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DEVELOPMENT OF BLACKLIGHT TRAPS FOR EUROPEAN CHAFER SURVEYS
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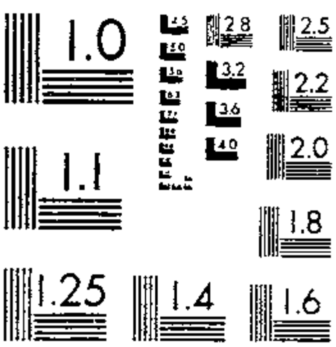


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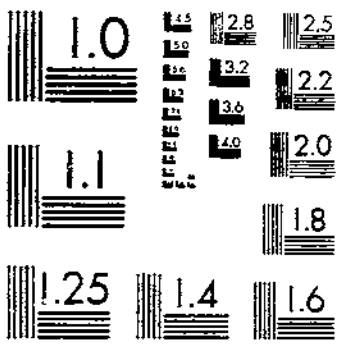


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# DEVELOPMENT OF BLACKLIGHT TRAPS FOR EUROPEAN CHAFER SURVEYS

By H. Tashiro, J. G. Hartsock,
and G. G. Rohwer

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# DEVELOPMENT OF BLACKLIGHT TRAPS FOR EUROPEAN CHAFER SURVEYS

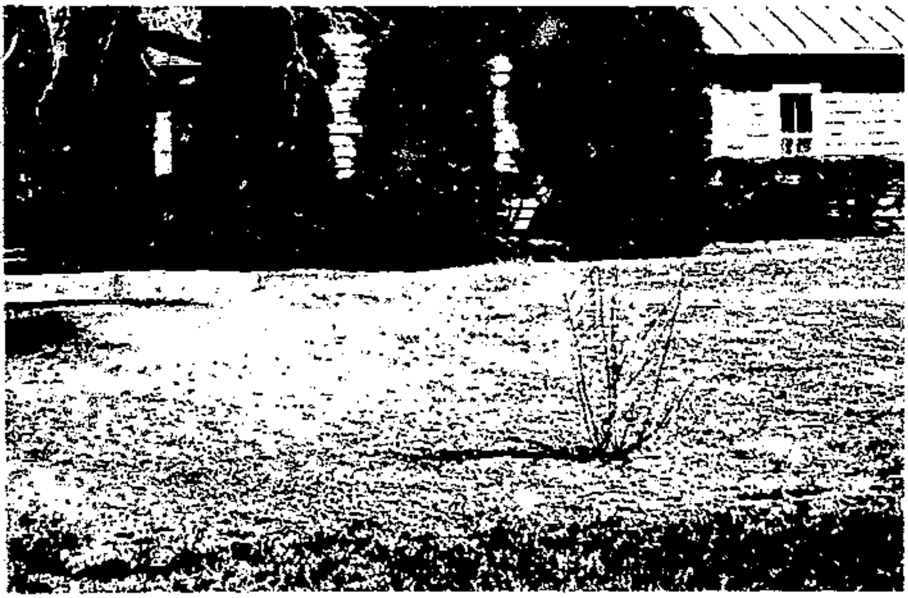
By H. TASHIRO,[1] *Entomology Research Division*, J. G. HARTSOCK, *Agricultural Engineering Research Division*, and G. G. ROHWER, *Plant Pest Control Division, Agricultural Research Service*

An effective method of detecting the presence of the European chafer (*Amphimallon majalis* (Razoumowsky)), a destructive pest of European origin, is needed to determine its distribution and spread. Until 1963 it occurred in the Western Hemisphere at scattered locations in New York, including parts of New York City, in New Jersey adjacent to New York City, in Connecticut, and in Ontario, Canada (*13*).[2] More recently it was found in Erie, Pa., (*16, p. 874*) and Cleveland, Ohio, (*17, p. 816*). An incipient infestation discovered in West Virginia is considered to have been eradicated. Federal and State quarantines are enforced to restrict the artificial dissemination of the insect.

The economic importance of this insect is apparent from the nearly complete destruction of turf by the grubs (fig. 1). Third-

[1] Assisted by G. R. Fryer, R. D. Clark (resigned), J. S. Avens (resigned), and C. W. Atkinson (resigned) of the Entomology Research Division.

[2] Italic numbers in parentheses refer to Literature Cited, p. 51.



BN-27600

FIGURE 1.—Lawn damage by European chafer grubs.

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FIGURE 2.—Third-instar grub of European chafer.

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FIGURE 4.—Swarming of European chafer beetles around branch of tree at dusk.

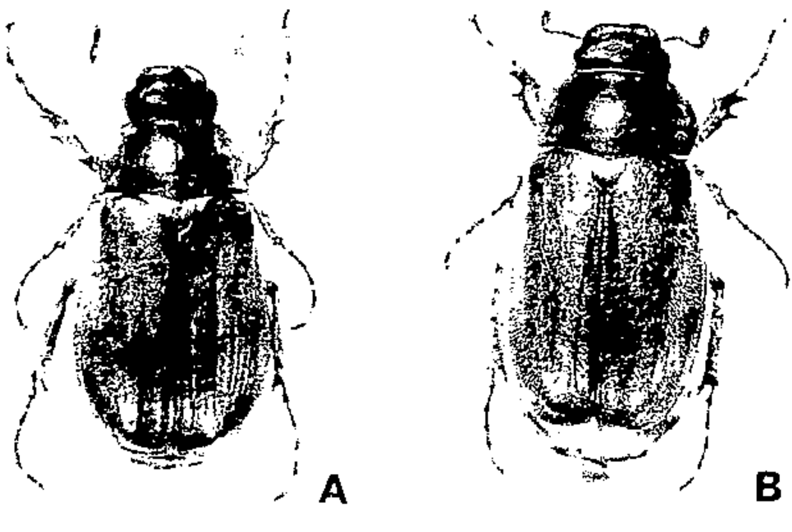


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FIGURE 3.—Male (*A*) and female (*B*) beetles of European chafer. Note longer segments of club in male antennae.

instar grubs (fig. 2) present during the spring and fall are responsible for most of the damage. Adults, which do little or no feeding, are present predominantly in June and July (*13*). The sexes can be distinguished readily by the longer lamellated segments of the antenna in the male (fig. 3).

During dusk after warm sunny days, the beetles emerge from the ground. Beginning about 8:30 p.m. they swarm around nearby trees, as shown in figure 4, reach their zenith of activity about 9 p.m., e.d.t. (eastern daylight time), during midseason and within 10 to 15 minutes settle in the trees for mating. Beetles leave the trees throughout the night, and the remaining few return to the soil at dawn.

Taylor et al. (*15*) indicated that nearly all economic species known to be photopositive responded to ultraviolet radiation. This prompted the investigations on the response of European chafer beetles to radiation from electric lamps.

## PRELIMINARY STUDIES IN 1958

Late during the 1958 beetle flight season, three omnidirectional traps (*9*) were tested. This trap was equipped with a 15-watt blacklight fluorescent lamp without baffles. As the name implies, the lamp is visible from nearly all directions.

Exposure of this trap to light flights of the chafer in 1958 (*14*) indicated that blacklight traps could be useful for detecting light infestations of the chafer. It caught up to 70 times more beetles than did chemically baited traps. It extended the effective period of capturing beetles from 30 minutes during dusk with chemical traps to 9 hours throughout the night. It was estimated that approximately one-third of the beetles flying to a single large tree were captured. Even on nights when none were observed in flight, beetles were captured. This particular trap, however, is too large and heavy for general use in chafer survey operations. A modification of this trap, made by Tashiro and Tuttle (*14*) and referred to as the Geneva trap, weighed only 3 pounds and appeared equally as effective as the omnidirectional trap.

## EXPERIMENTAL PROCEDURES, 1959-63

Discovering the response of chafers to blacklight opened the possibility of developing a more efficient means of determining the limits of known infestations of the pest and finding new infestations. Intensive studies were conducted in 1959 and continued through 1963 with lamps of different electromagnetic radiation and with traps of various designs.

### Standard Trap

To study the various modifications inherent in a light trap, it was necessary to design a model that could be easily and quickly modified. A trap shown in figure 5 was designed and is referred to hereafter as the standard electric trap.

