When protecting humans and other animals is the prime consideration, the bait station must be (1) completely enclosed, (2) attached so it cannot be moved and (3) have a lockable access panel. Baffles may also prevent small children from reaching inside the small openings.

While rats eat at a number of locations, mice are very erratic feeders. Many small stations are needed to control mice. Place baits or bait stations within 10 feet (3 m) of each other so that mice will intercept a station. Rats have larger home ranges, so baits can be placed 20 feet (6 m) apart. These distances are merely a guide, as a physical layout of a premise will determine optimal patterns of placement.

Baits should be placed under cover, in burrows and along walls. The amount of bait depends on the rodent species, the size of the infestation and the toxicant being used. There should be more than enough to feed all rodents present. Minimum placements should be 2 ounces (50 g) for mice and 4 ounces (100 g) for rats. Stack the bait so the rodent can see it over the lip of the bait trays. Bait stations should be set out a week before placing bait in them, if possible. Rats will not approach a new object. By waiting a week, the bait will be fresher when the rodents first encounter it.

It is better to replace water solutions completely rather than adding more liquid bait when stations reach a low level. If remaining dry baits are clean and fresh, small amounts can be added at these placements. Stir the bait at each visitation to aerate it and prolong freshness. At first appearance of mustiness or mold, empty and clean the container before refilling.

In baiting a premise, particularly a food-handling or processing establishment, don't overlook the advantages of "perimeter baiting." There are fewer restrictions on baiting (trapping and gassing, too) outside buildings. It can be easier to remove these peripheral rodents than those firmly established inside a building. Removing these rodents reduces the population of rodents that potentially could inhabit the building at a future time. The job inside will be much easier if the population outside has been reduced or eliminated entirely.

Special Situations – Sewers and Damp Locations

Baits mixed with paraffin are suitable for damp areas such as sewers and marshy outdoor habitats. While paraffin can lower acceptance, this is offset by the protection afforded from water and molds. Ready-made blocks are available commercially, but you can make your own by adding from 33 to 38% paraffin by weight to treated grain.

Heat the paraffin to a liquid state, add the poisoned bait base and mix thoroughly. Pour into a mold to solidify. Put a wire hoop into the mixture before it hardens. Use this handle to tie down the bait and prevent it from being washed away by water or carried away by rodents. An alternative for outdoor placements is to drive a wooden stake through the center of the mix and into the ground.

Waxed paper containers, reusable rubber/silicone molds or similar containers can be used to mold the bait mixture. These can be torn off when the mixture has hardened. Do not use identifiable food containers for molds.

Winter Baiting

Water baits are most effective during warm, dry periods. If water baits are used at temperatures below freezing, alcohol or glycerin up to 25% by weight or volume can be added to the water. These chemicals do lower the acceptance. Another alternative is to increase the sugar content to 10% which will prevent freezing if the temperature remains just below 32ºF (0ºC). Higher amounts of sugar would reduce bait acceptance.

Bait Testing and Prebaiting

To determine an appropriate bait base, conduct a "bait test" by offering rodents bait food without toxicants. While this can act as "prebaiting," it is not the same. The purpose of bait testing is to determine the effect of the environment on the food choices of a particular population. Place several different baits in two to ten locations. The baits should be 4 ounces (100 g) amounts and within 1 foot (30 cm) of each other, cafeteria style.

"Prebaiting" involves offering rodents unpoisoned bait for three or more days prior to treatment. This serves to overcome new object shyness and gives an indication of the amounts and optimum locations for placing the toxic materials. This is not necessary when using anticoagulant baits or treating for mice alone. It is a good practice when exposing an acute toxicant for rats in a difficult baiting situation. However, the economic realities of the industry make this impractical under many situations.

Traps and Trapping

There are a number of things wrong with trapping. It doesn't look professional as anybody can buy and set a trap from the dime store. It is very expensive in terms of labor. It is a slow way of removing a heavy infestation.

All true. But trapping has been and should remain a tool for solving rodent problems. Traps can be used where it is necessary to remove an animal completely from the premises eliminating a potential odor problem. Traps can be used where toxicants should not be used such as food handling areas, residences with small children, hog farms and zoos where poisoned rats might be eaten, etc. The snap trap is the best answer for removing pests as humanely as possible without toxicants.

The most important consideration is the attitude of the person doing the trapping. Any person can set a trap, but the successful trapper realizes he or she is dealing with a wary animal, looks for signs carefully and adjusts methods to outwit the adversary. There are no magic lures to bring rodents into a trap. You have to put traps where the rodents will encounter them.

Types of Traps

Single-Door Cage Trap

Commercially available single-door cage traps such as the Tomahawk® and Kage-All® are durable and function well under field conditions. They are usually the traps to choose when live capture of rats is necessary. These traps will, in many situations, give higher capture success of rats than will snap traps.

Wind-up Multiple Catch Traps

Multiple-catch (automatic) mousetraps such as the Ketch-All® and Victor Tin Cat® are commercially available. A good choice for warehouses, restaurants, food processing plants, etc., these traps work using the principle that mice enter small holes with hesitation. The Ketch-All® has a wind-up spring which powers a rotating paddlewheel that, when triggered, entraps mice in a holding compartment. The Tin Cat® has one-way doors that mice cannot exit, once having entered. Such traps may catch many mice in a single setting, but they should be checked and emptied periodically so that mice do not die of starvation or exposure in the traps.

Snap Traps

The "snap trap" is cheap, easy to operate, requires few inspections, can be set in many situations, and since the animal is killed almost instantly, more humane.

Operation of Traps

One basic principle of effective trapping is that time and opportunity are lost if the trap set in the field is not in prime operating condition. In using cage traps, the triggers should be checked several times to achieve the proper sensitivity to respond to the weight of the target animal. Double entrance traps with mesh sides present the least sinister appearance to the proposed victim. They should be as large as possible and still enable the target animal to trip the trigger. The simpler the trigger mechanism of these traps, the less chance of failure.

The trigger mechanism for snap traps must also be in good working condition. Be certain the

staples holding the spring are firmly embedded in the wood. The trigger catch should be bent in the right position so that the bait pan lies at the proper distance above the trap base. The wooden base should be flat and not warped or it will roll as the rodent steps on it. While some commercial firms make enlarged bait pans for their traps, these can be added easily to others. Material can be of corrugated cardboard, fly screening, wire mesh, sheet metal, etc. A really good material for mousetraps is made from aluminum cans. This material is easy to work, light in weight, does not rust and will not become limp as cardboard does in damp situations. In making the pan, cut it out at least 1/4 inch (0.5 cm) smaller than the area covered by the trap jaw. Rivet or fasten to the regular bait pan. The leverage increases the sensitivity of the trigger, and for runway traps, provides additional surface area to increase the possibility of the rodent tripping it as it runs down a trail.

When oiling a trap, use a medicinal grade mineral oil instead of a petroleum-based oil as this may increase repellency. Traps do not have to be clean to be effective; in fact a dirty trap is probably less repellent to a mouse than a shiny new one from the factory. But while dirt is probably attractive to mice, in a commercial situation, its value must be weighed against its public relations effect.

Traps should be cleaned up and possibly painted before placing at a food-handling account. Painting with a water-based fluorescent paint may aid in recovery of the few traps that might be dragged away. Numbers should be painted on them to help in record keeping. This also adds to the professional appearance of these devices.

