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UNITED STATES DEPARTMENT OF AGRICULTURE

The Use of Traps Against the Japanese Beetle[1]

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CONTENTS

INTRODUCTION

Thousands of traps, baited with a mixture of two liquids known as geraniol and eugenol, are used annually to capture the Japanese beetle. It is estimated that each year billions of the insects are destroyed after being captured in these devices. The successful operation of traps is dependent upon many factors, and unless these are recognized the user may be disappointed with his results. The purpose of this circular is to give an appraisal of the value of traps, to offer some suggestions on the selection, operation, and care of these devices, and to point out the important factors governing their effectiveness.

THE VALUE OF TRAPS

Traps are of value in determining the presence of beetles in areas, remote from the generally infested region, to which they have been carried accidentally by human agencies, and in reducing the density of the population in the areas in which they have become established. The capture of a beetle before it has done all its feeding reduces the extent of damage of which it is capable. Any device that will destroy a female beetle before all her eggs have been deposited in the soil is a factor in reducing the number of beetles in the succeeding generation. It is apparent that the sooner a female beetle is captured after

[1] This circular supersedes Miscellaneous Publication No. 201, Traps for the Japanese Beetle and How to Use Them.

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emergence, the fewer will be the number of eggs deposited. About equal numbers of both sexes are taken in traps.

Traps probably have greatest value controlling the Japanese beetle in localities remote from the generally infested region, particularly during the 10-year period following its introduction which usually elapses before the beetles become sufficiently numerous to cause serious damage to trees, shrubs, orchard crops, and turf. Each female beetle captured during the early stages of the invasion is an important factor in delaying the normal increase in the density of the population. The extensive use of traps under these conditions retards the normal development of the infestation, and, if carried on annually, may postpone the time when the insect becomes a serious economic pest and additional control measures must be employed.

In the older infested areas, where beetles are generally distributed and the density of the population is such that serious injury occurs annually to fruit, foliage, blooms, and grass, enormous numbers of beetles may be captured by traps without any resultant noticeable decrease in the extent and degree of damage. It is known that placing even as many as 100 traps in a square mile of a heavily infested area usually will cause only a minor reduction in the established population of beetles in the area and may even attract a sufficient number from surrounding areas to increase the density. Furthermore, the use of traps by an individual without the cooperation of his neighbors under conditions of severe infestation generally produces no noticeable diminution in the population and usually results in more extensive damage on the property on which the traps are placed. In heavily infested areas traps should not be depended on to protect plants from attack by the beetles or to prevent injury to lawns by the larvae. This protection at present can be obtained best by the use of sprays and the treatment of turf.[2]

Although immediate control of severe beetle infestations cannot be expected, it may be anticipated that general trapping of the beetles may produce tangible results when many traps are employed over a period of several years and the cooperation of practically all persons is secured. In combating the Japanese beetle in the heavily infested regions the individual needs the cooperation of his neighbors in a trapping campaign to reduce or retard the general infestation in the locality. This is in contrast to the use of sprays to repel the beetles from plants, or of soil treatments to control the grubs in the grass. In such efforts the cooperation of neighbors, although very desirable and helpful, is not entirely necessary.

In localities remote from the generally infested region, traps attract and capture beetles, even when a diligent search often fails to reveal their presence. Thousands of traps are used each year by the Bureau of Entomology and Plant Quarantine to determine the presence of beetles in various localities, in connection with efforts to retard their spread. There is some evidence indicating that in several localities the capture of the first invaders by traps has prevented the establishment of infestation.

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[2] FLEMING, WALTER E. PREVENTING INJURY FROM JAPANESE AND ASIATIC BEETLE LARVAE TO TURF IN PARKS AND OTHER LARGE AREAS. U. S. Dept. Agr. Cir. 403, 12 pp., illus. 1936.
——— and METZGER, F. W. CONTROL OF THE JAPANESE BEETLE AND ITS GRUB IN HOME YARDS. U. S. Dept. Agr. Cir. 401, 15 pp., illus. 1936. (Revised 1938.)
——— and METZGER, F. W. CONTROL OF THE JAPANESE BEETLE ON FRUIT AND SHADE TREES. U. S. Dept. Agr. Cir. 237, 12 pp., illus. 1936. (Revised.)

