12-1922

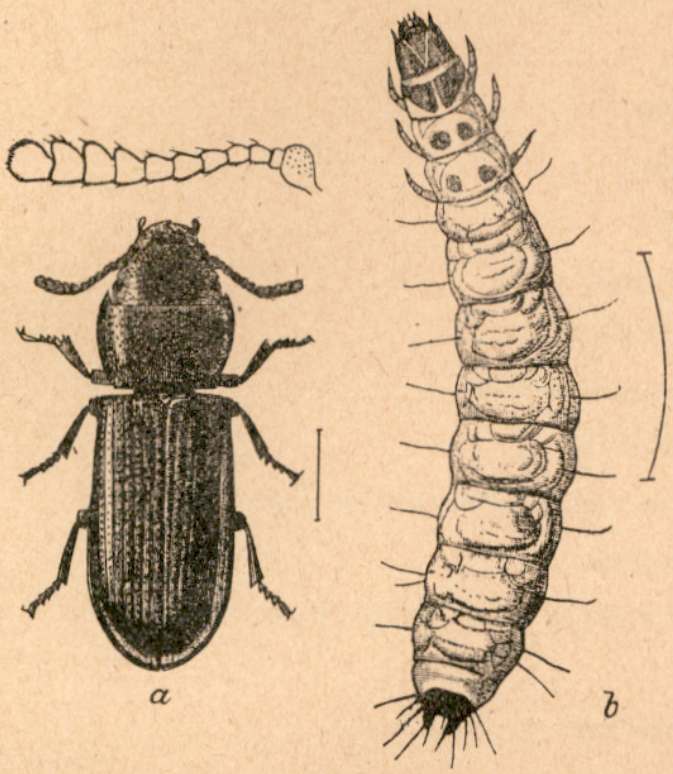
Insect Pests of Stored Grains and Their Control

M. H. Swenk

Circular 15 (revised) December, 1922

Insect Pests of Stored Grains and Their Control

M. H. SWENK



The cadelle (*Tenebroides mauritanicus*): *a*, adult beetle, enlarged 5x; *b*, larva, enlarged 4x. (From Chittenden, 1896.)

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEBRASKA
LINCOLN

CONTENTS

INSECT PESTS OF STORED GRAINS AND THEIR CONTROL

BY M. H. SWENK, STATION ENTOMOLOGIST

Farmers are well aware that their warfare against destructive insects is not ended when their wheat is in the bin and their corn is in the crib, but that the garnered crops become immediately subject to attack by various insect pests of stored grain, commonly called "weevils." The loss from this attack is never small, but it becomes of especial seriousness when, because of prevailing low prices for grain, unusually large stocks are being held in the farm granaries and cribs, awaiting an improvement in the market. When once started in the grain, these pests often work so energetically that the farmer finds he must either destroy them, sell his grain at once, or allow the pests to seriously damage it. It is estimated by competent authorities that in the United States stored grain pests cause a loss of over $100,000,000 worth of grain and grain products annually, this loss being proportionately much heavier in the South than in the North.

In Nebraska there are about 20 species of insects that injure stored grain more or less. Some are beetles and their larvae, others are the caterpillars of small moths. To the farmer all are "weevil," tho that name is really properly applied only to two beetle species—the granary weevil and the rice weevil. The following paragraphs and illustrations will describe the several more important stored grain pests to be found in this State, so that the farmer may recognize the particular pest or pests that are doing the injury to his grain, and may then apply the proper remedy.

THE TRUE GRAIN WEEVILS

The true granary weevil (*Calendra granaria*), which is common in granaries thruout Nebraska, is a *uniformly shining* dark brown to blackish, hard-bodied, wingless beetle, a little less than one-sixth of an inch long, with its head prolonged into a stout snout or bill and the thorax with elongate spaced punctures *arranged in lengthwise rows* (fig. 1, *e*). It infests not only stored wheat but also stored oats, barley, rye, corn, and kafir. The female beetle uses her snout to bore a tiny hole into a kernel of grain, after which she deposits a minute white egg

