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Insect pests and their control - Stored-Grain pests

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STORED-GRAIN PESTS

STORED foodstuffs such as grain, dried fruits and flour are constantly liable to the attacks of insect pests, with the result that the farmer, grain merchant, miller and grocer have a continual war to wage in order to keep their products in a wholesome condition. During the 1914-18 World War, millions of bushels of bagged wheat were stored in Australia on account of the lack of shipping space, and incalculable damage was done by mice and “weevil” attack. When there is a possibility that stocks of grain are to be stored, precautions must be taken to protect it from rodent and insect damage.

Before dealing with the methods which may be adopted to safeguard the grain, it will be well to know the names of the insects with which we are concerned, how they may be recognised and the way in which they affect the wheat.

Grain insects may be divided into two main groups which can be listed as follows:

**Primary Insects.**—Those capable of affecting sound grain—
- Rice weevil (*Calandra oryzae* L.).
- Granary weevil (*C. granaria* L.).
- Lesser grain borer (*Rhizopertha dominica* Fabr.).
- Angoumois grain moth (*Sitotroga cerealella* Oliv.).

**Secondary Insects.**—Those incapable of attacking sound grain—
- Confused flour beetle (*Tribolium confusum* Jacq.-Duv.).
- Rust-red flour beetle (*T. castaneum* Herbst.).
- Saw toothed grain beetle (*Oryzaephilus surinamensis* L.).
- Flat grain beetle (*Laemophloeus* spp.).

There is a belief prevalent even in these times that “weevils” appear spontaneously in grain just as toads were believed by the ancients to be the product of mud and slime, and flies an inevitable sequel to filth. That there is absolutely no foundation for this will be seen from the life history details which follow. Clean wheat will remain free from insect attack indefinitely if no outside infection is permitted. Every “weevil” is derived from an egg laid by a female and there is definitely nothing spontaneous or mysterious about an outbreak, however obscure the source of infestation may be.
from reddish brown to almost black and usually four light-coloured spots are distinguishable on the back. The thorax is densely pitted with round punctures.

Beneath the wing covers are a pair of fully developed wings and although the insect is seldom seen in flight, it is quite capable of adopting this method of progression.

In some countries indeed these weevils fly from the barns into the fields and attack standing grain, but careful observations have failed to reveal any such tendencies in this State and it is considered that summer conditions are unsuitable for the field activity of this insect.

The adult weevil can live for a considerable period, published figures varying from four to eight months, and during this time 300 to 1,000 eggs may be laid.

Before laying her eggs, the female bores a small hole with her mandibles into the wheat grain and therein deposits an egg. This is then covered with a gelatinous fluid which entirely plugs the hole. The fat, legless grub which emerges after three or four days feeds in the grain for about a fortnight and then pupates to emerge as an adult weevil at the end of about a week. It will be seen, therefore, that from egg to adult occupies from three weeks to a month. This time varies greatly according to temperature and humidity, and under cool conditions would be greatly increased. Below an average temperature of 50°F. weevil activity is considerably checked, but in this State the mean monthly temperature falls below 50°F. in but a few districts and then for only a short period. Weevils when working in wheat themselves tend to raise its temperature so that our winter conditions cannot be regarded as a serious check upon the pest.

**Granary Weevil**
(Caliandra granaria L.).

The granary weevil is reddish brown to black in colour, and about the same size as the rice weevil from which it may be distinguished by the lack of the light spots on the wing covers and the presence of elongated instead of circular punctures on the thorax. Another important difference is the absence of flight wings.

As in the case of the rice weevil, the adults and grubs feed voraciously on grain, and the life history and habits of the two are so similar as to require little further comment.

The grain weevil, although usually associated with the rice weevil, prefers a temperate climate and considerable damage is not experienced locally from this species with the possible exception of some of the extreme southern regions.