HOW THE TRAPS CATCH BEETLES

Beetles are drawn from the leeward to a trap by means of the attractant, geraniol. Most of the beetles captured are those that fly into the superstructure of the trap and then fall into a receptacle from which they cannot escape.

The number of beetles captured by a trap is dependent on many factors, among which are the season of the year, the activity of the beetle, the nature of the attractant, the method of dispersing the attractant, the construction and color of the trap, the placing of the device in respect to the source of the infestation, and the presence of favored food plants, buildings, and other obstructions.

CONSTRUCTION OF THE TRAP

Some of the more recent styles of traps which have been developed by the Bureau of Entomology and Plant Quarantine and the cooperating State agencies are shown in figures 1 to 3. The essential structural features of these traps are (1) a four-winged baffle mounted on top of a funnel, (2) a device for holding the bait dispenser, and (3) a receptacle for holding the captured beetles. The influence of each of these parts on the efficiency of the trap is discussed briefly in the following paragraphs.

FIGURE 1.—A satisfactory type of trap for the Japanese beetle. A bottle-and-wick dispenser can be placed in the perforated cylinder. Formerly the bran bait was used in this cylinder. This trap is painted a solid yellow, now known to be the most desirable color.

THE BAFFLE

As most of the beetles captured are those that have flown into the wings of the baffle, the area of the baffle above the rim of the funnel is considered the most important structural feature of the trap. It has been found that the most effective height of the baffle above the funnel is about 4 inches. When the height is less than this, many of the beetles fly over the trap without hitting the baffle; when the height is

much greater, many of the beetles that strike near the upper edge of the baffle are thrown outside the funnel or are able to escape without dropping into the funnel. The lower part of each wing should extend a sufficient distance into the funnel to hinder the beetles from recovering their balance. At present the traps considered to be the most effective have baffles with four wings, each of which is 3 to 4 inches wide and 6 to 8 inches high, mounted over the mouth of the funnel in such a manner that the lower end of each wing extends 2 to 4 inches into the funnel.

The Funnel

The function of the funnel is to deliver the beetles into the receptacle attached to its base before they can recover their balance. After experimentation with different funnels, it was found that the most efficient funnel is one with the upper diameter equal to the width of the baffle, the opening at the bottom about three-fourths inch in diameter, and the slope about 30° from the perpendicular. If the diameter of the opening at the bottom is greater than three-fourths inch, some beetles are able to fly back through it from the receptacle into which they have fallen; if it is less than this, many beetles are able to recover their balance at this point. When the slope is greater than 30° from the perpendicular, many beetles are able to fly out, and fail to reach the lower part of the funnel. Of course the inside of the funnel should be smooth, so that there are no surfaces to which the beetles can cling.

The Bait Dispenser

The type of bait dispenser used and the way in which it is placed in, or built into, the trap are important factors influencing the effectiveness of the traps.

Although any method of dispensing the attractant will draw some beetles, it is most desirable that a dispenser be used that will allow the material to evaporate at a practically constant rate throughout the season, thus maintaining the level of attractiveness. When the evolution of the attractant is not constant, there may be a waste of material at the beginning of the season, and later the evaporation may not be sufficient. A bottle-and-wick dispenser has been found to be the most satisfactory device for the purpose. The geraniol and eugenol are evolved from the part of the wick exposed above the lid of the bottle at practically a constant rate as long as any material remains in the bottle. This method has the further advantage over the others in that it is possible to determine by visual examination when the bait is exhausted. It has been found that a cotton wick having a woven cotton sheath covering the inner fibers which run lengthwise is the most satisfactory. Felt wicking, while dispensing the bait as well as the cotton wicking, is somewhat less attractive. It has been found that the desired amount (about 1½ to 2 ounces) of the geraniol-eugenol mixture is given off by a Pett wick, ¼ inch in diameter, when exposed 2 inches, by a ½-inch Torch wick exposed 1¼ inches, or by a ⅝-inch Torch wick exposed 1 inch. It is desirable to place a metal band or clip around the upper portion of these wicks near the

tip to prevent fraying and subsequent siphoning of the material from the bottle. It is the usual practice to cut these wicks of such lengths that when the lower end is resting on the bottom of the bottle, the upper end is projecting the desired distance through the hole in the cap. If the wicks are exposed to a lesser extent than that indicated above, the amount of the mixture given off will be reduced and the attractiveness of the bait will be decreased; if a greater area of these wicks is exposed, an unnecessarily large amount of geraniol and eugenol will be dispensed, resulting in a waste of material.