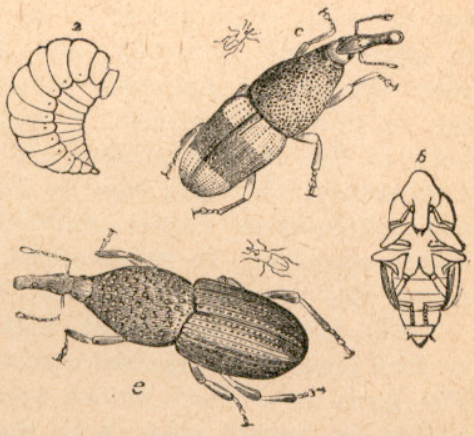


FIG. 1.—The grain weevils (*Calendra*): *e*, the true granary weevil (*C. granaria*) enlarged about 6x, natural size at side; *c*, the rice weevil (*C. oryzæ*), same; *a*, larva, enlarged about 4x; *b*, pupa, same. (From Packard, 1869.)

in the hole. This process she repeats many times in different kernels during her period of life, which extends over several weeks. In a few days the egg hatches into a short, fat, footless, white, grub-like larva that at once begins to eat out the inside of the kernel. By the time the larva is matured (fig. 1, *a*) and a little less than one-eighth of an inch long, it changes to a white pupa (fig. 1, *b*) inside the kernel, which has been hollowed out to a mere shell, and a few days later the new beetle comes forth. All the time that the beetles are laying eggs in some kernels they are gnawing into and eating out others, so that the beetles and their larvae are about equally destructive. The whole life cycle is only 6 or 7 weeks during the warmer months, so that the insect undergoes 4 generations in a year, and can increase enormously in a granary, once it becomes infested. It has been estimated that a single pair can, in the course of a year, produce 6,000 descendants.

The rice weevil (*Calendra oryzae*) is of the same size and general appearance as the true granary weevil, but is of a *dull* brownish to blackish color, usually relieved by *four reddish spots* on the wing covers, two at the base and two near the tip, and the punctures of the thorax are round, dense, and *not arranged in rows* (fig. 1, *c*). It infests not only the grains infested by the true granary weevil but also rice, buckwheat, caked flour and meal, and even cereal products. It occurs in southern Nebraska, but it is not found doing serious injury in this State as frequently as is the true granary weevil, being more distinctly a southern insect. Its life-history is essentially like that of the true granary weevil, except that, as it possesses wings, it sometimes infests standing grain in the field.

THE CADELLE

Next to the true grain weevils, the cadelle (*Tenebroides mauritanicus*) has in recent years proved to be the most important pest of stored wheat in southeastern Nebraska, and it is also at times a serious flour mill pest. In the fall and early winter of 1921 and 1922, from middle September to middle December, it was unusually injurious to stored wheat, both in the farm granaries and in the country elevators, especially over southeastern Nebraska west to Dundy, eastern Frontier, western Dawson, and southeastern Custer counties, and north to Douglas, Colfax, and Nance counties. In northeastern Nebraska it did considerable injury to stored oats at the same time in 1921.

The adult is an oblong, flattened, blackish beetle about one-third of an inch long, *distinctly constricted* at the joining of the thorax and abdomen. The larva is a *broad, flattish* worm about three-fourths of an inch long, whitish in general color, with the head, some marks on the thorax, and the tail dark brown, the last ending in *two sharp points* (see cover illustration). Both the beetles and their larvae feed on the stored grain, going from kernel to kernel, and eating out the embryo and causing much

injury when they are abundant, especially to grain intended for planting purposes. They also feed on other stored grain pests to some extent. The life-history is much like that of the mealworms, which are discussed beyond. The eggs are laid in the spring and summer, and the resulting larvae, when fully grown, live over as such until the following spring. There is thus but the one generation in a year.

THE GRAIN BEETLES

There are several kinds of related (family *Cucujidae*), small, reddish-brown beetles, about one-tenth of an inch long, to be found commonly in granaries and elevators, infesting all kinds of grains, as well as in mills, warehouses, and the household, infesting flour, meal, and other cereal products. The commonest one of these in Nebraska is the saw-toothed grain beetle (*Oryzaephilus surinamensis*), shown in the accompanying illustration, which differs from the other species in having *6 saw-like teeth* on each side of the thorax. This species is sometimes found in dried fruits and meats, sugar, salt, and nuts as well as in cereals and cereal products. Another very common species in Nebraska is the foreign grain beetle (*Cathartus advena*), which is of broader form than the preceding, and has the throax *wider than long, with convex sides* and prominent front angles. A less common species is the square-necked grain beetle (*Silvanus gemellatus*), which has the thorax about *square and parallel-sided*, as indicated by the name. The flat grain beetle (*Laemophloeus pusillus*) is another less common species, distinguished by the *narrow, slightly concave-sided thorax* and longer and more slender antennae than in the three preceding species.

