Management of Stored Grain Insects, Part II

Identification and Sampling of Stored Grain Insects

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Why Identify Stored Grain Insects?

Farmers are generally aware that an infestation of weevils and lesser grain borers can cause significant quality and monetary loss if left uncontrolled. These insects often are classified as "primary grain pests" because they attack and destroy whole, undamaged grain.

The immature stages occur inside the kernels, thus a "hidden" infestation may develop. "Secondary grain pests," the so-called "bran bug groups," include most other grain-attacking beetles. These insects frequently cause more serious losses where some type of kernel damage precedes their establishment.

Larvae of the Indian meal moth and miscellaneous pests, including psocids and grain mites, should be recognized. They can cause storage problems directly, may indicate that related problems exist, and may be commonly encountered when sampling infested grain.

Significance of infestations depends on the species, density, and ultimate plans for the grain. Insect infestations may indicate a more serious problem than first suspected. For instance, an infestation of foreign grain beetles may not seem important because that beetle is a fungus feeder rather than a grain-feeding insect.

In reality, significant numbers of fungus feeding beetles of any species should be adequate warning that a moisture management problem probably exists in the grain mass—because fungi typically are restricted to higher moisture environments.

Many insects are not able to cause significant direct damage to the grain they live in. But that does not mean they can be ignored. Their fecal material and hard body parts can still contaminate processed foods destined for human consumption. The most serious fragment contributors are those species that have at least one stage which develops within the grain kernels. Even if every individual is killed with a fumigant, mechanical sieving will not remove these insects.

Overall weight loss on a kernel basis can vary, depending on the species of stored grain insect. Some species riddle each kernel they attack; others feed primarily on the living portion of the seed (embryo or germ). Proper sampling and identification during storage help the manager recognize problems early and thereby prevent further damage.

Selecting the most appropriate curative or preventative action from among available alternatives is not easily accomplished, especially when the type of insect present is not known.

For example, if insects that feed inside the kernels are already present in significant numbers, a surface protectant applied as a dust or spray would not be the best management option. In this situation, the penetrating vapors of a fumigant are needed to stop further damage.

Usually a combination of tactics will provide the most reliable protection. Several types of "insect traps" are available to help in early detection of developing infestations. Dichlorvos-impregnated pest strips (Vapona) may be appropriate, if available, in many situations where Indian meal moth invasions are expected.

Some species are less able to tolerate grain temperatures near freezing than others. Proper aeration as air temperatures drop in the fall could lessen the amount of future darmage and may possibly eliminate the infestation entirely. Because insect responses to these management strategies vary, proper identification is very important.

Major Insect and Related Pests Infesting Kansas Stored Grain

At least 60 species of insects and related arthropods can infest stored grain. Less than 14 are typically associated with most of the concern, damage, and resulting economic losses encountered throughout Kansas. The drawings and discussions that follow should aid in identification efforts.

Descriptions are limited in most cases to adults because they are the most obvious and readily observed stages. The characteristically small size of these pests means that magnification is usually necessary before important structures can be viewed. Refer to the stylized insect (Figure 1) for help in locating and interpreting unfamiliar words in the descriptions.

Because positive identification may still be uncertain, the descriptions also review the appearance of damaged grain and other species-specific signs (webbing, odors, etc.) useful in confirming the identification and seriousness of an infestation.

Lesser Grain Borer - Figure 2

Head: downward facing, not visible when insect is viewed from above. Body: polished dark brown to black in color, 1/10 to 1/8 inch long, cylindrical in cross section, about 1/32 inch wide, many small pits on the wing covers. Antennae terminate in a loose three-segmented club. A strong flier, primarily a pest of whole grains.

Eggs: deposited outside the kernel, either singly or in clusters of up to 30, with 300 to 500 eggs laid per female lifetime. The majority of larvae will chew into a kernel to feed and complete their development.

Adults and larvae possess powerful jaws used to riddle the grain, creating large, irregularly-shaped holes.

Large amounts of dust are created by this insect. Heavily infested grain has a characteristic sweetish, musty odor.

Lesser grain borers can fly, attack whole grain, tolerate grain moisture levels down to 7 or 8 percent, tolerate higher temperatures, and seem more resistant to some insecticides than many other stored grain insects.

