Khapra larvae and adults on pecan meats.

Khapra Beetle Control

preliminary results of tests with fumigants a promise of effective treatments against destr

D. L. Lin

The State of California, by Quarantine Regulation 21, effective January 12, 1955, prohibits the removal from property infested with the Khapra beetle—*Trogoderma granarium*, Everts—of all materials that might help the spread of this insect which is so destructive to stored grain and grain products.

Since the Khapra beetle was first found established in the United States in stored barley in two warehouses in Tulare County—November 1953—infestations have been discovered in eight additional California counties.

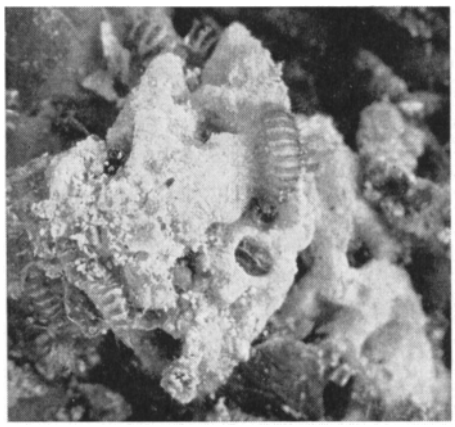
After the insect was found in Tulare County, United States Department of Agriculture entomologists made a survey of grain warehouses in the 11 western states and uncovered other infestations in Fresno, Imperial, Kern, Kings, Riverside, and San Diego counties of California; in Maricopa, Mohave, Pima, Pinal, and Yuma counties of Arizona; and in Curry and Roosevelt counties of New Mexico.

It is not known how the Khapra beetle was introduced into this country, but the United States Department of Agriculture is proposing a quarantine to help prevent the movement of the insect into uninfested areas. The quarantine, if warranted, would prohibit or restrict movement from the three states—or from infested areas within the states—of grain, grain products, dried seeds, of field and vegetable crops, bags and bagging, dried milk, dried blood, fish meal, meat scraps, and other items that might help spread the beetle.

Nature of Injury

The larvae of the Khapra beetle feed on a wide variety of stored products and by their continual gnawing reduce the material to a powdery mass. The fourth instar—stage of growth—larvae attack grain by gnawing at various parts of the kernel, and usually begin their attack at some weak place in the pericarp, or seed coat. The first, second, and third instar larvae are unable to feed on entire grains but can feed on broken kernels damaged by fourth instar larvae or on the floury debris which they create.

The adults, as a rule, do not feed, but they have been observed gnawing at the surface of wheat grains which have already been eroded by the larvae.



Khapra larvae on walnut meats.

The Khapra beetle tends to confine its activity to the top 2′ of grain, but it has been found to penetrate to depths of 9′. Although reported losses vary from 2% to 78%, an infested lot of grain, if left undisturbed, would eventually be a complete loss.

In infested bagged material, the larvae weaken the sacks to the extent that ultimately they tear.

Description

The egg of the Khapra beetle is a little under $\frac{1}{64}$″ in length, narrowly cylindrical, rounded at one end, somewhat pointed at the other, and is a translucent white when laid. The eggs are usually laid singly and often loosely in the grain, but occasionally when they are laid in the groove or furrow of a wheat grain, several may be deposited together.

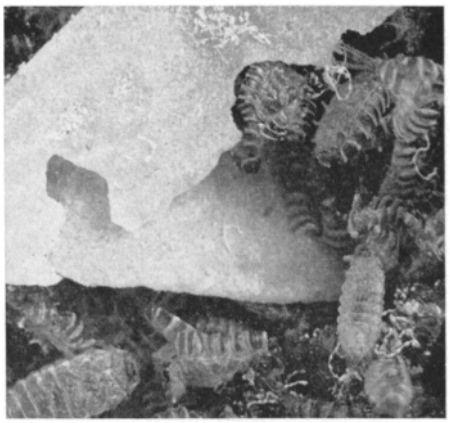
The newly hatched larva is about $\frac{1}{25}$″ in length and is yellowish-white in color. The mature larva is about $\frac{1}{4}$″ in length, is brownish-white in color, the body being covered with bundles of long, reddish-brown hairs.

The pupa is approximately $\frac{1}{25}$″ in length and is enclosed, with the exception of a portion of the dorsum, by the last cast larval skin.

When the adults emerge from the pupa, they remain quiescent within the last larval skin for a period which varies from a few hours to 10 days or more, according to temperature. The adult is a small beetle, the female measuring about $\frac{1}{8}$″ in length. It is a dark-brown, slow-moving insect. The adults do not fly, and this insect can be dispersed by wind, birds, and so forth.

The presence of the Khapra beetle in grain causes heating, as was indicated in Imperial Valley when the outside air temperature was 53F and the temperature of infested stored barley 12″ below the surface was 104F.

Observations indicate that the Khapra beetle remains active throughout the year in Imperial Valley. Larvae collected at intervals during the winter from infested warehouses, taken to the laboratory, and placed in a 90F temperature cabinet completed their life cycle and became adults in a relatively short time. This would indicate that these insects, under the conditions observed, do not hibernate.



Khapra larvae on egg noodles.