FIG. 2.—The saw-toothed grain beetle (*Oryzaephilus surinamensis*), enlarged about 8x. (From Bruner, 1893.)

These active little beetles lay their small, elongated eggs on the grains and these soon hatch into slender, whitish, active larvae, which feed on the grain or other food, nibbling here and there, until full grown. They pupate in a covering made by sticking together pieces of the infested material, and in a week or two have changed into beetles. In warm weather a generation requires only about 3 or 4 weeks, but in cooler weather 6 to 10 weeks are required. There are thus 4 to 6 generations in a year.

THE FLOUR BEETLES

There are several kinds of related (family *Tenebrionidae*), small, reddish brown beetles, commonly known as flour beetles or "flour weevils," which chiefly infest flour, but also corn meal or other grain products, and occasionally are found in stored grain in granaries and elevators. In mills and feed stores they often abound in flour. The commonest of

these flour beetles in Nebraska is a species known as the confused flour beetle (*Tribolium confusum*), which is of a rust red color and about one-sixth of an inch long, its larval stage being a small white worm about a quarter of an inch long with the tip of the tail ending in *two upturned points* (fig. 3, *c*). Another common species in Nebraska is the tiny, small-eyed flour beetle (*Palorus ratzeburgi*), which is only one-twelfth of an inch long. The beetle *Alphitophagus bifasciatus* is also frequently found in grain dust in Nebraska granaries, but is unimportant as a pest.

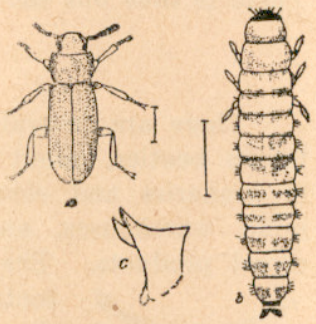


FIG. 3.—The confused flour beetle (*Tribolium confusum*): *a*, beetle; *b*, larva—enlarged about 4x; *c*, outline side view of tip of abdomen of larva—much enlarged. (From Bruner, 1893.)

These flour beetles lay their tiny white eggs in the flour, in cracks and corners of flour bins or barrels, on the seams of flour sacks, etc. These eggs hatch in a few days, and during the summer months the resulting larvae become fully grown in 3 or 4 weeks. During the spring and fall, development is much slower, and 14 or 15 weeks are required for a generation instead of about 5 weeks. Nevertheless, there are 4 or 5 generations in a year.

THE MEALWORMS

The mealworms to be found in Nebraska are two species of long, slender, cylindrical worms, about an inch long when fully grown, that occur frequently in stored grain but more especially in meal, bran, and other grain products. They are the larvae of flat, blackish beetles, about five-eighths of an inch long, that have the thorax *broadly* joined to the abdomen. In one species, the yellow mealworm (*Tenebrio molitor*), the worm is of a shiny *waxy yellow* color with darker joints, and the beetle is a *shining* blackish; while in the other species, the dark mealworm (*Tenebrio obscurus*), the worm is brownish with dusky joints and the beetle is a *dull* black (fig. 4).

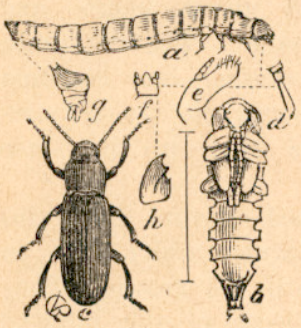


FIG. 4.—The dark mealworm (*Tenebrio obscurus*): *a*, mealworm, and *c*, adult—natural size; *b*, pupa, enlarged; *d*, *e*, *f*, *g*, *h*, antenna, mouth parts and tip of abdomen of mealworm, much enlarged. (Riley in Le Baron, 1874.)