Rice and Maize Weevils - Fig. 3
Adults: dull reddish-brown, 3/32 inch long, typical weevil snout with elbowed antennae. Capable of flight. The pronotal pits on the rice and maize weevils are numerous, closely spaced, and nearly round. Granary weevil pronotal pits are fewer, further apart and are elliptical. Rice and maize weevils have two light red to yellow spots on each wing cover. Larvae feed mostly within kernels.

Eggs are laid within a hole chewed into the seed. Larvae develop internally, destroying 25 to 30 percent of a wheat kernel. Holes in grain are more uniformly rounded than those created by lesser grain borers. Development from egg to adult requires about one month in 70 to 85° F grain.

Cadelle - Figure 4
Adults: ca. 1/3 inch long, black, flattened, elongated, with a noticeable constriction or waist between the first and second set of legs. Front outer corners of the pronotum project forward. Larva: dirty or chalky-white, approaching 3/4 inch long, relatively robust, with a black head. Two dark, horny projections arise from a terminal abdominal plate. Two other dark plates occur on the body just behind the head.

Seed germ damage. Larvae and adults bore into the wood where they can survive for many months.

Flat Grain Beetle - Figure 5
Adult: flattened, oblong, reddish-brown in color, and ca. 1/16 inch long. Antennae: one-half to two-thirds as long as body. The pronotum of the female is nearly square and does not taper as much as in the rusty grain beetle.

Highest populations develop in high moisture grain. Common early invader. Prefers to feed on fines and on the germ. Apparently cannot survive on undamaged, dry whole grain. Prefers poor condition grain; rice weevil attacked grain often supports very large populations of this insect.

Rusty Grain Beetle - Figure 6
Adults: flattened, oblong, reddish-brown in color, ca. 1/12 inch long. Male antennae are not more than one-half body length. Prothorax narrows slightly at the rear.

Eggs: deposited singly, usually in cracks or furrows on the grain surface. This insect probably feeds only on broken grain and contributes to contamination via body fragments.

Sawtoothed Grain Beetle - Fig. 7
Sawtoothed grain beetles are very flat, narrow, dark-brown insects, ca. 1/10-1/8 inch long. Easily recognized by the six sawtooth-like projections on the pronotum edges. Runs rapidly but probably does not fly. Antennal shape resembles a slightly swollen club.

Dust, fines, and kernels that have been damaged by other insects or by mechanical harvesting are acceptable food sources. The germ of intact grain may be attacked.

Foreign Grain Beetle - Figure 8
Very small, reddish-brown beetles, about 1/12 inch long. Easily recognized by the small rounded lobe on the front corners of the pronotum. Antennae have a three-segmented club.

Often found in large numbers within a month or two after new grain is put in a bin. Primarily a mold and fungi feeder. Presence usually indicates unacceptably high moisture conditions.

Mealworms - Figure 9
"Mealworm" refers to the larvae of any of several species of closely related beetles. Adults may be dull or shiny (depending on the species) dark-brown to black beetles; 1/4 inch to more than 1/2 inch in length. Grooved wing covers. Larvae may exceed 1 inch long, wireworm-shaped, usually somewhat yellowish in color.

Direct damage is largely limited to undistrubed, deteriorating grain. Grains that are heating, spoiling, or not in good storable condition are most commonly attacked.

Red and Confused Flour Beetles - Figures 10 a, b
Adults: uniformly reddish-brown, ca. 1/10 inch long. Last three segments of the red flour beetle's antennae abruptly enlarge to form a club-shaped tip. Confused flour beetle antennae gradually enlarge at the tip. The sides of the confused flour beetle head capsule are notched at the eyes so that a visible ridge is present. This ridge is absent in the red flour beetle. When viewed from below. the eyes of the red flour beetle are separated by less than two eye diameters while those of the confused flour beetle are separated by more than three eye diameters. Red flour beetles fly but confused flour beetles do not.