In some types of traps the bait dispenser is placed in a perforated metal cylinder, which is mounted in the center of the baffle (figs. 1 and 2), the wings being cut away in the central portion for this purpose; in others the lower and upper parts of the wings of the baffle are left intact, an opening of sufficient size to receive the bottle and wick is made at the middle of the intersection of the wings (fig. 3), and a cone is mounted over the bait dispenser to protect it from rain. When a bait consisting of bran, geraniol, and eugenol (see p. 8) is used, the bait may be placed in the perforated metal cylinder in the center of the baffle (fig. 1) or in the "bucket" type of trap in a special container in the bucket. It is preferable, however, to mount the bait dispenser in the baffle. In general there seems to be little difference in attraction whether the bait dispenser is placed in a perforated cylinder or under a metal cone in the baffle, although, if the perforations are partly closed by paint or dirt, the evaporation may be reduced to such an extent as to impair the effectiveness of the trap.

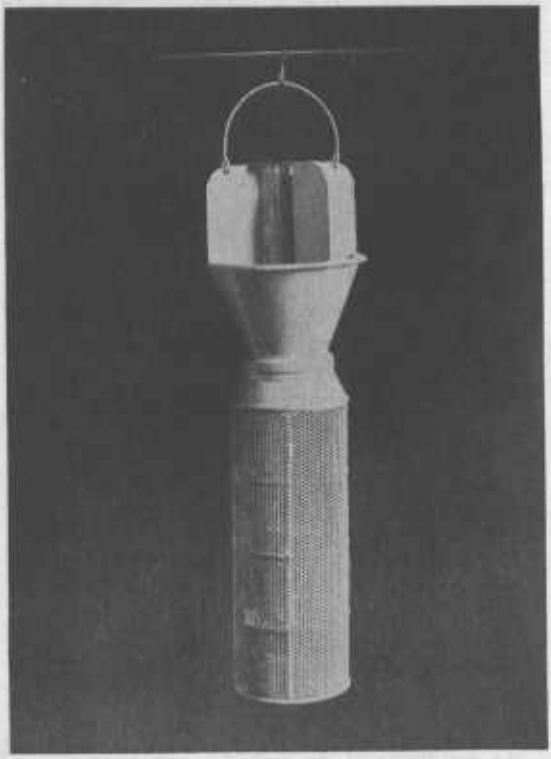

FIGURE 2.—This trap is similar in principle to the one shown in figure 1, except that the glass jar is replaced with a perforated metal container for use in more densely infested areas. The preferred color of this trap is yellow throughout.

THE BEETLE RECEPTACLE

The size and type of the receptacle attached to the bottom of the funnel seem to have little influence on the number of beetles captured.

The function of the receptacle is to hold the beetles that fall into it. To prevent the beetles from escaping, the lower end of the funnel should project about 1 inch into the receptacle and there should be no opening between the receptacle and the outside of the funnel. Satisfactory containers have been made from glass jars, cans, and cylinders of perforated metal. Provision should be made for drainage by putting one or more small holes in the bottom of the container so that it will not fill with water during periods of rain. It is important that the size of the container be such that it will not be filled to overflowing with beetles during the intervals between the removal of the beetles from the device. Otherwise, the size of the receptacle is not a factor. In lightly infested areas, a container with a capacity of 50 to 100 beetles is usually ample; in more heavily infested areas, a container with a capacity of 2 or more quarts of beetles is usually required.