The beetles begin to appear in the spring and continue to put in an appearance in diminishing numbers all thru the summer. They are active at night, hiding in the daytime. The females deposit their white eggs singly or in clusters in the grain or meal. These eggs hatch in 2 or 3 weeks, and the resulting small whitish worms become fully grown and colored within the next 3 or 4 months. After becoming fully grown the mealworms remain unchanged until the following spring, when they begin to pupate. The pupal stage lasts 2 or 3 weeks. There is thus but a single generation of mealworms in a year.

THE ANGOUMOIS GRAIN MOTH

Grains of all kinds, but especially ear corn in the crib, are frequently heavily infested in eastern Nebraska by small whitish caterpillars, about one-fifth of an inch long when fully grown, with a yellowish head (fig. 5, *a*). In a kernel of corn two or three of these caterpillars may commonly be found, but in kernels of wheat, rye, or barley usually there is but one caterpillar to the grain. These caterpillars burrow into the kernels of grain, and cause a loss of from 13 to 24 per cent in corn and of over 50 per cent in wheat when so infested. In the adult stage this pest is a small, light grayish brown or buffy moth slightly lined and spotted with black, with narrow, pointed wings, bordered with a long delicate fringe, and measuring a little over a half inch in expanse of wings (fig. 5, *c*). It is

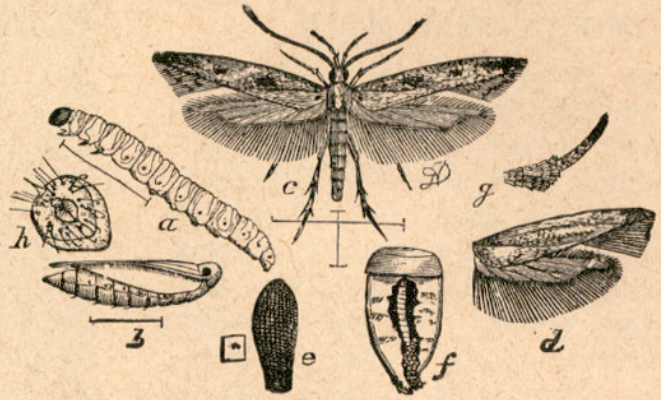


FIG. 5.—The Angoumois grain moth (*Sitotroga cerealella*): *a*, caterpillar, *b*, pupa, *c*, moth, *d*, wing of a paler form—enlarged about 1½x; *e*, egg, *g*, labial palpus of male moth, *h*, last segment of pupa—much enlarged; *f*, grain of corn cut open to show larva at work—natural size. (From Riley, 1884.)

known as the Angoumois grain moth (*Sitotroga cerealella*) because it was found in great numbers in the grain fields and granaries of the province of Angoumois, France, in 1736. As early as 1728, however, it had established itself on the South Atlantic coast of the United States, and is now found over the greater part of this country.

The female Angoumois grain moths, emerging from the stored grain in granaries, bins, and cribs in late May and June, not only lay their minute, oval, white to reddish eggs singly or in clusters of 20 to 30 upon stored grain in the bin or crib, but, flying outside to the fields, they lay eggs under the chaff of the kernels in the young green heads of standing small grains. Each female moth lays about 100 eggs. The eggs hatch in 4 to 10 days and the tiny caterpillars burrow into the grains thru almost invisible openings and feed on the starchy material within, hollowing out the soft interior of the grains (fig. 5, *f*). The caterpillars reach maturity in 20 to 24 days, pupate within the hollowed kernel, and in a few days produce the adult moths of the new generation thru a hole in the kernel. This second brood of moths occurs a little

after harvest, and lays its eggs between the rows of kernels of immature corn in the field and on the small grains in the shock or stack. Other generations follow every 5 or 6 weeks on the grain in the crib or bin until cold weather arrives, making in all about 4 generations in a year. A badly infested ear of corn is covered with the small round exit holes of the moths (fig. 6). During the winter the caterpillars remain inactive within the grain kernels, except when the grain is stored in warm buildings, when there are 5 or 6 generations in a year.