A section of flatiron ⅛ by ½ by

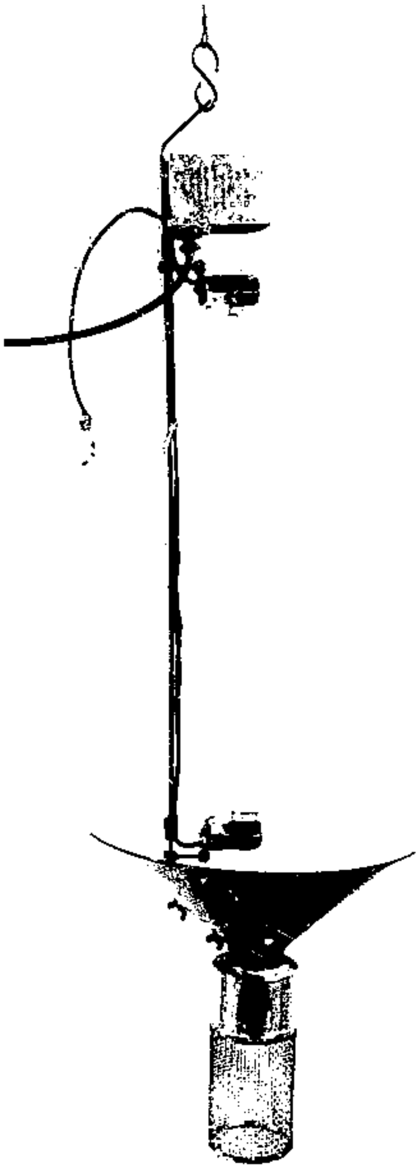

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FIGURE 5.—Standard electric trap.

29¼ inches served as the main framework. A metal box mounted open side down near the top of the frame housed the ballast, starter, and other electrical components. Two waterproof lampholders were mounted just short of the length of the lamp. A light metal lampshade served as the funnel. A pint can with the bottom half replaced with 6-mesh-per-inch hardware cloth served as the receptacle. The entire trap was painted green except for the original white interior surface of the funnel. A 15-watt blacklight lamp, designated in the trade as F15T8/BL, completed the trap. All lamps of the -/BL designation regardless of wattage are hereafter referred to as the BL lamp,[3] and the term BL trap indicates this type lamp in the trap mentioned.

Various modifications, including lamps and mechanical features, were tested and led to the development of a specifically designed trap for European chafer surveys.

## Types of Tests

Much of the work was conducted during 1959 and 1960 at Phelps, N.Y., in 5 by 5 Latin square blocks in an open field. The traps were spaced at 30-foot intervals in rows and columns and hung from steel rods at a height of 5 feet. Two blocks were wired by overhead lines to deliver 115 to 120 volts at 60 c.p.s. at each trap location (fig. 6).

Beetles emerged from the trap field and surrounding areas, flew

[3] References to BL-type lamps, except ones containing Philips phosphor, indicate lamps manufactured prior to 1962 with over 80 percent of their output in the 3,200- to 4,000-angstrom region.

BN-27605

FIGURE 6.—Layout of Latin square blocks, with traps at 30- by 30-foot intervals.

to nearby trees, then were attracted to the electric traps. Flights in this field in 1959 were very light and the catches were first considered too low for reliable evaluations. In 1960, the natural population was fortified with approximately 50,000 beetles collected at other sites and liberated at frequent intervals in this field. This provided adequate flights of beetles for a longer period than normally obtained in a natural population. Since the results with higher beetle populations in 1960 confirmed the reliability of the results with the low populations during the previous year, beetles were not added in 1961.

In addition to the Latin square blocks in an open field, numerous tests with traps in closer relation to trees were conducted during 1959-63, with greater emphasis on the latter tests during each successive year. Traps were hung from steel rods at a height of 5 feet and placed in various patterns underneath or in an arc or semicircle at the periphery or just beyond the periphery of single large trees, as shown in figure 7. They were spaced from 15 to 30 feet apart, the distance depending on the size of tree and available space. Traps were set out as single treatments in most studies and their positions rotated daily according to a predetermined schedule to minimize the effect of position on catches. In a few tests, traps in two-replication treatments were not rotated. Other arrangements of traps will be discussed under specific headings. Traps were emptied daily.

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FIGURE 7. Arrangement of traps around periphery of large tree.

# EVALUATIONS OF LAMPS FOR ATTRACTIVENESS TO CHAFERS

## Spectral Distribution of Fluorescent Lamps and Response of Chafers

Priority was given to determining the wavelength most attractive to the chafer beetles, since the electromagnetic radiation rather than the mechanical aspects of the trap appeared the dominant feature governing attractiveness.

Fluorescent lamps with peak emissions from 2,537 to 6,450 angstroms were tested. Among the various colored lamps of equal electric input, wattage—the relative radiant-energy output—varies considerably according to General Electric (*3*). In spite of these differences, we considered that variations in attractiveness large enough for practical application would overshadow the differences caused by energy output.

All lamps were 15-watt except the 20-watt erythemal lamp. The upper 6 inches of this lamp was masked so the length of the illuminated tube was 16 inches, the same as in the other lamps.

All the lamps were mounted in the standard electric trap. They were exposed in Latin square blocks to relatively light flights for 10 nights in 1959 and to heavier flights for 8 nights in 1960. The BL lamp was exposed as the standard in each comparison. These studies were supplemented by placing traps around the periphery of a large tree to which beetles flew. All but two of the different colored lamps were evaluated in the supplemental studies.

Table 1 summarizes the results obtained for the two seasons in the Latin square blocks. The BL blacklight lamp, with peak radiation of 3,650 angstroms, was outstandingly the most attractive of these lamps. Chandler et al. (*1*) tested practically the same group of lamps on the closely related May beetles (*Phyllophaga* spp.) and also found that the BL lamp was the most attractive to these beetles. The BLB blacklight lamp, with most of the visible radiation filtered out by a blue-purple tube, also removes some of the ultraviolet radiation, reducing its output from 1,950 to 1,650 fluorens.[4] This lamp was 65 percent as attractive as the BL lamp. Pfrimmer (*10*) found that more species of Lepidoptera responded in greater numbers to the BL lamp than to the BLB lamp. Attractiveness diminished rapidly as the peak radiation deviated from this area. The erythemal lamp, peaking at 3,100 angstroms in the middle utraviolet range, was only 24 percent as attractive as the BL lamp.

[4] "Fluoren" is defined by the General Electric Company as 1 milliwatt of radiant flux in the 3,200- to 4,000-angstrom region (near ultraviolet) and is analogous to 1 lumen for visible radiation.

Evaluation of the lamps around the periphery of a large tree is summarized in table 1. Slightly higher attraction was recorded with the BLB, daylight, and pink lamps than in the Latin square blocks, but the relative attractiveness of the lamps remained about the same.

We conclude from both methods of evaluation that, of the lamps tested, the BL lamp is the most attractive.

## Response of Chafers to 15-Watt BL Lamps With Philips and Conventional Phosphors

The BL fluorescent lamps manufactured by General Electric after 1962 utilized a new phosphor referred to as the Philips phosphor. These lamps produce their peak radiation at a slightly longer

TABLE 1.—*Effect of wavelength emitted from fluorescent lamps on attractiveness to beetles, with traps in Latin square blocks and around periphery of individual large trees, 1959-60*

| Lamp | Trade designation | Peak emission | Average relative efficiency of lamps [1]: In Latin square blocks, 1959 | In Latin square blocks, 1960 | Around periphery of trees, 1959-60 |
|---|---|---|---|---|---|
| | | *Angstroms* | *Percent* | *Percent* | *Percent* |
| Germicidal | G15T8 | 2,537 | 16 | 5 | .................. |
| Erythemal | FS20T12 | 3,100 | 30 | 18 | 24 |
| BL blacklight | F15T8/BL | 3,650 | [2] 100 | [2] 100 | 100 |
| BLB blacklight | F15T8/BLB | 3,650 | 62 | 69 | 81 |
| Blue | F15T8/B | 4,400 | 20 | 21 | 16 |
| Green | F15T8/G | 5,300 | 3 | 7 | .................. |
| Daylight | F15T8/D | 4,900-5,900 | 9 | 11 | 39 |
| Gold | F15T8/GO | 5,900 | 2 | 2 | 0 |
| Pink | F15T8/PK | 6,200 | 9 | 6 | 18 |
| Red | F15T8/R | 6,450 | 0 | 1 | 1 |
| | | | *Number* | *Number* | *Number* |
| Total beetles captured | | | 583 | 2,021 | 576 |

[1] $\frac{\text{Number beetles caught with test lamp}}{\text{Number beetles caught with BL lamp}} \times 100.$

[2] Significant over other lamps at 1-percent level in all tests.

wavelength than the lamps manufactured prior to 1962 utilizing the conventional phosphor, but their outstanding difference is in the much greater energy output toward the blue in the 4,000-angstrom region.

Fifteen-watt lamps with these two types of phosphors, both lamps designated as F15T8 BL, were compared during the 1963 season in both a heavy and light population of chafer beetles. Four traps—two with the Philips and two with the conventional phosphor—were placed in an arc around the periphery of a large tree at two locations. The traps were rotated daily so that each trap occupied each position once every 4 nights. This constituted a series. The traps were operated for four series at each location.

The results of these tests, summarized in table 2, demonstrated that BL lamps manufactured with either of these two phosphors were equally attractive to the beetles.