Under laboratory conditions, cultures held at 93–95F, at either 100% light or 100% darkness, have completed six generations since June 1953. At 90F, in 100% darkness, or a combination of 50% darkness and 50% light, eight generations have been completed since May 1954. These experiments indicate that

Studies

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dgren, L. E. Vincent, and H. E. Krohne

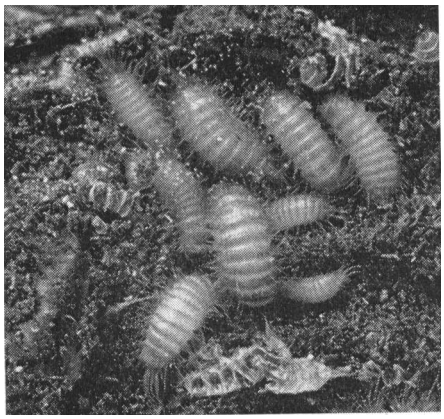
Average Life History in Days of Individual Khapra Beetles Reared at Various Temperatures.

Temperature F	Egg	Larva	Pupa	Egg to Adult
70	13	161	19	193
80	8	153	10	171
90	5	27	6	38
93–95	3	19	4	26

the light and temperature combinations tested had no effect on insect development or egg laying.

The average total number of days required from egg to adult for the Khapra beetle, when reared as individuals, was 193 at 70F, 171 at 80F, 38 at 90F, and 26 at 93–95F. The critical temperature appears to be somewhere between 80F and 90F, as the life cycle is very much shortened in this interval. This corresponds to other data, which indicate that this insect is a much more serious pest in warmer climates.

During its larval stage, the Khapra beetle may molt anywhere from two to nine times, depending on the temperature, although under adverse conditions, it may molt as many as 15 times.



Khapra larvae on dried prunes.

The average viable egg production at 90F was 93 and at 70F was 65, indicating the higher temperature to be closer to the optimum for the development of this insect.

The adults were found to live from three to 47 days, depending on temperature.

A few eggs survived a two-hour exposure at –5.8F. The majority of larvae survived a 28-day exposure at 24–48F, and some larae survived a four-hour exposure at –5.8F. Preliminary results indicate that the pupae are more susceptible to cold temperatures than are the larvae.

Larval survival has been obtained following a six-hour exposure at 120F.

Larvae kept in cultures and exposed to an outside temperature became active during the warmer part of the day, although the temperature dropped to as low as 34F at night.

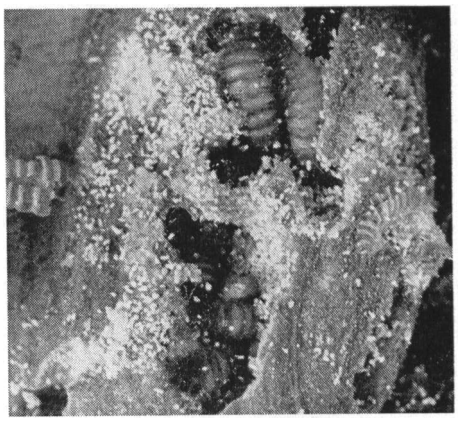
Larvae placed at 90F are continuing to survive after 160 days without food. Other workers have found that the Khapra beetle larvae will survive for as long as three years without food.

Khapra larvae on spaghetti.

Various foods being tested to determine whether the Khapra beetle can develop on them include raisins, walnut-pecan-almond meats, spaghetti, egg noodles, prunes, dried peaches, pearl barley, tapioca, dried beans, flax, powdered beef blood, various grains, dog food, and skim milk. Although these tests have not been concluded, it is evident that the materials vary greatly in susceptibility to attack. The developmental period was shortest on wheat, barley, dog food, and rice. Such materials as raisins, prunes, and peaches were fed on, but no adults have been observed.

Control Studies

A series of laboratory experiments were conducted to determine the relative susceptibility of naked Khapra beetle larvae, confused flour beetle adults—*Tribolium confusum*—and granary weevil adults—*Sitophilus granarius*—to ten different fumigants. Results of these tests are shown in the table at the lower right. The Khapra beetle larvae were more resistant than the other two insects tested to all fumigants, with the exception of hydrocyanic acid and ethylene dibromide. The granary weevil adults



Khapra larvae in almonds.

were the most resistant to hydrocyanic acid and ethylene dibromide.

Preliminary results of fumigation tests conducted at 70F, with a two-hour exposure on eggs, larvae, and pupae of the Khapra beetle, indicate that the eggs are the most susceptible stage to fumigation by hydrocyanic acid, acrylonitrile, ethylene dibromide, methyl bromide, and ethylene chlorobromide. Of the ten fumigants tested hydrocyanic acid, acrylonitrile, chloropicrin, ethylene dibromide and methyl bromide are the most toxic fumigants to egg, larval, and pupal stages of the Khapra beetle.

Preliminary results with malathion used at the rate of 4, 8, 12, and 16 parts per million on wheat of 9% moisture content appeared to control this insect effectively. The residual action of malathion depends on the concentration used and the moisture content of the grain.

Tests are being conducted in cooperation with the State of California Department of Agriculture to determine the effect of various fumigants on seed germination.

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FUMIGATION TESTS

Milligrams per Liter to Kill 95% at 70F with a 2-Hour Exposure

	Khapra Beetle	Confused Flour Beetle	Granary Weevil
	Larvae	Adults	Adults
Hydrocyanic acid	7.8	2.2	29.0
Acrylonitrile	18.0	11.0	8.0
Ethylene dibromide	27.0	21.0	29.0
Chloropicrin	34.0	31.0	34.5
Methyl bromide	54.0	44.0	27.0
Ethylene chlorobromide	110.0	26.5	48.0
Methallyl chloride	135.0	75.0	87.0
Carbon bisulphide	215.0	>179.0	149.0
Ethylene dichloride	>271.0	226.0	271.0
Ethylene oxide	> 48.0	> 40.0	31.0