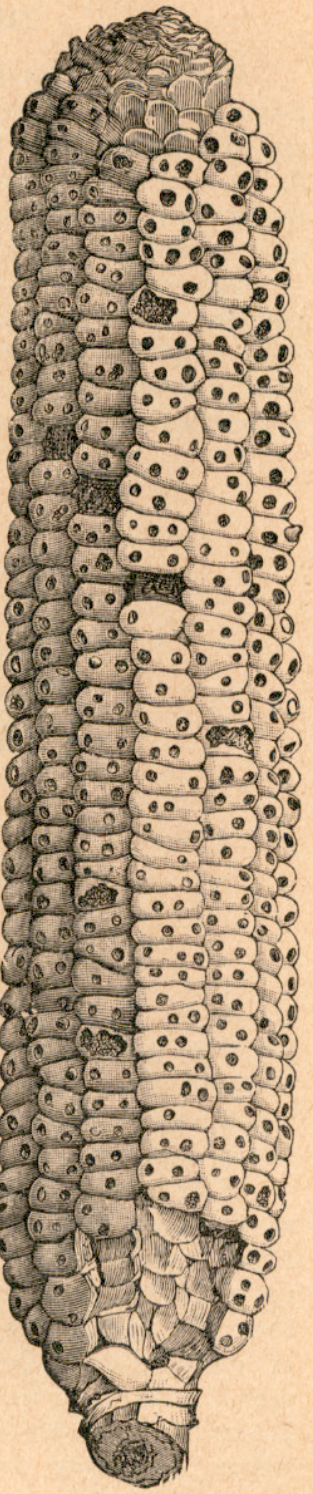


FIG. 6.—Ear of pop corn showing work of Angoumois grain moth. (From Riley, 1884.)

THE INDIAN-MEAL MOTH

Cereals and cereal products of all kinds in Nebraska are at times injured by small caterpillars, about a half inch long when full grown, of a whitish color tinged with pinkish, yellowish, or greenish (fig. 7, *a*), that spin silken tubes thru the food material and profusely web together the grains or food particles with threads of silk. This pest is known as the Indian-meal moth (*Plodia interpunctella*), its adult stage being a moth with a wing expanse of nearly three-fourths of an inch, with the basal third of the front wings and all of the hind wings soiled light gray and the outer two-thirds of the front wings coppery brown (fig. 7, *c*). When attacking grain the caterpillars show a special fondness for the germ. Not only cereals and cereal products are attacked, but seeds, dried roots and bark, dried fruits, nuts, etc. In 1918 at Lincoln it was even found ruining a large supply of nut candy held in one of the chain stores.

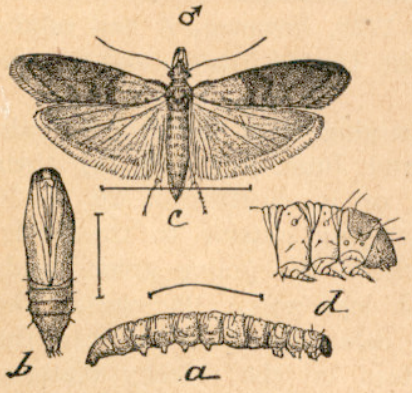


FIG. 7.—The Indian-meal moth (*Plodia interpunctella*): *a*, caterpillar; *b*, pupa; *c*, adult moth—enlarged about 2½x; *d*, head and thorax of caterpillar—much enlarged. (From Riley and Howard, 1889.)

The Indian-meal moth lives entirely within doors, and the number of annual generations varies from 4 to 6, according to the temperature of the building. The female moths lay their minute white eggs singly or in groups of 3 to 12 directly upon the food substance, until a total of about 350 eggs have been laid. The eggs hatch in about 4 days and the caterpillars become fully grown, pupate, and produce the next generation of moths in about a month.

THE MEDITERRANEAN FLOUR MOTH

Rather closely related to the Indian-meal moth is the Mediterranean flour moth (*Ephestia kuehniella*), which, while it will on occasion attack grain, bran, meal, and cereals after the manner of that species, is preeminently a flour pest, and mostly found in Nebraska in the flour mills. It does much injury by spinning thru the flour, causing it to become lumpy and matted, and by clogging the milling machinery. The caterpillars of the Mediterranean flour moth greatly resemble those of the Indian-meal moth, but are a little longer and more slender, of more uniform diameter, with longer and more cylindrical (less conical) abdominal legs, and minute but distinct blackish warty spots bearing short hairs on the body, which warty spots in the Indian-meal worm are colored like the rest of the body and therefore hardly distinguishable (fig. 8, *a*). The moth has a wing expanse of somewhat less than an inch and its front wings are pale leaden gray with more or less distinct cross-markings of blackish, while the hind wings are soiled whitish—thus being larger and very differently colored from the preceding species (fig. 8, *c* and *f*).