Not usually able to chew through the outer coating of grain unless the moisture content is above 12 percent. However, other grain-feeding insects and mechanical harvesting injury provide a source of cracked kernels and dust food for them. The adults have glands on the abdomen and thorax which release a pungent gas when the insects are irritated. This, in turn, may produce a very undesirable odor in the grain. Contamination also occurs from the accumulation of dead bodies and waste products.

Indian Meal Moth - Figures 11 a,b
The Indian meal moth is the only moth commonly found in stored grain in Kansas.* The adult appears to have an obvious snout and measures about 2/5 inch long with a 3/5-inch wingspan. The front wings are somewhat reddish-brown with a coppery luster on the outer two-thirds gradually fading to whitish-gray near the body. Hind wings are uniformly silver gray and have a long trailing fringe. Older moths have less distinctive markings as they lose their scales. Adults usually rest quietly on walls or ceilings

**** Formerly a serious problem of crib-stored ear corn, the Angoumois grain moth a delicate insect with pale yellow wings, is no longer a major stored grain pest.***

during the day and are active at night. Larvae have a light-brown head, are up to 7/10 inch long, dirty white to greenish, sometimes pinkish in color. Indian meal moth larvae can readily be distinguished from most other larvae found in grain by the presence of fleshy "prolegs" on some segments of the abdomen. The presence of larvae often can be detected by a shiny, silky webbing they trail over the surface of the grain.

Larval infestations are usually restricted to within 4 to 6 inches of some type of surface, which may be the top of the grain mass, grain behind unsealed doors, grain around aeration fan openings, etc. The larvae feed on the germ and one larvae may damage 40 to 45 kernels. This "scalping" of the grain greatly decreases germination. Fecal material, shed skins, and webbing contaminate the grain and cause kernels to stick together and to the sides of the storage structure. Probably even more importantly, the surface webbing effectively prevents aeration fans from moving the volume of air through the grain necessary to prevent temperature gradients, moisture migration, and spoilage. Crusted surfaces often result. Larvae may be seen leaving the grain in large numbers to pupate elsewhere. Typically there are four to six generations per year.

Psocids or Book Lice - Figure 12

Book lice are tiny (1/25th inch long), pale, wingless, soft-bodied, louselike insects with fairly large heads and poorly developed eyes. Psocids have long, slender antennae.

Young resemble adults in appearance. This insect is most common in grain needing moisture management to maintain storability. Nuisance value is usually of much greater concern than direct injury to the grain.

Grain Mites - Figure 13

Grain mites are near relatives of insects and are included here because they may become very common in stored grain. Because they only measure about 1/50 of an inch, they are extremely difficult to see — even with some magnification. They are pale, soft-bodied, wingless creatures. In severely infested grain, a light fluffy material composed of cast mite skins may "float" with the slightest air movement. Samplers frequently report the feeling that their skin is "crawling" after leaving mite-infested grain without being able to detect a visible cause.

Grain mites cannot penetrate the seed coat. However, since a large proportion of the seed coats possess minute cracks or more significant damage at harvest, plenty of entry points occur. They feed first on the embryo and can inhibit germination. Large numbers cause heating and add to the existing moisture in the grain. Grain mites are most often of concern because of nuisance value.

Sampling for Insects

Infestations can only be detected and evaluated through a sound sampling program. Once serious or potentially serious insect infestations are located then the decision to alleviate, eliminate, or simply monitor the problem can be addressed. **Remember, those areas within the grain mass that show a 10° F or greater difference from the average bin-wide temperature should be intensively sampled.** In many instances, the minimal management response should probably be turning the aeration fans on for at least one complete aeration cycle, followed by resampling to confirm elimination of the temperature imbalance.

Insuring personal safety is a prerequisite to sound sampling of grain. Ladders should be present both inside and outside the bin to faciliate easy entry and rapid exits. Be sure that all unloading equipment cannot be turned on. Make sure you are fully aware of suffocation hazards, bridged grain situations, undissipated fumigants or other chemical residues, and the possible respiratory consequences of working with grain dust. If the situation is questionable, do not enter the bin, at least not without adequate protective gear. If at all possible, do not inspect grain in a bin without having a partner stationed outside to help should it become necessary.