**The Lesser Grain Borer**
(Rhizopertha dominica Fabr.).

The lesser grain borer is not a true weevil, but belongs to the same group as many of the timber borers (Bostrichidae). It is one of the smallest grain pests, but one of the most serious in this country.

During World War I, many shipments of Australian wheat were heavily infested by this beetle and it became known abroad as the Australian wheat weevil, although its native home is probably India. It is cylindrical in shape, dark brown or black, and about one-eighth of an inch in length.

Both the adults and the larvae are responsible for serious damage to a variety of grains. The beetles may live for a period

![Fig. 1.—Life stages of rice weevil in wheat. 1.—Grain dissected to show egg; 2.—Well grown larva; 3.—Pupa; 4.—Adult feeding upon kernel. Note in 4 the hole in lower portion of kernel made by the adult on leaving the seed. The other shallow holes were made by the adult in feeding after emergence (From U.S. Dept. Agric.).]
of up to four months and during that period lay 300 to 500 eggs. The eggs are laid singly or in clusters in the loose grain, and the young larvae feed upon any floury material present or bore into grain damaged by the attack of the parents. They are generally incapable of entering a sound grain. From egg to adult is said to occupy about a month under favourable conditions, but may be extended to several months.

This pest is now widely distributed in Western Australia, having been first recorded at Fremantle in about 1916. The Geraldton zone was the first country area to be widely affected, but in recent years many other districts have reported the pest.

The Angoumois Grain Moth
*Sitotroga cerealella* Oliv.

The Angoumois grain moth is buff or yellowish brown in colour with a wing spread of about half an inch. It is sometimes found infesting old hay stacks and is parasitised by the hay itch mite (*Pediculoides ventricosus*) which sometimes produces an annoying irritation during the process of chaff cutting.

Like the rice weevil, this moth is known in some countries to fly into the field to infest the standing grain, but so far no
proof of this habit has been received locally, and we can confine our attentions to the insect as a pest in store.

An average of 40 or 50 eggs are laid by the female, but sometimes as many as 250-300 may be deposited. They are laid on or near the grain and the tiny grub on hatching bores into the kernel, often spinning a small cocoon at the entrance. When fully fed it eats out a channel to the seed coat, but leaves a small portion intact which is later pushed off as a lid when, after the pupal stage spent in a silken cocoon within the grain, the adult moth finally emerges. From egg to adult occupies about five weeks but again development is greatly slowed down under cold conditions, although the moth is said to be capable of working at lower temperatures than the weevils.

SECONDARY PESTS
Confused Flour Beetle
(Tribolium confusum Jacq. Duv.).

The confused flour beetle is a rather elongated shiny reddish brown beetle about one-seventh of an inch in length. The head and thorax are densely pitted and the wing covers ridged lengthwise with punctures sparsely distributed between the ridges.

Like the other storage pests mentioned it is not native to Australia but has been widely distributed by commerce and may be found attacking farinaceous materials in all parts of the world. It is principally a pest in flour mills, being incapable of feeding upon sound grain, but it will attack broken grains and kernels damaged by weevils and consequently helps in the final destruction of stored wheat.

The average life of a beetle is said to be 12 months or more, and females may lay over 400 eggs. These are deposited loosely, and being covered with a sticky secretion become covered with flour or grain dust and readily cling to the sides of bags and other receptacles so that clean material placed in them can rapidly be infested. In five to 12 days the eggs hatch into small grubs about 3/16ths of an inch long and resembling tiny wireworms. These pupate as naked yellowish-white pupae and about six weeks after the egg was laid the adult beetle emerges. As with the other insects mentioned, this life cycle may be greatly prolonged by adverse conditions.

Rust-Red Flour Beetle
(T. castaneum (Herbst)).

The rust-red flour beetle cannot be distinguished from the foregoing species without a magnifying glass, but whereas the antennae of the confused flour beetle increase gradually in size towards the tip, those of the rust-red species increase abruptly at the tip, giving them a clubbed appearance. In addition, as can be seen from the accompanying illustrations, the sides of the head of the confused flour beetle are expanded and notched at the eyes whereas in this species the sides of the head are nearly continuous at the eyes.