A hole should be drilled in one corner as close to the edge as possible on the side away from the bait pan. It is rarely necessary to set a drag or otherwise fasten down these traps on a horizontal surface. But if the occasion arises, a drag wire can be slipped through this hole without interfering with the operation of the jaw when it is pulled back in the set position. This hole also makes a convenient way to string a number of traps on a wire for ease of transporting.

Store traps away from insecticides or other chemicals that might impart a strong repellent odor. Carry them on wires or in boxes where they'll be kept in order rather than carelessly tumbled into a heap with resultant damage to trigger mechanisms.

Trap Placement

Next to having a trap that will function properly, the most important consideration is proper trap placement. Do not rely on any lure to bring the animal to the trap. Put the trap in a place where the rodent will literally stumble over it in the normal course of his activities. Put traps next to walls, in dark corners, behind and under objects, where tracks and droppings are numerous, and in normal travel lanes going from cover to food and water. Force the animals to pass over the trigger by putting boxes or boards to form barriers that will guide them to where you want them to cross.

Placement of Snap Traps

Traps should be placed in groups or areas so they can be easily accounted for. Use many rather than a few traps. Possibly a dozen would be the minimum number to use in a private dwelling while 50 to 100 is not excessive for a warehouse or other commercial installation. Traps should not be spaced more than 10 feet (3 m) apart, preferably as close as 3 feet (1 m) for mice due to their limited range in certain environments. For rats a minimum of 20 feet (6 m) should be observed.

Trap shelters are an effective modification of trapping technique. They enhance the professional appearance of the job. It is easier to locate the traps when rechecking. The possibility of something being dropped on the traps and setting them off is reduced. The trap is anchored so an animal cannot drag it off. Trapped animals are concealed from a sensitive human audience. They provide the necessary guide forcing the animal to pass over the triggers of runway traps. The danger to pets and children is somewhat reduced. In building the shelter, make certain it is curved enough to give clearance to the jaw as it closes.

If rodents are difficult to trap, it is possible to bury traps lightly in sawdust, flour, feathers, confetti, etc. Bait is set in the center and the traps left unset for several days to overcome shyness. When covering with loose material, it is necessary to put a lightly rolled wad of cotton under the bait pan or lay a small piece of paper or cloth over the bait pan to keep the material from sifting under the pan and preventing it from moving. In other situations it might be necessary to set taps in groups of three or more where animals appear to be jumping over a trap set. Tracking patches can be used to locate good trapping areas and activity around an ignored

trap. Do not place traps above food handling areas. It is better to trap a small area intensively than undertrap a larger one as this increases the danger of educating a population into trap shyness.

Baiting Traps

A chapter could be written solely about baiting and not cover all the circumstances. Different baits for different places seem to be the story. Some good basic baits for mice are peanut butter, cereal, raisins, nutmeats, bread, bacon, gumdrops, strawberry jam, etc, and for Norway rats about the same plus meat, fish and pieces of wieners. For roof rats fresh fruit and nutmeats seem to be about the best. The best procedure is to use three or more different baits in a given area and keep a record of those that appear more attractive.

If fresh baits like meat or fish are used, replace them often to maintain attractiveness. Baits should be secured to the bait pan by thread or wire to prevent it from being stolen. It is recommended that traps be baited and left unset for three or more days to accustom the animals to this new source of food; however, this is often economically impractical. With reality in mind, this practice should be used only for the few occasions you encounter a rat population demonstrating a high degree of trap shyness and "new object" reaction.

Runway traps do not normally need to be baited. However, capture can be improved using bait. Peanut butter smeared in the center of the bait pan or cereal sprinkled over the surface are good attractants.

It is good practice to bait with attractive foods not present in the area when there is considerable competition from available food sources. It is not always necessary to use food materials. Cotton can be tied to the trigger in places where nesting material is apparently at a premium.

The use of odors as attractants to increase trapping success is not clearly understood. Do not pet a dog or cat before handling traps. Rodents may avoid these odors but they are not bothered by human scents. Probably odors of other rodents will attract. Some pest managers feel putting traps in cages of rats or mice before exposing them in the field will help condition them. Others swear by various chemical odors such as cinnamic aldehyde produced by rubbing a split red carnation over the bait pan. An increased understanding of pheromones may some day assist in this area, too.

Trapping Schedules

In planning a trapping program, it is best to set a large number of traps at first and then taper off. Traps should be checked each morning to remove dead rodents from view. If possible, the trap line should be rechecked in the late afternoon. Clients do not want to see the visual evidence of a successful catch.

As mentioned before, it is better to trap small areas intensively than larger ones extensively. It is also better trap intensively for 2 to 3 weeks and then suspend trapping completely. If they can be spared, traps should be unsprung and left in place. After a couple of weeks trapping can be started up again. One problem with trapping is young rodents being weaned seldom get out of the nest far enough to reach your traps. This blank period will give you a better chance of getting these animals as they grow large enough to find your traps.

Another argument for keeping close records on the catch is that you will be able to pick out unproductive locations. Traps should not be moved about constantly as it may take a while for animals to approach them. Those that are unproductive after seven days should be moved to more fertile hunting grounds.

In taking animals out of the traps, do not handle them any more than necessary. You can usually drop them in a paper or plastic sack without having to touch them. If you have to pick them up, use gloves or tongs. An insecticide should be sprayed or dusted around the trap area and over the trapped animals. A dust like carbaryl is good for this purpose. This practice is essential in areas where vector borne diseases are prevalent.

Rodent Glues

Rodent glues are sticky chemicals that entangle the victim like flypaper. Ready-to-use glue boards are commercially available from various suppliers, or bulk glue can be purchased. The sticky material is spread on heavy craft paper, cardboard, roofing paper, boards, etc. Lengths of it are placed in runways. When an animal steps on the glue he is unable to remove his foot. His struggles will eventually cause him to end up with more feet and possibly his nose in the material. Glue boards are used under most of the same situations as traps and are sometimes effective where trap shyness has developed. Glues are nontoxic and hold the animals for disposal the same as traps.

Problems with glue boards can occur in extremely hot weather when some glues can run off the board and cause staining. On the other extreme, in cold weather the material may harden too much to be effective. In dusty areas, the surface may coat over so that it is unable to hold the animal.

Before handling bulk glue, wet your hands and putty knife with soap and water. Scoop up the glue and spread it on a sheet of roofing paper or other backing material. It is best to keep these separate. However, where necessary, another piece can be squeezed on top of this to form a sandwich. Pry the pieces apart when ready to use making sure the glue does not run out to the edge of the backing material.

Glue boards are more effective for capturing mice than rats. In severe mouse infestations, they can be used to quickly and safely reduce mice populations. Unless placed under cover, glue boards should not be used in areas where there is excessive dust.

Predators

Dogs and cats, particularly certain individual animals, will catch and kill rodents. However, there are few situations where they do so sufficiently to control rodent populations. Around most structures, rats and mice can find many places to hide and rear their young out of the reach of such predators. It is not uncommon to find rats or mice living in close association with cats or dogs, relying on pet food for nourishment. Rats often live beneath a doghouse and soon learn they can feed on the dog's food when he is asleep or absent.

