United States Department of Agriculture

Marketing and Regulatory Programs

Animal and Plant Health Inspection Service

Cooperating State Departments of Agriculture

New Pest Response Guidelines

Khapra Beetle

New Pest Response Guidelines
Khapra Beetle

7/23/09

New Pest Response Guidelines: Khapra Beetle was prepared by Jeffrey N. L. Stibick, USDA–APHIS–PPQ–Emergency and Domestic Programs, 4700 River Road, Unit 134, Riverdale, Maryland and edited by Patricia S. Michalak, USDA–APHIS–PPQ–Manuals Unit, Frederick, Maryland.

Cite this report as follows: Stibick, J. 2007. *New Pest Response Guidelines: Khapra Beetle.* USDA–APHIS–PPQ–Emergency and Domestic Programs, Riverdale, Maryland. [http://www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml]

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October 24, 2007

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Cover

Wheat Products—Keith Weller, USDA–Agricultural Research Service [http://www.ars.usda.gov/is/graphics/photos/]

Khapra Beetle on Wheat—Al Barak, USDA–APHIS–PPQ–CPHST

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1

Khapra Beetle

Chapter 1

Introduction

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Introduction

Use *New Pest Response Guidelines: Khapra Beetle* as a guide when designing a program to detect, monitor, control, contain, or eradicate an infestation of this pest. If khapra beetle is detected in the United States, PPQ personnel will produce a site-specific action plan based on the *Guidelines*. State agriculture department personnel and others concerned with developing local survey or control programs will find the *Guidelines* useful in developing an action plan for the khapra beetle.

United States Department of Agriculture (USDA)–Animal and Plant Health Inspection Service (APHIS)–Plant Protection and Quarantine (PPQ) developed this guide through discussion, consultation, or agreement with staff at USDA–Agricultural Research Service (ARS), universities, industries, and State departments of agriculture.

The *Guidelines* will be updated as new information becomes available. Specific emergency programs should be based on information available at the time of the incident.

Pest Status

The khapra beetle is one of the world's most destructive pests of grain products and seeds. Populations of this pest can build rapidly in a short time under hot, dry conditions. Grain damage, depending on existing conditions, often reaches 30%; up to 70% damage has been reported. Khapra beetle has earned a reputation as a dirty feeder, since it damages more kernels that it consumes. Feeding and contamination by khapra beetles results in the following changes to grain: weight loss, reduction in grade, and quality damage of processed products (USDA–APHIS–PPQ, 1983).

Khapra beetle earned the attention of USDA early in the 20th century. In 1953, an extensive infestation was found in California, which may have been present since 1946. Subsequent detection and delimiting surveys revealed its presence in Arizona, California, New Mexico, and Texas, as well as in Mexico in the states of Baja California, Chihuahua, Jalisco and Sonora (USDA–ARS, 1959). The infestation was finally eradicated in 1966 (USDA–APHIS–PPQ, 1983).

Other infestations were discovered in isolated areas of California, Maryland, Michigan, New Jersey, New York, Pennsylvania, and Texas in 1980. These were eradicated by 1983 (USDA–APHIS–PPQ, 1983). PPQ developed an action plan during this time to aid in program efforts (USDA–APHIS–PPQ, 1982). An infestation was also discovered in Owings Mills, Maryland, in 1997, but it was a localized infestation that was quickly eradicated.

Pasek (1998) rated the pest risk potential of khapra beetle as high. For pests with this rating, specific phytosanitary measures are strongly recommended. Port-of-entry inspection is not considered sufficient to provide phytosanitary security. Detailed examination and choice of appropriate sanitary and phytosanitary measures to mitigate pest risk should be undertaken as part of the pest risk management phase.

Disclaimers and Document Comprehension

This document is not intended to be complete and exhaustive. It provides a foundation, based upon the literature available, to assist further work. Some key articles were not available at the time of writing, and not all specialists and members of the research community were consulted for their advice. Search recent literature and Web sites frequently, since material is updated periodically.

Commercial Suppliers

References to commercial suppliers or products should not be construed as an endorsement of the company or product by USDA.

Contacts

When an emergency program for the pest has been implemented, its success depends on the cooperation, assistance, and understanding of other involved groups. The appropriate liaison and information officers should distribute news of program progress and developments to interest groups, including:

- Other Federal, State, county, and municipal agricultural officials
- Grower groups (such as specific commodity or industry groups)
- Commercial interests
- Academic entities with agricultural interests
- Land-grant universities with Cooperative Extension Services
- State and local law enforcement officials
- Public health agencies
- National, State and local news media
- The public

Initiating an Emergency Pest Response Program

An emergency pest response program or incident response consists of detection and delimitation, and may be followed by programs in regulation, containment, eradication and/or control.

If a newly detected exotic or imminent pest threat lacks a current *New Pest Response Guidelines* for reference, the New Pest Advisory Group (NPAG) evaluates the pest. After assessing the risk to U.S. plant health and consulting with experts and regulatory personnel, NPAG makes a recommendation to PPQ management for a course of action.

Follow this sequence in any order when initiating an emergency pest response program:

1. A new or reintroduced pest is discovered and reported.
2. The pest is examined and pre-identified by regional or area identifier (**See Identification on page 4-1**).
3. Pest identity is confirmed by national taxonomic authority recognized by the USDA–APHIS–PPQ National Identification system.
4. Existing *Guidelines* are consulted or new NPAG is assembled to evaluate the pest.
5. Depending on the urgency, official notifications are made to the National Plant Board, cooperators, and trading partners.

6. A delimiting survey is conducted at site of detection (**See Survey Procedures on page 3-1**).
7. An Incident Assessment Team may be sent to evaluate the site.
8. A recommendation is made, based on the assessment of surveys, other data, and recommendation of the Incident Assessment Team and/or an NPAG, as follows (**See Regulatory Procedures on page 5-1** and **Control on page 6-1**):
   - ❖ Take no action.
   - ❖ Regulate the pest.
   - ❖ Contain the pest.
   - ❖ Suppress the pest.
   - ❖ Eradicate the pest.
9. State Departments of Agriculture are consulted.
10. If appropriate, a control strategy is selected (**See Control on page 6-1**).
11. A PPQ Deputy Administrator authorizes a response.
12. A command post is selected and the Incident Command System is implemented.
13. State Departments of Agriculture cooperate with parallel actions using a unified command.
14. Traceback/trace forward investigations are conducted (**See Survey Procedures on page 3-1**).
15. Field identification procedures are standardized.
16. Data reporting is standardized.
17. Regulatory actions are taken (**See Regulatory Procedures on page 5-1**).
18. Environmental assessments are completed as necessary (**See Environmental Regulation on page 7-1**).
19. Treatment is applied for required pest generational time.
20. Environmental monitoring is conducted, if appropriate.
21. Pest monitoring surveys are conducted to evaluate program success.
22. Programs are designed for eradication, containment, or long-term use.

Program Safety

Safety of the public and program personnel has priority in program planning and training, and throughout operations. Safety officers and supervisors must enforce on-the-job safety procedures.

Support for Program Decision Making

The USDA–APHIS–PPQ–Center for Plant Health, Science and Technology (CPHST) provides technical support to emergency pest response program directors concerning risk assessments, survey methods, control strategies, regulatory treatments, and other aspects of pest response programs.

2

Khapra Beetle

Chapter 2

Pest Information

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Introduction

Use the *Pest Information* chapter to learn more about the classification, history, host range, and biology, of the khapra beetle.

Classification

Use **Table 2-1** as an aid to the classification of khapra beetle.

TABLE 2-1. Classification of Khapra Beetle

Phylum	Arthropoda
Class	Insecta
Order	Coleoptera
Family	Dermestidae
Species	*Trogoderma granarium*
Common name	khapra beetle
Easily confused with the following beetles	Other *Trogoderma* and dermestids

History and Distribution

Khapra beetle is apparently native to India (Rahman *et al.*, 1945). Hinton (1945) reported that it was distributed in India, Ceylon, Malaya, Europe, (former) U.S.S.R., China, Japan, Korea, Philippines, Australia, and

Madagascar, and had become established in most of those countries. It was discovered in stored guinea corn in Nigeria in 1948, and may have been present in stored groundnuts as early as 1944 (Howe, 1952; Pasek, 1998).

In North America, khapra beetle was found in Mexico but failed to become established. In the United States, khapra beetle has been detected in Arizona, California, New Mexico, and Texas; it was eradicated from those sites. The beetle was detected at a Connecticut residence in 2006; control activities were conducted, and monitoring was scheduled for 2007 (EPPO, 2006).

Quarantine Regulations

Current quarantine regulations for the United States recognize 25 countries as harboring endemic populations of khapra beetle: Afghanistan, Algeria, Bangladesh, Burkina Faso, Cyprus, Egypt, India, Iran, Iraq, Israel, Libya, Mali, Mauritania, Morocco, Myanmar, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, and Turkey (USDA–APHIS–PPQ 2003).

World Distribution and Status

EPPO (2006) provided the following update on the distribution and status of khapra beetle:

Established In—Algeria, Austria, Cyprus, Egypt, Israel, Lebanon, Libya, Morocco, Spain, Switzerland, Syria, Tunisia, Turkey (southeastern), United Kingdom (protected environments only).

Found But Not Established In—Belgium, Denmark, Germany (protected environments only), Ireland, Luxembourg, Netherlands, Russia.

Intercepted Only In—Hungary, Italy.

Ecological Range

Khapra beetle is **unlikely** to become established in most climates in the United States. However, it is able to survive almost anywhere in storage facilities that are protected from cold environments.

Favorable Climates in the United States

The following States have the greatest potential for establishment of khapra beetle due to their warm climates (**Figure 2-1 on page 2-3**):

- Arizona
- California
- Kansas
- New Mexico
- Oklahoma
- Texas

According to some reports (Howe & Lindgren, 1957; Pasek, 2004), the following States are at less risk for establishment of khapra beetle:

- Utah
- Nevada

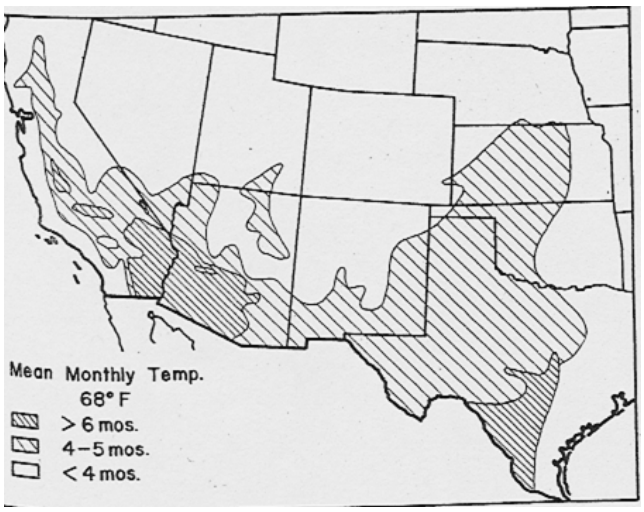

FIGURE 2-1 United States Climates Favorable for Development of Khapra Beetle

In Storage

Khapra beetle is able to survive almost anywhere in storage facilities that are protected from cold environments. Storage facilities can be artificially heated, or become much warmer when insect activity causes the temperature to rise (Howe and Lindgren, 1957).

Hosts

Khapra beetle prefers grain and cereal products, particularly wheat, barley, oats, rye, maize, rice, flour, malt, and noodles. Given a choice of rye, wheat, and oats, khapra beetle prefers wheat. This pest will feed on almost any dried plant or animal matter, including dog food, dried orange pulp, bread, and dried coconuts (Hinton, 1945; Szito, 2005).

Khapra beetle can feed on products with as little as 2% moisture content, and can develop on animal matter such as dead mice, dried blood, and dried insects (Pasek, 1998).

Grocery commodities that can serve as hosts include bread, dried coconuts, cornmeal, crackers, white and whole wheat flour, hominy grits, baby cereals, pearl barley, and wheat germ (Szito, 2005).

Damage

Infestation affects grain quality as well as quantity. Infestation of commodities with khapra beetle can lead to the following consequences:

- Economic loss of valuable grain or other domestic or export products
- Lowered quality of products due to contamination
- Costs associated with prevention and treatment
- Consumer health risks when exposed to products contaminated with insect parts

In India, khapra beetle infests about 5% of stored grains, but can affect an entire bin or lot under heavy infestation (Pasek, 1998).

Economic

In the United States, infestation can result in the loss of export markets. If khapra beetle became established in the United States, other countries would likely place restrictions on imports of U.S. grain, cereal products, or seed. For example, exports of coarse grains to countries outside the current restricted area averaged $5.8 billion per year in the period 1993–1997 (Mason, 2002).

Grain Quality

Khapra beetle is a dirty feeder because it damages more grain kernels than it consumes. The larvae contaminate grain with body parts and setae.

Severe infestations can make grain unpalatable or unmarketable (**Figure 2-2**). Heavy infestations of larvae can reduce the host to frass (USDA, 1982). Feeding activity reduces plant material to crude fat, sugar, starch, protein, and nitrogen. Feeding also results in an increase in moisture, crude fiber, and total protein content (Mason, 2002).

FIGURE 2-2 Adults, Larvae and Cast Skins of Khapra Beetle in Grain [Image courtesy of R. Hodges, Natural Resources Institute, UK]

Prevention and Treatment

The cost of prevention and treatment associated with khapra beetle can be great.

Health Risks

Like many beetles in this family, the body of the immature stage has barbed hairs that can contaminate grain (**Figure 4-6 on page 4-7**). Exposure to grain contaminated with hairs can lead to dermal and gastric health hazards. The hairs can cause skin irritation in people handling heavily infested grain (Mason, 2002; Barak, 1995). If swallowed, consumers can experience ulcerative colitis. This is particularly distressing for young children, who develop vomiting and diarrhea, and refuse food (Bennett, 2003; Anon., 2001).

Biology

The optimum conditions for development of khapra beetle do not correspond well with its geographical distribution, which indicates a preference for hot, dry areas. Where conditions are more humid, khapra beetle may not be able to compete with other beetle species which typically have a higher reproductive potential and shorter life cycle.

Larvae

Khapra beetle larvae are characterized by two genetic types: larvae that are able to undergo a facultative diapause, and those that are unable to do so. The types are indistinguishable from each other and can only be separated by adverse conditions (CABI, 2005).

Capable of Diapause

In the absence of food, diapausing larvae are stimulated to diapause by adverse conditions, such as extremes of temperature, humidity and crowding. Without food, diapausing larvae may survive about nine months. With food, they may live for six years. In this state of very low metabolic activity, they are extremely resistant to the effect of contact insecticides or fumigants and complete disinfestation may thus be difficult.

Diapausing larvae will pupate in response to a considerable temperature shock—such as a much lower temperature for at least one month, followed by a return to a warm temperature. Larvae respond similarly to the introduction of fresh food.

Diapause seems to assist the larvae in surviving adverse conditions. It may also promote dispersal, as diapausing larvae are frequently found on movable objects or transport equipment such as sacks and trucks (CABI, 2005).

Incapable of Diapause

When almost mature, the nondiapausing type of khapra beetle larvae leave their food and seek out a refuge such as a crevice in a store (Burges, 1963). Their respiration rate drops to an extremely low level. Large numbers of larvae in this condition may be found together and, although they are inactive, will seek a new refuge if disturbed. The larvae molt periodically with hardly any increase in the rate of respiration. The larvae also feed occasionally; their respiration returns to normal during this time (CABI, 2005).

Adult

Adult females die soon after oviposition is complete. The adult males live 1–4 days longer (Howe, 1952). Adults are usually short-lived, but have been known to survive several months or years at temperatures below 16ºC (USDA, 1982). Under optimal conditions, khapra beetle can sustain a population increase of 12.5 times per month. For that reason, populations can build up rapidly in a short time under hot, dry conditions. They can survive in colder climates in heated situations such as warehouses, food plants, and grain storage. Khapra beetle is primarily active at dusk (Howe, 1952).

Adults possess wings, but are not known to fly (Howe, 1952). The pest is spread mostly by man in commerce and trade, and in personal luggage. However, adults and larvae can be spread for short distances by actively crawling larvae, birds, other insects, and especially by wind (Lindgren *et al.*, 1955 *in* Howe, 1952). Their natural habitat seems to be in areas with large pecan, walnut, acorn and other nut trees (Anon., 2005).

Reproduction

Completion of the life cycle usually lasts 4–6 weeks, but can last up to three years depending on temperature, available food supply, and potential for diapause. There are usually 4–5 generations per year, but there can be as many as 12 under optimum conditions.

Virgin females secrete a pheromone that attracts virgin males and, to a lesser extent, mated males and other females. Reproduction sites may be established in this way. Female khapra beetles need only to mate once.

Oviposition

After copulation, oviposition commences immediately at 40ºC and lasts 3–4 days. At 25ºC, there is a preoviposition period of 2–3 days and oviposition may extend over 12 days. The abdomen of the female is distended by its eggs and several segments may extend beyond the elytra; the abdomen returns to normal as oviposition takes place. Temperatures between 25–40ºC seem to have little or no effect on the average number of eggs laid, which is approximately 35 per female (Howe, 1952; CABI, 2004).