The habits and life history of this species resemble very closely those of the confused beetle and so need not be further detailed.

The Saw-Toothed Grain Beetle
(Oryzaephilus surinamensis L.).

The saw-toothed grain beetle is smaller than the flour beetles and of rather a darker brown colour. It may also be recognised by the six saw-toothed projections on each side of the thorax from which the popular name is derived.
It is one of the commonest insects found in stored grain in this State, and also attacks many other foodstuffs such as dried fruits, nuts, etc.

The female beetles live from six to 10 months and may lay from 50 to 250 eggs which may be deposited loosely or in the crease of a wheat grain. After three or four days the larvae appear and two weeks elapse before they spin a thin covering in which to pupate. From egg to adult occupies about four weeks under suitable conditions.

Like the flour beetles, this insect in its adult and larval stage feeds upon flour and damaged grain and assists materially in furthering the damage commenced by the weevils and grain borers.

Flatt Grain Beetles
(*Læmophloeus* spp.).

The flat grain beetles are amongst the smallest of beetles found in stored grain, being only about one-sixteenth of an inch in length. The colour is reddish brown and the antennæ are relatively much longer than in any other beetles mentioned.

The eggs are laid loosely or in grain crevices and the tiny larvæ form gelatinous cocoons, covered with food particles in which to pupate. From egg to adult occupies about eight or nine weeks.

**Mill Floss, Flour Bugs, and Bran Bugs.**

The beetles described under the heading of "Secondary Insects" are variously known as flour bugs, bran bugs, and mill floss. They are often to be found swarming on bags and in wheat bins and their presence is undesirable, especially in flour mills, but to the farmer or wheat merchant they are not of much consequence and so it is important to be able to distinguish between the primary pests which are able to destroy sound grain and the secondaries which follow in their wake.

This knowledge may save unnecessary anxiety and expenditure in control measures.

**PREVENTIVE MEASURES**

**Moisture Content.**

It is generally known that wheat with a high moisture content is more prone to insect attack than that which is very dry, consequently the climatic conditions in Western Australia themselves afford one of the greatest protections to stored grain. Wheat when harvested may contain up to 12 per cent. moisture, but if stored in inland districts the figure may drop in the summer months to as low as eight per cent. or nine per cent. and the scarcity of summer rains favours the safe keeping of the crop. When, as in times of war, grain may have to be stored over one or two winters it is essential to see that no water
is allowed to leak in, as damp wheat is one of the most favourable media for the rapid multiplication of weevils.

Much has been written about the figure at which weevil activity ceases on account of the lack of moisture in wheat, and about 10 per cent. is the figure usually quoted. There is much more work to be done on this matter before this can be taken as final, but it is certainly a guide to the degree of liability to attack, and wheat which can be kept in this dry condition is certainly less liable to damage than that with a higher moisture content.

Sanitation.

This is undoubtedly the most important factor in insect control and scrupulous sanitation should be observed right from the harvester box to the bakehouse door. All wheat should be cleared out of the harvester before it is put away and this ensures that when it is taken out next season clean wheat will not be contaminated before it enters the bags.

Second Hand Bags.

The mention of bags brings us to another extremely important point. In districts where bulk installations are present the same bags may be used year after year to cart to the siding. A little grain may be left in the bags when they are put away and this may be sufficient to harbour enough weevils to cause trouble the following year.

When finished with, bags should be turned inside out, thoroughly shaken and brushed, and hung away from any grain. They will then be quite clean and safe when needed later. If there is any reason to suspect that bags have contained weevily wheat, they should be given special treatment and, if possible, placed in boiling water for five or ten minutes as this will kill all stages of insects that may be present and cause only the slightest shrinkage of the bag.