Equipment and Application Techniques

It is important to know the characteristics, advantages and limitations of various kinds of control equipment so that you can choose the equipment best suited to each job and use it safely and effectively. Proper maintenance of equipment is important to safety, efficiency and profitability.

Along with knowledge of equipment, pesticides and pests, it is important to be familiar with the application techniques suited to a given situation. Many current and all future pesticide product labels will indicate how a pesticide is to be applied. Application techniques vary with the equipment used, type of pesticide applied, target pest involved and size and scope of the application job involved. Proper application techniques insure effective control and proper use and prevent drift and pesticide loss into the environment.

Sprayers

Compressed Air Sprayer

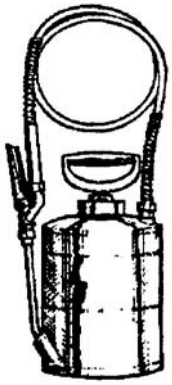

Figure 26.
Compressed Air Sprayer.

The basic piece of spray equipment used in general pest control is a small, hand-operated and hand-carried compressed air sprayer with a capacity in the range of 1/2 to 1 1/2 gallons. Air pressure is supplied by a hand-operated pump or by an electrically or gasoline-operated air compressor. The air pressure is contained in the tank above the surface of the liquid to be dispensed. This air, usually compressed to 20 to 50 pounds pressure forces the pesticide out through a discharge tube to the nozzle when the discharge valve is opened. The liquid is not mixed with air, but is pushed out as a wet spray without atomization. There are several sprayers of this type made by several different companies. The pest control operator should choose the type best suite to his needs.

These types of sprayers are used for a variety of insect control by the general pest control operator, including cockroach, ant, flea, stored product and numerous other types of pests. It is used for applying crack and crevice, spot and general sprays. It is the workhorse of a pest control operation.

A compressed air sprayer consists of (1) a tank for the spray mixture, (2) a hand-operated pump for compressing air in the tank, (3) a siphon tube to carry the spray mixture to the hose, (4) a hose which connects the sprayer tank and siphon tube to the valve, (5) a valve to control the spray flow and (6) a nozzle to distribute the spray in the desired application pattern. Use a wand or short piece of curved tubing to extend the distance between the valve and nozzle. Compressed air forces the spray material out through the nozzle when the valve is open.

Hand-operated compressed air sprayers are designed to operate with 20 to 50 pounds of air pressure. Usually, pressure of less than 20 pounds is desirable when operating indoors, when making crack and crevice applications and to reduce splashing. Higher pressures of 20 to 50 pounds are necessary when operating outdoors, projecting a spray stream over long distances, spraying large volumes and to develop proper nozzle patterns when using fan or cone nozzles. The tank is made of stainless steel, brass or galvanized steel; however, plastic tanks are coming into greater use. Stainless steel tanks are generally resistant to the corrosive effects of many pesticides. Some tanks may have an air release valve and/or a pressure gauge.

The air pump is usually mounted in the cover of the head opening. It consists of a handle, cap, sealing ring, plunger rod and piston to force air into the tank through a check valve in the bottom of the pump and a brass or stainless steel cylinder. The piston has a leather or synthetic rubber cup that may require maintenance. The check valve at the bottom of the pump cylinder prevents air and spray material from being forced back into the cylinder, and it, too, may require periodic replacement.

The nozzle is the most important part of the sprayer because it determines whether the insecticide will be sprayed as a solid stream, flat spray, hollow cone or solid cone. It also determines the rate of spray output at a given pressure, the thoroughness of application and the safety with which a spray is applied. Nozzles are available in many types, each designed for a specific delivery pattern and discharge rate. Base the selection of nozzles on the proper particle size and application rate.

Solid stream nozzles are used in crack and crevice treatment. Use fan nozzles in making flat surface applications. Solid and hollow cone nozzles distribute sprays in a circular pattern and are used more often in applications to trees and shrubs. Adjustable nozzles containing a variety of tips are available and useful when varying spray patterns.

If a sprayer is used daily, clean it after each use. When cleaning the tank, use hot water and a good detergent, preferably one containing ammonia. Remove any residue accumulations on the inside of the tank by scrubbing the inside and bottom of the tank with a stiff bristle brush until the surface is perfectly clean. Clean and polish the outside of the tank to preserve the surface and to prevent contamination or damage to other objects. Pressurize the tanks after cleaning to check for small pinhole leaks.

Store upside down when the sprayer is not in use. Remove the pump unit and turn the tank upside down, lay the pump assembly on a clean surface, hang the shutoff valve on a hook and let the hose extend its full length. Open the shutoff valve so that any liquid trapped in the extension can drain out of the hose. Also, sprayers need to be protected during freezing weather to prevent damage (e.g., valves may freeze and crack).

Inspect the pump unit and maintain the three gaskets. At 2- or 3-week intervals, lubricate the cup leather of the pump with a few drops of neat's-foot oil. Oiling the cup leather in this manner helps retain its shape and keeps it moist for maximum efficiency when pumping. The sealing ring, in time, becomes worn and needs replacing. When worn out, this gasket can cause severe pressure leaks.

Periodically inspect the lip of the pump cylinder for cracks as this causes pressure loss around the pump cap. Clean and polish the inside of the pump cylinder. Remove the check valve and polish the valve seat with steel wool.

Sprayer malfunction often occurs within the pump assembly. Proper diagnosis will indicate the problem that may require repair or replacement. Frequent replacement of the gaskets is much less costly, in most instances, than solving the problems of accidental pesticide discharge.

Problem	Cause/Answer
Failure to develop pressure or no back pressure when plunger is pushed down.	Worn plunger cup, or plunger cup needs oiling.
Liquid or air flows into pump, causing liquid to shoot up out of the cap around the handle or handle "creeps" up when not locked down.	Worn check valve.
Sprayer loses pressure slowly, even when no spraying is being done.	Worn sealing ring.

Thoroughly inspect, rinse and clean the sprayer hose once a week. This is most convenient when the tank is rinsed with detergent. After the tank has been washed thoroughly, pressurize the sprayer and spray the detergent through the hose, shutoff valve and nozzle. Never let the sprayer hose stand unused for more than one day with pressure in the sprayer. Even the best sprayer hoses show some deterioration if left standing under pressure when filled with solvents and insecticides. Never leave an unattended sprayer of any kind with the pressure up. The next person walking by may try the shutoff valve and contaminate himself or the area. Loosen the cap slowly, and after the pressure is released extend the hose upward full length and depress the valve. This allows spray material accumulated in the hose, valve and wand to drain back into the tank.

Occasionally oil the valve plunger and replace the packing around it. When the valve fails to feed or stops up when operating, it may be clogged. Also, the valve may fail to shut off completely, permitting a continued drip from the nozzle. There may be some dirt lodged in the valve seat, or there may be a scratch on the valve surface. When these problems occur, take the valve apart. The manufacturer can provide the necessary diagrams and instructions to aid in this procedure.

The strainer assembly of any sprayer is a very important part. A properly functioning strainer filters out particles that would clog nozzle tips or interfere with shutoff closure. Remove the assembly once a week and wash

thoroughly to remove all sediment and residue from the strainer screen. Otherwise residue builds up on the screen and stops the flow of insecticide. Normally these sediments can be removed by running hot water over the strainer. However, if necessary, soak the strainer a few minutes in a suitable solvent and clean with a soft bristle brush.