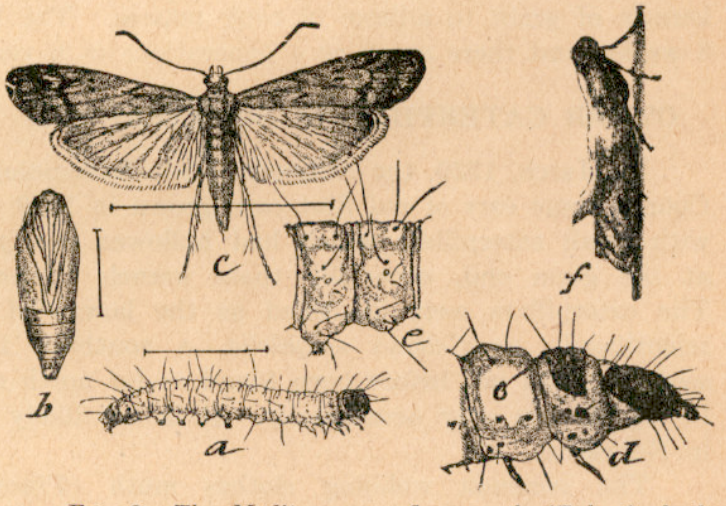


FIG. 8.—The Mediterranean flour moth (*Ephestia kuehniella*): *a*, caterpillar; *b*, pupa; *c*, and *f*, adult moth—enlarged 2x; *d*, head and thorax of caterpillar; *e*, abdominal joints of same—much enlarged. (From Riley and Howard, 1889.)

The eggs of this moth are laid in the flour or on the milling machinery in mills, or on the grains in granaries. They are tiny and white, hatch in about 3 days, producing caterpillars that mature in about 6 weeks, meanwhile spinning an immense amount of webbing. The moths of the next generation appear 8 to 12 days after the maturity of the caterpillars. The life cycle thus consumes about 9 weeks, and in well-heated mills there may be 6 or more generations in a year.

THE MEAL SNOUT-MOTH

The meal snout-moth (*Pyralis farinalis*) is of about the same size as the Mediterranean flour moth, having a wing expanse of about an inch, but is very differently colored from any other of the grain moths, its front wings being centrally light reddish brown, bounded by two wavy curved white lines, at the base before and at the apex beyond which the color deepens to a chocolate brown. The caterpillars are about an inch long, whitish shading to orange yellow toward each end, with the head shiny brownish red. They attack all kinds of grains and grain products, especially meal and bran, wherever these are in warm and slightly damp places. Each caterpillar constructs for itself a long tube of silk mixed with particles of the food material, in which it develops to maturity, thus causing the infested meal or bran to become stringy or the infested kernels of grain to adhere in ropy masses. The life cycle requires about 8 weeks, and there are 3 or 4 generations in a year.

OTHER CATERPILLARS OCCASIONALLY INFESTING GRAIN

In March, 1920, the Nebraska State Entomologist received from Boone County some ears of red flint corn grown in 1919 that were badly infested with small caterpillars which had hollowed out or consumed the kernels at the germ end, especially those kernels toward the tip of the ears. The caterpillars were identified as the larvae of a tineoid moth known scientifically as *Celama sorghiella*, a southern insect pest of sorghum seed that had not before been found as far north as Nebraska, and known to injure corn only occasionally. It is not likely to prove a serious pest in Nebraska.

The common webbing clothes moth (*Tineola biselliella*) has long been suspected of possibly occasionally breeding in cereals, having been reared from stored corn and wheat. In latter September of 1921 its caterpillars were found heavily infesting stored dried sweet corn at Omaha, copiously webbing the dried grains together after the manner of the Indian-meal worm, and a number of the moths were reared. Similar injury to stored wheat at Seward was reported at about the same time. It is not, however, to be as yet regarded as a serious pest in Nebraska.