Store houses and sheds should be thoroughly swept of all old grain and refuse and treated with some suitable insecticide, and new wheat should never be stacked near that of another season. Where possible wheat should be stored on a sound grain-proof floor, so that seed cannot trickle through on to the ground beneath and so be out of reach of the broom.

Conveyances, such as railway trucks and lorries should not be overlooked as sources of trouble, as wheat and insects harboured in cracks and runners can easily be responsible for infesting fresh consignments, or even during their passage about the countryside, bringing contamination to clean storage sites.

To carry out the above instructions may seem irksome and fiddling, but if clean wheat is put into a clean container and no infested material is allowed to contaminate it, there will be no trouble from weevils. Never was the saying "Prevention is better than cure" more worthy of observation than in the case of combating storage pests, for once a serious outbreak occurs, its control cannot be obtained without great expense, labour and loss.

A few weevils in the bottom of a bag may be enough to infest a whole bin or even a shipment, and so every farmer should strive to see that his carelessness is not the cause of a widespread loss.

Storage Methods.

The bulk storage of grain has much to recommend it for the prevention of insect attack, especially if the bins or silos are of a type that can be readily fumigated or cleaned. On this account steel or concrete bins are desirable, for the walls and floor can be made practically insect-proof and
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if thoroughly cleaned before being filled, clean wheat can only be contaminated from the top. The infestation will not penetrate to any great distance, as the weevil is said to be unable to penetrate further than about five feet, and the Grain Moth could only work in a very superficial layer.

Wooden silos are sometimes bored into by various insects; e.g. the Grain Borer, and cracks also offer a suitable harbour from which it is difficult to dislodge pests by any other means than fumigation, hence as little woodwork as possible should be employed in constructing grain receptacles.

**Pickling.**

The pickling of wheat for the control of fungus diseases has been found to also constitute a very effective safeguard against “weevils.” Copper carbonate dust used at 2 ounces to the bushel and the various mercurial pickling agents have proved effective insecticides. This method of control is, of course, only practical for seed wheat, as pickled wheat is not suitable for milling or for stock.

**PROTECTION OF BAGGED AND BULK WHEAT ON THE FARM**

Bins and sheds used for grain storage should be thoroughly cleaned before new seasons wheat or oats are introduced. On no account should new grain be added to old stock. After carefully sweeping out the bin and disposing of old infested grain the walls and floor should be thoroughly sprayed or dusted with an insecticide. If the structure can be reasonably sealed then “Gammexane” smoke bombs or fogging treatments would give a satisfactory kill of the insects still remaining in the cracks and crevices.

If bagged wheat is being stored the exterior of the bags may be sprayed or dusted as each layer is added. Additional protection may also be obtained by dipping wheat bags in 5% DDT and allowing them to dry before filling.

A liberal sprinkling of DDT or B.H.C. dust (Gammexane or Benzenehexachloride dust) around the base of the completed stack will act as a further protection from crawling weevils.

**Surface Treatment of Bulk Wheat.**

Before filling a silo the walls and floor should be thoroughly dusted or sprayed so that cracks and crevices will contain insecticide. The surface layers of wheat may also be protected by a light dusting with DDT or B.H.C. or by raking the insecticide into the top few inches of grain.

**Insecticides Recommended.**

The dusts recommended are 10% DDT or 10% B.H.C. For the surface treatment of bulk wheat a rate of about 1 oz. to every 17 sq. ft. is recommended. Where spray materials are used 2% water mixture of DDT or Chlordane 0.5% Lindane or Dieldrin should be satisfactory.

**CONTROL**

Probably the most universal control treatment for grain pests is fumigation, but other treatments such as heat and insecticides have their place. Many other methods, including electricity and sifting, have been attempted, but without encouraging results. The latter may free the wheat from adults, but does not deal with the eggs and other stages in the grain; hence reinfestation soon follows.