Nozzle tips occasionally become clogged with extraneous materials that distort the spray pattern or completely prevent liquid passage. There are several remedies for clogged tips. Use compressed air to blow foreign matter out of the tip, and for best results, always force the air through the front of the orifice. Soaking the tip in a suitable solvent and cleaning with a toothbrush usually cleans out the accumulated sediment.

Never use anything more rigid than a toothbrush bristle to clean the spray tip, and never insert any metal object such as a pin, wire, etc., in the end of the tip. The orifice is precision machined and can be marred easily, causing a distortion in the spray pattern.

Small Hand Sprayers

There are uses for even small hand sprayers in public health programs. The "flit gun" type sprayer and the pistol sprayer can be used for treating very small areas when extreme portability is important or when only small quantities of pesticide are needed, as when treating small mosquito-breeding areas or wasps' nests.

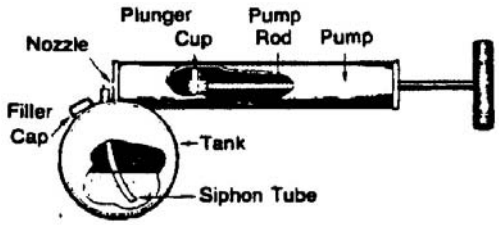

Figure 27. Flit Gun Sprayer.

Dusters

Equipment for applying dusts varies with the use and the type of practice. Some of the more common types of dusters are:

Hand Shakers

Hand shakers are available in a wide range of sizes or can be homemade. Shakers may be used for applying tracking powders and patches for mice and rats in runs along the base of walls or foundations or on beams. They maybe used for insects where careful placement and neatness are not essential. Do not apply too much in one place. If the shaker is fitted with a 16- to 20-mesh screen, over-application is less likely to occur.

Figure 28. Hand Plunger Duster.

Figure 29. Bulb Duster.

Figure 30. Bulb Rotary or Hand-Crank Duster.

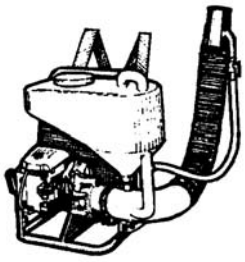

Figure 31. Portable Power Duster.

Hand Bellows Duster

A hand bellows duster is a rubber cylinder with a metal or plastic top and bottom. The bottom has an extension tube for delivery of the dust. The top contains an opening for filling and a tight stopper. Inside the rubber cylinder there is also a large coil spring that resumes its shape after compression. The dust is delivered by squeezing the top and bottom of the bellows together. This duster is used where small quantities are needed, and careful placement and neatness are important. They are used to apply a thin layer of dust or to force dust into small cracks or voids where insects may be hiding. They are sometimes used for cockroach control or treating and nests in voids in walls.

Bulb Duster

A bulb duster is a rubber bulb with a screw cap cover fitted with a dust nozzle. Dust is distributed by squeezing the bulb. These dusters are used in the same situations as hand bellows dusters.

Hand Plunger Dusters

Hand plunger dusters consist of a plunger-type pump and a metal or glass reservoir into which the airblast goes when the plunger is pushed. The dust is dispersed as a relatively fine cloud or a heavy blast, depending on how the duster is held. They are not suitable for most inside work but are sometimes used for treating large areas such as crawl spaces or attics when larger rotary or power dusters are not available. They might be used to apply insecticide dusts for silverfish and spider control in attics or crawl spaces.

Foot Pump

A foot pump is similar to the hand plunger duster but is held down on the ground by placing the foot in a stirrup and pumping with the hands to force the insecticide out through a short, flexible delivery tube. It is useful for applying dusts to rat burrows.

Rotary or Hand Crank Dusters

These dusters have a 5- to 10-pound capacity hopper. Some are designed to be carried on the operator's back. When the crank is turned, a fan blows air through a long delivery tube. Dust is dropped into a mixing chamber or directly into the fan chamber from a hopper which may or may not contain an agitator to fluff the dust and feed it into the fan for dispersion out the tube. Most have adjustments to regulate the delivery rate of the dust. Usually a fan- shaped tip is supplied with the duster to produce a broad band of dust. With the fan tip removed, it can be used to treat rodent burrows. These dusters are primarily for outdoor use but also are used to treat larger indoor areas such as crawl spaces and attics and for treating sewers.

Power Dusters

Power dusters vary in size and output. They are similar in principle to the crank dusters but have a larger capacity and power-driven fans and agitators. Small electrically-driven dusters produce a very fine layer of dust and are used effectively to treat small cracks or wherever deep penetration is required. Another type of power duster is the compressed air duster. It is similar to a dry-type fire extinguisher and must be pressurized with air before operation. A mixture of dust and air is discharged when the valve handle is depressed. These dusters also would be used to treat attics and crawlspaces to control several kinds of insects that may be a problem in these areas.

Most dust application equipment is maintained easily, but periodic maintenance is essential to keep this equipment in effective working condition. Empty dusters frequently and clean thoroughly to remove all caked or hardened dust. Insert a piece of stiff wire in the tubes to scrape caked dust from the sides and tip of the tube. Clean screens and all other small openings frequently to insure they are not clogged. When storing the duster, first remove all dust and then clean thoroughly. Also, make sure the storage area is dry so that metal parts do not rust.

Space Treating Equipment

Space treatments for quick knockdown and control of flying insects have been used extensively. Any insecticide used to fill a space must first be broken down into fine particles or droplets to allow their suspension in air or to allow the particles to be moved by wind currents. Fine-droplet dispensers-foggers, misters, aerosolizers and ULD-were developed for this purpose.

Equipment used in dispensing fine particles comes in a variety of types and sizes, each designed to produce particles within a specific range of sizes. At present, there are no particular field methods for determining droplet size quickly. Many types of equipment can be adjusted within certain limits to produce a wide range of droplet sizes.

It is a common mistake to relate the type of application specifically to the piece of equipment being used. One should (to be effective, safe and efficient) know fogs, mists, aerosols and ULD in terms of droplets size and their characteristics and usages in given control situations, then use the proper equipment for the purpose.

Distribution and effectiveness of insecticides in space treatments are dependent on the production of very small drops in much larger numbers than with conventional application methods. These very fine drops, however, are more subject to drift and tend to deflect around target insects instead of hitting and impinging on them.

The micron (a unit of measurement) is used to measure droplet or particle size. A micron is 1/25,000 of an inch.

Effectiveness of spray droplets depends on their size, their ability to penetrate or to reach the target area and their ability to impinge on or hit the insect. Research indicates that droplets in the 5- to 15-micron range (most conventional spray droplets are in the range of 100 to 400 microns) are more efficient for controlling cockroaches and other indoor pests.

Spray droplet size is affected by the pressure or flow rate, the size of the outlet orifice and the viscosity and physical characteristics of the spray mixture. The higher the air pressure or flow rate or the smaller the orifice outlet, the smaller the droplets produced. Viscosity affects flow rates and evaporation rates; higher viscosities generally reduce both rate of flow and evaporation. Penetration of droplets into an area not in direct line with the spray outlet is dependent primarily on droplet size, speed or velocity of the droplets, air currents and gravity. Impingement is affected by the same factors affecting penetration plus the size and shape of the target insect.