Each female usually deposits about 50 eggs in its lifetime. At temperatures above 32ºC this number may go up to 100 eggs per female. Eggs are deposited loosely and usually singly in host material and also in grooves or cracks formed by the removal of the fried shoots at the ends of the grain. Hatching usually takes place in 1–2 weeks (Hadaway, 1956).

Larval Development

Larval development does not occur at temperatures below 21ºC, but can proceed at very low humidity such as 25ºC and 2% RH. Development is most rapid in hot, humid environments, taking about 18 days at 35ºC and 73% RH. Under these conditions, the average number of larval molts is four for males and five for females, although this is highly variable (CABI, 2004).

Pupation

The larvae leave diapause and pupate if subjected to a considerable temperature shock (i.e., a much lower temperature for at least one month, followed by a return to warm conditions). A similar but less effective stimulus is the introduction of fresh food.

The pupa usually remains inside the skin of the final-instar larva. Pupal development is unaffected by humidity and varies in length from five days at 25ºC to three days at 40ºC. On adult emergence, the pupal skin is pushed to the posterior end of the larval skin; the adult remains within the larval skin for a day or more (CABI, 2004).

Adult Emergence

When the adults have fully emerged, copulation can take place immediately (CABI, 2004). Sexual maturity is usually reached 2 days after emergence (USDA, 1982).

Development

Temperature is one of the most important factors influencing the development of all insect life stages and this is true for khapra beetle as well. However, because khapra beetle is a pest in controlled environments, its development will not restrict program actions nor influence the selection and success of eradication treatments, the duration of trapping activities and regulatory functions. It is unlikely that estimates will have to be made of its survival outside storage environments.

Degree Day Value

To predict the development of khapra beetle outside the storage environment, use site-specific temperature data in a tool known as the degree day value.

Use degree day values for the following actions:

- Predicting emergence of adults
- Determining the time to began trapping
- Monitoring cycles of generation during a season
- Monitoring the effect of eradication or suppression measures

Degree day values are based on the developmental threshold temperature of an insect and are species typical. Threshold temperatures can represent either upper or lower limitations, and may be measurements of air or soil temperature, depending on where the insect lives.

To determine degree day values for any pest, use the formulas (**Formulas**) below. Or, you can use an online interface (**NAPPFAST**) or utility (**U of CA IPM**) below.

Formulas

Developmental values for khapra beetle in the following table can be useful when predicting the development of this pest.

TABLE 2-2 Developmental Values for Khapra Beetle

Minimum temperature for development	20°C
Maximum temperature for development	40°C
Maximum preoviposition period[1]	3 days
Maximum oviposition period[1]	12 days
Maximum egg development[1]	10 days
Maximum female larval development[1]	47 days
Maximum male larval development[1]	39 days

1 At constant temperature of 25°C and relative humidity of 50%

Use **Equation 1** or **Equation 2** (below) to calculate degree day values (Hadaway, 1956):

Equation 1 Degree Days = [(Average Daily Temp.) – (Developmental Threshold)]

Equation 2 Degree Days = [(Max. Temp. + Min. Temp.)/2] – (Developmental Threshold)

NAPPFAST

In a joint venture, APHIS, North Carolina State University, and the information technology company ZedX, Inc., have developed a new internet tool known as NAPPFAST. NAPPFAST uses weather, climate and soil data to model pest development. The models supply the predictive pest mapping needs of the Cooperative Agricultural Pests (CAPS) program. In addition, the models produce potential establishment maps for exotic pests, which supports the risk assessment activities of the Pest Epidemiology Risk Assessment Laboratory (PERAL). Access the graphical user interface at the NAPPFAST Web site.

Address **http://www.nappfast.org/index.htm**

U of CA IPM

Use the Degree-day Utility (DDU) available online from University of California, Integrated Pest Management Programs, to determine degree day values for khapra beetle as well as other pests. Access the utility at the University of California Web site.

Address **http://www.ipm.ucdavis.edu/WEATHER**

3

Khapra Beetle

Chapter 3

Survey Procedures

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Introduction

Use the *Survey Procedures* chapter as a guide to conducting a pest survey for khapra beetle.

The purpose of a survey is to determine the extent and means of pest dispersal. Surveys are also used to assess the effectiveness of treatments. Use detection and delimiting surveys to detect and delimit khapra beetle. Use a monitoring survey to measure the effectiveness of applied treatments on the pest population. Use **Table 3-1** and the following sections to learn more about survey procedures.

Before initiating survey and control activities in the United States, a national authority recognized by USDA–APHIS–PPQ–National Identification Service must verify the identity of this pest. See Authorities on page 4-1 for more information.

TABLE 3-1 Survey Methods for Khapra Beetle

If:	Then use this survey method:
You are unsure that the pest is present	**Detection Survey on page 3-2.** Use visual inspection and/or traps to capture specimens. Place traps, carry out debris/product sampling and inspect plants at suspect location. Consult with **Authorities on page 4-1** to confirm your identification.
You know the pest is present and you need to define its geographic location	**Delimiting Survey on page 3-3.** Use traps and debris/product sampling at specific locations and densities to capture specimens according to the plan outlined below. Use **Traceback and Trace Forward Investigation on page 3-3** to delimit areas of infestation. Consult with **Authorities on page 4-1** to confirm your identification.
You have applied a control and need to measure its effectiveness	**Monitoring Survey on page 3-4.** Use visual inspection, debris/product sampling and/or traps to capture specimens. Place traps and inspect host plants at suspect locations. Consult with **Authorities on page 4-1** to confirm your identification.

Detection Survey

Use a detection survey to determine if khapra beetle exists in an area. Conduct a detection survey by using visual inspection and trapping of all properties capable of supporting a khapra beetle infestation. For more information on visual inspection and trapping, see Survey Tools on page 3-4.

Priorities

Some types of properties are more likely to harbor khapra beetle. Inspect properties within an area according to the following order of importance (USDA–AMS–Stored Products Insect Branch, 1959):

1. Distributors
2. Grain dealers
3. Feed lots
4. Users
5. Farm storages
6. Stands of pecan, acorn, walnut, pistachio and other nut trees

Frequency of Inspection

If resources permit, distributors and grain dealers should be inspected two times each year. All other establishments, including nut tree stands, should be inspected once each year.

Delimiting Survey

After an area, establishment, or premises has been determined to be infested with khapra beetle, use a delimiting survey to establish the extent of the infestation. Use the findings from the survey to determine the type and extent of control measures to apply (**Table 3-2**). Conduct visual inspection and trapping of all properties capable of supporting an infestation of khapra beetle. For more information on visual inspection and trapping, see **Survey Tools on page 3-4**.

If surrounding buildings pose a hazard because of the proximity or their use, inspect them in order to delimit the extent of the infestation in the area.

TABLE 3-2 Delimitation Survey for Khapra Beetle

If you find:	In an area that is:	Take this action:	And supplement with:
One or more live specimens	Apparently in the original premises or area	Initiate delimiting survey in and around premises up to ½ mile off	
	In other premises or areas	Initiate delimiting survey in the other premises or areas.	Delimiting survey along roads, highways, footpaths, or other connections between infested areas and use trace-backward

Traceback and Trace Forward Investigation

Use a traceback investigation to locate the source of an introduction after khapra beetle has been detected. Traceback investigations help to determine if an isolated detection is spurious, or if it is evidence of an established population.

If an infestation of khapra beetle is confirmed, start tracking all incoming and outgoing commodities and compose a priority list of secondary location warranting inspections. Use the survey tools in this chapter when surveying secondary locations, and for follow up surveys after the initial inspection or treatment of the original find (USDA–APHIS–PPQ, 1981).

Develop secondary inspection lists to include distribution outlets supplied from the infested property and other similar or related businesses that may be infested. Notify State cooperators of high risk khapra beetle premises in their respective States, based on the sight inspection lists that have been prepared.

Monitoring Survey

Source Information in this section was revised from the following source: USDA–APHIS–PPQ. 1981. Khapra Beetle Program Manual, *Trogoderma granarium* (Everts). Complete Revision October, 1981: 1-25.

Conduct a monitoring survey in any area where treatments were applied, and repeat at prescribed intervals. Conduct monitoring surveys as follows:

- Use **PPQ 523 Emergency Action Notification on page A-4** to notify the owner of this inspection requirement prior to conducting treatments.
- Inspection will verify the success of the treatment by not less than three inspections made of the entire property over a period of one year.
- In the northeast United States and other cool regions, inspections must extend through two summer seasons, with inspections made at times when khapra beetle activity would most likely occur.
- At least 90 days shall elapse between each official inspection, and the last inspection shall be made within 30 days of the date release will be effected.

Carry out all inspections in accordance with methods outlined in **Survey Tools on page 3-4**.

Survey Tools

Use visual inspection and trapping as tools to survey for khapra beetle.

Visual Inspection

Source Information in this section was revised from the following source, unless noted: USDA–APHIS–PPQ. 1981. Khapra Beetle Program Manual, *Trogoderma granarium* (Everts). Complete Revision October, 1981: 1-25.

Begin inspection on arrival at the premises or location. Check exit and entry areas, as well as any storage locations on the premises. Observe the movement of products, containers, or people handling such products, which could have been exposed to khapra beetle.

Be alert for cartons, sacks, debris, woodwork, cracks, loose plaster, loose paint, and other such hiding places. Rodent bait stations with grain or cereal and other such traps should be carefully inspected.

Collect milled products or debris from areas such as cracks and cervices of bins or silos or wherever grain is stored or vacuumed, such as in farm buildings, homes, stores, etc. This visual inspection is to be carried on as part of other collecting and trapping activities.

Light infestations are very difficult to find, and may require repeated inspections. Dirty grain and dockage are attractive to the khapra beetle; conversely, sanitary conditions are a deterrent (USDA–ARS, 1959).

In bulk storage where heavy infestations occur, the larvae tend to congregate in the surface grain and on or near the walls. In empty bins and warehouses, likely places to find larvae are in or on ledges, cracks in the floor or walls, old cartons, rags, sacks, newspapers, and scrap lumber, or other debris. Elevator tunnels also serve as hiding places for the larvae. In the inspection of sacked material, the ears and seams of bags are likely hiding places to examine.

Inspections should be performed at the time of year when insects are active. In areas where khapra beetle cannot survive outside warehouses, conduct surveys indoors in stored grains or other foods.

In areas where khapra beetle can survive outdoors, it will be least active in hot summer months—for example, in Arizona or southern California. Likewise, during the cold months in States to the north, inspections will not be as productive as during the months of warmer temperatures.

Limit outdoor surveys to known hosts of khapra beetle, especially the nut trees such as pecan and walnut. If an area within the regulated area has such trees, they should be regularly inspected and fallen nuts and other debris collected and examined for khapra beetle.

Records

Survey records and data recording formats should be standardized. Maintain survey records, noting the premises and areas surveyed, sites trapped, dates, locations and hosts, materials or storage situations in which the pest was found. Survey records should be entered into the National Agriculture Survey Information System (NAPIS).

Least Risk

Areas at low risk for khapra beetle infestation include well lighted areas or areas where sun can penetrate. Also at low risk are areas which are moist or where debris is covered with mold.

Greatest Risk

Areas with inadequate sanitation, low light levels, or cracks and crevices, are at the greatest risk. Mature larvae tend to crawl upward, so places located high up should be checked as well as those locations lower down (**Table 3-3**).

TABLE 3-3 Areas at Greatest Risk of Infestation by Khapra Beetle[1]

Indoors	Outdoors
◆ Walls, ledges, corners, shelves, and window sills or other places where dead insects of any kind may accumulate ◆ Cracks in floors or walls ◆ Paint scales, cartons, rags, sacks, old papers, scrap lumber, and piles of debris ◆ Elevator tunnels, pits and stairwells ◆ Sacked and packed materials [*Check seams of bags and sacks.*] ◆ Food storage, preparation, and eating areas ◆ Concrete and wood construction joints ◆ Cleaning devices, such as bag or spice cleaning machines, unused on premises and any debris removed from such devices ◆ Rat or mouse bait stations ◆ Equipment used to handle or process food	◆ Sidewalk and wall cracks ◆ Debris, garbage, or litter ◆ Frequently traveled pathways, especially if suspect goods are transported thereon ◆ Leaf litter ◆ Garages, storage sheds ◆ Movable loading platforms ◆ Stands of nearby nut trees

1 USDA–ARS (1959)

Sample Collection

Prior to inspecting, divide large structures into smaller units for survey purposes. Inspection time will vary, depending on the type, location, layout, use and management of a given facility, the inspector's skill, and other factors.

Follow these guidelines on proper inspection procedure:

Important Place all debris samples in separate bags labeled with the location and collector. Suspect skins, larvae, pupae or adult beetles should be placed in vials.

- Use a portable hand or bench type vacuum cleaner equipped with a shoulder strap and smooth-walled hose to remove suspect material from corners, cracks, and crevices.
  - At each location, warehouse, or subunit, clean the vacuum cleaner and hose, and replace the vacuum bag.
  - Place each used vacuum bag in a plastic bag.
- Use a brush to sweep out corners, cracks, under containers, etc. A sturdy probe or knife may be used to break away areas near cracks (as in concrete walls) to facilitate examination.
- Inspect every room of the premises, emphasizing those used for storage of host material, shipping and packing materials, coffee rooms and other places where food might be kept. Untidy areas or areas where refuse is kept for lengthy periods should also be carefully inspected
- Inspect the perimeter of the premises, particularly areas in or near exit points which are likely pathways for movement of suspect materials, and any outside storage or trash areas.
- Bulk grain storage areas should be thoroughly inspected. Larvae tend to congregate in the surface grain and on or near walls, especially when heavy infestations occur. Stored material, such as grains, should be sifted carefully.
- During inspection, any suspect skins, larvae, pupae or adult beetles should be placed in vials. Specimens from different portions of a building must be kept in separate vials and identified by the portion where found and whether they are dead or alive. It may be necessary to warm the specimens to determine if they are alive.

Premise Inspections

Follow these guidelines when inspecting premises:

- Inspectors will locate and survey premises for which their work unit is responsible that receive or distribute cargo potentially infested with khapra beetle.
- If practical, initial inspection and survey will be conducted of all premises. This will be done according to the inspection techniques previously described. Limitations of personnel and other resources will require prioritizing premises according to khapra beetle risk and inspecting high priority premises first.
- Premises that receive direct shipments of khapra beetle cargo are considered high risk and should be inspected at least semiannually.
- Premises that receive manufactured or processed khapra beetle cargo are considered low risk and should be inspected at least annually.
- Inspectors will notify State personnel of high risk khapra beetle premises in their respective States.
- Inspectors will be responsible for monitoring containerized khapra beetle cargo moving in and out of their respective work unit area (example: interstate trucking terminals, transfer points for vans, etc.).
- Trapping will be done according to instructions in the following section.
- Inspectors will survey premises when climatic conditions for establishment of an infestation are most ideal (for example, during summer months in northern areas).

Outdoor Inspections

Follow these guidelines when inspecting outdoors:

- Inspections of the outdoor locations listed above around premises are mandatory, following survey guidelines as given above.
- The locations of nearby stands of pecan, acorn, walnut, pistachio and other nut trees must be charted and a visual inspection made of the debris under such trees. Any fallen nuts should be collected for close examination.
- Any other nearby hosts should also be examined, especially for decaying material on them or under them.
- Do not search beyond ½-mile of any infested area or facility and then only if suspect hosts are in the area.

Trapping

Use the vertical wall-mount trap inside and outside structures, or on hosts such as nut trees, to trap crawling khapra beetle larvae. If other *Trogoderma* spp. are present, use aerial traps in addition to vertical wall-mount traps. The aerial traps will exclude khapra beetle, since it does not fly. See **Diversion of Common Warehouse Beetle** below. **See Resources on page B-1** to locate trap suppliers.

Contact Alan V. Barak with any questions concerning trapping.

Address	Alan V. Barak Otis Methods Development Center Building 1398 Otis ANGB, MA 02542 Telephone: 508/563-9303 x216 FAX: 508/564-4398 al.barak@aphis.usda.gov
Source	Information in this section was revised from the following source, unless noted: Barak, A. 2004. Khapra Beetle Trapping Instructions. USDA–APHIS–PPQ–Cooperative Agriculture Pest Survey (CAPS) Fact Sheet 34. Sponsored by Center for Environmental and Regulatory Information Systems, Purdue University. [http://ceris.purdue.edu/napis/pests/khb/topics/trap-instruct.html]

Diversion of Common Warehouse Beetle

The common warehouse beetle (*Trogoderma variable*) is a strong flyer. If it is abundant, its numbers may overwhelm the vertical wall-mount traps meant to trap khapra beetle. Use aerial sticky traps to resolve this problem by diverting the common warehouse beetle. *Trogoderma* spp. caught in aerial sticky traps cannot be khapra beetle (since it does not fly), eliminating the need for further identification.

Use a sticky aerial trap such as the Pherocon II or any diamond-, delta-, or wing-shaped trap to capture the common warehouse beetle. Fit the trap with a pheromone lure, and hang it high in the open headspace of the building. Use one aerial trap per 2,500–5,000 sq ft or one for every 5–6 khapra beetle wall traps. Dispose of traps when they are full.

To further reduce the number of common warehouse beetles captured in vertical wall-mount traps indoors, install sticky aerial traps outdoors near a premises.