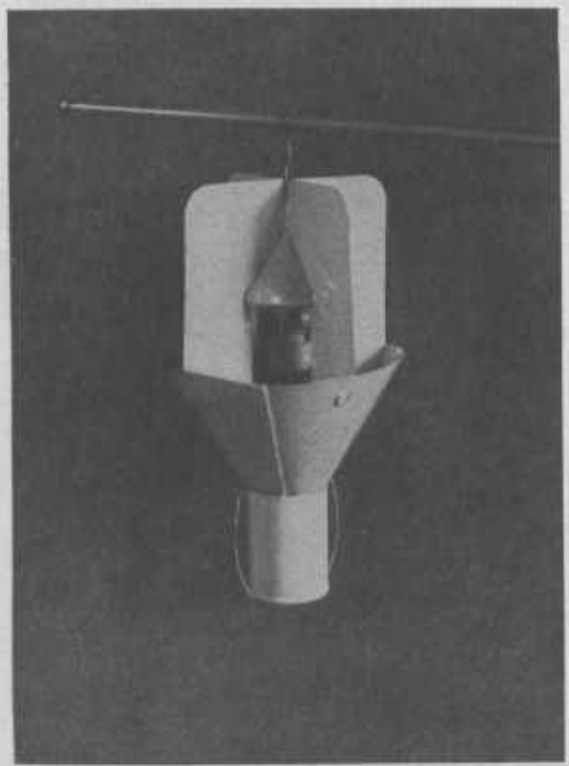

FIGURE 3.—Type of trap for use in scouting to determine the distribution of the beetle in newly infested areas or areas believed to have become infested. The preferred color of this trap is yellow throughout.

COLOR OF THE TRAP

It has been found that a yellow trap is definitely superior to those painted any other color. Traps painted yellow have captured more beetles than those painted red, blue, white, or aluminum. The addition of yellow to other pigments always increased the effectiveness of the traps in capturing beetles. The number of beetles taken in traps painted white or yellow was progressively decreased as red was added in increasing amounts to these pigments. The same result was obtained when blue or white was added to other pigments.

Until 1939, a trap painted green and white was considered to be the most effective for capturing beetles. Thousands of these devices are on the market, with shades of green varying from light to dark and from yellowish green to bluish green. Many questions have been raised in reference to the proper shade of green and the importance of having the different parts painted green or white. There is no

doubt that a trap with the baffle and the inside of the funnel painted white and the outside of the funnel and the receptacle for the beetles painted green is more effective than an entirely green trap. It is known now that when the baffle and the inside of the funnel of a green trap are painted white, the performance of the trap is very similar to that of one painted entirely white; and that when these parts of a white trap are painted green, the performance is of the order of that of a trap painted entirely green. The shade of green on the outside of the funnel and the container for the beetles seems to be a minor factor. As regards the coloration of the trap, the color of the baffle and of the inside of the funnel is the most important factor governing the effectiveness of a trap in capturing the beetles which are attracted to it. There seems to be no advantage in using a dual color scheme on traps. As yellow traps are more effective than those painted green and white, or any other color, it logically follows that, to secure the greatest capture of the beetles attracted, the trap should be painted with a primary yellow.

Traps painted with paints having a high luster, such as the "automotive type" lacquers, capture more beetles than those painted with materials having a dull finish. The effectiveness of the highly lustrous traps decreases as exposure to the weather reduces the luster, changes the color of the pigment, or causes the film to crack. All paints investigated are removed by the geraniol-eugenol bait. For this reason it is important that the bait be prevented from coming into contact with the painted parts of the trap. To maintain the yellow trap at its highest efficiency, it should be repainted when the film of paint is damaged or changed greatly in luster or color.

THE BAIT MATERIAL

Among many materials that have been tested as attractants for the Japanese beetle, the most effective ones that have been discovered are two higher alcohols, geraniol and eugenol. Geraniol, which is obtained commercially by the distillation of oil of citronella, is an entirely different material from geranium oil. The latter is only slightly attractive to the beetle. The chemistry of geraniol and its closely related compounds is complex, and much remains to be learned about it. Several grades of geraniol, differing somewhat in attractiveness, are available on the market. The best results have been obtained thus far with geraniols meeting the following general specifications:

Specifications for geraniol

Specific gravity at 20° C.	0.875 to 0.895.
Total free alcohols as geraniol and citronellol	Not less than 70 percent.
Ester content	Not more than 15 percent.
Aldehydes as citronellal	Not more than 3.5 percent.
Solubility	1 part in 2 parts of 70-percent ethyl alcohol.
Boiling range	Not more than 5 percent to distill below 225° C. or more than 18 percent to distill above 245° C.
Odor	Absence of any significant indication that materials foreign to geraniol have been added.

Eugenol derived from clove oil has been found to be more attractive than the material derived from cinnamon oil. The most satisfactory results have been obtained with a eugenol of the U. S. P. grade, derived from clove oil, and meeting the following specifications:

Specifications for eugenol

Specific gravity at 25° C	1.064 to 1.070.
Solubility	1 part in 2 parts of 70-percent ethyl alcohol.
Boiling range	250° to 255° C.
Odor and color	Colorless to pale yellow thin liquid having a strong aromatic odor of cloves and a pungent spicy taste.