PREVENTIVE MEASURES

Small grain left in the field in the stack until early fall, as is sometimes done, may become seriously infested with the Angoumois grain moth or the rice weevil. In order to avoid such field infestation, if there is great probability of injury, the grain should be thrashed from the shock, or, if stacked, then as soon after harvest as circumstances will permit.

Granaries should be so constructed as to be as cool and dry as possible

in order that the grain may not become so damp as to induce heating, since this favors the rapid increase of "weevil" of all kinds. Frequent agitation or handling of the grain will destroy many of the caterpillars of the Indian-meal moth and other grain-infesting larvae. Granaries should also be so constructed as to be easily kept clean, without cracks in which grain dust can accumulate and the pests breed continuously even when the bin is apparently empty, and with tight-fitting doors and windows so as to readily permit of fumigation.

Infested old grain left in bins or granaries will serve to quickly infest any new grain put in with it. Therefore, before new grain is added, the old grain should be thoroly fumigated with carbon bisulphide; or better yet, the old grain should be removed, the floors, walls, and ceilings of the bins thoroly cleaned, and the floors sprinkled with air-slacked lime (which should be again removed before the grain is stored) or sprayed with benzine or gasoline (care being taken to keep away all fire and lights until the liquid has evaporated and the vapors have disappeared); or, if necessary, the whole granary fumigated with carbon bisulphide or sulphur dioxide fumes. Especially should all accumulations of dust, dirt, and refuse grain or meal be removed and all corners sprinkled with lime, as these serve as breeding places for stored grain pests.

If corn in the open crib shows serious infestation it cannot be successfully treated in that condition, but should promptly be shelled, stored in tight bins or in the granary, and there fumigated.

DESTROYING STORED GRAIN PESTS BY FUMIGATION

The most satisfactory method of destroying stored grain pests or "weevil" of all kinds is by careful fumigation. Various vapors have been used for this purpose—carbon bisulphide, carbon tetrachloride, chlorpicrin, hydrocyanic acid gas, sulphur dioxide, and others of less importance. Of all these vapors, the most practical from the combined standpoints of safety to the operator, efficiency, availability, and harmlessness to the germination and flour-making qualities of the grain, is carbon bisulphide.

Carbon bisulphide (CS_2) is a heavy liquid, with a very disagreeable odor, that evaporates very rapidly upon exposure to air, forming a vapor heavier than air that tends to penetrate downward in the grain, and kills the pests by suffocating them. To a great degree the successful destruction of stored grain pests by a fumigation with this vapor depends upon the thoroness of the preparation for the fumigation. It must be remembered that the vapor of this chemical is very penetrative, and unless the bin is quite tight it will seep out and the effect of the fumigation thus largely be lost. It is necessary for the vapor to remain in the bin at full strength for the proper length of time so that it may penetrate

to all parts of the interior of the bin without escaping from the bin. All large holes and cracks should be pasted over with paper or plugged tight with cotton batting or rags. Doors and windows should be made tight by the same methods, but some arrangement should be made for the opening of a window or door from the outside when the fumigation is completed. The top of open bins can be made sufficiently tight with canvas or blankets, since the vapor works downward. Everything should be made ready before the fumigation is begun, and after it is begun it should be carried thru as rapidly as possible.

The liquid carbon bisulphide should be evaporated from shallow pans at the top of the bin, or sprinkled over the grain, or both. It is desirable to have the liquid evaporate as rapidly as possible, and over all parts of the infested grain, hence only shallow pans, with a large evaporating surface, placed here and there over the grain and containing a pound or less of the liquid, should be used. In large bins, especially if the grain is not to be used for seed, it is also a good plan to loosely plug the end of a gas pipe, thrust the pipe into the grain, loosen the plug with a rod, pour a quantity of the chemical down into the grain thru the pipe, and then withdraw it and use at another spot.