Factors influencing the effectiveness of conventional sprays also affect fine particle dispensing, including the insecticide used, concentration and rate of application, thoroughness of application, amount of harborage area (hiding places) and the nature of the treated surfaces.

Aerosols

Insecticides in extremely fine mists are aerosols. Aerosols used indoors may be gas propelled or thermally released. Gas-propelled aerosols are insecticides in special containers in which a liquefied gas is used to force the contents under pressure out through the nozzle in droplets of 0.1 to 50 microns. They are presently available in a variety of sizes from the disposable" soft drink" can size used by the public and industry to the heavier specially developed, reusable containers for use by industry for space, crack and crevice treatments. They are handy and convenient to use and require no special motors, electrical outlets, water or oil, but are more expensive per unit of insecticide. They are sometimes used for "flushing" or inspection to determine the nature of the problem, such as in cockroach control. Some are available with long flexible nozzles for crack and crevice treatments. Other aerosols are used in space treatments for the quick knockdown and control of crawling and flying insects and to increase insect activity to insure contact with deposits of residual insecticides.

Figure 32. Disposable Aerosol Dispenser.

Aerosols may be purchased as timed-release dispensers with a clock-like mechanism that releases the spray on a preset schedule.

Total release aerosols are being used increasingly. These dispensers contain residual or nonresidual insecticides or both. They are designed so the release valve can be locked in an open position for total release of the contents.

Pressurized spray applicators are used commercially and by the general public. These spray applicators differ from aerosols in that they usually contain a much larger percentage of petroleum and diluent, and the nozzle produces a coarse spray that deposits a thin film of insecticide directly on surfaces.

Pressurized aerosols require some special care. Store them in temperatures between 70°F and 120°F. Higher temperatures increase the pressure within the container and can cause it to explode. Lower temperatures cause the pressure to drop, resulting in improper operation and larger droplets. Store and transport them in such manner that they will not discharge accidentally.

Fogs

Fogs can be produced thermally or mechanically. A mechanical fog generator is most often a mist machine adjusted to produce fog-sized droplets. Most fogs, however, are produced thermally.

Fogs and aerosols technically are dispersions of droplets ranging from 0.1 to 50 microns, with the preferred range of droplets thought to be five to 10 microns for greatest efficiency. Many formulations are produced for fogs or aerosol applications. Some specify the range of particles or droplets to use (i.e., none over 50 microns and 80 percent less than 30 microns). Fogs may be used to treat warehouses for stored product pests, cockroaches or other insects. There are many makes, models and sizes of thermal fog machines available. These machines break the pesticide into fine droplets with hot exhaust gases. The oil solution of an insecticide is vaporized by the hot exhaust gases, and as the vapor is discharged into the cooler outside air, it condenses into very fine droplets producing a fog. Some people believe heat causes some insecticide decomposition. This may be minimized by using less volatile oils. Thermal fog generators sometimes produce a flame when started and, thus, should be started outdoors or in a safe area. If a fogger ceases to function, take it outside to restart it.

Thermal fogs may be used alone, indoors or along with residual applications for controlling crawling insects. Indoors, fog rarely penetrates into cracks and crevices unless air currents are running into such areas to carry the fog with it. Fogs usually do not move against cold exterior walls.

Thermal fogging can cause explosions. Usually this is the result of having too high a concentration of fog in the structure and operating near a spark or flame that ignites the explosive mixture. Turn off all pilot lights by shutting off the main gas valve rather than individual valves. Wait until the gas in the line has been used and the pilot lights go out.

The concentration of fog can be too high from overdosing or from pockets or accumulated fog material. Good practice and most labels call for using 21 gallons of fogging compound per 50,000 cubic feet, which is well below the explosive limit, but an open flame can ignite the oil and cause a fire. Know the cubic footage of the area being treated and the amount of fogging mixture to put into the space. Then you must know how fast your fogger puts out the mixture. Record the information so that you do not have to recalculate if retreatment is required.

Mists

Mist particles or droplets range from 10 to 80 microns in diameter and can be dispersed using oil or water as a base. Since mists are generally larger particles than other types of space treatment, they settle out fairly rapidly. Use mists in conjunction with a residual treatment for long-lasting control of crawling insects, but apply them following the residual application. Mists like fogs are used more frequently in warehouses.

Mist-producing applicators break up the insecticide mechanically into fine particles using low pressures and a high volume of air. The smaller units most commonly used inside are electrically driven at high speeds. Some force air and liquid through a hollow shaft and between pairs of disks by centrifugal force. A blower on the same shaft blows across the outer edges of the disks, shearing droplets off and into the airstream at high speed. Particle size depends generally on rotation speed, delivery rate and viscosity of the insecticide solution or emulsion. Others produce an airblast that sucks the spray mixture from the tank, shears it into a fine insecticidal mist and projects it for several feet.

Mist applicators are available in a wide range of sizes and can be used to apply oil-based sprays or water emulsions. They have low manpower requirements and can apply small amounts of toxicant to a large area in a short time. Oil-based mists can be ignited by an open flame but are generally considered less hazardous than thermal fogs. Water-based mists have no fire or explosion hazards. When used outside, cars and windows may be spotted by the insecticides, and shrubbery may be burned by the oil if the machine is not properly operated.

Ultra Low Dosage (ULD)

ULD uses high concentrations of insecticide (as fine droplets) at reduced application rates. A very high percentage of the droplets are produced in the range of one to 30 microns with none exceeding 50 microns in size. Also,

the droplet size appears fairly uniform. Distribution and effectiveness depend on the production of very fine drops in much larger numbers than with conventional application methods. These very fine drops, however, are more subject to drift and tend to deflect around target insects instead of hitting and impinging (sticking) on them.

There are many makes, models and sizes of ULD applicators available. Some have fixed nozzles while others have remote nozzle hose assemblies. They may be powered by electric motors, gasoline engines or by compressed gases (pressurized aerosols). In the electric- and gas-powered units, the insecticide is drawn into the nozzle and forced out at high speed, producing small droplets. Pressure in these units usually is produced by a supercharger. Follow the manufacturer's directions to obtain the desired range of droplet size. Both oil- and water-based formulations are available for use in this equipment.

ULD treatments provide good flushing action for cockroaches but should be used after first making a residual treatment.

Since ULD involves the use of higher than normal concentrations and lower than normal application rates, this information must appear as a part of the labeling to avoid misuse of the product. At this time, the number of insecticides registered for ULD use is limited.

The disadvantages of ULD in comparison to conventional space sprays are poor residual life, chemical slick if oversprayed, poor results in ventilated areas, the necessity of wearing protective equipment, a certain degree of fire and explosion hazard compared to conventional space sprays and the necessity of applying at a time when the area is unoccupied. If a gasoline-powered spray unit is used, the additional disadvantages of carbon monoxide and noise may be a factor. Because droplet size is critical, maintain the equipment and operate at specific pressures and flow rates.

The advantages of ULD include shorter treatment time and lower fire and explosion hazard than with foggers. Other more debatable advantages include deeper penetration, more thorough flushing action and more effective use of the insecticide. Information provided by the manufacturer for care and maintenance of equipment should be consulted. The following general considerations and safety recommendations for using fine droplet-dispensing machines may also be useful.