Assembled Wall Mount Traps

Trécé Inc., Salinas, CA, will supply APHIS with trap kits. Khapra beetle trap kits include six vertical wall-mount traps, one Storgard II aerial sticky trap, and all septum-type lures. The traps should arrive fully assembled. **See Trap Supplies on page B-1** for more information.

Wall Mount Traps Requiring Assembly

Older vertical wall-mount traps, used prior to 2007, require assembly of the following parts:

- Corrugated paper housing

- Die-cut cardboard jacket with 1-inch tape
- Clear plastic collection tray
- Khapra beetle pheromone lure
- Wheat germ (ground, raw wheat germ is now the preferred bait material

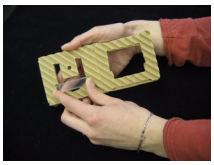
To assemble wall-mount traps, follow the instructions in **Assembly Instructions on page 3-11**.

Assembly Instructions

Step 1

A. Grasp the jacket at each end; fold at the hinges so that the shiny or printed side faces out.

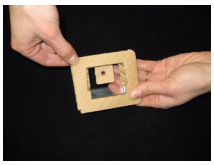
B. Insert the tab into the slot from the outside and carefully lock each side. The tab will point to the top of the trap on the inside, when properly closed. Set the jacket aside.



Step 2

A. Strip the cutouts from the corrugated piece. Lay the housing flat, faced side up.

B. Remove the pheromone lure from its packet. Remove the release paper, and stick the lure on the face surface of the downward projecting center tab in the second section.



Step 3

A. Fold the housing in half, corrugations out.

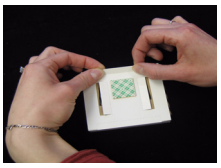
B. Hold the section with the pheromone lure in the palm of the hand and insert a plastic tray into the housing in the cutout just below the pheromone lure, pushing in until the tray is centered.

Step 4

A. Fold the end sections of the housing over the inner sections, holding the tray and lure so that the faced surfaces are on the outside.

B. Pinch the hinged corners of the housing to keep it folded.

C. Slide the housing, with tray and lure, into the folded jacket, with the lure facing the front of the trap (the front has the locking tab).



Step 5

A. Lay the assembled trap flat with the perforated flaps up. Bend the narrow top and bottom flaps outward at about a 45° angle. Avoid excessive bending.

B. Remove the narrow strips at the edges of the two vertical back flaps and bend them out 45° as well.

C. Apply a piece of mounting tape to the back of the trap so that the tape is centered between the back flaps, and with the top edge of the tape about 1/8 inch below the hinge of the top flap.

Step 6

A. Holding the trap upright, slide out the housing and use a disposable spoon to add ground wheat germ to the plastic tray, to a depth of about 2–3 mm, so tray is only 1/4 to 1/3 full. Do not overfill trap trays, as this would negate the escape-proof feature and allow insects to escape.

B. Remove the backing from the mounting tape and stick the trap to any vertical surface. To help the tape stick better, partially slide out the housing, insert two fingers inside the jacket and apply pressure against the mounting tape from the inside. If surfaces are very rough, apply a second tape sticker below the first. If the surface is dusty or loose, clean off as necessary. Remember to mark the trays and traps so that the trap location is precisely known.

Placement

Place traps around the inside of exterior walls and along interior walls of structures under investigation. Pay special attention to cracks in the walls. Cracks may serve as pathways for insect movement. If possible, place a trap over a wall crack if one is found.

Areas to Avoid—Avoid areas easily affected by activities such as sweeping or foot traffic. Avoid very oily or damp locations.

Height—Place the trap at any height, as well as at floor level, as long as it is attached to a vertical surface. Mount the trap high enough to be easily serviced (about 2 feet off the floor). Larvae have been trapped as high as 20 feet on walls within buildings; traps should be kept at least above broom height to avoid trap loss.

Density—Allow 25–40 feet between traps. Or, base placement of traps on the layout of buildings. The more traps that are set, the greater the chance of finding khapra beetle, if present. However, if there are too many buildings and travel is a problem, half of the locations can be trapped in alternate years. This way, a building can be more intensively trapped, thus increasing the chances of finding khapra beetle.

Records

Use a permanent, alcohol-proof marker to mark each trap with an identification number. Record the location of each trap.

Monitoring

Traps should be checked every 1–2 weeks at a minimum, primarily for the sake of obtaining specimens in good condition.

Optimal Temperature

Begin trapping when the warm season starts and average temperatures are above 70°F in the trapping environment. At ports where temperatures remain warm, or in heated environments, use practical judgment to determine if temperatures are warm enough. In more temperate areas, conduct surveys between mid-May through mid-September. Exceptions are heated warehouses, food storage and processing areas, dwellings, and other environments which are heated. These may be surveyed with traps at any time.

Servicing

Transfer the contents (wheat germ and insects) into a vial for inspection and rearing out in a lab. Used, transparent film canisters work well. Small resealable plastic bags work well for collecting dishes and trays. Or, place the entire dish, with contents, into a vial and then replace with a new tray. The traps are supplied with two plastic traps per trap. Used trays can be washed and re-used. Or, put the tray and contents into a small resealable plastic bag (supplied with the trap kits) and then replace the tray. Bag and contents must be labeled.

Traps should be checked every 1–2 weeks. When checking a trap for the last time and removing it, place the complete trap in a resealable plastic bag. Later, the trap can be firmly tapped over a tray to dislodge any insects that may be present.

Upon returning to a secure lab, examine and immediately remove adults and large larvae. The food material can be retained in the vial or bag for several days or weeks until the small larvae have grown large enough to identify.

Outdoor Trapping

Place traps in any outdoor location where khapra beetle activity is detected or travel between locations is known or suspected. Use the section **Greatest Risk on page 3-6** as a guide. Generally, only one or two traps per location should suffice. The vertical wall mount trap may be used against a vertical surface such as a wall or tree, whichever is more suitable. Do not go more than ½ mile away from an infested premises or verified location for khapra beetle, and only where possible khapra beetle hosts might be found.

Interpretation of Trap Catch

Important Take immediate action if one or more khapra beetle of any life stage, or exuviae, are trapped (pers. comm. Barak, 2007).

Larvae—Larvae are less mobile than adults, and more difficult to catch in traps. The presence of larvae in traps is significant. Trapping one larva has 50–100 times the significance of trapping a single adult. As with other *Trogoderma* spp., if one larva is trapped, be alarmed. Trapping of two or more, or if one location produces consecutive larval catches, this indicates a potential problem.

Adults—Adults are more mobile than larvae, and much easier to catch in traps. Adults may be absent from traps set at the site of the infestation.

Handling Specimens

See Collection, Rearing and Preparation of Specimens on page 4-12 for information on handling specimens.

Orientation of Survey Personnel

Experienced personnel should train their replacements. Adequate training on survey techniques and procedures will likely require three working days.

4

Khapra Beetle

Chapter 4

Identification

Contents

Introduction **page 4-1**
Authorities **page 4-1**
Keys to Dermestidae **page 4-3**
Characteristics **page 4-5**
Similar Species **page 4-10**
Collection, Rearing and Preparation of Specimens **page 4-12**
Screening **page 4-14**
Shipping **page 4-14**
Determination of Infestation **page 4-14**

Introduction

Use the *Identification* chapter as a guide to recognizing the khapra beetle and its relatives. Accurate identification of the pest is pivotal to assessing its potential risk, developing a survey strategy, and determining the level and manner of control.

Authorities

Qualified State, county, or cooperating university personnel can screen and perform tentative identification of suspected khapra beetle specimens. Before survey and control activities are initiated in the United States, a specialist recognized by USDA–APHIS–PPQ–National Identification Services (NIS) must verify the first detection of khapra beetle.

Specimens for Screening

Send specimens for screening to your local port or area identifier. Find names of identifiers in *Appendix G* of the *PPQ Manual for Agricultural Clearance* (http://www.aphis.usda.gov/import_export/plants/manuals/ports/mac.shtml).

Routine Surveys

For suspect *Trogoderma granarium* specimens encountered in routine survey activity, submit specimens marked *Prompt* to Chuck Brodel.

Address	Chuck Brodel Coleoptera Identification Specialist USDA–APHIS–PPQ Plant Inspection Station 3500 NW. 62nd Avenue P.O. Box 59-2136 Miami, FL 33159

Suspect Domestic Infestations

For suspect domestic infestations and new State or national records, submit speciments marked *Urgent* and send to USDA–Systematic Entomology Laboratory.

Address	USDA–Systematic Entomology Laboratory National Museum of Natural History NHB 168 10th & Constitution Ave., NW Washington, DC 20004

To inquire about the progress of samples marked *Urgent* contact the USDA–APHIS–PPQ–National Identification Services.

Address	USDA–APHIS–PPQ–National Identification Services Telephone: 301-734-8758

Keys to Dermestidae

Use **Abridged Key for Larvae in the Family Dermestidae on page 4-3** to identify larvae, and pupae inside cast larval skins, in the family Dermestidae. Use **Abridged Key for Adults in the Family Dermestidae on page 4-4** to identify adults. Since larvae are more readily found than adult khapra beetles, the key for larvae will likely be most useful. The egg has too few characters to be useful for identification purposes, except in association with the adult or larva.

Abridged Key for Larvae in the Family Dermestidae

TABLE 4-1 Abridged Key for Larvae to Genus Level[1]

If larva with this character:	Then:
1. Urogomphi absent	Go to 2
Urogomphi present	*Dermestes*
2. Each tergum with a row of course spiny, club-shaped setae along posterior margin and a cluster of spiny, sharp-pointed setae on each side	*Thylodrias*
Each tergum with club-shaped spiny setae absent, spiny, sharp-pointed setae may be present	Go to 3
3. Hastisetae present	Go to 4
Hastisetae absent	Go to 7
4. Hastisetal tufts inserted on islands in membrane behind strongly curved posterior margins of abdominal segments, 5, 6, and 7	*Anthrenus*
Hastisetal tufts inserted on tergal plates	Go to 5
5. Hastisetal tufts inserted on tergal plates	*Trogoderma*
Hastisetal tufts inserted on each side of intersegmental membrane behind the abdominal tergum only	*Cryptorhopalum*
6. Hastisetal tufts inserted on each side of intersegmental membrane behind the abdominal tergum only	*Cryptorhopalum*
Hastisetal tufts inserted on each side of intersegmental membranes behind the abdominal tergites of 7 and 8 only, each tergite with a single line of large spicisetae and fine spicisetae behind these	*Orphinus*
7. Body setae broad and flattened	*Novelsis*
Body setae narrow	*Attagenus*

1 Gorham (1991); Kiselyova (2002); Beal (1961)

Abridged Key for Adults in the Family Dermestidae

TABLE 4-2 Abridged Key for Adults to Genus Level[1]

If adult with this character:	Then:
1. Antennae with apical club	Go to 2
Antennae filiform	*Thylodrias*
2. Head with median ocellus	Go to 3
Head without median ocellus	*Dermestes*
3. First segment of hind tarsi much shorter than second segment	Go to 4
First segment of hind tarsi as long or longer than second	Go to 5
4. Segments of antennal club compact	*Attagenus*
Segments loosely joined (Southwest United States)	*Novelsis*
5. Body covered with flattened scales	*Anthrenus*
Body covered with hairs	Go to 6
6. Antennal club of three segments	*Trogoderma*
Antennal club of two segments	Go to 7
7. Antennal club oval, penultimate segment longer than last segment	*Cryptorhopalum*
Antennal club nearly circular; terminal segment largest	*Orphinus*

1 Arnett (1963)

Characteristics

Eggs

Eggs of the khapra beetle (**Figure 4-3**) share the following characteristics:

- Color initially milky-white, later pale-yellowish
- Shape typically cylindrical; one end rounded, the other more pointed
- Pointed end bearing a number of spine-like projections, broader at the base and tapering distally
- Size 0.7 mm long and 0.25 mm broad (EPPO, 2004)

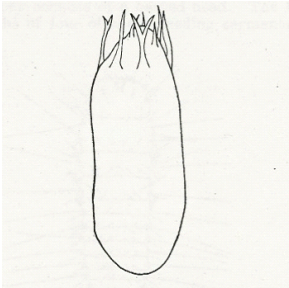


FIGURE 4-3 Egg of Khapra Beetle [Courtesy of Hadaway (1956)]

Larvae

Use the following characters to distinguish larvae of the khapra beetle from other dermestid species (Kingsolver, 1991):

- Setae of first antennal segment almost completely encircling segment and reaching or surpassing apex of segment two
- Distal sensory cup with four papillae (**Figure 4-4**)
- Antecostal suture of abdominal segment eight usually **absent** or weak and interrupted at several points (**Figure 4-5**)
- Hastisetae (spearheaded setae) present, inserted on tergal plates
- No urogomphi on last abdominal segment

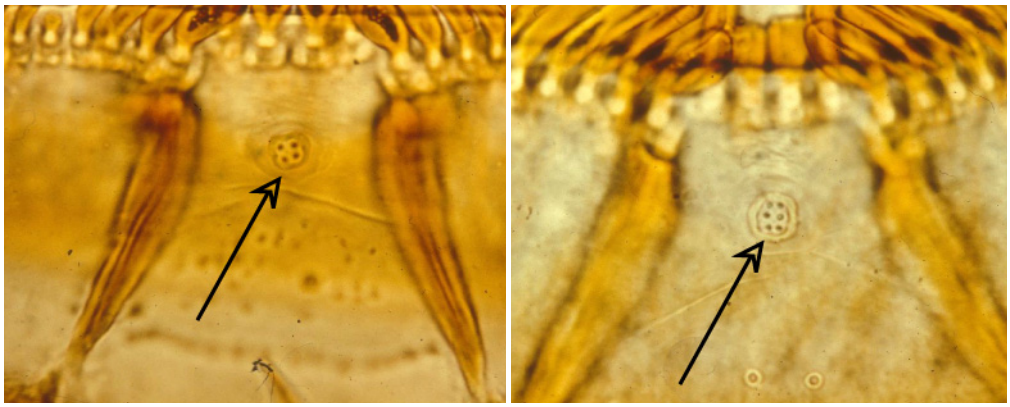


FIGURE 4-4 Left: Distal Sensory Cup with Four Papillae, as with Khapra Beetle; Right: Cup with Six Papillae, Unlike Khapra Beetle [Images Courtesy of A. Barak, USDA–APHIS]

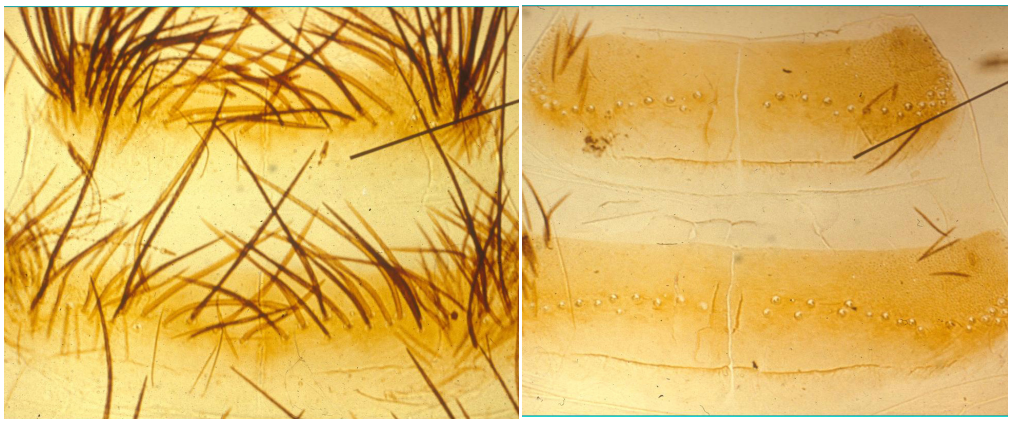


FIGURE 4-5 Left: Weak or Absent Antecostal Suture, as with Khapra Beetle; Right: Strong Antecostal Suture, as with *T. glabrum* [Images Courtesy of A. Barak, USDA–APHIS]

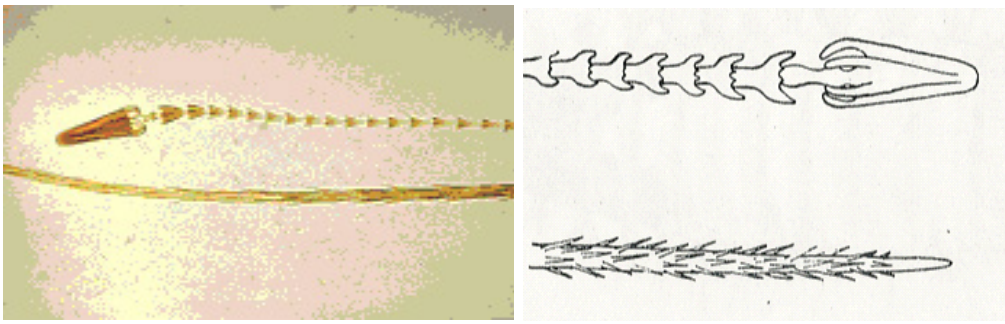


FIGURE 4-6 Hastisetae Typical of *Trogoderma* [Left Image Courtesy Of A. Barak, USDA–APHIS]

The following characters are useful for recognizing the larval stage of the khapra beetle:

- Total length of 1st instar larva is 1.6–1.8 mm, a little more than half of which consists of a long tail, made up of a number of hairs borne on the last abdominal segment. The tail consists of two groups of long simple hairs, borne on the 9th abdominal segment (**Figure 4-7**).
- Body width is 0.25–3.0 mm.
- Color is uniformly yellowish-white, except for the head and body hairs, which are brown.
- Head bears a short antenna of three segments.
- Two kinds of body hairs are present:
  - Simple hairs, in which the shaft bears many small, stiff, upwardly directed processes. Simple hairs are scattered over the dorsal surface of the head and body segments.
  - Barbed hairs, in which the shaft is constricted at regular intervals, and in which the apex consists of a barbed head. The head is as long as the combined lengths of four of the preceding segments. Barbed hairs are found in pairs of tufts, borne on certain abdominal tergites.