Grain should be *leveled* after being put in the bin, not only because peaked grain prevents proper air flow during aeration, but it also makes insect sampling difficult or impossible. Most on-farm sampling is limited to the depth that manually operated sampling devices can be inserted. Realize that these limitations mean nothing is known about the condition of grain deeper in the bin.

Types and Use of Sampling Devices

Many *sampling devices* (Figure 15 a-f) are available to evaluate if the grain has become infested with insects. These devices include grain triers, bullet or torpedo probes, vacuum probes, screens and sieves, plastic grain probe or pitfall traps, and sticky traps baited with pheromones (volatile chemical sex attractants). Even though reliably relating numbers of insects captured to potential economic damage has not yet been achieved, data on populations are useful in determining management strategies. With virtually all devices, The more samples taken, the more accurate the information collected.

Grain temperatures and moisture also should be recorded frequently as grain samples are taken, especially if the sample feels noticeably warmer during handling.

Grain triers

Several types of *grain triers* are available. All triers are developed around a tube with one or more grain collection chambers. *Compartmentalized grain triers* possess several collection chambers so that the depth from which a layer of grain and insects was collected can be more easily determined. Extensions may be available which allow the trier to be inserted to greater depths. The extensions should be solidly locked together and the sampler should resist motions which rotate and possibly unscrew the handle once the device has been inserted into the grain.

Probes

Bullet or *torpedo probes*, sometimes called *deep bin cups*, consist of a short hollow tube or container that collects a small amount of grain (about one pint is typical). This device is inserted into the grain mass manually. A quick upward pull opens the sampling chamber so it can fill with grain from one narrow layer. The bullet probe has less surface area in contact with the grain, giving it less resistance so deeper depths can be sampled than with standard grain triers.

Vacuum probes require an external vacuum pump and a power supply to operate. Although expensive and more massive to carry, these devices often are the only way to effectively sample the bottom portions of bins. Vacuum probes are used more in commercial storage than on-farm storage.

Traps

Plastic grain probe traps are elaborate *pitfall traps.* The plastic tube contains many small holes, through which insects (mainly beetles) fall as they move about in the grain. These traps contain a vial and funnel device to retain the insects entering them. These traps may be baited with an appropriate pheromone to increase the capture of selected insect species.

Grain probe traps are efficient in detecting several beetle species at very low densities. Some idea of the relative insect population increase over a period of time can be obtained with these devices. Most importantly, insects can be identified and counted rapidly because the sample contains only small amounts of foreign material. Unless unusually small-seeded varieties of wheat or sorghum are being stored, the sieving of the sample can be omitted. Unlike the trier and bullet probe (which only operate when the sampler is present), traps collect insects over a period of time, whenever the insects are active.

Sticky traps are available for the detection of some flying insects such as the Indian meal moth and the lesser grain borer. These traps are baited with a sex or aggregation pheromone that lures adult insects and entangles them in the sticky coating. The user should recognize that pheromone traps, like all sampling devices, are designed for detection and not for use as primary population control measures. For instance, if a sex pheromone is used, only males are captured. Therefore, female moths that do enter the structure are not removed and thus can lay eggs on the grain. Over time, sticky traps indicate relative numbers and population increase of only those species attracted by the pheromone.

Sampling Tips

Grain in storage should be sampled at least once a month when the average grain temperature is above 50 degrees and in-bin conditions are relatively stable (no evidence of deterioration). Bi-weekly or even more frequent sampling is justified in situations where problems have been detected (insects, moisture movement, hot spots, etc.) and before conditions stabilize just after binning. It is wise to check the grain thoroughly if pockets of high moisture, high temperature, and beginning signs of insect infestation are detected. Small problems are usually early indicators that conditions are favorable for large problems to develop, possibly resulting in substantial economic loss.

Prolonged temperature change, as in the spring and fall, can result in moisture movement within the bin and consequently moisture condensation. This leads to fungal growth, heating, and spoiled grain, all of which can favor insect buildup. Similar problems occur at other times, particularly if high-moisture grain was put into storage or if aeration is not used to remove temperature differences. Grain temperatures should be taken away from the walls of the bin and at several points and depths.