## Wattage of BL Lamps and Response of Chafers

The response of chafer beetles to blacklight was determined initially with the 15-watt fluorescent BL lamp. Other straight-tube BL lamps from 2 to 65 watts are available in commerce. These range in length from less than 3 inches for the lowest to 96 inches for the highest wattage; blacklight output varies from 110 fluorens for the smallest to 14,000 for the largest lamp. For the lamps of greatest interest to us, General Electric (*4*) gives the following specifications:

| *Lamp wattage* | *Length (inches)* | *Fluoren output* |
|---|---|---|
| 4 | 6 | 270 |
| 8 | 12 | 890 |
| 15 | 18 | 1,950 |
| 20 | 24 | 3,500 |
| 30 | 36 | 5,100 |

Since the length of the lamp in-

TABLE 2.—*Attractiveness to beetles of 15-watt BL lamps with Philips and conventional phosphor, 1963*

| Population density and series | Total beetles captured | Proportion of total captured with lamps containing— Philips phosphor | Proportion of total captured with lamps containing— Conventional phosphor |
|---|---|---|---|
| | *Number* | *Percent* | *Percent* |
| HEAVY | | | |
| 1 | 7,699 | 46 | 54 |
| 2 | 4,125 | 40 | 60 |
| 3 | 2,339 | 55 | 45 |
| 4 | 1,158 | 58 | 42 |
| Total or average | 15,321 | 50 | 50 |
| LIGHT | | | |
| 1 | 409 | 47 | 53 |
| 2 | 206 | 49 | 51 |
| 3 | 55 | 50 | 50 |
| 4 | 47 | 45 | 55 |
| Total or average | 717 | 48 | 52 |

dicates to a large extent the size of the trap, it was important to determine the relative attractiveness of lamps of different wattage so that the most efficient trap consistent with practical size for survey operations could be designed. The possibilities of developing a battery-operated trap also called for the evaluation of the smaller lamps. Frequency of recharging batteries would be inversely proportional to lamp wattage.

### *Exposure of BL Lamps in Competition With Each Other*

The 4-, 8-, 15-, 20-, and 30-watt BL traps, as shown in figure 8, were constructed identically to the standard electric trap except for length. These lamps were exposed in a Latin square block in 1959 for 3 nights to very low populations of beetles. They were again exposed in 1960 for 5 nights to slightly higher populations.

To supplement these studies, a lamp of each wattage was placed in a semicircle around the periphery of a large tree and exposed for 5 nights in 1959. The results of both types of tests are summarized in table 3.

Attractiveness to beetles was directly related to lamp wattage and fluoren output. The 8-, 15-, 20-, and 30-watt lamps attracted approximately 2, 6, 8, and 16 times more beetles, respectively, than the 4-watt lamp. Differences in beetle population between the two seasons did not alter the relative

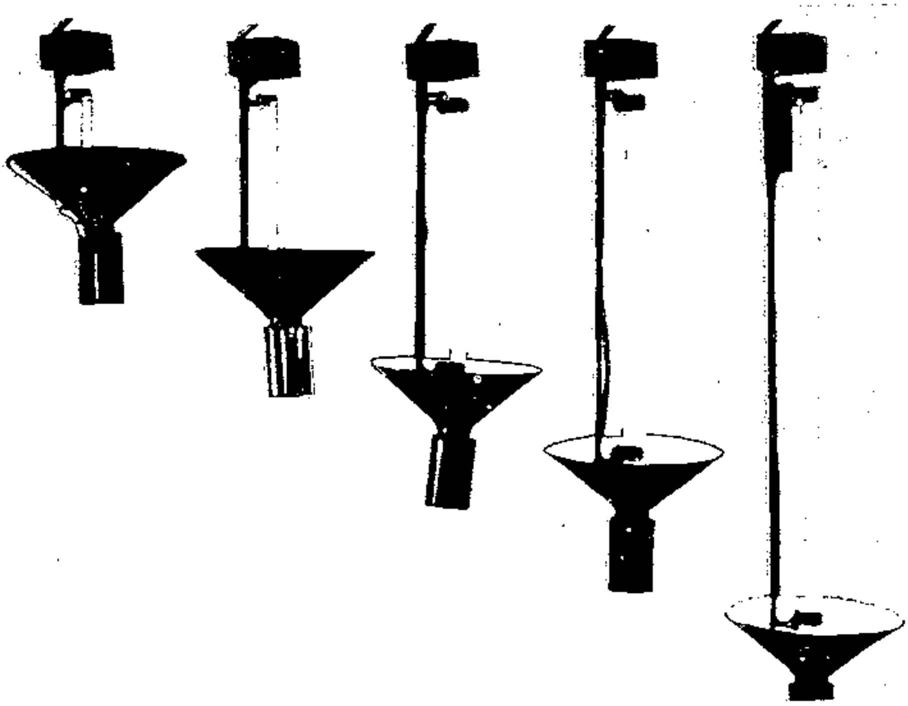

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FIGURE 8.—Standard electric trap modified and equipped with 4-, 8-, 15-, 20-, and 30-watt BL lamps.

TABLE 3.—*Relative attractiveness to beetles of BL traps of various wattage when exposed in Latin square block and around periphery of large tree, 1959-60*

| Lamp (watts) | Proportion of total beetles captured when lamps were exposed— | | |
|---|---|---|---|
| | In Latin square block | | Around periphery of tree, 1959 |
| | 1959 | 1960 | |
| | *Percent* | *Percent* | *Percent* |
| 4 | 2 | 5 | 2 |
| 8 | 3 | 8 | 6 |
| 15 | 15 | 17 | 20 |
| 20 | 25 | 20 | 28 |
| 30 | 55 | 50 | 44 |
| | *Number* | *Number* | *Number* |
| Total beetles captured | 154 | 317 | 223 |

attractiveness of the lamps. Also, beetle response to lamps of different wattage around the periphery of a tree was similar to that in a Latin square block.

#### Exposure of BL Lamps Isolated From Each Other

Exposing lamps of different wattage in close proximity and in direct competition with each other raised the question of whether the lamps of higher wattage reduced the inherent attractiveness of the smaller lamps and, therefore, did not present a true value of the performance of the smaller lamps for use in survey operations. The relative attractiveness of lamps of different wattage when not in competition with each other was determined.

Traps were exposed in a relatively new housing development of four by six city blocks, where fairly low but relatively uniform populations of the chafer were present. Traps with BL lamps were hung from steel rods placed under trees and located so that a given trap was not visible from the location of any other trap. All the traps had baffles. It had been established in the meantime that the incorporation of a four-winged baffle to each trap increased its effectiveness. The traps were operated on 110- to 120-volt 60-cycle a.c. (alternating current) circuit furnished by each home.

The 4-, 8-, and 15-watt BL traps were compared during 1961. Previous to the experiment, 10 standard electric traps with 15-watt BL lamps were operated for 7 nights under trees less than 30 feet high, and daily beetle catches were determined. Nine of these sites were then grouped into three categories of light, medium, and high populations. The 4-, 8-, and 15-watt traps were placed at the three locations of each population density so that a comparison could be made of the three lamps in a light, medium, and high population. The traps were exposed for 15 nights. Beetles were counted daily, and the traps in each category were rotated so that a given

TABLE 4.—*Relative attractiveness of 4-, 8-, and 15-watt BL traps to different populations of beetles when operated under isolated conditions, 1961*

| Population density and series | Total beetles captured | Proportion of total captured in traps of— | | |
|---|---|---|---|---|
| | | 4 watts | 8 watts | 15 watts |
| LIGHT | *Number* | *Percent* | *Percent* | *Percent* |
| 1 | 41 | 19 | 12 | 69 |
| 2 | 42 | 28 | 29 | 43 |
| 3 | 59 | 17 | 29 | 54 |
| 4 | 65 | 22 | 35 | 43 |
| 5 | 170 | 21 | 22 | 57 |
| Total or average. | 377 | 21 | 25 | 53 |
| MEDIUM | | | | |
| 1 | 27 | 21 | 25 | 54 |
| 2 | 62 | 25 | 33 | 42 |
| 3 | 125 | 27 | 36 | 37 |
| 4 | 283 | 28 | 35 | 37 |
| 5 | 380 | 22 | 21 | 57 |
| Total or average. | 877 | 25 | 30 | 45 |
| HIGH | | | | |
| 1 | 55 | 25 | 28 | 47 |
| 2 | 104 | 22 | 32 | 46 |
| 3 | 193 | 23 | 28 | 49 |
| 4 | 366 | 18 | 36 | 46 |
| 5 | 625 | 31 | 21 | 48 |
| Total or average. | 1,343 | 24 | 29 | 47 |

trap occupied each of the three positions once every 3 nights. During the 15-night exposure, totals of 377, 877, and 1,343 beetles were captured in the three locations of light, medium, and high populations, respectively.

The results, summarized in table 4, indicated that the relative attractiveness of the lamps when not in competition with each other was also directly related to lamp wattage, but the differences were not so great as when lamps were in direct competition. The 8-watt lamp was only slightly more attractive than the 4-watt lamp. The 15-watt lamp was approximately twice as attractive as the 4-watt lamp. Density of beetles had little effect on the relative attractiveness of the three lamps.