Eugenol is about as attractive as geraniol and it is a more standard product with less tendency to decompose when exposed in a trap in the field. However, it is more costly than geraniol and at present can not be substituted economically for the cheaper material.

Mixtures of geraniol and eugenol have been found to be more attractive than either of the materials alone. These mixtures are more luring to the beetles than any other known attracant. The composition of the attractant now generally used is as follows:

Composition of the attractant

Geraniol	10 parts by volume.
Eugenol	1 part by volume.

This attractant is used in large quantities by the Bureau of Entomology and Plant Quarantine, various State agencies, and most of the manufacturers and dealers in traps and bait.

The most satisfactory method of dispensing the bait is the use of a bottle and wick. The best way of placing this in the trap has already been discussed (p. 5).

The bait used in the older types of traps, and in some that are still on the market, consists of geraniol and eugenol mixed with bran and other ingredients in the proportions indicated in the following formula:

Formula of bran bait

Geraniol	cubic centimeters	15
Eugenol	do	1.5
Water	do	13
Molasses, table grade	do	39
Glycerine, C. P. grade	do	6
Bran	grams	75

The water, glycerine, and molasses are mixed and poured onto the bran. Then the geraniol and eugenol are added and the stirring is continued until a homogeneous mixture is obtained. The total weight of the material, about 150 grams, or ⅓ pound, is sufficient to bait one trap. It is not usually profitable for an individual to obtain these ingredients and mix them unless he is operating a large number of traps. The bran bait prepared according to this or a similar formula can usually be obtained from the dealers in traps.

When the bran bait is first placed in the trap, the evaporation of geraniol and eugenol is relatively rapid. Then, owing to the loss of the attractant, the drying and compacting of the bait, the development of molds, and other factors, the quantity given off decreases until, after 2 or 3 weeks, the attractiveness of the bait is greatly reduced. It is usually necessary to renew the bran bait at least every 2 weeks to maintain the attractiveness throughout the season.

PLACING TRAPS

The position of the trap with reference to its surroundings greatly modifies the number of beetles captured and the distance from which they are attracted. Most beetles are attracted from the leeward of the trap. If located so that the odor of the attractant is carried across an open field, a trap may attract beetles from a distance of 300 to 500 yards. In suburban areas, where trees, walls, buildings, and other obstacles deflect and impede the movement of air, the zone of attraction is much more limited.

The best results are obtained when a trap is hung in an open, sunny position on a rod to the windward of the plants most subject to attack and not closer than 10 to 25 feet to plants on the leeward. When a trap is suspended in a tree or shrub, or placed on a standard in a bed of roses or other favored food plants, many of the beetles attracted will ignore the trap and will attack the plants. In protecting orchards, better results may be expected by placing the traps on the windward side (on the basis of prevailing winds) at a distance of 10 to 25 feet from the trees, than by placing traps throughout the orchard.

When a good trap is properly placed it can be expected to capture approximately 75 percent of the beetles attracted to it. It is, however, impossible to estimate what proportion of the beetles within the zone of its attraction are captured, because of the indefinite limits of this zone and because of the difficulty in determining the total population of beetles within this zone.

REMOVING CAPTURED BEETLES

The odor of decomposing beetles is repellent and definitely decreases the effectiveness of the bait. When large numbers are captured, it is desirable to empty the traps at least every other day to prevent the dead beetles from decomposing in the containers. It is also desirable to wash these containers occasionally. The effectiveness of the trap can be maintained by exercising these sanitary measures.

ACTIVITY OF THE BEETLE

The greatest movement of beetles occurs between 9 a. m. and 6 p. m. on warm, sunny days, when the temperature is between 80° and 90° F. When such conditions prevail, the beetles move rapidly from plant to plant and are most easily attracted to a trap. At night and during cool, rainy days the beetles remain in the ground or on the plants. Under these conditions even the most attractive bait will not lure them from their resting places to the trap.