FIGURE 4-7 Mature Larva of Khapra Beetle [Image Courtesy of Bennett (2003)]

As the larva increases in size, the color changes progressively from the pale yellowish-white of the first instar to a golden or reddish-brown. The density of the body hairs increases, but the hairs and the tail become much shorter in proportion to the length and breadth of the larval body. In the 4th instar, the hairs give the appearance of four dark transverse bands.

A conspicuous feature of khapra beetle infestation is masses of hairy larvae and their cast skins (EPPO, 2004).

Pupae

At the last ecdysis, the larval skin splits, but the pupa remains within this skin for the whole of its life. Pupae of the khapra beetle have the following characters:

- Pupal type exarate
- Male smaller than the female, average lengths being 3.5 mm and 5 mm, respectively (EPPO, 2004)

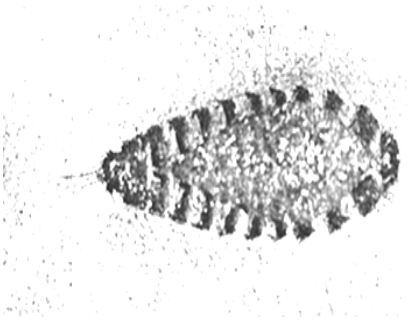


FIGURE 4-8 Pupal Stage of Khapra Beetle [Image Courtesy of Lindgren *et al.* (1955)]

Adults

The following characters are useful for recognizing the adult stage of the khapra beetle (EPPO, 2004):

- Body shape broad, oblong-oval
- Size about 1.6–3.0 mm long by 0.9 mm wide; females slightly larger
- Color of males brown to black, with indistinct reddish-brown markings on the elytra; color of females lighter
- Head small and usually deflexed
- Antenna short, thick, and clubbed, 11-segmented
- Antennal cavity **not** visible in anterior view, posterior margin marked by a fine, transverse carina
- Median ocellus present between the eyes
- Elytron unicolorous or vaguely mottled, but **without** a clearly defined pattern
- Hind coxae concave to receive femur, posterior margin curved or sinuate
- First segment of hind tarsus longer than second segment
- Anteromedial metasternal margin **without** nipple-like projection in middle

FIGURE 4-9 Adult Stage of Khapra Beetle [Image Courtesy of Bennett (2003)]

Similar Species

The khapra beetle is easily confused with the warehouse beetle, European larger carpet beetle, and the glabrous carpet beetle.

Warehouse Beetle

In the United States, the khapra beetle is most likely to be confused with the warehouse beetle (*Trogoderma variabile*) (Barak, *pers.comm*.).

FIGURE 4-10 Warehouse Beetle (*Trogoderma variabile*) Adult (Left) and Larva [Images Courtesy of Steve Jacobs, Pennsylvania State University [http://www.ento.psu.edu/imagegallery/beetles-2.htm]]

European Larger Carpet Beetle

The European larger carpet beetle (*Trogoderma versicolor)* (ELCB) is similar in appearance to khapra beetle. The two species are found under similar conditions, but usually the population density of ELCB is small compared with khapra beetle. Adults of ELCB are considerably larger (2.0–5.0 mm long) than adult khapra beetles. Their ground color is black mottled with reddish brown, covered with gray and light brown scale-like hairs forming a distinct pattern on the elytra.

FIGURE 4-11 European Larger Carpet Beetle (*Trogoderma versicolor*) Adult and Elytron Pattern [Right Image Courtesy of Kingsolver (1991)]

Glabrous Carpet Beetle

Another dermestid that may be mistaken for khapra beetle is the glabrous carpet beetle (*Trogoderma glabrum*) (GCB). In the larval stage, GCB population density increases in grain at a rate similar to khapra beetle (USDA–AMS–Stored Products Insect Branch, 1959).

FIGURE 4-12 Glabrous Carpet Beetle (*Trogoderma glabrum*) Adult and Elytron Pattern [Right Image Courtesy of Kingsolver (1991)]

Collection, Rearing and Preparation of Specimens

Rearing

In most situations, collected specimens will not need to be reared out, because late-instar larvae, pupae and adults can be submitted for examination and identification. However, if eggs or young larvae are collected as part of a survey effort, these may need to be reared, especially in the absence of any identifiable adults or older larvae.

Important Always rear suspect khapra beetle eggs and larvae in a quarantine facility with proper APHIS permits and containment. Maintain optimum temperature and humidity.

Sample Preparation

Collected Debris

Collect milled products and debris from areas such as cracks and cervices of bins, silos, or wherever grain is stored in homes or stores. Use the following procedure to prepare the milled products and debris before extracting the pests (Girish *et al.*, 1972).

Step 1 Prepare a supersaturated solution of sodium chloride.

Step 2 Mix the milled products and debris with the solution.

Step 3 Remove the scum; mix scum with tap water.

Step 4 Centrifuge the scum water for 5 minutes at 2000 revolutions/min. Eggs and heavy particles will settle at the bottom of the tube.

Step 5 Drain the liquid, then remove the heavy particles for examination under a microscope.

Step 6 Inspect for eggs, larvae and adults, then consult **Table 4-3 on page 4-13** for additional instructions that vary with life stage.

TABLE 4-3 Decision Table for Preparation of Khapra Beetle Specimens

If the following life stage is present:	Then follow this procedure:
Eggs	1. Prepare a vial containing 10 grams of fresh wheat flour enriched with dried yeast; mix with the scum. 2. Store vial under optimum conditions for egg hatch for 10 days. 3. Retain until larvae develop to a stage that can be identified. 4. Proceed as with **Larvae** (below).
Young larvae	1. Decant. 2. Retain until larvae develop to a stage that can be identified. 3. Proceed as with **Larvae** (below).
Larvae	1. Decant. 2. Boil mature larvae in water for 1–2 min. 3. Place in properly labelled vial filled with 79% alcohol. 4. Submit for identification.
Adults	1. Decant. 2. Place in properly labelled vial filled with 79% alcohol. 3. Submit for identification.

Larvae Collected in Traps

Use the following procedure to prepare larvae, collected in traps, for identification.

Step 1 Place food material from each trap in a separate, labeled vial.

Step 2 In the laboratory, remove adults and large, older larvae and place in separate, labeled vial(s) of 79% alcohol for identification.

Step 3 Use a collection vial or bag to retain the remainder of the food material for several days or weeks, until small larvae have been reared to a size suitable for identification.

Step 4 Remove remaining larvae; boil in water for 1–2 min.

Step 5 Place boiled larvae in a properly labeled vial of 79% alcohol.

Step 6 Submit for identification.

Vial and Label

Always submit reared or collected adults and larvae for identification in properly labeled vials of 79% alcohol. Use an alcohol-proof, permanent marker or pencil to record information on a label; place the label inside the vial.

Include the following information on the label:

- Date of collection
- Identification number
- Initials of the collector
- Exact location and address where found
- Life stage of the specimen
- Dead or alive status
- Circumstances in which specimen was found

Screening

If necessary, separate material that does not fit the preliminary identification profile and note the differences before shipping.

Shipping

Double box and ship specimens with at least 2 inches of padding around each sample.

Include **PPQ 391 Specimens For Determination on page A-2** marked *Urgent* with all specimens. **See Specimens for Screening on page 4-1**, **Routine Surveys on page 4-2**, and **Suspect Domestic Infestations on page 4-2** for additional information.

Determination of Infestation

A premise or area will tentatively be considered infested when the inspector has recovered at least one live adult or larval khapra beetle suspect from the premise or area or its contents.

Only on Imported Articles

If the infestation is found only on imported articles which have been in the building or area for a short period of time, and intense inspection fails to uncover more khapra beetle in or on the premises or area itself, then only the contents on which the infestation was found will be considered to be infested. If there is uncertainty as to whether the premises or area should be considered infested, there should be consultation with staff before making the

determination. When such a determination is made, the suspect material must be forwarded for positive identification and the owner of the premises or area must be notified about the suspected infestation and be advised of the nature of the situation and any subsequent actions which may ensue. Discovery of cast skins alone will not be considered to be evidence of an infestation on premises (USDA–APHIS–PPQ, 1981).

Determination by Area Identifier

A tentative determination for khapra beetle may also be made by the area identifier, in which case the procedures are the same as above. The responsible State official and the APHIS–State Plant Health Director (SPHD) should be notified when khapra beetle is identified by the area identifier prior to forwarding suspect specimen for final identification (USDA–APHIS–PPQ, 1981).

Identification of the specimens is confirmed by personnel at the Systematic Entomology Laboratory. The infestation is then confirmed and appropriate steps taken, including immediate quarantine measures (USDA–APHIS–PPQ, 1981).

5

Khapra Beetle

Chapter 5

Regulatory Procedures

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Introduction

Use the *Regulatory Procedures* chapter to learn about the rules that must be followed by regulatory personnel when conducting pest survey and control programs.

Instructions to Officers

Officers must follow instructions for regulatory treatments or other procedures when authorizing the movement of regulated articles. Understanding the instructions and procedures is essential when explaining procedures to persons interested in moving articles affected by the quarantine and regulations. Only authorized treatments can be used in accordance with labeling restrictions.

Find instructions for regulatory treatments in *PPQ Treatment Manual* (http://www.aphis.usda.gov/import_export/plants/manuals/ports/treatment.shtml). If a regulatory treatment does not appear in the manual, the proposed treatment will be reviewed and tested by CPHST treatment specialists.

Issuing an Emergency Action Notification

PPQ 523 Emergency Action Notification on page A-4 can be issued pending positive identification or further instruction from the USDA–APHIS–PPQ Deputy Administrator.

If necessary, the Deputy Administrator will issue a letter directing PPQ field offices to initiate a specific emergency action under the Plant Protection Act of 2000 until emergency regulations can be published in the *Federal Register*.

Emergency Quarantine Action

The Plant Protection Act of 2000 provides for authority for emergency quarantine action. This provision is for interstate regulatory action only. Intrastate regulatory action is provided under State authority. However, if the Secretary of Agriculture determines that an extraordinary emergency exists and that the measures taken by the State are inadequate, USDA can take intrastate regulatory action provided that the governor of the State has been consulted and a notice has been published in the *Federal Register*. If intrastate action cannot or will not be taken by a State, PPQ might find it necessary to quarantine an entire State.

Access to Private Property

PPQ works in conjunction with State departments of agriculture to conduct surveys, enforce regulations, and take control actions. PPQ employees must have permission of the property owner before accessing private property. If an extraordinary emergency is declared or if a warrant is obtained, PPQ can enter private property without owner permission. PPQ prefers to work with the State to facilitate access when permission is denied; however, each State government has varying authorities regarding accessing private property. A General Memorandum of Understanding (MOU) exists between PPQ and each State. PPQ officers must have permission of the owner before accessing private property. For clarification, check with your State plant health director (SPHD) or State plant regulatory official (SPRO) in the affected State.

Regulated Articles

Regulated articles include the following commodities:

- Grains and grain products (including but not limited to barley, corn, oats, wheat, whether moved as such or an ingredient in other products)
- Dried seeds and seed products of field and vegetable crops (including, but not limited to alfalfa seed, cotton seed, cottonseed meal and cake, flaxseed, sorghum seed, soybean meal, pinto beans, and black-eyed peas)
- Pecan, acorns, walnuts, pistachio and other nuts from trees or other debris from under hosts
- Used bags and bagging (including but not limited to those made of burlap or cotton)
- Dried milk, dried blood, fish meal, meat and bone meal, and dried animal hides
- Any other products, articles, or means of conveyance, of any character whatsoever, when it is determined by an inspector that they present a hazard of spread of khapra beetle and the person in possession thereof has been so notified

Pest Risk Appraisal

In applying safeguards, the officer should consider the pest risk in the particular commodity or material at hand. The appraisal should include the character of the actual or suspected khapra beetle infestation, its possible mobility and the ecological conditions of the immediate area (APHIS, 1981).

Regulatory Action

Regulatory action will be required if one or more live specimens of *Trogoderma granarium* in any stage of development are collected under such circumstances that the specimen(s) obviously originated in the premises or area.

After an initial suspect positive detection, an Emergency Action Notification (PPQ Form 523) may be issued to hold articles or facilities, pending positive identification or further instruction from the USDA–APHIS–PPQ Deputy Administrator. If necessary, the Deputy Administrator will issue a letter directing PPQ field offices to initiate specific emergency action under the Plant Protection Act of 2000 until emergency regulations can be published in the *Federal Register*.

The Plant Protection Act of 2000 (Statute 7 USC 7701-7758) provides for authority for emergency quarantine action. This provision is for interstate regulatory action only; intrastate regulatory action is provided under State authority. State departments of agriculture normally work in conjunction with Federal actions by issuing their own parallel hold orders and quarantines for intrastate movement. However, if the U.S. Secretary of Agriculture determines that an extraordinary emergency exists and that the measures taken by the State are inadequate, USDA can take intrastate regulatory action provided that the governor of the State has been consulted and a notice has been published in the *Federal Register*. If intrastate action cannot or will not be taken by a State, PPQ may find it necessary to quarantine an entire State.

Cooperation with State Departments of Agriculture

PPQ works in conjunction with State departments of agriculture to conduct surveys, enforce regulations, and take control actions. PPQ employees must have permission of the property owner before entering private property. Under certain situations during a declared extraordinary emergency or if a warrant is obtained, PPQ can enter private property in the absence of owner permission. PPQ prefers to work with the State to facilitate access when permission is denied, however each State government has varying authorities regarding entering private property. A General Memorandum of Understanding (MOU) exists between PPQ and each State that specifies various areas here PPQ and the State department of agriculture cooperate. For clarification, check with your State Plant Health Director (SPHD) or State Plant Regulatory Official (SPRO) in the affected State.

Cooperation with Tribal Governments

PPQ works with Federally Recognized Indian tribes to conduct surveys, enforce regulations and take control actions. Each tribe stands as a separate governmental entity (sovereign nation) with powers and authorities similar to State governments. Permission is required to enter and access Tribal lands.

Executive Order 13175, Consultation and Coordination with Indian and Tribal Governments, States that agencies must consult with Indian Tribal governments about actions that may have substantial direct effects on tribes. Whether an action is substantial and direct is determined by the tribes. Effects are not limited to current Tribal land boundaries (reservations) and may include effects on off-reservation land or resources which tribes customarily use or even effects on historic or sacred sites in States where tribes no longer exist.

Consultation is a specialized form of communication and coordination between the Federal government and Tribal government. Consultation must be conducted early in the development of a regulatory action to ensure that tribes have opportunity to identify resources which may be affected by the action and to recommend the best ways to take actions on Tribal lands or affecting Tribal resources. Communication with Tribal leadership follows special communication protocols.

For additional information, contact PPQ's Tribal Liaison. To determine if there are Federally Recognized Tribes in a State, contact the State plant health director. To determine if there are sacred or historic sites in an area, contact the State Historic Preservation Officer (SHPO).

Emergency Action Notification

Issue **PPQ 523 Emergency Action Notification on page A-4** requiring the holding of articles and treatment or other approved handling procedures. The EANs or comparable State notifications are issued by field personnel to the property owners or managers of all establishments handling, moving, or processing articles capable of spreading khapra beetle. A notification may be issued pending positive identification and/or further instruction from the Deputy Administrator.

Description of Regulated Area

Prepare a description of the regulated area with support documents with cooperators and provide to the Regulatory Services staff for publication in the ***Federal Register*** with emergency regulations under the Federal Plant Protection Act of 2000.

Necessary Information

Collect necessary information about the infestation (USDA–APHIS–PPQ, 1981), including the following:

Possible source(s) of infestation—

- What types of cargo are handled by the premises?
- What is the country of origin of the cargo?
- What is the cargo receiving route?
  - Direct route cargo is cargo shipped direct from a foreign source to importers premises.
  - Indirect route cargo is cargo shipped from one importers' premises in the continental United States to another premise in the United States for processing.

Processing of cargo—

- Is cargo processed on the premises?
- Is cargo sold in unmanufactured lots to other premises?
- What are names and address of other premises?

Disposition of burlap or other bagging used as containers or wrapping—

- Obtain names and addresses of companies to which bagging is sold.

Storage facilities, processing locations, or other types of receiving locations other than the immediate premises—

- List the locations

Structural Details—

- Is construction wood, masonry, metal, other?
- How large are premises (in cubic feet)?
- Is a ventilation system present and functioning?
- Is a drainage system present and functioning?
- Is the building segregated or attached to other structures?