During the 1962 season, 4-, 8-, 15-, and 30-watt BL traps were compared under small and very tall trees. Four traps, one of each lamp wattage, were individually placed under four trees from 12 to 25 feet high and similar traps under four trees from 60 to 80 feet high. Traps were exposed for 16 nights under the smaller trees and for 20 nights under the taller trees. Beetles were counted daily, and the traps in each category were rotated daily so that each trap occupied each position once every 4 nights. The results of these studies are summarized in table 5.

TABLE 5.—*Relative attractiveness to beetles of 4-, 8-, 15-, and 30-watt BL traps when operated under small and tall trees in isolated conditions, 1962*

| Trap location and series | Total beetles captured | Proportion of total captured in traps of— | | | |
|---|---|---|---|---|---|
| | | 4 watts | 8 watts | 15 watts | 30 watts |
| UNDER SMALL TREES | *Number* | *Percent* | *Percent* | *Percent* | *Percent* |
| 1 | 1,357 | 15 | 24 | 28 | 33 |
| 2 | 586 | 12 | 19 | 27 | 42 |
| 3 | 495 | 16 | 17 | 34 | 32 |
| 4 | 172 | 19 | 15 | 34 | 32 |
| Total or average | 2,610 | 16 | 19 | 31 | 35 |
| UNDER TALL TREES | | | | | |
| 1 | 2,119 | 15 | 23 | 23 | 39 |
| 2 | 1,301 | 13 | 21 | 26 | 40 |
| 3 | 722 | 22 | 26 | 21 | 31 |
| 4 | 398 | 16 | 18 | 32 | 34 |
| 5 | 215 | 13 | 16 | 21 | 50 |
| Total or average | 4,755 | 16 | 21 | 25 | 39 |
| Grand average | | 16 | 20 | 28 | 37 |

These results confirm all previous studies in that the larger the lamp wattage the greater the attractiveness to beetles. It was also evident that the attractiveness of the different lamps operated under these conditions was not so great as when operated in competition with each other. The 30-watt lamp was slightly more than twice as attractive as the 4-watt lamp as compared with more than a tenfold difference between these two under direct competition. Placing the traps under tall trees did not change the relative attractiveness among the lamps from that under small trees.

## 32-Watt Circline BL Lamp

The 30-watt BL lamp was the most attractive tested, but a trap built to accompany this lamp becomes too large and cumbersome for survey work. The 32-watt circline BL lamp (FC12T10/BL) appeared to offer the possibility of developing a highly attractive and compact trap. This lamp is 12 inches in diameter and has an output of 5,000 fluorens compared with 5,100 for the 30-watt lamp (*4*).

Traps to accompany the 32-watt circline lamp were constructed with 30-gage galvanized sheet iron, as shown in figure 9. This trap is 14 by 24 inches in overall dimensions compared with a 30-watt BL trap 11¾ by 50½ inches. These traps were compared with the 15- and 30-watt BL traps with baffles in a Latin square block and also with the 30-watt trap around a large tree. Comparisons were made for 11 nights in 1960.

BN-27608

FIGURE 9.—32-Watt circline BL lamp in specially constructed trap.

The relative attractiveness of these traps is summarized in table 6. The 32-watt lamp was much inferior to the 30-watt lamp in both tests and caught one-fourth to one-half as many beetles. It was only slightly superior to the 15-watt lamp when compared in a Latin square block. Later in the season the 32-watt lamp was placed in a horizontal plane and exposed simultaneously with another lamp in a vertical plane. Its attractiveness was lowered in the horizontal position. The 32-watt circular lamp showed no promise for developing a highly attractive and compact trap.

## Ultraviolet Depreciation and Attractiveness to Chafers

### *Ultraviolet Output of BL Lamps*

The BL lamps have an expected burning life of 7,500 hours. Their ultraviolet output depreciates rapidly during the first 100 hours of burning, then continues

TABLE 6.—*Relative attractiveness of 32-watt circline and 15- and 30-watt BL lamps to beetles with traps in 2 locations, 1960*

| Trap location and nights of operation | Total beetles captured | Proportion of total captured in traps with lamps of— | | |
|---|---|---|---|---|
| | | 15 watts | 30 watts | 32 watts |
| LATIN SQUARE BLOCK | *Number* | *Percent* | *Percent* | *Percent* |
| 1 | 50 | 16 | 62 | 22 |
| 2 | 66 | 4 | 82 | 14 |
| 3 | 72 | 11 | 76 | 13 |
| 4 | 141 | 13 | 76 | 11 |
| 5 | 201 | 13 | 60 | 27 |
| Total or average | 530 | 11 | 71 | 17 |
| AROUND LARGE TREE | | | | |
| 1 | 43 | | 81 | 19 |
| 2 | 113 | | 48 | 52 |
| 3 | 130 | | 62 | 38 |
| 4 | 137 | | 77 | 23 |
| 5 | 149 | | 55 | 45 |
| 6 | 252 | | 65 | 35 |
| Total or average | 824 | | 65 | 35 |

at a gradually decreasing rate throughout the life of the lamp. According to General Electric (*4*), the depreciation during the first 100 hours is roughly equivalent to the depreciation over the subsequent 3,000 hours of burning. To assure high lamp output and minimize lamp failure problems, Taylor et al. (*15*) suggested that the lamps in insect traps for general survey use be replaced every season.

For use in European chafer surveys, even when the lamps are burned continuously, they would be in operation for approximately 1,000 hours a season (6 weeks). At this rate, a given lamp could be used for several seasons if the attractiveness to the beetles was not significantly altered. The response of chafer beetles to 15-watt BL lamps of different age and diminishing ultraviolet output was determined.

#### *Depreciating Ultraviolet Output of BL Lamps*

Groups of seven 15-watt BL lamps were burned for 100, 500, 1,500, and 3,000 hours in 1959 to obtain varying degrees of ultraviolet depreciation. These groups plus seven new ones were calibrated for output of each lamp. In 1960, those burned previously for 500, 1,500, and 3,000 hours were burned again to obtain groups with 1,000, 3,000, and 4,500 hours. These plus an unburned group and another group burned 100 hours were again calibrated for ultraviolet output.

Comparative differences in ultraviolet output were measured using a Westinghouse WL 773 phototube and Hewlett-Packard 400C vacuum tube voltmeter. Each lamp was preheated for 6 minutes in a fixture similar to the test fixture and with a ballast of the same type. The lamp was then transferred to one test fixture and ballast. After 3 more minutes' burning to stabilize operating temperature, the ultraviolet output was measured with the phototube. Regulated 115 volts was maintained for all tests. The distance from the lamp center line to the phototube emitting surface was maintained at 54 inches. This allowed measurement of radiation from the entire lamp length and minimized range changing on the voltmeter. Since the WL 773 phototube is sensitive only to a wavelength below 4,000 angstroms, its electrical response, measured in millivolts, provides a relative measurement of the ultraviolet output for each lamp.

Five of the seven lamps of each group having the least variation from the median were selected for exposure to the beetles. The relative ultraviolet output of the selected lamps was determined by comparing the average millivolt output of each group with that of lamps burned 100 hours. The output of individual lamps and the average of each group used in 1960 are shown in table 7. Ultraviolet maintenance of the lamps used during the 2 years, shown in figure 10, compares favorably with the rate of fluoren depreciation established by General Electric (*4*). Test lamps used in these studies had a more rapid depreciation during the 2,000- to 3,000-hour period and then leveled off to correspond more nearly to the established curve around the 4,000-hour period.

#### *Testing Procedures and Results*

These 15-watt BL lamps were exposed in the standard electric traps in a 5 by 5 Latin square block in 1959 and 1960. During

TABLE 7.—*Comparative differences in ultraviolet output and maintenance of 15-watt BL lamps after different periods of burning, 1960*

| Period lamps burned (hours) | Relative lamp output from WL 773 tube | | Ultraviolet maintenance from 100 hours |
|---|---|---|---|
| | Individual lamp | Group average | |
| | *Millivolt* | *Millivolt* | *Percent* |
| 0 | 2.91<br>2.91<br>2.95<br>2.99<br>3.05 | 2.96 | [1] 123 |
| 100 | 2.39<br>2.39<br>2.41<br>2.42<br>2.44 | 2.41 | 100 |
| 1,000 | 1.93<br>2.10<br>2.14<br>2.18<br>2.26 | 2.12 | 88 |
| 3,000 | 1.72<br>1.76<br>1.83<br>1.91<br>1.98 | 1.84 | 76 |
| 4,500 | 1.54<br>1.61<br>1.68<br>1.73<br>1.74 | 1.66 | 69 |

[1] $\frac{2.96}{2.41\ (100\ \text{hours})} \times 100 = 123$ percent.