- Maintain the equipment well. The engine should run evenly at the proper speed, and keep it well tuned. The flow rate or pressure must be correct.
- Allow use only by an experienced operator trained in safe and effective use.
- Keep insecticides and solvents at room temperature. Low temperatures increase viscosity and cause larger droplets to form resulting in poorer control and a tendency to create oil slicks on horizontal, hard-finished surfaces.
- Keep temperatures of the area to be treated above 50ºF.
- Direct the insecticide into harborage areas for maximum penetration and greatest contact (impingement) with the pests.
- Reduce airflow and air currents in treatments area by closing doors and windows to allow droplets to stay in suspension longer.
- Shut off the ventilating system.
- Turn off smoke alarms.
- Do not use more than one gallon of oil solution to 50,000 cubic feet of space. If using gasoline engines: Start engines and generators outside if possible. Keep engine mufflers, exhaust pipes and the hot tip of the generator away from combustible materials and items that might be damaged.
- If using oil-based materials: Extinguish all flames and pilot lights. Use only those diluents approved by the machine manufacturer. Notify local fire authorities. Have a fire extinguisher handy.
- Use only materials and formulations registered for use in your application equipment.
- Keep the treated area closed and secured for as long as specified on the label. After the treatment and exposure period has been completed:
  - ✓ Open doors and windows.
  - ✓ Remove any seals.
  - ✓ Ventilate thoroughly (30 minutes or longer) as specified on the label.
  - ✓ Inspect and clean up.
  - ✓ Remove warning signs.
  - ✓ Turn on utilities that were shut off, making sure that all pilots are relit.
- Use after residual treatment if for crawling insects.

- Follow label instructions.
- Follow safety precautions:
  - ✓ Remove occupants, pets and birds.
  - ✓ Cover or remove plants and aquariums.
  - ✓ Remove food or place it in tight containers.
  - ✓ Cover food preparation surfaces or clean after treatment.
  - ✓ Wear an approved respirator and goggles.
  - ✓ Applicators should work in pairs and in sight of one another in large buildings if the machine is operated indoors.
  - ✓ Post warning signs at all entrances.

Fine droplet-dispensing equipment requires continuous maintenance, because the equipment is costly and because it will not dispense correct particle sizes and dosages unless properly maintained.

Keep instructional materials, diagrams and other information supplied by the manufacturer readily available. Consult this literature for instructions when you disassemble equipment during maintenance or repair.

All moving parts of fine droplet-dispensing equipment should be routinely inspected, cleaned and lubricated if necessary. Give particular attention to those parts that regulate calibration or droplet sizes to insure they are in good working order.

Foggers and heat generators require special attention. The high degree of heat in these machines causes a carbon formation from the insecticide formulation that must be removed regularly to prevent interference with the normal flow of insecticide through the machine. Remove carbon immediately after each use before it hardens or builds up into a thick layer. Heated carbon particles could dislodge and start a fire. It is especially important not to damage any portion of the heat chambers or any small orifices that may be present.

Respiratory Protection

Most applicators do not feel that inhalation of pesticides is a serious hazard, but it is next in importance to skin contact as a cause of pesticide accidents. Because the lungs have such a large (about 40 times larger than the skin) and highly absorptive surface area, even small amounts of pesticide are hazardous because they are almost completely absorbed. The respiratory system does have defenses, but they are not 100 percent effective against toxic gases, vapors or particulates. Toxic vapors, poisonous gases, dusts and mists that are extremely small in particle size (10 microns or smaller) are a particular hazard as they are easily inhaled. Application of insecticide sprays, dusts, mists or fogs in attics, crawl spaces, warehouses or other similar enclosed situations can expose the lungs to small particle sizes and vapors and, thus, require the use of some form of respiratory protection. Respirators should be worn as indicated on the pesticide label and whenever the application situation calls for it.

Respiratory protective devices are of two basic types: (1) air-purifying or (2) air-supplying. The pest control operator most commonly uses air-purifying respirators when protective devices are needed. However, some individuals have difficulty breathing with air-purifying respirators. These individuals should use a respirator which supplies air from its own supply or from outside.

Air-Purifying Respirators

Basically respiratory hazards can be broken down into two classes: particulates (dusts and droplets) and vapors/gases. Particulates are filtered by mechanical means while vapors and gases are removed by sorbents that react chemically with them. Respirators using a combination of mechanical and chemical sorbent will effectively remove both hazards. These respirators are limited in their capacity to purify air by the size of the cartridge or canister to remove the toxic substance.

Particulates can occur as dusts, fumes or mists. The particle size can range from macroscopic (visible to the naked eye) to microscopic (invisible to the naked eye), and their toxic effects can be severe or harmless. Mechanical filters are classified according to the protection they provide. Most particulate filters are approved only for dusts and/or mists. The filters have an efficiency of 80 to 90 percent for 0.6-millimeter (mm) particles. Respirators approved for fumes are more efficient, removing 90 to 99 percent of 0.6 mm particles. Mechanical filters load up with particulates as they are used. As they do, they become more efficient, but also become more difficult to breathe through. When a mechanical filter becomes difficult to breath through, it should be replaced. Respirators with mechanical filters are commonly referred to as **mechanical filter respirators or dust respirators**. These respirators may be desirable even though not required by the label if work is being done with mist and dust applications in attics, crawl spaces or other similar areas.

Sorbents are manufactured to remove a specific chemical or group of chemicals. In contrast, particulate-removing filters remove particulates regardless of their composition. Sorbents are available to remove specific organic vapors, acid gases and ammonia, among others. These sorbents are used in chemical cartridge respirators. These respirators, in addition to being equipped with filters to remove particulate matter, also have one or two chemical cartridges that remove toxic gasses and vapors by absorption. Each sorbent used in the cartridge has a maximum concentration use limit for that specific contaminant. Once the sorbent has been filled up with the contaminant, it will break through – that is, it will allow the full ambient concentration of the contaminant to enter the facepiece. This is in contrast to the particulate-removing filters that become more efficient as they fill up but harder to breathe through. The sorbent volume in the cartridges for these respirators is small and its lifetime is generally short. Chemical cartridge respirators are used for low concentrations and short exposure periods. Some pesticide labels may specify on the label the need to wear a respirator of this type. **Cartridge respirators are not suitable for use with fumigants.** The cartridges are too small and they tend to leak around the face piece.

Gas mask or canister respirators are equipped with canisters containing the sorbent for removal of the toxic gasses and a filter. Besides protecting the face from absorption, they contain more sorbent than cartridge respirators so they may be used for higher concentrations of toxicant and/or longer periods of exposure. These respirators are suitable for use with fumigants. The canister or, more specifically, the sorbent in the canister must be specific for the type of fumigant being used. The canisters are color coded for the various fumigants.

Cartridges and canisters have an expiration date. They can be used up to that date as long as they were not opened previously. Once opened, they begin to absorb humidity and air contaminants whether or not they are in use, and their efficiency and service life decrease.