Be particularly alert if any of the following are detected:

- Grain mass smells musty or has other unnatural odors associated with it.
- Temperature variations approach or exceed 10 degrees F within the same grain mass.
- Water vapor is visible.
- Signs of sprouting are found.
- Snow is melting off the bin faster than from other unheated building roofs.

How to best interpret the data obtained from sampling devices is not always clear. Research clarifying this issue is continuing. The information that follows is offered to provide some guidance to the inexperienced sampler. The sample record sheets (Figures 14, 16, 17) were taken from *Management of On-Farm Stored Grain,* a federally sponsored grain management manual coordinated by Cooperative Extension Service Personnel at the University of Kentucky. *Regardless of the style of record-keeping adopted, some type of detailed written summary (including information contained in the "grain bin history form," Figure 16) should be maintained on every grain mass placed in storage.* Without this information, it will be very difficult or impossible to detect changes in conditions which are important in maintaining grain quality.

Initial samples can be removed from in-bin locations approximating the 4 cardinal compass directions. In addition, thoroughly sample the top center of the grain mass.

Treat any peak or high point in large flat storage (Figure 14) as if it was the center of a round bin and sample accordingly. Note sampling locations, insect infestations, hot spots and other signs of deteriorating grain on the bin diagram (Figure 17). If the bin is overfilled, sample as thoroughly and deeply as possible, probably using the bullet probe with 3-foot extensions, pushing the probe down at an angle, if necessary, so grain somewhat near the wall is also sampled. Opening the roof cap may be necessary to adequately sample the central core. The intersecting lines on the bin diagram (Figure 17), top view, indicate reasonable sampling locations. Obviously, samples cannot be taken from each of the available sites.

Grain Triers

Several trier samples should definitely be taken at the top center of the bin. This location is where temperature extremes are the greatest. Fines also tend to concentrate in the central core, and the top surface usually represents an "open area" where insects entering the structure may first encounter the grain. Bins with perforated aeration floors have two surfaces for insect invasion.

Some of these top-center trier samples should be taken with the probe positioned horizontally approximately 2 to 4 inches beneath the *grain surface. Vertical samples from various depths also should be removed from the central core.*

Other key areas to use the tier include samples from the south to southwest quadrant where elevated temperatures also may favor insect development. Any area where moisture might enter the bin should be checked closely (such as around doors and aeration fans).

Deeper regions ideally should be checked in a similar fashion with a bullet or vacuum probe. Experience indicates that a minimum of eight trier samples should be taken in a bin to obtain some idea of the presence and abundance of stored grain insects.

Grain triers are inserted into the grain at a slight angle with the compartment(s) closed and facing up. Once the desired depth is reached, the compartments are opened to allow grain and insects to flow in. Two or three short push-pull movements of the trier will help fill it more completely. The chambers should then be closed and the trier removed from the grain for inspection.

Before *sieving,* grain from a trier should be placed in a *slick-sided container* long enough to accommodate the probe sample as it occurred in the grain mass. A piece of rain guttering can be used so the inspector can determine if infestations are restricted to one or several layers of the grain.

If grain is cold, it should be placed in *reclosable plastic bags* and allowed to warm to room temperature before sieving. If this is not done, it will be impossible to distinguish dead from living insects since many insects are immobile at low temperatures.

Probe Traps

Experience with plastic grain probe or pitfall traps in bulk grain is limited because their use in management situations is a recent occurrence. Five pitfall traps should be adequate for detecting many beetle species in bins up to 20 feet in diameter. One of these five should be in the bin center; the others, half way from the center to the bin wall. In larger bins, it is desirable to place more probe traps.

These traps should be pushed about 3 inches below the grain surface, leaving an attached rope visible so the traps can be retrieved. To detect increases in insect numbers, trap for at least two days at one-month intervals. Time interval is important and must remain the same throughout a trapping program. The number of insects captured is dependent on the length of time the trap is in the grain. Traps are useful for detecting infestations of many beetles at much lower densities and with less effort than sampling with grain triers.

Indian meal moth pheromone-baited sticky traps (see Figure 15f) are useful for determining when adult male moths are flying. Their use can indicate that egg-laying female moths are or soon will be active. Traps should be suspended inside the storage structure.