TABLE 8.—*Effect of ultraviolet depreciation of 15-watt BL lamps on attractiveness to beetles, 1959-60*

| Period lamps burned (hours) | Ultraviolet maintenance from 100 hours | Proportion of total beetles captured | |
|---|---|---|---|
| | | 1959 | 1960 |
| | *Percent* | *Percent* | *Percent* |
| 0 | 123 | 30 | 24 |
| 100 | 100 | 19 | 19 |
| 500 | 88 | 16 | ... |
| 1,000 | 88 | ... | 22 |
| 1,500 | 81 | 16 | ... |
| 3,000 | 76 | 19 | 17 |
| 4,500 | 69 | ... | 18 |
| | | *Number* | *Number* |
| Total beetles captured | | 134 | 1,023 |

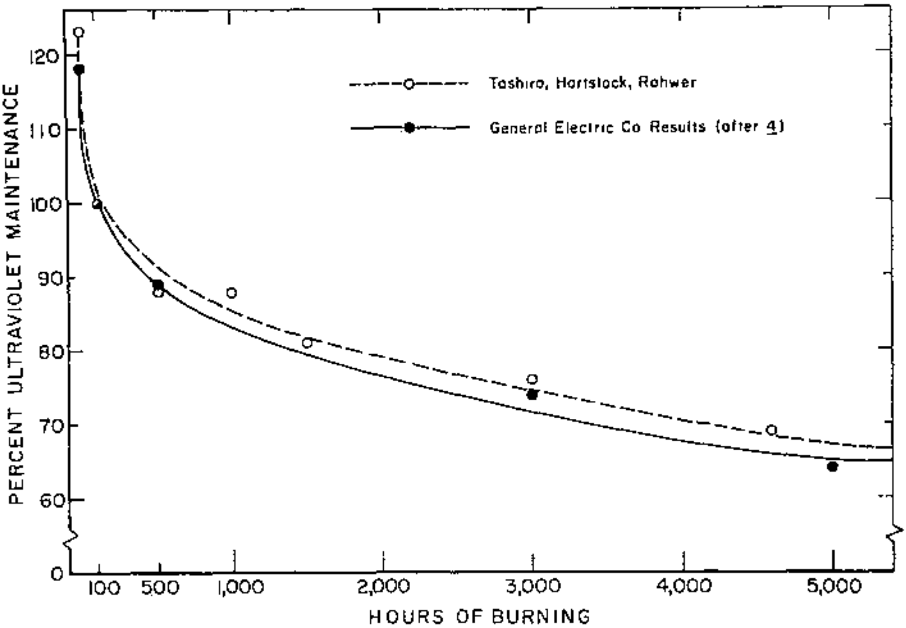


FIGURE 10.—Ultraviolet maintenance of BL lamps.

1959, lamps burned 0, 100, 500, 1,500, and 3,000 hours were exposed for 12 nights to light flights of beetles. During the following season, lamps burned 0, 100, 1,000, 3,000, and 4,500 hours were exposed for 4 nights to considerably heavier populations.

The results of these studies for the two seasons are summarized in table 8. New lamps with ultraviolet output of 123 percent were slightly more attractive than the others during both years. However, after lamps were burned for 100 hours, additional burning and depreciation from 100- to 69-percent maintenance did not reduce their attractiveness to beetles. These studies indicated that BL lamps could be used for several seasons in survey operations without loss of trap efficiency.

## Response of Chafers to Other Types of Lamps

### *Argon Glow Lamp*

The 2-watt argon glow lamp (G.E. AR-1) is essentially a low-intensity ultraviolet lamp. Interest in testing this lamp on the chafer stemmed from its reported attractiveness to the pink bollworm (*Pectinophora gossypiella* (Saunders)) and other insects by Glick et al. (*6*), its simpler operation without the need of ballasts and starters required for fluorescent lamps, and its operation from either d.c. (direct current) or a.c. circuit.

In 1958, one and two such lamps were attached to traps and exposed simultaneously with the omnidirectional trap fitted with a BL lamp. The omnidirectional trap caught 83 chafer beetles during 6 nights compared with only 1 beetle for the argon glow lamp. In 1959, three argon glow lamps were attached to each trap and compared in a Latin square block with standard electric traps fitted with BL lamps. During 3 nights' exposure the latter captured 103 beetles compared with only 1 beetle for the argon glow lamps.

#### *Incandescent Lamps*

In 1958, a single 15-watt frosted white lamp was placed in a trap exposed simultaneously with the omnidirectional trap fitted with a 15-watt BL lamp. The latter captured 83 beetles and the former only 1 during 7 nights' use.

In 1960, three 25-watt blue incandescent lamps illuminating a standard electric trap were compared with the standard electric trap equipped with a single 15-watt BL lamp. During 5 nights the latter captured 107 beetles, but the former caught none. In another comparison, two 25-watt blue incandescent lamps were fitted with a flasher to flick the light on and off at approximately 100 flashes per minute. During 4 nights' comparison with the standard electric trap, the latter captured 31 beetles and the former none. Traps were placed around the periphery of a large tree in both tests.

The argon glow lamp and the incandescent lamp are considered totally ineffective in attracting European chafer beetles.

## DEVELOPMENT OF TRAP DESIGN

### Types of Traps Tested

A comparison of the large omnidirectional trap and a smaller Geneva trap in 1958 indicated that the size of the trap was not important in capturing chafer beetles when both were equipped with the 15-watt BL lamp (*14*). Since aluminum reflects ultraviolet energy, we considered that this might have a bearing on the performance of the trap. Another trap for burning the 15-watt lamp, constructed with sheet aluminum, was made specifically for tests on the European chafer. It is referred to hereafter as the aluminum trap. The omnidirectional trap and the latter are shown in figure 11.

The omnidirectional, standard electric, and aluminum traps with 15-watt BL lamps were exposed in

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FIGURE 11.—Omnidirectional trap (*A*) and aluminum trap (*B*).

TABLE 9.—*Performance of different types of traps with 15-watt BL lamps in capturing beetles, 1959*

| Nights of operation | Total beetles captured | Proportion of total captured with indicated trap | | |
|---|---|---|---|---|
| | | Omnidirectional | Standard | Aluminum |
| | *Number* | *Percent* | *Percent* | *Percent* |
| 1 | 99 | 24 | 31 | 45 |
| 2 | 103 | 26 | 21 | 53 |
| 3 | 259 | 36 | 20 | 44 |
| Total or average | 461 | 29 | 24 | 47 |

a Latin square block for 3 nights in 1959. The results, shown in table 9, indicated that there was little difference between the first two, but the aluminum trap was the best on all 3 nights. Frost (*2*) indicated that reflections from baffles, especially plastic, plexiglass, and bright aluminum, reduced catches, but with the lamp in the center of the trap between baffles the reflection was negligible. Further studies on the value of baffles demonstrated that their presence was responsible for the increased efficiency of the aluminum trap.

## Value of Baffles

The exploratory studies in 1958 (*14*) gave no definite evidence that baffles were essential for maximum efficiency of traps. Observations were considered too limited for drawing conclusions. This phase of trap design needed further study. In the light of results with the aluminum trap, the need for baffles was strongly indicated.

The standard electric trap was modified so that easily removable crossarms at 90° could be attached just above the upper lamp holder and just below the bottom lamp holder. Four plates, each measuring 4¾ by 20 inches, were attached to each trap by placing them between the corresponding upper and lower crossarms. Baffles of transparent plastic, sheet aluminum, and 32-gage galvanized

TABLE 10.—*Value of baffles on 15-watt BL traps in increasing trap efficiency for beetles, 1959-60*

| Type of baffle | Proportion of total beetles captured | |
|---|---|---|
| | 1959 | 1960 |
| | *Percent* | *Percent* |
| Transparent plastic | 23 | 20 |
| Sheet aluminum | 21 | 23 |
| Galvanized sheet iron unpainted | 20 | 24 |
| Galvanized sheet iron painted | 29 | 24 |
| No baffles | [1] 7 | [1] 9 |
| | *Number* | *Number* |
| Total beetles captured | 588 | 319 |

[1] Significantly lower catches than baffled traps at 5-percent level.

sheet iron were used. The last material was tested for unpainted baffles and baffles painted with white enamel.

A trap fitted with a baffle is shown in figure 12. The electric trap served as the standard for comparisons. These were placed in a Latin square block and exposed for 4 nights during 1959 and 1960. All traps were equipped with the 15-watt BL lamp. The results of the two seasons are summarized in table 10.

All baffled traps caught two to three times more beetles than the unbaffled traps during both seasons. The results of these studies strongly emphasized the need of baffles as an essential part of the trap.

## Color of Light Traps

Because electric-light traps function after dark, their color was considered insignificant. However, since color of chemical traps does affect catches, it was desirable to resolve this factor in the electric traps. In chemical traps, red is the most attractive, followed by black, yellow, blue, and white in descending order (*12*).