Location of the structure—

- Is the location rural, urban or city?
- What is the population density?
- What is the nature of businesses in the surrounding area?

List of distribution outlets that premises deal with—

- Wholesalers
- Retailers
- Small Stores
- Other

Secondary Inspection List

Compose a list of businesses which should be inspected as a result of this infestation. Distribution outlets and other potentially infested properties should be included on this list (APHIS, 1981). Include the following types of premises:

- High priority secondary premises are those premises receiving raw goods or unprocessed material from infested premises.
- Low priority secondary premises are those premises receiving manufactured or processed material from the infested premises.

Notification

Officers will notify their work unit supervisor of all information and details gathered. Further chain of command notifications are handled by the supervisor.

Regulated Establishments

Field personnel will attempt to detect the pest within the regulated area at all establishments where regulated articles are sold, grown, handled, moved, or processed. Establishments that might be involved are distributors, grain dealers, feed lots, user, farm storage and any other establishments that handle regulated articles. Surveys may be set up at establishments deemed to be at risk by project personnel. Wherever possible, money and manpower permitting, distributors and grain dealers should be inspected two times per year. All others should be inspected once per year. Service traps weekly if insect catches are high and biweekly if trap catches are low. Alternately, hosts near or at the establishment may be visually surveyed or trapped at two sites.

Use of Pesticides

PPQ Treatment Manual (http://www.aphis.usda.gov/import_export/plants/manuals/ports/treatment.shtml) and this document identify the authorized chemicals, and describe the methods and rates of application, and any special application instructions. Concurrence by PPQ is necessary before using any other pesticide or procedure for regulatory purposes. **See Control on page 6-1** for more information on use of pesticides.

Approved Regulatory Treatments

Approved regulatory treatments appropriate for this pest are determined by program management or a Technical Advisory Committee in conjunction with the USDA-CPHST. Check *PPQ Treatment Manual* (http://www.aphis.usda.gov/import_export/plants/manuals/ports/treatment.shtml) for current recommendations.

Principal Activities

The degree of regulatory activity required depends, among many other factors, on the degree of the infestation. For example, it may not be necessary to check all establishments throughout the regulated area if there is no contact with the infested premises in any way. However, if the infestation is heavy, mandatory checks of all establishments may be necessary.

Principle activities for conducting a regulatory program to contain khapra beetle include the following:

- Advise regulated industries of required treatment procedures.
- Carry out surveys of regulated establishments.
- Supervise, monitor, and certify commodity treatments of commercial lots of regulated articles.
- Make regulatory visits to:
  - Distributors
  - Grain Dealers
  - Feed Lots
  - Users
  - Farm Storage
  - Any other establishments that handle regulated articles.
- Monitor the movement of waste material to and from landfills to ensure adequate disposal of regulated articles.
- Monitor the movement of regulated articles through major airports, seaports, and other transportation centers.
- Observe major highways, roads, and footpaths and quarantine boundaries for movement of host materials.
- Compete a pest risk appraisal for each of the premises, areas and commodities involved.
- Carry out a comprehensive study of the infestation and as much relevant detail as possible, including:
  - Source
  - Processing of cargo
  - Disposition of packing material
  - Storage facilities
  - Structural details
  - Location
  - Distribution outlets

- Compose a secondary inspection list from the above study.
- Notify work unit supervisor of all information and details that have been gathered.

Removing Quarantines

Project managers identify and remove premises and areas from quarantine requirements after the khapra beetle is declared eradicated from that premises or area. Eradication is assumed when sufficient time, equal to three years after the last specimen at a premises or area, has been found.

Orientation of Regulatory Personnel

Initially, program personnel will be limited to those already trained or experienced. Experienced individuals train their replacements. A training period of three working days should be sufficient for the orderly transfer of these functions.

Regulatory Records

Maintain standardized regulatory records and database(s) in sufficient detail to carry out an effective, efficient, and responsible regulatory program.

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Khapra Beetle

Chapter 6

Control

Contents

Introduction **page 6-1**
Eradication **page 6-3**
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Introduction

The *Control* chapter provides information about methods used to eradicate or manage an infestation of khapra beetle. Consider all possible methods of control before beginning a program. Eradication is the first priority if khapra beetle has been introduced. **See Technical Control on page E-1** for additional information on methods of control.

TABLE 6-1 Decision Table to Eradicate or Control Khapra Beetle

If:	Then:
You want to eradicate the pest	GO TO **Eradication on page 6-3**h
You want to control the pest	GO TO **Nonemergency Control on page 6-5**
You need additional resources	GO TO **Technical Control on page E-1**

Laws Pertaining to Pesticide Use

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) authorizes the Environmental Protection Agency (EPA) to regulate pesticides. All persons using and applying pesticides should understand the laws pertaining to pesticide use and application. The following are provisions of FIFRA that are most pertinent to emergency pest control programs:

- Restricted use pesticides must be applied by a certified applicator
- Use of any pesticide inconsistent with the label is prohibited
- Violations can result in heavy fines and/or imprisonment

States may register pesticides on a limited basis for local needs according to the following Sections:

- **Section 18**—EPA administrators may exempt Federal or State agencies from FIFRA if it is determined that emergency conditions exist that require such exemptions
- **Section 24**—A State may provide registration for additional uses of federally registered pesticides formulated for distribution and use within that State to meet special local needs in accordance with the purposes of this act

For additional information concerning exemptions, see the *PPQ Emergency Programs Manual*, Section 14 (http://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/epm.pdf). Contact staff at Environmental Compliance (http://www.aphis.usda.gov/regulations/compliance/environmental_guidance.shtml) to assure that any pesticide being considered as part of an eradication program conforms to pesticide use requirements. Obtain all required environmental documentation before beginning.

Environmental Monitoring

Environmental monitoring is an important consideration in all programs. Contact staff at Environmental Compliance (http://www.aphis.usda.gov/regulations/compliance/environmental_guidance.shtml) to learn if environmental monitoring is required. Environmental Compliance staff may evaluate environmental impact by monitoring the following:

- Water, to detect insecticide levels resulting from direct application, leaching, and runoff
- Soil, to determine insecticide levels and residues
- Foliage, to identify residues
- Non-target organisms before, during and after applications and post treatments, to determine impact of pesticides

Treatment Duration

Monitor the success of the program for at least one life cycle after the termination of eradication measures.

Insecticide Efficacy

It may be necessary to test live members of the khapra beetle population in order to determine the degree of resistance to various treatments. Employ those treatments to which the pest population has **no** resistance. Personnel must provide data for assessment of application methods against the target pest.

Orientation of Personnel

Experienced personnel will train their replacements. A training period of three days should be sufficient for training.

Records

Program personnel must maintain records and maps noting the locations of all detections, the number and type of treatments, and the materials and formulations used in each treated area.

Eradication

Stored foodstuffs are the most likely commodities to require control measures against the khapra beetle. In the *PPQ Treatment Manual* (http://www.aphis.usda.gov/import_export/plants/manuals/ports/treatment.shtml), control measures are organized in the following groups:

- Sacked or packaged commodities
- Bulk commodities
- Used sacks and bagging
- Seed treatment
- Debris and transport vehicles

Control measures will be required less often in the following situations:

- On nut trees including oak, acorn, walnut, and others
- On peanuts
- On pathways near infected structures
- In vehicles or other shipping containers

Infested structures or shipping containers will often require fumigation. Cracks and crevices within some structures, such as houses and secondary structures at lesser risk, can be treated with an insecticide.

See Technical Control on page E-1 for more information on control of khapra beetle.

Defining the Treatment Area

Once a decision has been made to eradicate the khapra beetle, use the *PPQ Treatment Manual* (http://www.aphis.usda.gov/import_export/plants/manuals/ports/treatment.shtml) to define the treatment area.

Treatment Options

Important Treatments should be complete and thorough, resulting in 100% eradication, or followed by other treatments which will effect 100% eradication of the khapra beetle population.

Authorized Treatments

Fumigation with methyl bromide is the most effective treatment. However, alternative treatments are authorized if the treatment will result in the eradication of khapra beetle.

All treatments with methyl bromide for khapra beetle are currently under quarantine exemption. These uses must be recorded and reported in accordance with applicable regulations for such exemptions. Any food or feed

commodities involved in the methyl bromide treatments must be sampled for residue analysis. See **Technical Control on page E-1** for treatment alternatives to methyl bromide.

Authorized Treatments—Authorized treatments may include any of the following:

- Fumigation
- Application of recommended fumigants
- Insecticides
- Treatment of surfaces with pesticides
- Supplemental actions

Authorized Fumigants and Pesticides—Authorized fumigants and pesticides may include the following:

- Phosphine
- Methyl bromide
- Malathion
- Permethrin

Treatments are explained in more detail in *PPQ Treatment Manual* (http://www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml). A Section 18 exemption may be necessary when using permethrin. Also see **Laws Pertaining to Pesticide Use on page 6-1** for more information on Section 18 exemptions.

Fumigations—Infested structures and equipment can be fumigated with methyl bromide. See the *PPQ Treatment Manual* (http://www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml) more information. When using methyl bromide, follow these guidelines:

- Conduct fumigation after all openings in a structure are sealed with masking tape, putty, polyethylene, or other materials as needs indicate.
- Cover with a tarp and fumigate shipping or storage containers separately when required.
- Cover with a tarp and fumigate stationary equipment separately.
- Also see **Phosphine on page E-2**

Other Treatments—Malathion or permethrin may be used where it is desirable not to fumigate. Use any of the following variations:

- Crack and crevice treatment
- High pressure treatment
- High pressure broadcast treatment

Heat treatments may be applied to certain commodities. Irradiation treatments may also be applied to commodities approved for such treatments.

Supplemental Actions—Use the following actions to supplement treatments:

- Extensive trapping
- Cleaning and sanitation
- Treatment of outside surfaces
- Extensive repeated inspection program

Nonemergency Control

See Technical Control on page E-1 for more information on nonemergency control.

Application of Cultural Controls

Cultural control may be subject to obtaining environmental documentation under the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA). Check with the program manager to make sure such documentation is in order. The following cultural controls can be effective and are necessary in most situations:

- Sanitation
- Inspect/Clean Vehicles

The following cultural controls offer can be **ineffective**, but may work in some situations:

- Host destruction (very limited at best)
- Flooding surrounding surface area (very limited)

Application of Biological Controls

Effective biological control has **not** been developed for control of khapra beetle. **See Biological Control on page E-8** for information concerning planning a biological control program when effective organisms become available.

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Khapra Beetle

Chapter 7

Environmental Regulation

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Environmental Monitoring **page 7-3**
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Introduction

A key element in designing a program or an emergency response is consultation with Environmental Services (ES), a unit of APHIS' Policy and Program Development Staff (PPD). ES prepares environmental documentation such as environmental impact statements (EIS) and environmental assessments (EA) to aid in program operational decisions, as well as endangered species consultation. ES also coordinates pesticide registration and approvals for APHIS pest control and eradication programs, ensuring that registrations and approvals meet program use needs and conform to pesticide use requirements.

Environmental Compliance

Environmental Monitoring, Categorical Exclusions

Address	USDA–APHIS–PPQ–Emergency and Domestic Programs Environmental Compliance 4700 River Road, Unit 150 Riverdale, MD 20737 Telephone: 301-734-8247

Environmental Services

FIFRA, ESA, Environmental Assessments

Address	USDA–APHIS–Policy and Program Development Environmental Services 4700 River Road, Unit 149 Riverdale, MD 20737 Telephone: 301-734-8565

Disclaimer

All uses of pesticides must be registered or approved by appropriate Federal, State, or Tribal agencies before application. Pesticide labels might not reflect all State or local restrictions. Read and abide by the label, including labeling that has been approved for the particular State or locality. Comply with all Federal, State, Tribal, and local laws and regulations relating to the use of the pesticides. APHIS program staffs are responsible for their compliance with applicable environmental regulations. **See Laws Pertaining to Pesticide Use on page 6-1** for more information.

National Environmental Policy Act

Agencies should prepare an environmental assessment or environmental impact statement concurrently and integrated with environmental impact analyses, surveys, and studies required by the Fish and Wildlife Coordination Act, National Historic Preservation Act of 1966, Endangered Species Act, and other laws and executive orders. Environmental document prepared to comply with other acts also may be incorporated into National Environmental Policy Act (NEPA) documents as part of the NEPA process.

Categorical Exclusions

Categorical exclusions are categories of actions that do not have a significant effect on the quality of the human environment and for which neither an EA nor an EIS is generally required.

APHIS managers are encouraged to use categorical exclusions where appropriate to reduce paperwork and speed the decision making process. Proposed actions are subject to sufficient environmental review to determine whether they fall within the broadly defined categories. Each time a specific CE is used, the required review must be done. An EA may be prepared for proposed actions otherwise excluded when the manager determines that the action may have potential to significantly affect the environment or an EA would be helpful in planning or decision making.

Environmental Impact Statements

An environmental impact statement is a detailed statement that must be included in every recommendation or report on proposals for legislation and other major Federal actions that significantly affect the quality of the human environment. The primary purpose of an EIS is to serve as an action-forcing device to insure that the policies and goals defined in the NEPA are infused into the ongoing programs and actions of the Federal government. Generally, EISs are prepared when Federal agencies recognize that their actions have the potential for significant environmental effects (adverse or beneficial), or when an environmental assessment leads to a finding of potential significant impact.

APHIS prepares EISs for administrative proceedings that establish broad scale significant impact-generating strategies, methods, or techniques such as large-scale aerial pesticide applications. This can include contingency or emergency strategies that are comprehensive in scope or long-range plans with potential for significant environmental impact. APHIS also prepares programmatic EISs to examine strategies and options for dealing with issues with important implications for the maintenance and enhancement of environmental quality.

Environmental Assessments

An environmental assessment is a concise public document that briefly provides sufficient evidence and analysis for determining whether to prepare an EIS or finding of no significant impact (FONSI). An EA aids an agency's compliance with the NEPA when no EIS is necessary and facilitates the preparation of an EIS when necessary. Generally, an EA leads to a FONSI or an EIS, but it could also lead to abandonment of a proposed action.

The content of an EA must include brief discussions of the need, alternatives, and potential environmental impacts of the proposal a list of agencies and persons consulted.

Environmental Monitoring

PPQ requests assistance from ES before PPQ personnel or funding are used for control operations. Additionally, program staff should consult with the PPQ–EP–ISPM–Environmental Monitoring staff to determine if an environmental monitoring plan is required for the operation. State, regional, and national program managers determine counties where treatments may be needed.

Program personnel should evaluate the success of biological control agents and herbicide treatments used in eradication or suppression of the target FNW or host weeds and avoid damage to non-target plants.

Biological Assessment

A biological assessment (BA) is an analysis of the effects that a Federal agency action may have on listed or proposed endangered or threatened species and designated critical habitat. The Endangered Species Act (ESA) requires this analysis if the proposed action may affect a listed species. In such a case consultation with the U.S. Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS) is required. Federal agencies are required to insure that any action authorized, funded, or carried out is not likely to jeopardize listed species or result in adverse modification of designated critical habitat.

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Khapra Beetle

Chapter 8

Pathways

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Introduction

The *Pathways* chapter provides information on the interceptions of khapra beetle at U.S. Ports.

Sources

Information in this chapter was compiled from the following sources, unless noted otherwise:

Pasek, J.E. 1998. USDA Pest Risk Assessment: Khapra Beetle. Sponsored by CERIS, Purdue University. [http://www.ceris.purdue.edu/napis/pests/khb/freg/khb98pra.html]

Touhey, P. 2005. *Trogoderma granarium*. Personal Report to J. Stibick on Interceptions in the PIN 309 Reports: 4 pp.

History

Prior to 1957

Khapra beetle was found in California in 1953. Products containing the pest were destined for 24 States. The beetle could easily have become established in seven of the States: Arizona, California, Kansas, New Mexico, Nevada, Oklahoma and Texas (Howe & Lindgren, 1957). Khapra beetle was intercepted 42 times during the period 1954–1957.

Period 1985–2005

Khapra beetle was intercepted in the United States 456 times during the period 1985–January 2005.

Period 1985–1998

During the period 1985–1998, almost all intercepted cargo containing khapra beetle arrived through airports (63%) and maritime ports (36%). Less than 1% arrived at land border crossings and plant inspections stations.

At airports, interceptions were primarily in baggage. At maritime ports, interceptions were primarily in general cargo and stores. The greatest number of airport interceptions occurred at Houston, which accounted for nearly one-half of the khapra beetle finds. In Houston, 78% of the interceptions were found at the airport; 22% were found at the maritime port.

Eighty-eight percent of the airport interceptions occurred in passenger baggage on more than 75 hosts. The majority of khapra beetle interceptions occurred in shipments of seeds from forty different plant species, although other plant materials (flowers, fruits, and spices) also served as hosts. Cucurbits and rice accounted for 18% and 14%, respectively, of all interceptions of khapra beetle in this time period.

Period 1999–2005

Proportions remained almost the same through 2005. However, interception of khapra beetle in rice increased to 18%.

Dissemination

Movement of khapra beetle into the United States can be aided by travel, commerce, or natural means.

Travel

Travel of khapra beetle to the United States requires either of the following:

- Transport of items on which they rest
- Shipment of infested products

The great frequency of foreign interceptions indicates that khapra beetle has a high risk of establishment in the United States. Since 1985, at least 70% of U.S. interceptions were from international airline passenger baggage. During the period 1985–1998, 55% of interceptions occurred in baggage.