**Fumigation.**

For this method to be effective the container to be treated must be more or less gas tight. Carbon bisulphide and hydrocyanic acid gas are the two most
common gases used. The latter, being lighter than air, has poor penetrating properties and is more suitable for fumigating containers and mills than quantities of bulk wheat. Temperature is an important factor in fumigation, and a temperature of at least 70° to 75° is desirable for good results, as anything lower tends to reduce the efficiency of many fumigants. The volatilisation of fumigants may be increased either by spraying them into the fumigation chamber or by vaporizing the liquid by the application of heat in an apparatus called a vaporizer.

Carbon Bisulphide.

This gas which is heavier than air is very inflammable and explosive and hence requires considerable care in its use. The method of application is to pour the desired amount of liquid into shallow pans or pieces of sacking and place them on the top of the grain. If the depth of grain is greater than five feet, it is desirable to introduce the fluid by means of a pipe with outlets at suitable distances and in this way the gas which is given off will penetrate to all parts. Moist grain may be injured in its germination properties by this gas, and the baking quality of flour is said to be sometimes injured by the vapours, but this may be prevented by airing the flour before baking.

Carbon bisulphide should be applied at the rate of 1 lb. per 25 bushels of grain, or 4 lb. per thousand cubic feet of space to be fumigated. The wheat should remain sealed for 48 hours. If any leakage of gas is likely to occur the amount of fumigant should be increased.

**Hydrocyanic Acid Gas.**

This is chiefly used in this country for fumigating flour mills as the fire hazard is too great when carbon bisulphide is used. Cyanide, however, is very toxic to humans and must be used with great care. The gas may be generated by what is known as the "pot method" or from a number of proprietary preparations.

The standard formula for preparing the gas is as follows:

- Sodium cyanide, 1 ounce.
- Commercial Sulphuric Acid, 1½ fluid ounces (3 tablespoonsful).
- Water, 2 fluid ounces.

In the case of a mill each storey is treated as a separate unit and made as airtight as possible, but as the gas tends to rise the dosage on the bottom floor should be somewhat increased and the upper ones somewhat decreased. The dosage may be worked out on the basis of 1 lb. of cyanide to 1,000 cubic feet of space for the ground floor.

In preparing the mixture the sulphuric acid should be poured into the water and not vice versa, and the cyanide should be suspended over the earthenware crock, containing the liquid, in a paper bag and lowered in as the door is being closed.

A granular form of cyanide known as Cyanogas G is recommended for mixing with wheat when entering silos at the rate of 1% by weight, and other preparations...
such as Zyklon B and liquid Hydrocyanic Acid may be used as sources of this fumigant.

Grain or buildings treated with Hydrocyanic Acid should be sealed for at least 12 hours and from 24-36 hours if possible.

**Chloropicrin or “Larvacide.”**

This gas is also known as tear gas and has given considerable promise as a fumigant. It is non-inflammable and heavier than air. Unsatisfactory points about “larvacide” are that it is detrimental to the baking qualities of flour and has an adverse effect upon seed germination. Also it does not disperse rapidly and as it is highly irritant to the eyes and lungs material and premises must have a lengthy airing after treatment.

Larvacide should be used at the rate of 1 lb. per 1,000 cubic feet of space in airtight bins, the dosage being increased if leakages are unavoidable.

**Fumigant Tablets.**

Various proprietary tablets, as for instance “Phostoxin” pellets, have been recommended for the fumigation of weevil-infested grain. These preparations should be used in strict accordance with the recommendations of the manufacturers. In the case of “Phostoxin” (Aluminium phosphide) the poison gas phosphine is slowly liberated when the chemical is exposed to the air. The residue left by the tablets is quite harmless.

**GENERAL RULES TO BE OBSERVED WHEN FUMIGATING**

1. See that the container is as airtight as possible.
2. Do not fumigate wet or immature grain if it is desired for seed purposes.
3. Air foodstuffs or buildings as much as possible after treatment.
4. Take all necessary precautions with inflammable or highly toxic fumigants.

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