The standard electric trap was green except for the original white interior of the lampshade adapted as the funnel. Other standard electric traps were painted green, white, yellow, and red. These were equipped with the 15-watt BL lamps and exposed in Latin square blocks during 3 nights in 1959 and 4 nights in 1960. These results are summarized in table 11.

Although there were small differences among the traps in the numbers of beetles caught, there was no evidence that their color affected attractiveness. In 1959, the largest numbers were captured in the standard electric trap and the lowest in the red. In 1960, the largest numbers were taken in the red trap and the smallest num-

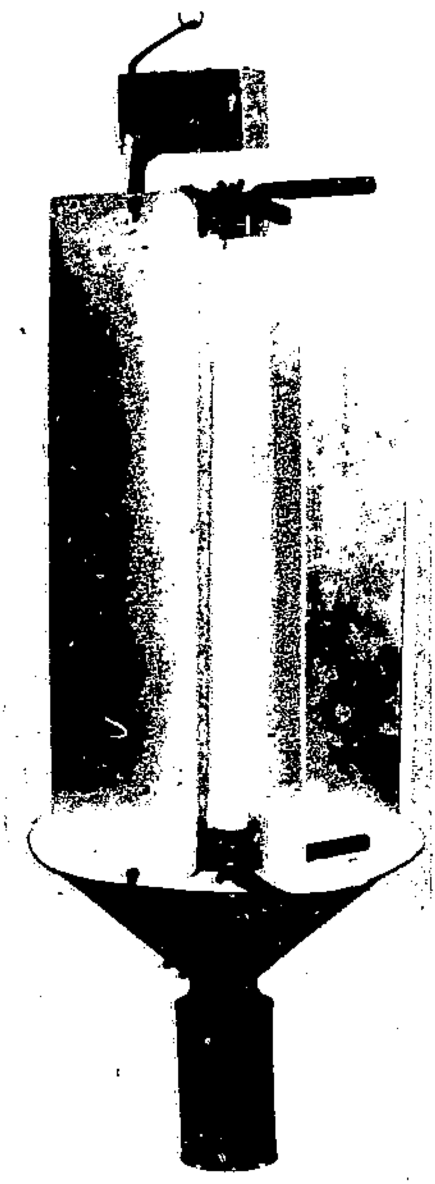

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FIGURE 12.—Standard electric trap fitted with four-vaned baffle.

TABLE 11.—*Effect of color of BL traps on their attractiveness to beetles, 1959-60*

| Color of traps | Proportion of total beetles captured | |
|---|---|---|
| | 1959 | 1960 |
| | *Percent* | *Percent* |
| Green | 22 | 20 |
| White | 21 | 18 |
| Yellow | 19 | 21 |
| Red | 15 | 22 |
| Green and white (standard) | 23 | 19 |
| | *Number* | *Number* |
| Total beetles captured | 177 | 1,283 |

bers in the white. The results of the two seasons confirmed the belief that painting the traps was of value solely as a protection against weathering.

## Effect of Funnel Diameter on Trap Efficiency

The funnel of a trap directs insects coming to the attractant into the escape-proof receptacle below. Blacklight traps tested previous to 1961 had the upper edge of the funnel flush with the outside vertical edge of the baffle. This was a diameter of 11¾ inches. A test was conducted during 1961 to determine whether extending the funnel beyond the edge of the baffle would increase the efficiency of the trap. This might capture some of the beetles that strike the outside edge of the baffle and ordinarily fall beyond the funnel.

The 15-watt and 30-watt BL traps were equipped with the standard funnel 11¾ inches in diameter. Others were fitted with funnels having the same slope and orifice of three-fourths inch, but a diameter of 14 inches. This extended the funnel slightly more than an inch beyond the baffle. Traps with each combination of lamp wattage and diameter of funnel were placed in a three-replication randomized block and exposed for 9 nights. The results are summarized in table 12.

TABLE 12.—*Effect of funnel diameter of 15- and 30-watt BL traps on effectiveness in capturing beetles, 1961*

| Nights of operation | Total beetles captured | Proportion of total captured with indicated lamp wattage and funnel diameter (inches) | | | |
|---|---|---|---|---|---|
| | | 15-Watt lamp | | 30-Watt lamp | |
| | | 11¾ | 14 | 11¾ | 14 |
| | *Number* | *Percent* | *Percent* | *Percent* | *Percent* |
| 1 | 76 | 12 | 13 | 55 | 20 |
| 2 | 111 | 17 | 11 | 46 | 26 |
| 3 | 166 | 10 | 12 | 51 | 27 |
| 4 | 211 | 16 | 12 | 52 | 20 |
| 5 | 224 | 16 | 19 | 49 | 16 |
| 6 | 596 | 12 | 13 | 40 | 35 |
| 7 | 914 | 10 | 11 | 37 | 42 |
| 8 | 1,109 | 11 | 9 | 47 | 33 |
| 9 | 1,119 | 10 | 13 | 39 | 38 |
| Total or average | 4,526 | 13 | 12 | 46 | 28 |

The larger funnel did not increase trap efficiency over that of the smaller funnel with either size lamp. As expected, the 30-watt lamp increased catches two to three times over the 15-watt lamp. There was no advantage in widening the funnel beyond the vertical edge of the baffle. The reason for the increased catch with the 30-watt lamp and smaller funnel is unknown.

### Increasing Numbers of BL Lamps in Each Trap

Testing lamps of different wattage indicated that trap efficiency was directly related to increased wattage. The 30-watt BL lamp was the most attractive and traps with this lamp caught two to three times more beetles than the 15-watt BL lamp. Glick and Hollingsworth (*5*) found that two BL lamps were nearly three times as attractive as a single lamp in attracting pink bollworm moths. Adding more lamps per trap as a possible means of increasing the efficiency of the 15-watt trap without increasing its size was investigated.

All the traps in these studies were equipped with four-vaned baffles. A lamp was mounted vertically in the center between the vanes in a single lamp unit. In traps with multiple lamps, they were mounted in vertical slots in the vanes, as shown in figure 13.

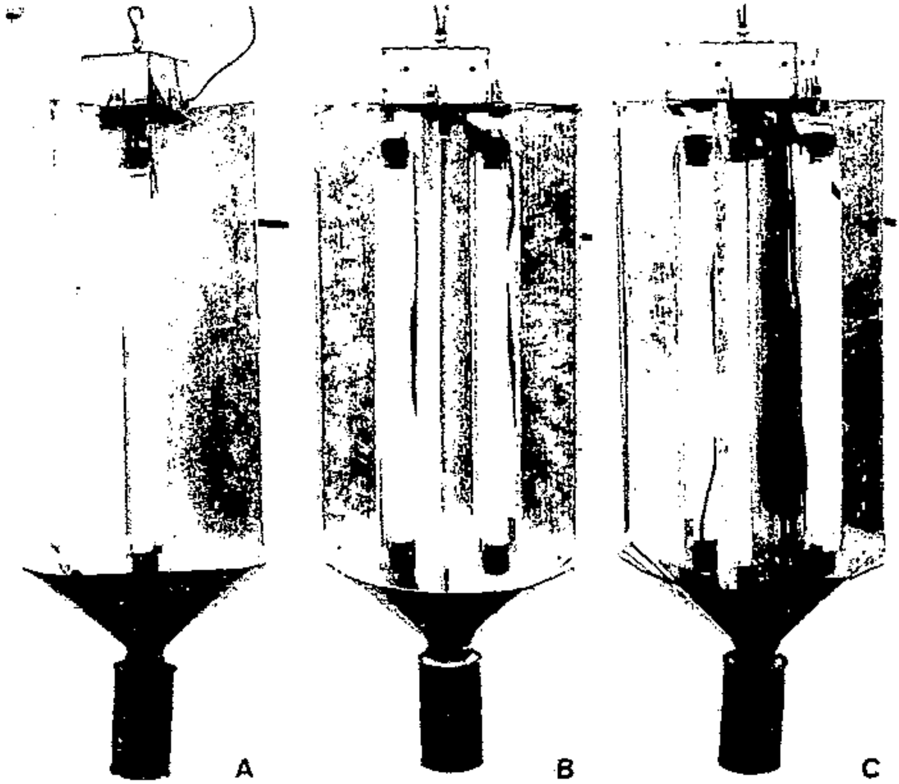


FIGURE 13.—Traps with one (*A*), two (*B*), and four (*C*) 15-watt BL lamps.

Two and four 15-watt lamps in a trap were compared with a single lamp in 1960. Also, two 30-watt lamps per trap were compared with a single 30-watt lamp. The 15-watt traps were placed around the periphery of a large tree and exposed for 6 nights. The 30-watt traps were exposed in a similar test to 5 nights of flight.

In two other tests, one in a Latin square block and the other around the periphery of a large tree, two 15-watt lamps in a trap were compared with a single 30-watt lamp. These were exposed for 4 and 5 nights, respectively, in 1960.