Commerce

During the period 1985–1998, only two interceptions were from ships or other sources; the rest were from airports. General cargo accounted for 25%, almost all from airports and ships. The rest were from permit cargo (5%) and maritime stores (14%). Airport mail, maritime holds, and miscellaneous accounted for 0.5%, 0.75%, and 1.25%, respectively.

Natural

Originating in Asia, Africa and other parts of the Far East and the Mediterranean, khapra beetle is unable to reach the United States by natural means. The adult does **not** fly, but can walk and climb. Adults and larvae can be spread naturally for short distances by crawling. Adults and larvae are also transported on birds, other insects, and wind currents. Other methods of air transport have not been studied (Lindgren *et al.*, 1955).

Countries of Origin

India, Saudi Arabia, Iran and Pakistan

1985–1998

Khapra beetle was intercepted 380 times during the period 1985–1998. Most interceptions occurred in cargo originating in countries in Southwest Asia. Four countries accounted for 79% of interceptions in that period: India, Saudi Arabia, Iran and Pakistan. India accounted for 34% of the interceptions. Saudi Arabia had 22%, Iran had 14%, and Pakistan had 9% of the interceptions. The four countries have endemic populations of khapra beetle; 303 interceptions originated in the countries.

1999–2005

During the period 1999–2005, the combined number of interceptions originating in India, Saudi Arabia, Iran and Pakistan decreased (from 79% in 1985–1998) to 62%. The rate decreased in each country except Iran, where the number of interceptions remained unchanged.

Other Countries

Khapra beetle was intercepted 77 times from 31 other countries. Most of the countries, including those in Europe and one in Mexico, reported only one or two interceptions in the period. Exceptions were from countries adjoining those considered to be infested: Kuwait (12), Jordan (9), United Arab Emirates (4), and China (3).

Instances of only one or two interceptions from countries not known to have populations of khapra beetle may reflect cases where contamination from shipment to or from infested countries occurred prior to arrival in the United States. Or, the origin of small quantities of infested material in passenger baggage may be uncertain.

Destinations

Approximately one-half of the interceptions were found at nine ports in areas where khapra beetle could establish itself. Ports in Houston and San Francisco lead with the most finds; they also provide favorable climates for the establishment of khapra beetle.

Ports in Dallas, TX (14), and Los Angeles (12) followed, with Port Arthur, TX (6), San Pedro, CA (1), San Diego, CA (1), Corpus Christi, TX (1), and Denver, Colorado (1) trailing behind. All of the ports are in susceptible areas.

Based on the biology and host range of khapra beetle, this indicates an extremely high risk of establishment in the United States.

TABLE 8-1. Interceptions of Khapra Beetle at United States Ports of Entry, 1985-2005

Port Of Entry	Number Of Interceptions
Houston, Texas	199
San Francisco, California	25
Dallas, Texas	14
Los Angeles, California	12
Port Arthur, Texas	6
San Pedro, California	1
San Diego, California	1
Corpus Christi, Texas	1
Denver, Colorado	1
Total	260

Risk of Establishment

According to a rating of pest risk used by Pasek (1998), the likelihood of introduction of khapra beetle to the United States is high. The following factors were considered to determine the rating.

Quantity of Commodity Imported

Rice—an important host material of khapra beetle—is imported in great quantities from India, Pakistan and Saudi Arabia. During the period 1994–1996, over 26,000 metric tons were imported each year.

Untreated seeds are a potential source of khapra beetle, too. For example, commercial shipments of cucurbit seeds require fumigation. But, small quantities of untreated cucurbit seeds and other host materials can be carried in passenger baggage. Information on the quantity of such material is unavailable.

Surviving Post-harvest Treatment

Fumigation with methyl bromide is very effective. However, many potential hosts of khapra beetle can be imported without mandatory fumigation. Also, commodities and associated products or packaging often become infested following harvest while stored in grain facilities or warehouses or during transit in infested containers or vessels.

Surviving Shipment

Khapra beetle is highly likely to survive shipment. It thrives in stored grains, especially in hot, dry conditions. It does especially well in cracked or broken grain, which is common in seed that has been harvested or jostled in

containers. It can remain dormant for several years under less than ideal conditions, and can live through temperatures less than 350ºF for at least short periods.

Detection at Port of Entry

Current methods of detecting khapra beetle rely almost entirely on visual inspection. This can be difficult due to the small size of the pest. Adults are about 1.8 to 3 mm long and about half as wide; adults comprise less than 2% of all stages present. Larvae are smaller (1.6 to 6 mm long), depending on sex and age. Eggs and early instars may be nearly imperceptible and are scattered through host material, while adult and diapausing larvae tend to hide in cracks and crevices and other dark places. All stages can be transported in a variety of materials such as bagging, clothing, household good and vehicles, making it difficult to determine where to inspect for this pest.

Moving to Suitable Habitat

Khapra beetle arriving in permit cargo would likely find suitable habitat upon arrival at grain or food storage facilities and processing plants, which are controlled environments. Khapra beetle arriving in small quantities such as passenger baggage, would likely find suitable environments in people's homes. Khapra beetle in general cargo, holds or stores could be moved to warehouses or other buildings which may provide protected environments.

Finding Suitable Hosts

Khapra beetle arriving in commercial shipments of permit cargo would find ample grain or other plant hosts available in grain and food storage facilities or processing plants. Khapra beetle arriving in passenger baggage or stores would be less likely to find suitable hosts, but could become established if placed with other foods in pantries or kitchens. If khapra beetle larvae are stored in general warehouses, they may survive if the contents of those facilities ever include host material, as they can survive for several years without food until conditions become suitable for further development.

Glossary

APHIS. Animal and Plant Health Inspection Service.

array. Arrangement of traps within and around an establishment or location.

block. Unit of a detection survey in which all survey activities are conducted.

backtrack. Trace the possible movement of khapra beetle infested materials to determine the extent of the infestation. *See also traceback*.

buffer. Survey area that is beyond the targeted area to one-half mile beyond.

cast skin. Exuvium of khapra beetle larva.

commodities. Materials regulated by the quarantine; packaged in sacks, multi-walled paper bags, shipping cartons, or other containers not containing a non-permeable layer such as polyethylene or cellophane film, wax paper, or tar; or such hosts as wheat, barley, shelled corn, milo, mixed feeds; or used sacks, debris; or any seed regulated by the quarantine.

detection, confirmed. Positive identification by a recognized expert.

crepuscular. Active in the twilight hours.

day degree. Measure of physiological time using the accumulation of heat units (degrees) above an insect's developmental threshold for a 24-hour period.

delimiting survey. Determination of the extent of an infestation in an area where an exotic species has been detected. The survey will include adjacent structures and those establishments, conveyances, and containers that might have received infested material or been the source of infested material.

detection. Collection of any life stage of an exotic species.

detection survey. Activity conducted in a susceptible area not known to be infested with khapra beetle.

developmental threshold. Minimum or maximum temperatures that support physiological development for a species.

diurnal. Active during the day.

eclosion. Leaving the egg or the terminal molt into an adult.

epicenter. Initial site of an infestion.

eradication. Elimination of khapra beetle through the application of approved treatments; declared after three years from the date of the last specimen find.

establishment. Infested premises.

distributor. Establishment engaged in assembling, collecting, processing, storing, and further distributing khapra beetle host commodities to other establishments for either retail or wholesale; interstate or intrastate.

distributor, wholesale. Establishment engaged in redistributing to retail outlets, selling to jobbers or retailers rather than consumers.

dealer, used bag. Establishment engaged in collecting, cleaning, repairing, storing, and/or selling burlap or cloth bags.

distributor, bonded warehouse at port. Establishment receiving imports of khapra beetle host materials form foreign countries.

distributor, retail. Establishment engaged in selling commodities direct to the consumer.

dealer, grain. Engaged in buying, selling, storing, or transporting grain; interstate or intrastate.

entomopathogen. Induces illness in insects; includes baculoviruses, nematodes and fungi. May be species-specific; cause no collateral infection of other organisms.

feed lot. Engaged in feeding livestock.

user. Includes chicken ranches, rabbit ranches, dairies, hog farms, race tracks, riding academies, pet shops, nurseries, farms, ranches and residences.

farm storage. Farm structure used primarily for storage of grain, grain products, and seed. May be a crib, bin, silo or other structure of any kind.

exotic. Organism or pest species not native to or historically resident in North America.

fumigation. Application of an approved insecticidal chemical that enters the target pest's tracheal system in volatile form.

generation. Offspring of a parent population that moves through the life cycle together.

ground spray. Insecticide application in droplet form.

hastiseta. Larval body hair in which the shaft is constricted at regular intervals; apex consists of a barbed head. Barbed hairs are found in pairs of tufts, borne on certain abdominal segments.

host. Plant or animal products or by-products that provide for the reproduction of the khapra beetle and any commodity or article with which it is found commonly associated; sometimes collected and retained to rear eggs or larvae.

infestation. Collection of one or more live specimens in any stage of development, when collected under such circumstances that the specimen obviously originated in the premises or area.

infested area. Area surrounding a single detection site at a premises or a group of premises; may be limited to just outside the premises but may extend no further than ½ mile unless circumstances such as nearby premises also are at risk.

monitoring survey. Conducting surveys in an area that has been treated, in order to evaluate effectiveness of treatments.

natural enemy. Living organism found in a natural community that kill, weaken, or inhibit the biological potential of a pest species.

nocturnal. Active at night.

nonmigratory. Species in which individuals typically do not move far from their birthplace.

parasites. Natural enemy of a pest that lives on the host at one or multiple life stages; sometimes kill, but usually merely debilitate the host; often host specific.

parasitoid. Natural enemy of a pest that lives on the host when immature, but are free-living as adults; always kill the host; host-specific or obligate on certain hosts; able to find hosts effectively even when host population numbers are low.

pathogen. Agent, usually microbial, that induces illness.

phenology. Timing of recurrent biological events.

predator. Free-living organisms that consume substantial numbers of prey; generally do not prey exclusively on one target species over the course of a season. When population density of host species is great, predators can be very efficient.

PPQ. Plant Protection and Quarantine.

regulated area. Any warehouse, mill, or other premises in which khapra beetle is found and any surrounding environs up to ½ mile designed as a regulated area in administrative instructions.

regulated article. Products or other articles of any character whatsoever, the movement of which is regulated by quarantine and regulations supplemental thereto.

regulatory survey. Detection or trapping program conducted in and around establishments or other areas in which khapra beetle has been found up to ½ mile depending on circumstances.

residential. *See urban*.

sex pheromone. Chemical substance that is secreted by an insect to attract or to advertise reproductive competence to the opposite sex of the same species.

survey. *See delimiting, detection, monitoring, regulatory surveys.*

traceback. Tracking of all incoming and outgoing commodities through records.

traceforward. Composing a priority list of secondary location warranting inspections.

trap, aerial sticky. Attracts flying insects away from wall-mounted traps that catch crawling khapra beetles.

trap, hanging. Trap for hanging on walls or other vertical surfaces.

trap, surface. Simple bottle trap which is placed in corners or on counter tops; lures and catches insects with a thick oil.

trap, vertical wall mount. Narrow boxlike trap which uses a pheromone and a food lure; mounted on walls; constructed so insects can enter but not exit.

treatment, cold. Exposure of a host product to cold temperatures lethal to a target pest.

urban. Area containing a number of multiple or single family dwellings.

USDA. United States Department of Agriculture.

visual examination. Examination of premises or areas for eggs, larvae, pupae, cocoons, cast skins or other evidence that a particular insect species is present.

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A

Khapra Beetle

Appendix A

Forms

List of Forms

PPQ 391 Specimens For Determination **page A-2**
PPQ 523 Emergency Action Notification **page A-4**

PPQ 391 Specimens For Determination

This report is authorized by law (7 U.S.C. 147a). While you are not required to respond your cooperation is needed to make an accurate record of plant pest conditions. *See reverse for additional OMB information.*

FORM APPROVED
OMB NO. 0579-0010

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE

SPECIMENS FOR DETERMINATION

Instructions: Type or print information requested. Press hard and print legibly when handwritten. Item 1 - assign number for each collection beginning with year, followed by collector's initials and collector's number. Example (collector, John J. Dingle): 83-JJD-001.
Pest Data Section – Complete Items 14, 15 and 16 or 19 or 20 and 21 as applicable. Complete Items 17 and 18 if a trap was used.

FOR IIBIII USE
LOT NO.
PRIORITY

1. COLLECTION NUMBER

2. DATE — MO | DA | YR

3. SUBMITTING AGENCY
☐ State Cooperator ☐ PPQ ☐ Other _____

SENDER AND ORIGIN

4. NAME OF SENDER

6. ADDRESS OF SENDER

ZIP

INTERCEPTION SITE

5. TYPE OF PROPERTY *(Farm, Feedmill, Nursery, etc.)*

7. NAME AND ADDRESS OF PROPERTY OR OWNER

COUNTRY/ COUNTY

PURPOSE

8. REASON FOR IDENTIFICATION *("x" ALL Applicable Items)*

A. ☐ Biological Control (Target Pest Name)
B. ☐ Damaging Crops/Plants
C. ☐ Suspected Pest of Regulatory Concern *(Explain in* REMARKS*)*
D. ☐ Stored Product Pest
E. ☐ Livestock, Domestic Animal Pest
F. ☐ Possible Immigrant *(Explain in* REMARKS*)*
G. ☐ Survey *(Explain in* REMARKS*)*
H. ☐ Other *(Explain in* REMARKS*)*

9. IF PROMPT OR URGENT IDENTIFICATION IS REQUESTED, PLEASE PROVIDE A BRIEF EXPLANATION UNDER "REMARKS".

HOST DATA

10. HOST INFORMATION
NAME OF HOST *(Scientific name when possible)*

11. QUANTITY OF HOST
NUMBER OF ACRES/PLANTS
PLANTS AFFECTED *(Insert figure and indicate* ☐ Number ☐ Percent*):*

12. PLANT DISTRIBUTION
☐ LIMITED
☐ SCATTERED
☐ WIDESPREAD

13. PLANT PARTS AFFECTED
☐ Leaves, Upper Surface
☐ Leaves, Lower Surface
☐ Petiole
☐ Stem
☐ Trunk/Bark
☐ Branches
☐ Growing Tips
☐ Roots
☐ Bulbs, Tubers, Corms
☐ Buds
☐ Flowers
☐ Fruits or Nuts
☐ Seeds

PEST DATA

14. PEST DISTRIBUTION
☐ FEW
☐ COMMON
☐ ABUNDANT
☐ EXTREME

15. ☐ INSECTS ☐ NEMATODES ☐ MOLLUSKS

NUMBER SUBMITTED	LARVAE	PUPAE	ADULTS	CAST SKINS	EGGS	NYMPHS	JUVS.	CYSTS
ALIVE								
DEAD								

16. SAMPLING METHOD

17. TYPE OF TRAP AND LURE

18. TRAP NUMBER

19. PLANT PATHOLOGY – PLANT SYMPTOMS *("X" one and describe symptoms)*
☐ ISOLATED ☐ GENERAL

20. WEED DENSITY
☐ FEW ☐ SPOTTY ☐ GENERAL

21. WEED GROWTH STAGE
☐ SEEDLING ☐ VEGETATIVE ☐ FLOWERING/FRUITING ☐ MATURE

22. REMARKS

23. TENTATIVE DETERMINATION

24. DETERMINATION AND NOTES *(Not for Field Use)*

SIGNATURE DATE

FOR IIBIII USE
DATE RECEIVED
NO.
LABEL
SORTED
PREPARED
DATE ACCEPTED
RR

PPQ FORM 391 *Previous editions are obsolete.*
(AUG 02)

This is a 6-Part form. Copies must be disseminated as follows:
☐ PART 1 – PPQ ☐ PART 2 – RETURN TO SUBMITTER AFTER IDENTIFICATION ☐ PART 3 – IIBIII OR FINAL IDENTIFIER
☐ PART 4 – INTERMEDIATE IDENTIFIER ☐ PART 5 – INTERMEDIATE IDENTIFIER ☐ PART 6 – RETAINED BY SUBMITTER

FIGURE A-1 Example of PPQ 391 Specimens For Determination [side 1]

OMB Information
According to the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information collection is 0579-0010. The time required to complete this information collection is estimated to average .25 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Instructions
Use PPQ Form 391, Specimens for Determination, for domestic collections (warehouse inspections, local and individual collecting, special survey programs, export certification).

BLOCK	INSTRUCTIONS
1	1. Assign a number for each collection beginning the year, followed by the collector's initials and collector's number **EXAMPLE** In 2001, Brian K. Long collected his first specimen for determination of the year. His first collection number is 01-BLK-001 2. Enter the collection number
2	Enter date
3	Check block to indicate Agency submitting specimens for identification
4	Enter name of sender
5	Enter type of property specimen obtained from (farm, nursery, feedmill, etc.)
6	Enter address
7	Enter name and address of property owner
8A-8L	Check all appropriate blocks
9	Leave Blank
10	Enter scientific name of host, if possible
11	Enter quantity of host and plants affected
12	Check block to indicate distribution of plant
13	Check appropriate blocks to indicate plant parts affected
14	Check block to indicate pest distribution
15	• Check appropriate block to indicate type of specimen • Enter number specimens submitted under appropriate column
16	Enter sampling method
17	Enter type of trap and lure
18	Enter trap number
19	Enter X in block to indicate isolated or general plant symptoms
20	Enter X in appropriate block for weed density
21	Enter X in appropriate block for weed growth stage
22	Provide a brief explanation if Prompt or URGENT identification is requested
23	Enter a tentative determination if you made one
24	Leave blank

Distribution of PPQ Form 391
Distribute PPQ Form 391 as follows:
1. Send Original along with the sample to your Area Identifier.
2. Retain and file a copy for your records.