PERIOD OF BEETLE FLIGHT

In general, beetles can be expected to begin emerging from the soil in infested localities in the southern Atlantic States about June 1, in the middle Atlantic States and southern New England about June 15, and in the northern New England States about July 1. The data are not as yet sufficient for determining when emergence can be expected in the States of the northern Mississippi Basin. Variations in the altitude and exposure and changes in the weather conditions from season to season modify the time of emergence, so that it is impossible to predict accurately when the beetles will appear in a locality. Usually the emergence is earlier at sea level than at higher altitudes, and earlier on slopes with a southern exposure than on those with a northern exposure. A warm, moist period, particularly for the 30 days prior to the expected appearance, hastens the emergence, whereas cool, dry weather during this period retards it.

After the first appearance, the density of the population usually increases rapidly, reaching a peak 5 or 6 weeks later. Then there is a decline in the number of beetles, the rapidity of which is dependent upon the weather. A few beetles may be found 5 or 6 weeks after the period when the insects are the most numerous. For most effective trapping, the traps should be in position just prior to the first emergence, but usually these devices are not placed until the beetles begin to appear in the locality. Probably the most practical procedure is to place the traps as soon as the first beetles appear and to allow them to remain as long as the insects are present.

SUGGESTIONS ON THE OPERATION AND MAINTENANCE OF TRAPS

It is evident from the previous discussion that the effectiveness of a trap in capturing Japanese beetles is influenced by weather conditions, the activity of the insect, the nature of the attractant and the method of dispensing it, the structure, color, and placing of the trap, and the practice of sanitary measures during its operation. To obtain the best results, the user should be familiar with the effect of each of these factors on the efficiency of the device.

When an individual, after careful consideration of the value of traps for the control of the Japanese beetle, comes to the conclusion that under his conditions it would be desirable for him to operate one or more of these devices on his premises, he should give attention to the type of traps to be used and the number of positions where they can be set to advantage, and make plans for operating them during the season.

The Bureau of Entomology and Plant Quarantine does not sell traps or bait, and does not furnish them free; however, information regarding the manufacturers and dealers in these devices and the supplies for them can be obtained from the office of this Bureau in Washington, D. C., or from the Japanese Beetle Research Laboratory, at Moorestown, N. J.

The following suggestions are offered as a guide to individuals or groups planning to use traps to capture the Japanese beetle:

(1) Build or procure a trap which embodies the best structural features of those illustrated in this circular, including a dispenser of the approved type. Make sure that the capacity of the container for holding captured beetles is sufficient for the numbers of beetles likely to be caught. It is better to have the container too large than too small. If the trap is not yellow, it should be painted with a primary yellow paint of high luster when repainting is necessary.

(2) The average city dweller or suburbanite usually cannot use more than one trap to advantage on his premises. On large estates and parks, several traps can often be used to advantage, these being placed in the open grassy areas about 100 to 200 feet apart. The number of traps that should be used on the premises depends upon the size and the local conditions.

(3) Procure a bait composed of geraniol and eugenol.

(4) As soon as beetles appear, place each trap in a sunny location on an iron stake, or other suitable support, so that it is from 4 to 5 feet above the ground. Do not place traps in trees or in beds of roses and other plants subject to attack. Traps should not be placed closer than 10 feet to trees, shrubs, and other plants. Remember that beetles fly against the wind toward the source of the attractive odor. As far as possible, place the traps so the beetles will be drawn from the plants.

(5) Once a day if possible, empty the receptacle in which the beetles are captured, and make it a point to remove the beetles at least every other day. Removal of the beetles can be most easily accomplished early in the morning or in the evening when they are least active. It has been found most satisfactory to empty the container into a pail containing water with a small quantity of kerosene or gasoline, or even hot water. This procedure will make certain that all the beetles are killed. When kerosene or gasoline is used in this manner, great care should be taken not to get these materials on the container, because they are somewhat repellent to the beetles. If these materials should accidentally get on the container, it should be thoroughly washed before being put back on the trap.

(6) Dispose of the dead beetles as soon as possible. Burying them has been found to be the most satisfactory method. Burning, even with kerosene, is not satisfactory, because it is difficult to burn a large mass of beetles and the burning is accompanied by a most disagreeable odor. If the beetles are to be disposed of with trash, they should be kept in a closed container until carted away.

(7) When the season is over, collect the traps, remove the bait, clean them, and place them in storage. Plans should be made to repaint those that require it. When the bottle-and-wick dispenser is used, the bait may be salvaged and used the following season, providing it is stored in an amber-colored, tightly stoppered bottle in a cool, dark place. It is not advisable to use this bait for more than two seasons.

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