The amount of liquid carbon bisulphide to use depends upon the amount of grain to be fumigated, on the tightness of the bin, and on the temperature at the time of the fumigation. The warmer the air the more rapidly the carbon bisulphide will evaporate, and the more vapor it will take up before becoming saturated with it. Also the higher the temperature the more active are the insects, and because of their more rapid breathing when active they succumb more readily to the effects of the vapor. It is useless to attempt fumigation with carbon bisulphide at a temperature under 60°F. At a temperature of 70°F. and up fumigation is satisfactory. In empty or nearly empty tight bins, containing only scattering pests, at 70°F. one pound of carbon bisulphide will fumigate 300 cubic feet of air space; at 80°F. it will fumigate 400 cubic feet, and at 90°F. it will fumigate 500 cubic feet. At any of these temperatures, in filled tight bins, one pound should be used for every 35 bushels of grain. If the bins cannot be made thoroly tight the above amounts will need to be doubled. Since it requires a certain amount of the vapor to kill any insects at all, the degree of the infestation is not important in determining the amount to use, but it is well to use rather maximum amounts when the pests are very abundant.

In case the grain is not to be used for seed, the vapor should be kept confined in the grain for 48 hours. A good plan is to apply the liquid at midday on a Saturday and open up the bin the following Monday noon. Grain intended for seed purposes should be fumigated for 36 hours. At the close of the proper period the bin should be opened and aired thoroly for several hours before being entered for any length of time.

PRECAUTION

While the liquid carbon bisulphide is not explosive, and may be handled without particular caution when in tightly sealed cans or drums, *its vapor is, when mixed with air, highly inflammable and explosive.* The vapor ignites from any form of fire, even the slightest spark, and at a temperature without any flame of above 297°F., which is a lower ignition point than that of gasoline vapor. It is therefore, absolutely necessary that no light of any kind be brought near to a bin in process of fumigation, or to any other spot where the odor of the vapor is noticeable. Smoking in such places is equally dangerous, and there is a real risk in the snapping of electric buttons, driving of nails, or hot steam pipes. All these, and any other thing that might ignite the vapor, should be painstakingly avoided.

Another precaution that is necessary in connection with fumigation with carbon bisulphide is to avoid inhaling the vapor in any considerable amounts, or for a prolonged period, without breathing some fresh air. If, in fumigating with this chemical, there is felt any dizziness or nausea, the fresh air should be sought at once, when the ill effects will usually pass away within a few minutes. Also, since the vapor has an accelerating effect upon the heart action, persons having any heart trouble or weakness should never take any extended part in fumigating operations with carbon bisulphide.

Carbon bisulphide may be purchased in exactly the desired amount, from 1-pound or 5-pound cans to 50-pound, 100-pound or 500-pound drums. The price per pound will vary according to the amount purchased. If a large amount is required, the carbon bisulphide can be obtained most cheaply directly from jobbing firms handling it in drums. The drums are usually returnable at the price charged, if in good condition, and the buyer is usually credited with the return freight. The cost of enough carbon bisulphide to completely destroy the pests in 1,000 bushels of grain should not be more than $10, or at the rate of a cent a bushel, and usually will be considerably less.

Unlike carbon bisulphide, carbon tetrachlorid is not inflammable and does not explode in the presence of fire, hence it can be used under some conditions where carbon bisulphide could not be used. It is, however, more expensive than carbon bisulphide and is not so efficient. In general, it will require twice the amount of carbon tetrachlorid to secure the same effect, as compared with carbon bisulphide.

DESTROYING STORED GRAIN PESTS BY HEAT

Before the use of carbon bisulphide as a fumigant to destroy stored grain pests became general, the subjecting of these pests to great heat was the principal method of destroying them. The adult moths of our grain-infesting caterpillars will quickly die at a temperature of 116°F., while their caterpillars and pupae will die at about 118°F. The grain beetles and flour beetles perish at temperatures of 119° or 120°F. The cadelle, one of the most resistive to heat of all the stored grain pests, dies at a temperature of 122.5°F. A temperature of 120°F. continued for 3 minutes, or even 115°F. continued for 12 hours, is fatal to all stored grain pests. Inasmuch as wheat can be subjected to a temperature as high as 150°F., for a short time, without destroying its germinating power, the practicability of the heat method, where facilities for generating the proper amount of heat in the granary are at hand, is evident. However, in only occasional instances are such heat-producing facilities at hand in the farm granary, and in general the carbon bisulphide method above described must be relied upon to control stored grain pests on the farm.

[3 M]