Placing two lamps in each trap fell far short of doubling the efficiency of the trap with either the 15- or 30-watt lamps. Four lamps were required to double the efficiency of the 15-watt trap (table 13). Also, when compared with a single 30-watt lamp in each trap, two 15-watt lamps per trap failed to increase its efficiency. The 30-watt lamp was still three times more effective (table 14). Increasing the numbers of lamps in a trap was not a practical method of increasing its efficiency in attracting and capturing beetles.

## Position of 30-Watt BL Lamp in Trap and Effect on Chafer Catches

In observing flights around the 30-watt BL lamps, it appeared that chafer beetles were attracted only to the bottom half. No beetles were seen flying to the upper half of the lamp. Placing the lamp in a horizontal position seemed to offer the possibility of utilizing its entire length for attracting beetles. Construction of a more compact trap was also possible with the lamp in this position.

TABLE 13.—*Effect of increasing numbers of 15- and 30-watt BL lamps per trap on beetle catches, 1960*

| Lamp wattage and nights of operation | Total beetles captured | Proportion of total captured in traps with— 1 lamp | 2 lamps | 4 lamps |
|---|---|---|---|---|
| | *Number* | *Percent* | *Percent* | *Percent* |
| **15 WATTS** | | | | |
| 1 | 26 | 19 | 16 | 65 |
| 2 | 38 | 13 | 50 | 37 |
| 3 | 142 | 18 | 47 | 35 |
| 4 | 224 | 29 | 27 | 44 |
| 5 | 327 | 22 | 29 | 49 |
| 6 | 426 | 21 | 30 | 49 |
| Total or average | 1,183 | 20 | 33 | 46 |
| **30 WATTS** | | | | |
| 1 | 473 | 39 | 61 | ... |
| 2 | 489 | 42 | 58 | ... |
| 3 | 576 | 48 | 52 | ... |
| 4 | 726 | 39 | 61 | ... |
| 5 | 1,045 | 46 | 54 | ... |
| Total or average | 3,309 | 43 | 57 | ... |

TABLE 14.—*Comparison of two 15-watt BL lamps per trap with single 30-watt BL lamp on beetle catches in 2 locations, 1960*

| Trap location and nights of operation | Total beetles captured | Proportion of total captured in traps with— | |
|---|---|---|---|
| | | Two 15-watt lamps | One 30-watt lamp |
| LATIN SQUARE BLOCK | *Number* | *Percent* | *Percent* |
| 1 | 33 | 18 | 82 |
| 2 | 42 | 29 | 71 |
| 3 | 117 | 30 | 70 |
| 4 | 122 | 22 | 78 |
| Total or average | 314 | 25 | 75 |
| AROUND PERIPHERY OF LARGE TREE | | | |
| 1 | 288 | 28 | 72 |
| 2 | 373 | 26 | 74 |
| 3 | 255 | 27 | 73 |
| 4 | 667 | 28 | 72 |
| 5 | 383 | 26 | 74 |
| Total or average | 1,966 | 27 | 73 |

A trap was made to hold the 30-watt lamp in a horizontal position. A horizontal trough below the lamp was tapered on the two sides and ends to have a ¾-inch longitudinal opening into the receptacle. This trap was compared with a 30-watt vertical trap without a baffle. The two traps were placed under a large tree and their position was rotated daily. They were exposed for only a few nights to low populations of beetles at the end of the 1959 and 1960 seasons. During the 1963 season the same two traps were similarly exposed for 24 nights to heavy populations. The traps were rotated daily.

The results of all three seasons are summarized in table 15 by comparing catches over 2 nights after each trap had occupied each position once. This constituted a series. The vertical trap caught 4½ times more beetles than the horizontal trap in very low populations of beetles during the first two seasons. During the 1963 season with high populations the vertical trap caught more beetles in two-thirds of the 12 series, but the total captured by each trap was nearly the same. Results of only the odd-numbered series are given as representative of the entire test in 1963.

## Design of 15-Watt BL Traps With Baffles and Effect on Chafer Catches

After determining that baffles should be an essential part of the trap, attempts were made to modify the design from that of the standard electric trap with baffles. To have baffles, six additional parts have to be assembled—too many to make it a simple trap.

TABLE 15.—*Effect of vertical and horizontal positions of 30-watt BL lamp in trap on beetle catches, 1959-60 and 1963*

| Year and series | Total beetles captured | Proportion of total captured with lamp placed— | |
|---|---|---|---|
| | | Vertically | Horizontally |
| 1959 AND 1960 | *Number* | *Percent* | *Percent* |
| 1 | 49 | 80 | 20 |
| 2 | 31 | 68 | 32 |
| 3 | 19 | 79 | 21 |
| 4 | 3 | 100 | 0 |
| Total or average | 102 | 82 | 18 |
| 1963 | | | |
| 1 | 6,250 | 41 | 59 |
| 3 | 3,330 | 53 | 47 |
| 5 | 2,637 | 60 | 40 |
| 7 | 1,481 | 61 | 39 |
| 9 | 555 | 51 | 49 |
| 11 | 265 | 49 | 51 |
| Total or average | 14,548 | 52 | 48 |

In 1960, a 15-watt trap was designed following the principles of the aluminum trap (fig. 11). The lamp was mounted in a vertical cutout in the center of a 12- by 21-inch sheet of 28-gage galvanized iron. This made two opposite vanes of the four-vaned baffle. The other two opposite vanes were attached to the former with hinges so they would open at right angles.

For additional simplicity, a 15-watt trap (fig. 14) was designed based on information obtained with the various experimental models. This trap is referred to as the European chafer beetle survey trap (*9*) and is now in general use in survey operations by the Plant Pest Control Division. With the exception of having a slightly larger baffle, overall dimensions of 12 by 24 inches, and a 12¼-inch funnel, it was essentially the same as the others. This trap is wired to operate on either a.c. or d.c. circuit from storage batteries.

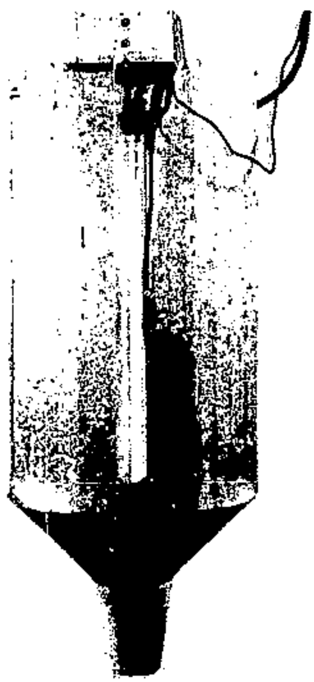

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FIGURE 14.—European chafer beetle survey trap.

These three traps and the standard trap without baffle were exposed in 1961 in a Latin square block for 9 nights. The results with various designs of the 15-watt BL traps on beetle catches when 2,086 beetles were captured were as follows:

| *Trap design* | *Proportion of total beetles captured (percent)* |
|---|---|
| Standard electric trap without baffle | 14 |
| Standard electric trap with baffle | 28 |
| Trap with hinged baffle | 27 |
| European chafer beetle survey trap with baffle | 31 |

All the baffled traps captured twice as many chafer beetles as the unbaffled standard and demonstrated again that baffles are essential for maximum efficiency. The three baffled traps showed essentially the same effectiveness.

# ELIMINATION OF EXTRANEOUS INSECTS

Since blacklight traps capture many nocturnal insects, they have to be serviced more frequently than chemical traps. Otherwise the decomposition of the accumulated insects becomes objectionable, and a detailed search has to be made through the debris to ascertain European chafer catches. Two approaches were taken toward alleviating this problem—to permit insects smaller than the chafer to escape from the receptacle and to exclude insects larger than the chafer.

## Elimination of Small Insects

During 1959, the 15-watt BL traps were fitted with 1-pint receptacles modified as follows: (1) With $\frac{3}{16}$-inch holes drilled in the bottom, (2) with the same size holes extending up the sides, and (3) with the bottom half of the receptacles replaced with $\frac{1}{8}$-, $\frac{1}{6}$-, and $\frac{1}{4}$-inch mesh hardware cloth. Traps with these receptacles were placed in a Latin square block and exposed for 3 nights. Each receptacle was enclosed in a plastic bag to determine whether chafers escaped. Essentially the same numbers of beetles were captured, but even the largest European chafer beetle was able to escape through the $\frac{1}{4}$-inch mesh screen. No chafer beetle regardless of its size escaped through the $\frac{1}{6}$-inch mesh screen.

In 1960, the 15-watt BL traps were equipped with three modifications of the receptacles—with $\frac{3}{16}$-inch holes in the bottom, with $\frac{1}{6}$-inch mesh hardware cloth bottom, and with $\frac{1}{6}$-inch mesh hardware cloth bottom and sides. A plastic bag covered each receptacle to retain the small insects that would otherwise escape. These traps were placed around the periphery of a large tree and exposed for 5 nights. These results are summarized in table 16.