Moth activity should be checked every five to 10 days. The pheromone dispenser should remain active for at least six weeks. Information from the University of Minnesota indicates that capturing 30 moths within five days should be considered serious. If seed wheat is involved, lower damage thresholds are indicated.

Dust, damage, and age will render the traps less efficient or useless. As soon as possible after males are collected, the manager should confirm that steps to prevent Indian meal moth infestations have been implemented.

The efficiency of most types of traps, including pitfall and pheromone-based traps, depends upon the activity level of the organism being sampled. During warm grain conditions, higher numbers may be collected. Traps must remain in place long enough for insects to encounter them, but not so long that unreasonably high numbers are collected which would lengthen the counting process unnecessarily. Unbaited (no pheromone) traps are not extremely effective in capturing lesser grain borers. However, in clean, dry, properly stored grain, traps may find use as an exclusive means of insect detection.

A simple rule for sampling is: “Be sure your samples are truly representative and take more samples than you think you need.” Ongoing research should provide definitive answers of “how many samples,” “by what method,” “where to take them,” and “what do the numbers mean. ”

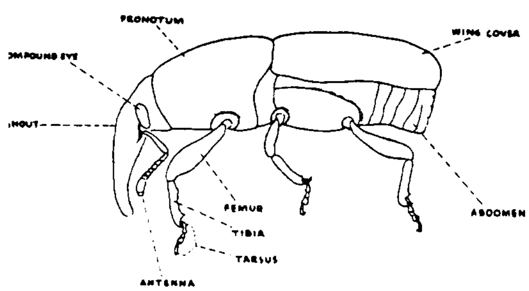


Figure 1. Stylized insect with major body regions identified.

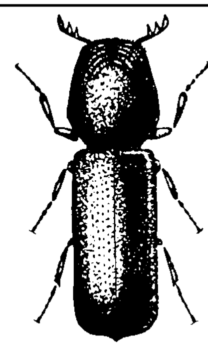


Figure 2. Lesser grain borer; adult.

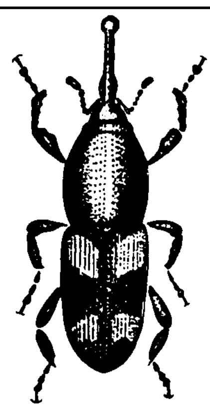


Figure 3. Rice weevil; adult.

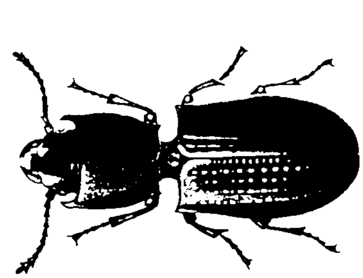


Figure 4. Cadelle; adult.

Figure 5.
Flat grain beetle; adult.

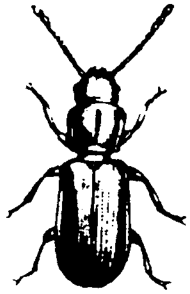


Figure 6.
Rusty grain beetle; adult

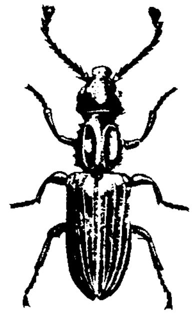


Figure 7.
Sawtoothed grain beetle; adult.

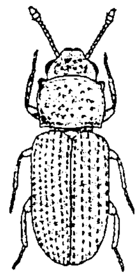


Figure 8.
Foreign grain beetle; adult.

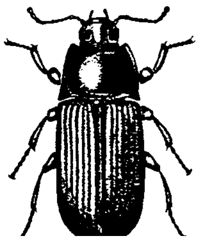


Figure 9.
Mealworm; adult

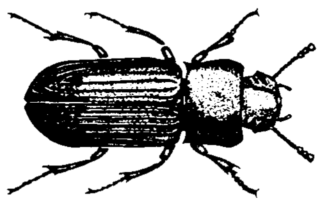


Figure 10a.
Red flour beetle; adult distinguishing characteristics.

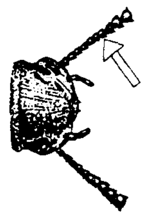


Figure 10b.
Confused flour beetle; adult distinguishing characteristics.