FIGURE A-2 Example of PPQ 391 Specimens for Determination [side 2]

PPQ 523 Emergency Action Notification

According to the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information is 0579-0102. The time required to complete this information collection is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

FORM APPROVED - OMB NO. 0579-0102

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE

EMERGENCY ACTION NOTIFICATION

SERIAL NO.

1. PPQ LOCATION
2. DATE ISSUED
3. NAME AND QUANTITY OF ARTICLE(S)
4. LOCATION OF ARTICLES
5. DESTINATION OF ARTICLES
6. SHIPPER
7. NAME OF CARRIER
8. SHIPMENT ID NO.(S)
9. OWNER/CONSIGNEE OF ARTICLES

Name:

Address:

PHONE NO. FAX NO.

SS NO. TAX ID NO.

10. PORT OF LADING
11. DATE OF ARRIVAL
12. ID OF PEST(S), NOXIOUS WEEDS, OR ARTICLE(S)
12a. PEST ID NO.
12b. DATE INTERCEPTED
13. COUNTRY OF ORIGIN
14. GROWER NO.
15. FOREIGN CERTIFICATE NO.
15a. PLACE ISSUED
15b. DATE

Under Sections 411, 412, and 414 of the Plant Protection Act (7 USC 7711, 7712, and 7714) and Sections 10404 through 10407 of the Animal Health Protection Act (7 USC 8303 through 8306), you are hereby notified, as owner or agent of the owner of said carrier, premises, and/or articles, to apply remedial measures for the pest(s), noxious weeds, and or article(s) specified in Item 12, in a manner satisfactory to and under the supervision of an Agriculture Officer. Remedial measures shall be in accordance with the action specified in Item 16 and shall be completed within the time specified in Item 17.

AFTER RECEIPT OF THIS NOTIFICATION, ARTICLES AND/OR CARRIERS HEREIN DESIGNATED MUST NOT BE MOVED EXCEPT AS DIRECTED BY AN AGRICULTURE OFFICER. THE LOCAL OFFICER MAY BE CONTACTED AT:

16. ACTION REQUIRED

☐ TREATMENT:

☐ RE-EXPORTATION:

☐ DESTRUCTION:

☐ OTHER:

Should the owner or owner's agent fail to comply with this order within the time specified below, USDA is authorized to recover from the owner or agent cost of any care, handling, application of remedial measures, disposal, or other action incurred in connection with the remedial action, destruction, or removal.

17. AFTER RECEIPT OF THIS NOTIFICATION COMPLETE SPECIFIED ACTION WITHIN (Specify No. Hours or No. Days):
18. SIGNATURE OF OFFICER:

ACKNOWLEDGMENT OF RECEIPT OF EMERGENCY ACTION NOTIFICATION

I hereby acknowledge receipt of the foregoing notification.

SIGNATURE AND TITLE:

DATE AND TIME:

19. REVOCATION OF NOTIFICATION

ACTION TAKEN:

SIGNATURE OF OFFICER:

DATE:

PPQ FORM 523 (JULY 2002) Previous editions are obsolete.

FIGURE A-3 Example of PPQ 523 [http://www.aphis.usda.gov/library/forms/pdf/ppq523.pdf]

B

Khapra Beetle

Appendix B

Resources

Trap Supplies

Vertical Wall Mount Trap and Pherocon II Aerial Sticky Trap—
Trécé Incorporated
7569 Highway 28 West
P.O. Box 129
Adair, Oklahoma 74330
T: (831) 758-0204
Order Center: (866) 785-1313
F: (918) 785-3063
E: custserv@trece.com
[http://www.trece.com]

Yellow Delta Trap—
ISCA Technologies, Inc.
P.O. Box 5266
Riverside, CA, 92521
T: (909) 686-5008
F: (815) 346-1722
[http://www.iscatech.com/exec/index.htm]

Entomology Supplies—
Great Lakes IPM, Inc.
10220 Church Road
Vestaburg, MI 48891-9746
T: 1-800-235-0285
F:(989) 268-5311
[http://www.greatlakesipm.com/]

Scentry Biologicals, Inc.
610 Central Avenue
Billings, Montana 59102
(406) 245-3016 (800) 735-5323
F: (406) 245-2790
Email: scentry@imt.net
[http://www.scentry.com/]

BioQuip Products, Inc.
2321 Gladwick Street
Rancho Dominguez, CA 90220
T: (310) 667-8800
[http://www.bioquip.com/]

Wards Natural Science
PO Box 92912
Rochester, NY 14692-9012
T: 800-962-2660
[http://www.wardsci.com/]

Carolina Biological Supply Co.
2700 York Road
Burlington, NC 27215-3398
T: (800)334-5551
[http://www.carolina.com/]

Beneficial Organisms

Cornell University—Weedon, C.R., A.M. Shelton, Y. Li, and M.P. Hoffmann. Biological Control: A Guide to Natural Enemies in North America. [http:/www.nysaes.cornell.edu/ent/biocontrol/]

Association of Natural Biocontrol Producers
10202 Cowan Heights Drive
Santa Ana, CA 92705
T: (714) 544-8295
[http://www.anbp.org/]

North Carolina State University—
Biological Control Virtual Information Center. Center for IPM. North Carolina State University.
[http://cipm.ncsu.edu/ent/biocontrol/]

Predicting Insect Development

University of California Statewide Integrated Pest Management Program 2003 [http://www.ipm.ucdavis.edu/WEATHER]

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

NAPPFAST
[http://www.nappfast.org/index.htm]

Local Cooperative Extension Service

Private, State, university, or industry sources

Cornell University
Weedon, C.R., A.M. Shelton, Y. Li, and M.P. Hoffmann. Biological Control: A Guide to Natural Enemies in North America. [http://www.nysaes.cornell.edu/ent/biocontrol/]

Insecticides

Methyl Bromide Meth-O-Gas® Q—
Great Lakes IPM, Inc.
10220 Church Road
Vestaburg, Mi 48891-9746
T: (989) 268-5693 / (989) 268-5911
F: (989) 268-5311

Neem—
M/S RYM EXPORTS
Administrative Office:
1, Apollo Chambers,
Mogra Lane, Andheri (e)
Mumbai–400069, India
T: +91 22 30956539, 28210025
F: +91 22 56991480
E: info@neemfromindia.com

Tempo SC Ultra (Cyfluthrin)—
Professional Pest Control Products
6920 Pine Forest Road
Pensacola, Florida 32526
T: 1-800-434-4555
E: pest@pestproducts.com

Bayer Environmental Science
95 Chestnut Ridge Road
Montvale, NJ 07645
[http://www.bayerprocentral.com]

Phosphine—
DEGESCH America, Inc.
Gardex Chemicals, Ltd.
P. O. Box 116 7 Meridian Road
Weyers Cave, Virginia 24486
T: 540-234-9281/800-330-2525
F: 540-234-8225

Northwest Wholesale Incorporated
P.O. Box 1659
1567 Wenatchee Ave.
Wenatchee, WA 98801
T: 509-662-2141, 800-872-2501

Morris Grain Company
1121 Atlantic Ave
Morris, Minnesota 56267
E: mgc@hometownsolutions.net

Fumigation Equipment

Power Plastics Ltd.
Station Road, Thirsk,
North Yorkshire, YO7 1PZ
United Kingdom
T: 44(0)870 850 8067
F: 44(0)870 850 8068
E: sales@powerplastics.co.uk

Uniweld Products Customer Service
2850 Ravenswood Road
Fort Lauderdale, FL 33312 - 4994
E: info@uniweld.com

AFC International, Inc.
PO Box 894, DeMotte, IN 46310
715 SW Almond St., Ste. C
DeMotte, IN 46310
E: sales@afcintl.com

Miscellaneous

National Grain and Feed Association
1250 Eye St., N.W., Suite 1003
Washington, D.C. 20005-3922
T: (202)289-0873
F: (202)289-5388
E: ngfa@ngfa.org

Environmental Compliance

Environmental Monitoring, Categorical Exclusions—

USDA–APHIS–PPQ–Emergency and Domestic Programs
Environmental Compliance
4700 River Road, Unit 150
Riverdale, MD 20737
Telephone: 301-734-8247

Environmental Services

FIFRA, ESA, Environmental Assessments—

USDA–APHIS–Policy and Program Development
Environmental Services
4700 River Road, Unit 149
Riverdale, MD 20737
Telephone: 301-734-8565

C

Khapra Beetle

Appendix C

Hosts

TABLE C-1 Preferred Hosts of Khapra Beetle

Common name	Scientific name	Reference
Almond	*Prunus dulcis*	Szito, 2005
Barley	*Hordeum vulgare*	Hinton, 1945; Lindgren *et al.*, 1955; Szito, 2005
Coconut	*Cocos nucifera*	Lindgren *et al.*, 1955
Corn	*Zea mays*	Hinton, 1945; Lindgren *et al.*, 1955; Szito, 2005
Cowpea	*Vigna unguiculata*	Szito, 2005
Garbanzo	*Cicer arietinum*	Szito, 2005
Gram	*Vigna radiata*	Lindgren *et al.*, 1955
Oat	*Avena sativa*	Hinton, 1945; Szito, 2005
Pea, garden	*Pisum sativum*	Szito, 2005
Peanut	*Arachis hypogaea*	Szito, 2005
Pecan	*Carya illinoinensis*	Anon., 2005: Szito, 2005
Pistachio	*Pistacia* spp.	Lindgren *et al.*, 1955
Beans	Various	Lindgren *et al.*, 1955
Peas	Various	Lindgren *et al.*, 1955
Lentil	*Lens culinaris*	Lindgren *et al.*, 1955; Szito, 2005
Oak	*Quercus* spp.	Anon., 2005
Rice	*Oryza sativa*	Hinton; Lindgren *et al.*, 1955; Szito, 2005
Rye	*Secale cereale*	Hinton, 1945
Sorghum	*Sorghum bicolor*	Lindgren *et al.*, 1955; Szito, 2005
Soybean	*Glycine max*	Szito, 2005
Walnut	*Juglans* spp.	Lindgren *et al.*, 1955, Anon., 2005; Szito, 2005
Wheat	*Triticum aestivum*	Hinton, 1945; Lindgren *et al.*, 1955; Szito, 2005

TABLE C-2 Other Hosts of Khapra Beetle

Common Name	Scientific Name	Reference
Alfalfa	*Medicago sativa subsp. sativa*	Szito, 2005
Lima bean	*Phaseolus lunatus*	Szito, 2005
Linseed	*Linum usitatissimum*	Munroe, 1940
Raisin	*Vitis* spp.	Szito, 2005

TABLE C-3 Potential Hosts of Khapra Beetle

Oak	Ash	Beech
Basswood	Birch	Black cherry
Black walnut	Black butternut	Cottonwood
Elm	Hackberry	Hickory
Holly	Locust	Magnolia
Maple	Poplar	Red alder
Royal paulownia	Sassafras	Sweetgum
Sycamore	Tupelo	Willow
Yellow poplar		

D

Khapra Beetle

Appendix D

Historical Survey Images[1]

FIGURE D-1 Khapra Beetle Larvae and Adults on Burlap

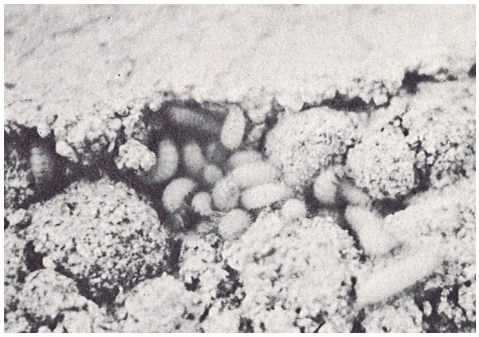

FIGURE D-3 Khapra Beetle Larvae in Cement Block

FIGURE D-4 Probing Cracks in Concrete Wall for Khapra Beetle

FIGURE D-2 Sifting Bulk Grain in Search of Khapra Beetle

1 Source: USDA–ARS. 1959. Khapra Beetle Manual. USDA–ARS–Plant Pest control Division, Oakland, California: 1-40.

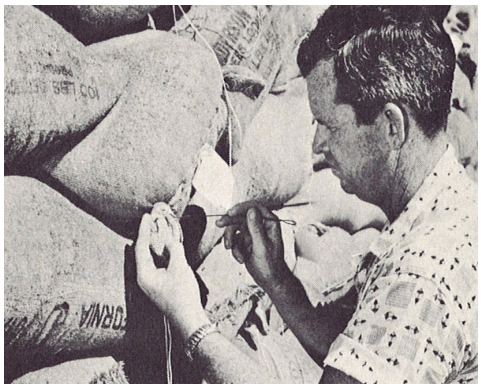

FIGURE D-5 Examining Seams of Sacks for Larvae

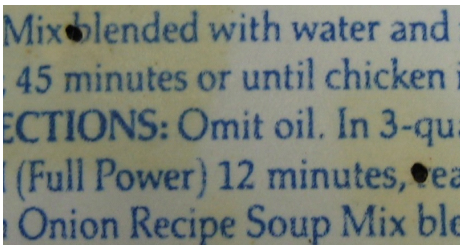

FIGURE D-7 Larval Entry Holes in Bag of Soup Mix

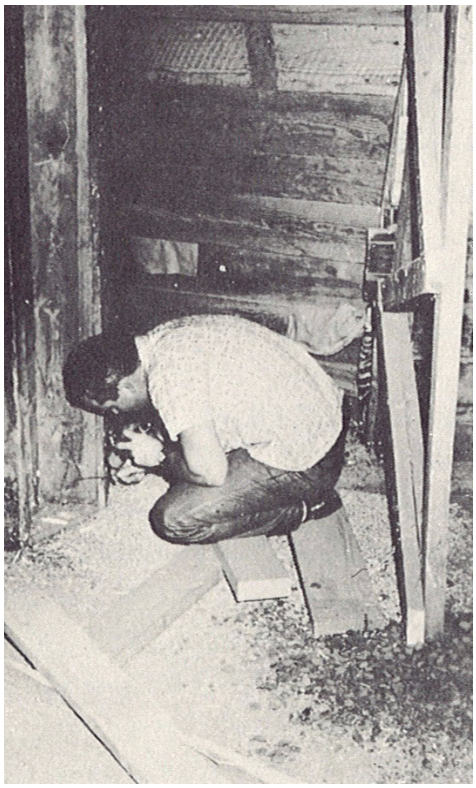

FIGURE D-6 Concrete and Wood Construction Joints offer Good Hiding Places for Khapra Beetle

FIGURE D-8 Examining Packaged and Bulk Pet Foods in Local Pet Stores

FIGURE D-9 Larval Entry Holes in Bag of Soup Mix

FIGURE D-11 Examining Grain Storage Bulkhead Supports

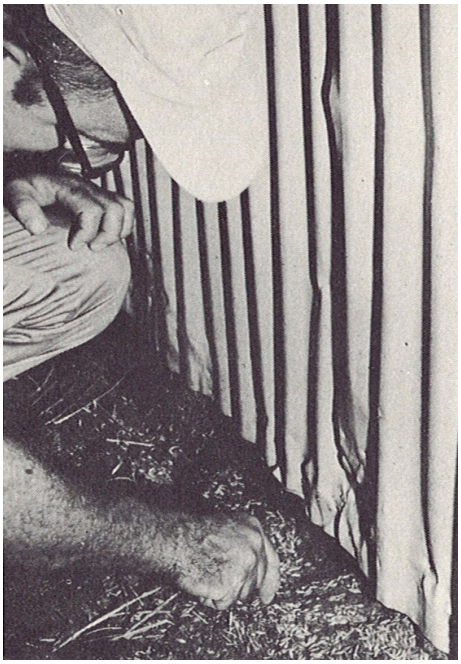

FIGURE D-10 Examining Floor Area Outside Grain Storage Warehouse

E

Khapra Beetle

Appendix E

Technical Control

Contents

Introduction **page E-1**
Pesticide Resistance **page E-1**
Conventional Treatment **page E-2**
Alternative Treatment **page E-6**
Cultural Control **page E-7**
Biological Control **page E-8**
Other Strategies **page E-10**

Introduction

Use *Appendix E Technical Control* as a source of additional information concerning the control of khapra beetle. Review **Introduction on page 6-1** before applying any control measure.

Pesticide Resistance

Khapra beetle shows signs of resistance to some common pesticides such as phosphine and malathion, probably due to overuse and improper fumigation procedures or other factors (Pasek, 1998). Khapra beetle is highly resistant to the contact insecticides in general use; even lethal doses are very slow to kill this pest. Khapra beetle is highly resistant to DDT, and mixtures containing Valone (isovaleryl indandione), with pyrethrins or gamma-BHC, have only moderate synergism even with refined kerosene as the spray carrier (Lingren *et al.*, 1955).