Approval of Air-Purifying Respirators for Pesticides

All respirators intended for use with pesticides must be approved jointly by the Mine Safety and Health Administration (MSHA) and the National Institute for Occupational Safety and Health (NIOSH). The Mining Enforcement and Safety Administration (MESA) preceded MSHA, so approved respirators available today will have approval numbers issued by MESA or MSHA. The approval numbers beginning with the letters TC are assigned to all respirators approved by the agency. This number must be on the box containing the facepiece. Cartridges and filters approved for pesticides are necessary and must have the TC number affixed to them, also.

Air-Supplying Respirators

These respirators supply fresh, clean air from an outside source or cylinder rather than purifying air at the location of use and may be useful for pest control operators who have difficulty breathing with air-purifying respirators. This type of respirator is more frequently used with fumigants. There are two basic types. There are the airline masks, which supply air from the outdoors through a hose, using a pump to pump the air through the hose to the mask. The other type is the self-contained breathing apparatus. A full mask is attached to an air tank or to an oxygen-generating canister.

Fitting Your Respiratory Protection Equipment

The most important factor in respirator safety is that the unit fits correctly on the wearer's face. If a respirator does not fit properly, then toxins are entering the lungs. A respirator should have a good, even seal and inhalation and exhalation valves that are functioning correctly (see next section on care and use for problem solving).

There are two types of fit tests: qualitative and quantitative. A qualitative fit test requires a personal response from the individual being tested. A test agent, such as isoamyl acetate (banana oil), saccharin aerosol or an irritant smoke is used. Proper fit is evident when the wearer cannot smell the test agent. This test should take place during the training program and not at the work location.

A qualitative test is easy to perform, requires little equipment, can be administered by an inexperienced person and is relatively low in cost. However, the test requires some subjective response from the wearer. In addition, employers must maintain their own documentation on each employee's test results because no other record of the test, such as a strip chart, is available.

The second type of fit test, the quantitative, uses a test aerosol and an analytical instrument to measure the amount of aerosol that seeps into the mask. The facemask's respirator is fitted with a probe that allows a small air sample to be continually taken from the interior of the mask. The air sample is then fed to an instrument that detects the amount of test aerosol present. Particulate aerosol, which is found in the facemask, is called leakage or penetration. Any leakage is indicated on a strip chart.

A quantitative test is more precise than a qualitative test and provides documentation of a good respirator fit; however, this test can be expensive and uneconomical. The test also requires an experienced operator and about 15 minutes.

There are also two tests that should be performed daily to check for a proper respirator fit. These are tests of negative pressure and positive pressure. These should be performed several times daily after finding a properly fitting respirator by the quantitative or qualitative methods. According to Occupational Safety and Health Administration (OSHA) regulations, the respirator should be worn for 10 minutes prior to performing any fit test.

The negative pressure fit check requires the wearer to inhale and hold his breath for 10 seconds, while the palms of the hands are placed over the inhalation valve openings. If there are no leaks, the facemask should collapse. If there is a leak, the mask's position can be shifted and the headband straps readjusted. If no air is leaking and the mask still does not collapse, the exhalation valve should be inspected.

The positive pressure fit check requires the wearer to place the palm of the hand against the opening of the exhalation valve. When gently exhaling, the mask should bulge slightly indicating no leaks. If there are noticeable leaks, and the mask still does not bulge, then the inhalation valves should be inspected for distortion and the facemask readjusted.

Care and Use of Respiratory Protection Equipment Filter and Chemical Cartridge Respirators

There are only three moving parts in many respirators. These include a pair of soft rubber intake valves and a clear plastic or rubber exhaust valve.

A dust filter respirator is nothing more than a mechanical filter. As air enters the unit laden with dust, the dust is deposited on the outer surface of the filter. The clean air passes through the filter and into your lungs.

Chemical cartridge respirators contain one or two cartridges with a filter on the outside to remove dust and droplets. The cartridge contains an absorbent to remove low concentrations of toxicants in the air. Cartridges should be used that are designed for the chemicals you are using.

The intake valve is hinged on one side. It swings in as you inhale and flaps shut upon exhalation.

When you inhale, you create a partial vacuum inside your respirator. This pulls air through your filter. It also pulls the exhaust valve closed, preventing dirty air from entering there.

This exhaust valve(s) is mounted over an opening(s) in the lower respirator body. As you exhale, a pressure is created inside your respirator. This pushes the intake valve(s) shut and forces the exhaust valve(s) open, letting the air escape.

Several conditions can create problems in using your respirator. If material builds up on the filter surface, the plugging will create a resistance as you try to breathe in. To correct this problem, take a new filter from the supply package. Fold the filter carefully over the filter fork, and insert the fork into the filter holder. Be sure that the edges of the filter are not creased. The filter is held in place with a spring retaining clip.

The second problem is caused by a missing intake valve. This will cause you to breathe in and out through the filter, and the exhaled moisture will cause the filter to plug quickly. Spare valves are available from the respirator manufacturer. Clip a new valve onto the raised retaining posts to solve this problem. This area of your respirator is usually wet from exhaled moisture and sweat. Dust will collect here and block a valve open, especially during below freezing weather. An exhaust valve could also be blocked open by having an edge tucked into the valve opening. Correct this problem by lifting the valve out of the opening.

Occasionally, a valve will become stiff and allow dust to enter your mask. Obtain a spare exhaust valve. It is installed by pushing out on a spring-loaded pin that raises the valve retaining post. The rubber valve is then stretched over the post. Inspect this part of your respirator carefully, several times each day.

The facepiece cushion, made of soft, spongy rubber, is stretched over the respirator body. You can bend the body to adjust the fit for a good seal against your face. Should you be unable to get a good, comfortable fit with the one type of respirator, then other types of respirators are available. Most have soft rubber bodies that tend to mold easily against your face. Beards and long sideburns can interfere with getting a tight facial seal.

In order for all these parts to function properly, it is necessary for you to regularly wash them in plain, warm water. Do not be afraid to take your respirator apart for cleaning, and be sure to remove any dust build-up you find around the exhaust valves. After each use, taking five minutes for this washing will assure you that your respirator will do its job. When you have finished washing your respirator, it belongs in your locker, if you have one, or it should be stored in its own box near your working area. Respirators must not be left hanging on a hook somewhere to be contaminated. All respirators used with pesticides must be approved jointly by MSHA and NIOSH. Make sure that your respirator has been approved by these government agencies.

All respirators have limitations. They do not supply oxygen. All they do is filter particles or vapors out of the available air.

Leave the area at once if you get dizzy, become ill, or smell any contaminant. Follow this rule anytime you wear respirator protection.

Selected References and Study Material

Code of Federal Register 40 Parts 150 to 189.

List of Proprietary Substances and Nonfood Compounds: Authorized for use under USDA Inspection and Grading Programs. USDA-FSIS, Miscellaneous Publication Number 1419.

Insect and Mite Pests in Food: An Illustrated Key. Volumes 1 and 2. Agricultural Handbook No. 655.
Superintendent of Documents
U.S. Government Printing Office
1100 Commerce Street, Rm. 1 C46 Dallas, TX 75242

PCT DATA TRIO
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4012 Bridge Avenue
Cleveland, OH 42113
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216-961-0364 FAX

American Institute of Baking
1213 Bakers Way
Manhattan, KS 66502
913-537-4750

National Pest Control Association
8150 Leesburg Pike Suite 1100
Vienna, VA 22180
703-790-8300

Arkansas State Plant Board
1 Natural Resource Drive
Little Rock, AR 72205
501-225-1598
Pesticide Laws and Regulations – http://www.plantboard.org/pesticides_laws.html

Oklahoma Cooperative Extension Service, 1995. Stored Product Management, Circular Number E-912.