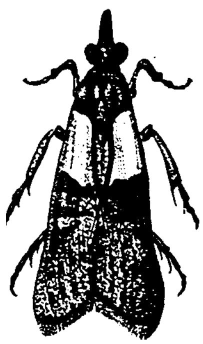


Figure11a.
Indian meal moth; adult.

Figure 11b.
Indian meal moth; larva.

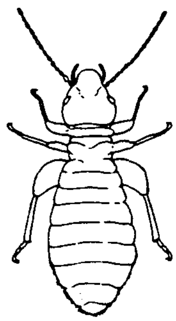


Figure 12.
Psocids (book lice); adult.

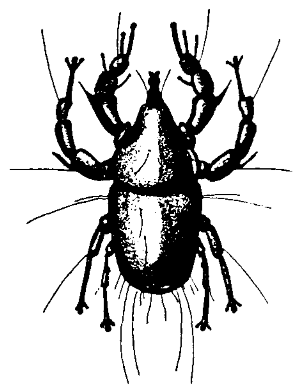


Figure 13.
Common grain mite

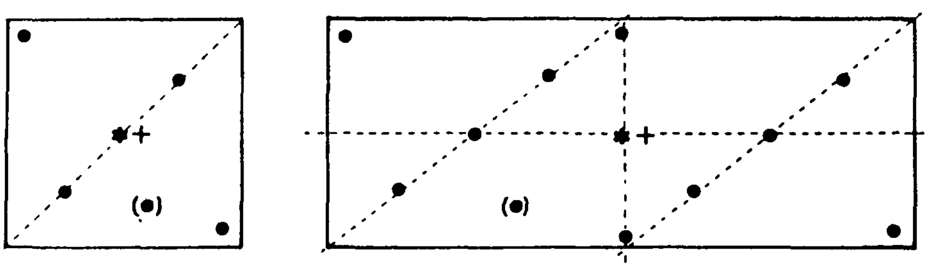
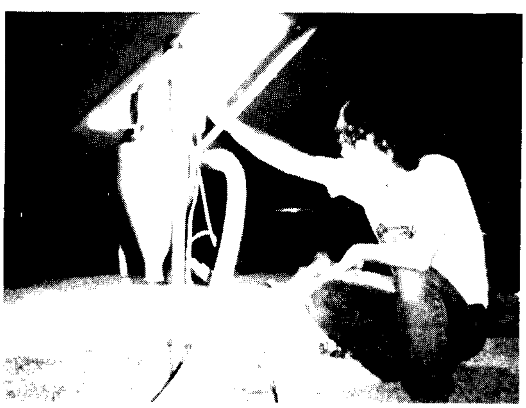


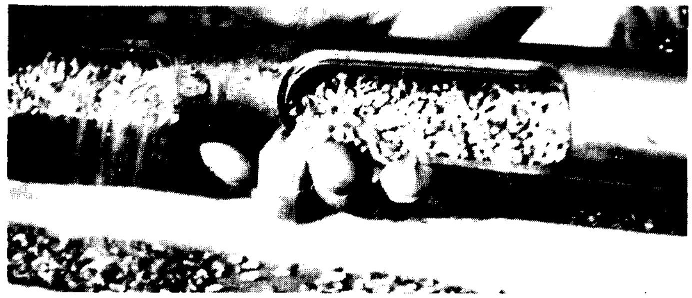
Figure 14.
Large flat storage and round bin sampling locations.

15a. Grain Trier.

15b. Bullet or torpedo probe.

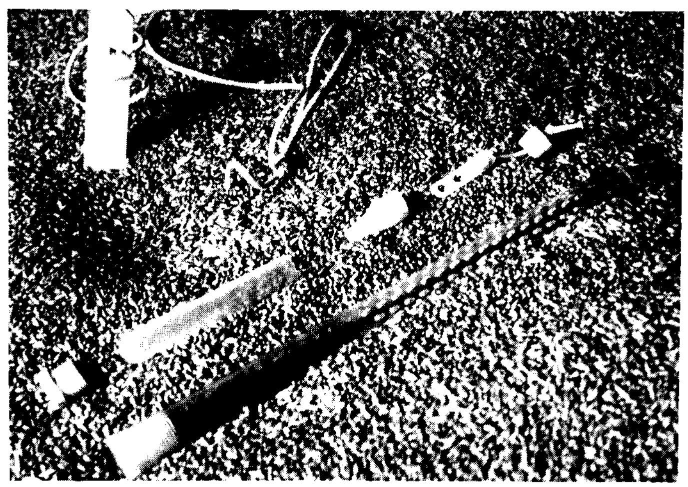


15c. Vacuum probe.