Methyl Bromide

Some claims of methyl bromide resistance have been made (Nautiyal, 2003), but have not been verified. Of greater concern is the role of methyl bromide as an ozone depleter: it may one day curtail the use of this pesticide.

Permethrin

Resistance to permethrin has not been reported.

Malathion

Khapra beetle developed resistance to malathion in Tunisia by 1967 (Pasek, 1998). Cufluthrin, a synthetic pyrethroid, may be substituted for malathion.

Phosphine

An early study found that Khapra beetle larval mortality in a resistant strain in India averaged 5–12% compared to 84–94% in a susceptible strain (Borah & Chahal, 1979). More recently, resistance ratios to phosphine fumigation in India have ranged from 10–47.9 (Udeann, 1990).

Conventional Treatment

When using any treatment, follow all instructions in *PPQ Treatment Manual* (http://www.aphis.usda.gov/import_export/plants/manuals/ports/treatment.shtml).The *Manual* covers chemical treatments, and the following fumigations:

- Bulk
- Container
- Tarpaulin

The *Manual* does **not** cover structural fumigation. If structural fumigation is required or urgently advised, consult the following publication, provided all clearances are given.

Publication	University of Minnesota Extension Service Manual on Private Stored Grain Fumigation Training Manual, 2001.

Primary Fumigants

Methyl Bromide

Methyl bromide will remain the primary treatment in the United States **except** when pesticide resistance, or proximity to human populations, makes its use obsolete.

Phosphine

Where it is **impractical** to fumigate with methyl bromide, phosphine may be used. Treatment with phosphine requires more time to kill target pests, compared to methyl bromide (3–7 days *vs.* 2–24 hours, respectively). Longer treatment time will lead to greater overall costs.

Other Fumigants

The following fumigants are potential replacements for methyl bromide and phosphine in the event that resistance is encountered.

Sulfuryl Fluoride

Currently, sulfuryl fluoride (Vikane®) is **not** approved as a fumigant by USDA. However, sulfuryl fluoride is commonly used to control pests of stored products. Check with staff at USDA–Center for Plant Health Science and Technology (CPHST) to determine if treatment schedules are available for this compound's use on structures or other infested items.

Ethylene Oxide

Ethylene oxide (EO) treatment was approved for treatment of khapra beetle in spice in 1981, but was **not** added to the *PPQ Treatment Manual* at that time since a *Notice of Rebuttable Presumption Against Registration* of EO was issued in the *Federal Register* in 1978. An EPA review would need to be completed prior to its use (McNally, Acting Director, PPQ–National Program Planning Staff, July 21, 1981, *pers. comm*.).

Ethyl Formate

Currently, ethyl formate is **not** approved as a fumigant by USDA. Ethyl formate is used as a fumigant in Australia on dried fruit. Recently, the usefulness of this fumigant in disinfesting stored commodities was re-evaluated. Ethyl formate has a very rapid action and this property could make it useful in rapid disinfestation.

The response of *Sitophilus oryzae* (L.) adults to ethyl formate in a sealed system in preliminary experiments was studied. *Sitophilus oryzae* is generally one of the more difficult stored-product beetles to kill by fumigation. The insects were exposed to three different dosages of ethyl formate for a range of exposure times with a 50% filling ratio of wheat. Ethyl formate required a very short time to kill all adults for the range of concentrations and times studied. Exposures of 12 minutes and 2 hours achieved 100% mortality for concentrations of 340 and 210 g/m^3, respectively. For 130 g/m^3, an exposure of 3 hours achieved 94% mortality. These results are consistent with the requirements for a potential replacement for methyl bromide as a rapid disinfestant.

Ethyl formate has the advantages of rapid loss from the gaseous phase and breakdown by the grain. The high flammability of ethyl formate, which may make its application a potential problem, can be significantly reduced by its application in water. The rapid kill makes ethyl formate suitable for treatments in conditions where long-term gas retention is not possible, for example, the disinfestation of machinery, work-spaces and surfaces (Damcevski and Annis, 2000).

Hydrogen Cyanide

Hydrogen cyanide (HCN) is **not** currently approved as a fumigant by the USDA. Hydrogen cyanide was used as the fumigant of choice for mills in the first part of the last century, and was then replaced by methyl bromide. Consequently, it should now be re-evaluated as a potential alternative to methyl bromide. However, knowledge about HCN's efficacy as a fumigant is outdated and does not conform to the notion of concentration time (Ct) product.

Rambeau *et al.* (2000) conducted a study to determine the biological efficacy of HCN in terms of Ct product for the different stages of three of the most prevalent species infesting mills and food manufacturing premises, the confused flour beetle (*Tribolium confusum)*, the red flour beetle (*Tribolium castaneum)*, and the Indianmeal moth (*Plodia interpunctella)*. In addition, the granary weevil (*Sitophilus granarius)* was studied in the adult stage only, since this is the only stage present in mills.

Two series of trials were carried out: one consisted of dose-trials to define the relationship between Ct product and insect mortality without presence of a rearing medium; the other consisted of trials in which inserts were placed at different depths in flour to measure HCN efficacy in penetrating residual heaps of flour.

The findings on the different stages of each species (eggs, young larvae, old larvae, pupae and adults) show that the Ct product required to obtain a LD90 ranged from 1–4 g.h/m^3, according to developmental stage, this being very low when compared to methyl bromide. Nevertheless, in contrast to methyl bromide, large differences were found between the species as shown in the high tolerance of granary weevils to HCN. The poor penetration of HCN into flour is due to significant sorption. Consequently, to be effective against *T. confusum* adults buried in flour, a Ct product as high as 60 and 100 g.h/m^3 is required to kill this species at depths of 10 and 15 cm, though it does not kill *S. granarius*.

In practice, the Ct product needed to kill all stages of these major mill and food factory pests should be around 10 g.h/m^3, though to obtain HCN penetration and kill insects at a depth of about 10 cm in flour heaps, the prevailing Ct products should be around 60 g.h/m^3. This implies that the corresponding initial dose should be 5 g.h/m^3, taking into account the presence of minor leaks.

Nitrogen Gas

Nitrogen is **not** currently approved as a fumigant by USDA. However, it might be a good alternative to methyl bromide. In Williams *et al*. (1980), all khapra beetle larvae were killed in a five day exposure time period.

Heat

Heat treatment is approved by the USDA as a nonchemical treatment for those commodities, such as feeds and milled products, that can be heated as part of the processing procedure, or other commodities that can be subjected to heat.

Dosage Schedule—The commodity shall be considered free from live khapra beetles if it reaches 180^{0}F during any part of its processing, or if it is held at 150^{0}F or above for a total of 7 minutes. The commodity must move through, or be turned over in the heating chamber, or otherwise manipulated to insure that all parts of it reach the required temperature (USDA–ARS, 1959).

Heat + CO_2

This treatment has **not** been approved by USDA. This combination treatment permits a lower heat level, thus allowing additional commodities to be processed. At 113^{0}F, with a CO_2 concentration of 90%, the exposure time is 7.8 hours (Rindner *et al*., 2000).

Irradiation

USDA has **not** approved treatment with irradiation. However, irradiation has several advantages over fumigation as a quarantine treatment, some of which are general in nature and some of which are peculiar to the khapra beetle. The major advantage of irradiation over fumigation is that a lethal dose can usually be delivered in minutes, or at the most an hour or two, depending on

the type, size and configuration of the irradiator and the dose rate. Thus, when unloading cargo, these could probably be irradiated during the unloading process (Brower, 1995).

The irradiation of at least one grain or cereal or processed grain product has been approved by 22 countries with rice being the most commonly approved cereal. Irradiation at the disinfestation dose prevents grain and cereals from sprouting, an advantage or disadvantage, depending on final product use.

Like fumigants, irradiation does not confer residual protection from re-infestation. Bagged grains or cereals require reasonably good packaging to prevent re-infestation (Marcotte, 2001).

Commercial Practice—Grains, cereals and pulses, either in bulk or bagged, can be irradiated, but several practical barriers to the irradiation of bulk grains exist. Currently, bagged rice is commercially irradiated in Indonesia. Mixed cereal products are irradiated in France and South Africa. Both gamma equipment containing radioisotopes such as cobalt 60 and electron beam accelerators can be used to disinfest these commodities, depending on whether the product is available bulk or bagged and other considerations (Marcotte, 2001).

Sensitivity—Pests and life stages vary in sensitivity to radiation. The bean weevils (bruchids) seem to be the most sensitive, but the rice, corn and granary weevils (curculionids) are almost equally sensitive. The sawtooth grain beetle, the merchant grain beetle and others in this group (cucujids), and most of the flour beetles (tenebrionids) are intermediate in sensitivity. The cigarette beetle, and other anobiids, the khapra beetle and other dermestids and the spider beetles (ptinids) form a series with increasing resistance. The depressed flour beetle (*Palorus subdepressus)* Wollaston, a tenebrionid, is the most resistant stored product beetle. It reproduced after 0.3 kGy (Marcotte, 2001).

Radiation Dose Required—Generally, for commercial applications, the dose of radiation is chosen to result in the extent of pest control or kill required. For grains and cereals, a minimum dose of 0.5 kGy will control even the most resistant beetle (and weevil) species and the immature stages of moths. At this dose, some resistant adult moths may remain fertile, but their progeny would be sterile. Irradiation at this dose results in a good quality product with little or no change in functional properties of the grain or cereal. Higher doses (2–3 kGy) can result in death of more resistant pests within 24 hours, but at this dose there may be starch changes that affect later food processing applications. For rice pests, 0.40–0.50 kGy can be used as the minimum dose for pest control. (Use the lower dose if the pest of concern is rice weevil.) The recommended maximum dose for rice is 2–3 kGy to prevent quality problems.

Wheat flour is more sensitive to radiation damage, but it is also not usually infested with anything but pest eggs, the most sensitive life stage. For this reason, 0.25 kGy is recommended as the minimum dose, with a maximum dose of 0.75 kGy (Marcotte, 2001).

Impact of Irradiation on Product Quality—Irradiation at the doses used for disinfestation does not affect product quality or the quality of processed foods made from grains and cereals. Some grains or cereals will show dose related starch changes at higher doses, so care should be taken to ensure minimum to maximum dose uniformity is not excessively large (e.g. < 3:1). Irradiated grains and cereals will not sprout, an advantage or disadvantage depending on the intended use.

The irradiation of wheat flour at dose ranges higher than 1 kGy is likely to result in undesirable flavor changes. Several studies reported on nutrient value effects of grain and cereals and processed products. To summarize, nutrient effects in mainly carbohydrate foods are well understood. Irradiation at disinfestation doses does not cause nutritionally significant changes to the nutrient value of grains and cereals. At higher doses there are some changes to vitamin content, in the B vitamins particularly (thiamin) and also to Vitamin E (Marcotte, 2001).

Irradiation only covers bagged and bulked commodities. It does not cover chamber, container, or structure treatment.

Alternative Treatment

Evaluate the following alternative treatments as needed.

Plant Derived

Lemongrass Oil

Shulka *et al*. (2000) screened some essential oils against the following stored-product insects: *Rhyzopertha dominica, Trogoderma granarium, Sitophilus oryzae, Corcyra cephalonica* and *Ephestia cautella*. The oil of lemongrass (*Cymbopogon flexuosus* (Steud.) Wats. [Poaceae]) was the strongest toxicant. This oil required only 6–8 hours to kill insect pests. In addition to its broad pesticidal spectrum, the oil is thermo-stable and persisted up to 36 months.

Further tests were conducted along with *in vivo* investigations. By observing the maximum phyto-tolerant concentration, formulations were developed. Further investigations have been carried out on various toxicological, organoleptic and pharmacological parameters, to determine the minimum effective dose of the formulation. A preliminary comparison of some common characteristic features of the formulated herbal fumigant with some synthetic fumigants showed that the herbal formulation is superior.

After successful multi-site trials, Shulka *et al*. (2000) recommended that the fumigant formulation of lemongrass oil could be commercialized for the management of stored-product pests.

Neem (*Azadirachta indica* A.Juss.)

Neem EC—RYM Exports (2005) has claimed that Neem EC is effective against khapra beetle as well as many other insects. There is some indication that burning neem leaves will fumigate stored goods, but no details have been given. The product may be used as a supplemental treatment.

Fumigants

Biogas

The use of biogas as a fumigant, with methane and carbon dioxide as its main components, may achieve good results in the control of stored product pests. It has been successfully tested and has killed 100% of *Sitophilus oryzae, Rhyzopertha dominica, Trogoderma granarium and Tribolium castaneum* after six days' exposure to biogas in PVC bins (Bennett, 2003).

Other Alternatives

Protozoa

Mattesia trogodermae—*Mattesia trogodermae* is a protozoan specific for species of *Trogoderma*. It is not pathogenic in certain vertebrates, and is fairly easy to produce in usable quantities. It may be introduced into *Trogoderma* populations by contaminating the males at bait stations and allowing them to subsequently rejoin the population to eat food, contaminating the food of other adults and larvae and to be consumed in turn when they die by the larvae and then contaminating these larvae in turn.

Bait stations may be introduced at various locations in a granary or even where small populations occur. An alternative is to leave treated food at various locations where khapra beetle is known to occur.

This approach is still under research and will not eradicate a population, but will undoubtedly control it (Henry, 1981).

Vitamins

Biotin (B-complex vitamin)—In a few insect species, an excess of biotin will cause a reduction in the fertility of those insects. Tests with khapra beetle showed that they were indeed adversely affected. High doses of Biotin, such as 0.5% and 1.0%, inhibited further development of the larvae, ultimately causing complete mortality.

Exactly how this could be applied in stored product situations is still not clear. This approach is still under investigation (Sehgal *et al*.,1970).

Cultural Control

Cultural control may be subject to obtaining environmental documentation under the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA). Check with the program manager to make sure such documentation is in order.

Host Destruction

In situations with a very limited area of infestation, if khapra beetle is present and persistent in nuts under nut trees or in peanuts, either cultivated or wild, use the following means to destroy material:

- Apply an herbicide to the host.
- Disk or plow the host under the soil.

- Remove, bury or incinerate the host.

In these cases, all host material must be destroyed completely to avoid regrowth of the host and subsequent reappearance of nuts or peanuts.

Sanitation

Carry out sanitation in and around structures where hosts are present within the regulated areas. Sanitation may include the following:

- Free the surface area of all debris around structure by raking or sweeping debris under tarpaulin before treatment.
- Harrow or disc the surface area.
- Spray the surface area with malathion.
- Thoroughly clean inside of structures and dispose of any debris by burning, discing or burial in an approved landfill.
- Inspect vehicles, trucks, wagons, and other vehicles used in and around structures or used to transport host material to avoid accidental movement of host material with eggs, larvae, or adults of khapra beetle.

Flooding

Flooding is another control option, if a field or surface area around a property can be flooded. Water should flood the site for at least two days.

Biological Control

Biological control agents are useful for suppressing pest populations. Some biological control agents are sufficiently effective to eradicate their host or prey. Rigorous screening of non-target organisms needs to be tested in order to assure safety of release with minimum risk. Proper permitting must be obtained prior to testing in the United States. Biological control agents can be effective alone or when used in combination with other control techniques. They are characterized as predators, parasites, parasitoids or pathogens.

Laelius pedatus

Laelius pedatus is a parasitoid of the khapra beetle. *L. pedatus* is native to North America and ranges from the eastern United States, west to Colorado and south to Mexico, and is known in Brazil (Mertins, 1980). Al-Kirshi (1999) studied the efficacy of this parasitoid in controlling khapra beetle, *T. angustum* and *A. verbasci*. The venom of *L. pedatus* caused 60% larval mortality in khapra beetle. At a parasitoid: host ratio of 1:25, *L. pedatus* reduced two populations of

khapra beetle by 75–80% within 6–8 weeks. The wasp was found to penetrate into wheat and successfully parasitize host larvae of khapra beetle to a depth of 3 feet.

While these results show promise, *Laelius pedatus* has not yet become commercially available. However, there has been some research for augmentative biological control of pests of stored products and any progress would need to be looked at if biocontrol options are to be considered for a program.

FIGURE E-1 *Laelius pedatus* Laying Eggs on a Beetle Larva (Mayhew & Godfray, 1997) [Image courtesy of P.J. Mayhew]

Planning a Biological Control Program

Biological control of African and Asian citrus psyllids requires further investigation to be effective. The following guidelines should be followed when planning a biological control program:

1. Identify an effective biological control agent with the potential to control the target pest or pests.
2. Locate a reliable source of the biological control agents.
3. Determine the following:
   - Release rates
   - Synchronization with the host
   - Temperature and other environmental requirements
   - Appropriate host plants
4. Coordinate their introduction with other strategies in a pest management program. For example, identify compatible pesticides and cultural practices.

Other Strategies

Attract and Kill Trapping

Install vertical wall-mount traps at the rate of one per 10 feet in a structure, or on every nut bearing tree outdoors. **See Trapping on page 3-9** for more information on assembly. At this intensive level, the traps could be considered a control device and therefore a Section 18 exemption will be needed. **See Laws Pertaining to Pesticide Use on page 6-1** for more information on exemptions.