Truman's Scientific Guide to Pest Control Operations. Bennett, G.W., J.M. Owens, and R.M. Corrigan. 1997. Advanstar Communications, Inc. Cleveland, OH.

Handbook of Pest Control. Arnold Mallis. Insects Limited, Inc. Indianapolis, IN.

Pest Control Magazine
Advanstar Communications, Inc.
P.O. Box 6215
Duluth, MN 55806-9833

Glossary

Absorption: The process by which a chemical is taken into plants, animals or minerals. Compare with adsorption.

Adherence: Sticking to a surface.

Adsorption: The process by which chemicals are held on the surface of a mineral or soil particle. Compare with absorption.

Adulterated: Any pesticide whose strength or purity falls below the quality stated on its label. Also, a food, feed or product that contains illegal pesticide residues.

Aerosol: An extremely fine mist or fog consisting of solid or liquid particles suspended in air. Also, certain formulations used to produce a fine mist or smoke.

Aggregation Pheromone: Chemical substances released to attract members of the same species. The most commonly used is the confused flour beetle pheromone.

Agitation: The process of stirring or mixing in a sprayer.

Anaerobic: Living in the absence of air. The opposite of aerobic.

Animal Sign: The evidences of an animal's presence in an area.

Aqueous: A term used to indicate the presence of water in a solution.

Bait Shyness: The tendency for rodents, birds or other pests to avoid a poisoned bait.

Broadcast: Uniform application to an entire, specific area.

Carcinogenic: Can cause cancer.

Concentration: The amount of active ingredient in a given volume or weight of formulation.

Contaminate: To make impure or to pollute.

Complete Metamorphosis: Development where there are four life stages (egg, larva, pupa and adult). The immatures and adults, besides having different appearances, have different habitats and food preferences.

Corrosion: The process of wearing away by chemical means.

Crack and Crevice: Application in structures to cracks and crevices where pests may live.

Degradation: The process by which a chemical is reduced to a less complex form.

Dermal: Of the skin; through or by the skin.

Dermal Toxicity: Ability of a chemical to cause injury when absorbed through the skin.

Diluent: Any liquid or solid material used to dilute or carry an active ingredient.

Dilute: To make thinner by adding water, another liquid or a solid.

Directed: Aiming the pesticide at a portion of a plant, animal or structure.

Dose, Dosage: Quantity of a pesticide applied.

Emulsifier: A chemical that aids in suspending one liquid in another.

Emulsion: A mixture in which one liquid is suspended as tiny drops in another liquid, such as oil in water.

Exuvia(e): The cast skin of an arthropod.

Excreta: Insect fecal matter (frass).

Gregarious: Living in groups.

Gradual Metamorphosis: development in which there are three life stages (egg, nymph and adult) and the nymphs resemble the adults, live in the same environment and have similar food .preferences.

Harborage: living areas for pests.

Hard (water): Water containing soluble salts of calcium and magnesium and sometimes iron.

Hydrogen-Ion Concentration: A measure of acidity or alkalinity, expressed in terms of the pH of the solution. For example, a pH of 7 is neutral, from 1 to 7 is acid and from 7 to 14 is alkaline.

Immune: Not susceptible to a disease or poison.

Impermeable: Cannot be penetrated. Semi-permeable means that some substances can pass through and others cannot.

Kairomone: chemicals involved in interspecific communication that is adaptively favorable for the receiving organism and not the emitting organism.

LC_{50}: The concentration of an active ingredient in air, which is expected to cause death in 50 percent of the test animals so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas or vapor. It is generally expressed as micro-grams per liter as a dust or mist but, in the case of gas or vapor, as parts per million (ppm).

LD_{50}: The dose of an active ingredient taken by mouth or absorbed by the skin, which is expected to cause death in 50 percent of the test animals so treated. If a chemical has an LD_{50} of 10 milligrams per kilogram (mg/kg), it is more toxic than one having an LD_{50} of 100 mg/kg.

Life Cycle: The chain or sequence of events that occurs during the developmental lifetime of an individual organism.

Mammals: Warm-blooded animals that nourish their young with milk. Their skin is more or less covered with hair.

Metamorphosis: Changes that occur during growth or development to the adult stage.

Miscible Liquids: Two or more liquids that can be mixed and will remain mixed under normal conditions.

Mutagenic: Can produce genetic change.

Nocturnal: Performs most activity at night.

Nymph: The immature stage in insects with gradual metamorphosis.

Oral: Of the mouth; through or by the mouth.

Oral Toxicity: Ability of a pesticide to cause injury when taken by mouth.

Organic Compounds: Chemicals that contain carbon.

Organophosphate: A synthetic organic pesticide containing carbon, hydrogen and phosphorus; parathion and malathion are two examples.

Pollutant: An agent or chemical that makes something impure or dirty.

PPB: Parts per billion. A way to express the concentration of chemicals in foods, plants and animals. One part per billion equals 1 pound in 500,000 tons.

PPM: Parts per million. A way to express the concentration of chemicals in foods, plants and animals. One part per million equals 1 pound in 500 tons.

Predator: Any animal that destroys or eats other animals.

Propellant: Liquid in self-pressurized pesticide products that forces the active ingredient from the container.

Sex Pheromone: Chemical substances used to facilitate mate location and mating. Most commonly used is the Indianmeal moth pheromone.

Soil Application: Application to the soil rather than to vegetation.

Soil Sterilant: A chemical that prevents the growth of all plants and animals in the soil. Soil sterilization may be temporary or permanent, depending on the chemical.

Soluble: Will dissolve in a liquid.

Solution: Mixture of one or more substances in another in which all ingredients are completely dissolved.

Solvent: A liquid that will dissolve a substance to form a solution.

Spreader: A chemical that increases the area that a given volume of liquid will cover on a solid or on another liquid.

Spot Treatment: Application to a small area.

Sticker: A material added to a pesticide to increase its adherence.

Surfactant: A chemical that increases the emulsifying, dispersing, spreading and wetting properties of a pesticide product.

Suspension: Finely divided solid particles mixed in a liquid.

Synergism: The joint action of two or more pesticides that is greater than the sum of their activity when used alone.

Target Pest: The pest at which a particular pesticide or other control method is directed.

Tolerance: (1) The ability of a living thing to withstand adverse conditions, such as pest attacks, weather extremes or pesticides. (2) The amount of pesticide that may safely remain in or on raw farm products at time of sale.

Toxicant: A poisonous chemical.

Trade Name: Same as brand name.

Vapor Pressure: The property that causes a chemical to evaporate. The lower the vapor pressure, the more easily it will evaporate.

Vector: A carrier, such as an insect, that transmits a pathogen.

Viscosity: A property of liquids that determines whether they flow readily. Viscosity usually increases when temperature decreases.

Volatile: Evaporates at ordinary temperatures when exposed to air.

Wetting Agent: A chemical that causes a liquid to contact surfaces more thoroughly.

Printed by University of Arkansas Cooperative Extension Service Printing Services.

AG1157-5-19RV