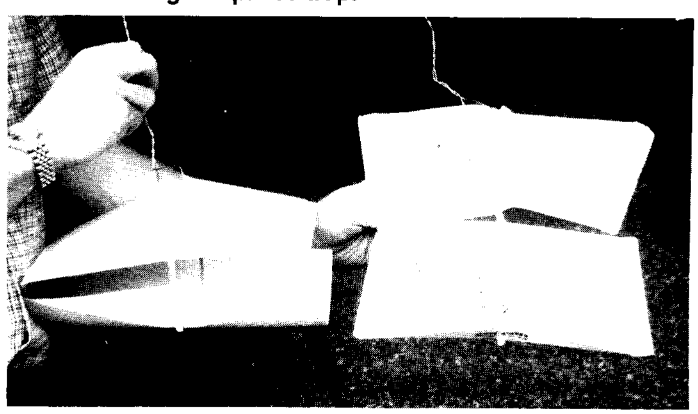


15d. Compartmentalized Grain Trier.

15e. Sieves and screens.



15f. Plastic grain probe trap.



15g. Indian meal moth sticky trap.

Cooperator's Name ______________________

Address ______________________

(Please fill in data for each bin)

Bin Number ______________

Location of Bin ______________________

Size of Bin ________ X ________ = ________
diameter height to eave capacity in bushel

Expected date of fill ________ ________
month day

Number of months grain is expected to be in storage ________

Drying System

In Bin Drying
Unheated air ____
Heated air ____

Out of Bin Drying
Batch ______
Continuous Flow ______

Number and size of aeration fans, if any ______

Type of Grain: Corn ____ Soybeans ____ Wheat ______

Will grain bin wall and floor be sprayed with insecticide prior to filling?

yes ____ no _____. If yes, what insecticide will be applied ____

______________.

Is there a stirring device?____. Grain spreader?_____ Cleaner?_____

Other relevant data that IPM personnel should know. ________

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Figure 16. Grain bin history form.

KENTUCKY GRAIN BIN INSPECTION

Cooperator's Name ______________ Date ________

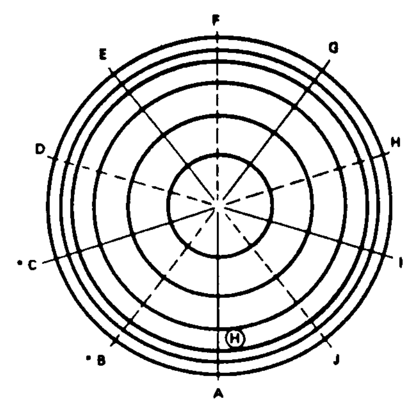
Bin Number ______ Bin Diameter ______ Crop ________

Sample Information

Probe ID*	Moisture Sample			Temperature Sample	
	Depth of Probe	Can No.	% Mo	Depth of Probe	Degrees F

*First letter = Radius used for sample
Second letter = Indicates a Temperature Probe
Number (s) = Probe distance in feet from Bin Center

Top View of Bin



*Use the 5 solid lines for bins under 24 feet in diameter

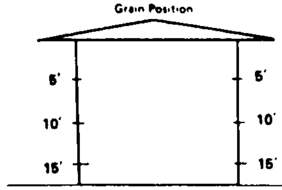
*Use both the 5 solid and 5 broken lines for bins over 24 feet

● = Moisture Probe Position

(H) = Hatch Position

X = Temperature Probe Position

Grain Position



Scout Comments

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Signature ______________

Figure 17. Data record sheet for bin sampling.

KSU
KANSAS STATE UNIVERSITY

COOPERATIVE EXTENSION SERVICE, MANHATTAN, KANSAS

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