By having $\frac{3}{16}$-inch holes in the bottom of the receptacle, 57 percent of the total insect catch was retained. This was further decreased to 38 percent by replacing the entire bottom with $\frac{1}{6}$-inch mesh screen. Replacing the sides of the container with the same size screen did not reduce the accumulation. Had the traps not been emptied daily, the screen sides would undoubtedly have

TABLE 16.—*Retention of small and large insects through modifications in trap receptacle and funnel opening, 1959-60*

| Modifications of trap | Chafer beetles captured | Volume of all insects captured | Proportion of total catch retained |
|---|---|---|---|
| RECEPTACLE | *Number* | *Cc.* | *Percent* |
| 3/16-inch holes in bottom | 137 | 485 | 57 |
| 1/8-inch mesh screen bottom | 119 | 525 | 38 |
| 1/8-inch mesh screen bottom and sides | 121 | 625 | 36 |
| FUNNEL OPENING | | | |
| 3/8 inch | 61 | 215 | 19 |
| 3/4 inch | 54 | 335 | 37 |
| 1 1/4 inches | 55 | 450 | 61 |

eliminated much more of the accumulation, because the entire bottom surface would have become covered.

## Exclusion of Large Insects by Modifying Funnel Opening

In an attempt to eliminate insects larger than the chafer, the same traps were fitted with funnels with openings of 3/8, 3/4, and 1 1/4 inches. The standard electric trap has the 1 1/4-inch opening. All funnels were fitted with receptacles having 1/8-inch mesh screens in the bottom. The receptacles were again enclosed with plastic bags to retain the smaller insects normally escaping. These traps were exposed for 8 nights. The results are also summarized in table 16.

European chafer catches were not altered by reducing the funnel opening from 1 1/4 to 3/8 inch, but the total catch of other insects was reduced by approximately 50 percent. The 3/8-inch opening, however, is considered too small for general use because it can become clogged much more easily than the larger openings. A 3/4-inch opening was considered the smallest that should be used. With the 3/4-inch funnel opening, total catch of extraneous insects was reduced by 25 percent. This prevention of capture plus the elimination of the smaller insects alleviated the problem of accumulating extraneous insects. A comparison of the insects retained is apparent in figure 15.

Because of the relatively cool nights in western New York, catches of extraneous insects are very light compared with those in the more southern areas. Plant Pest Control Division personnel conducting survey operations report that in many areas the flight of insects is so heavy that the 1-pint receptacle fills up in 1 night, and under such conditions the 3/4-inch opening occasionally becomes plugged.

## Exclusion of Large Insects by Screening Funnel

A screen disk placed in the funnel immediately below the bottom edge of the baffle should reduce the problem of plugging because the area involved is larger. This method of eliminating large insects was studied in 1962.

Five 15-watt BL traps with

four-vaned baffles and with funnel openings of three-fourths inch were placed in a semicircle around a large tree. No screen was placed in the funnel of one trap. A 6-inch disk was cut from hardware cloth of ¼-, ⅓-, ½-, and ¾-inch mesh. One of these was placed in the funnel of each of the other four traps. These were held in a horizontal position by the bottom of the baffle. They were exposed to flights of beetles for 20 nights. The traps were rotated daily, and a series was completed when each of the five traps occupied each position once. Four complete series were run. When beetles were counted daily, the other insects were killed and retained for determining the total volume of insects captured by each trap.

Decreasing the size of mesh in the screen disk progressively decreased the volume of extraneous insects caught, as shown in table 17. The ½-inch screen reduced the volume by 40 percent, and the ¼-inch screen practically eliminated the extraneous insects captured and retained. However, mesh smaller than one-half inch also reduced the numbers of European chafers caught. The ⅓-inch screen reduced catches slightly and the ¼-inch mesh reduced catches by 50 percent over that of the unscreened funnel. The ¾- and ½-inch screens had no adverse effect on beetle catches and, in fact, catches with the ½-inch mesh screen were consistently better than without the screen. The use of a disk of ½-inch mesh in the funnel should greatly alleviate the problem of accumulating extraneous insects.

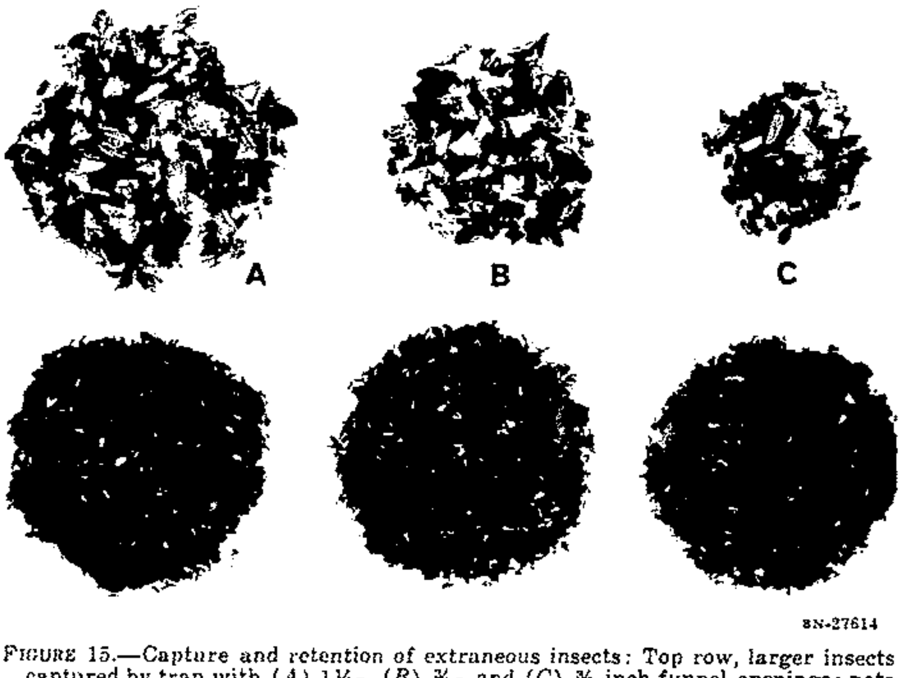


FIGURE 15.—*Capture and retention of extraneous insects:* Top row, larger insects captured by trap with (*A*) 1¼-, (*B*) ¾-, and (*C*) ⅜-inch funnel openings; note numerous European chafer adults in each group. Bottom row, smaller insects that escaped through ⅛-inch mesh bottom of receptacles.

TABLE 17.—*Effect of size of mesh in screen disk in funnel of BL traps on capturing beetles and retaining extraneous insects, 1962*

| Series | Total beetles captured | Proportion of total chafer beetles captured in each trap with indicated size mesh (inch) in disk | | | | |
|---|---|---|---|---|---|---|
| | | No screen | ¾ | ½ | ⅓ | ¼ |
| | *Number* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| 1 | 762 | 21 | 21 | 29 | 17 | 12 |
| 2 | 487 | 22 | 31 | 24 | 13 | 10 |
| 3 | 336 | 20 | 12 | 28 | 25 | 15 |
| 4 | 111 | 26 | 21 | 33 | 15 | 5 |
| Total or average | 1,696 | 22 | 21 | 28 | 18 | 10 |
| | | *Cc.* | *Cc.* | *Cc.* | *Cc.* | *Cc.* |
| Extraneous insects retained | | 475 | 415 | 275 | 110 | 25 |

## LOCATION OF TRAPS IN RELATION TO TREES

It was evident in 1958 (*14*) that chafer beetles first flew to the trees before being attracted to blacklight. Traps placed under a large tree to which they flew captured more beetles than those placed in an adjacent open field. Comprehensive studies were conducted during the following three summers to determine the effect of position of trap in relation to trees on capturing beetles.

### Location of Traps From Tree Trunk to Open Field

Five traps were placed 40 or 50 feet apart in a straight line from the trunk of a tree to a distance of 160 or 200 feet in an adjoining open field. Tests were conducted at three locations. The second trap from the tree trunk was placed under the periphery of the outermost branches in all but one test. Environmental conditions differed considerably at the three locations.

A large black walnut tree, approximately 90 feet high, at the rear of the Phelps Laboratory was one of the sites. Characteristic of this species, the foliage was sparse enough so that a considerable amount of sky was visible directly overhead from the base of the tree. Many incandescent street lamps that burned all night on nearby streets and parking lots were visible from the tree. The standard 15-watt BL traps without baffles were placed at 40-foot intervals to 160 feet, the maximum distance of open space available. In 1959, these traps were operated for 13 nights and then replaced for an additional 4 nights with unbaffled 30-watt BL traps. The results of these two tests are summarized in table 18.

A large maple tree, also about 90 feet high, on the Pollot farm near the Phelps Laboratory was sufficiently dense that virtually no sky was visible directly overhead. In contrast to the first site, the only illumination other than the BL lamps came from an occasional passing car. During 1960, five 15-watt BL traps without baffles were placed 40 feet apart to a distance of 160 feet and operated for 13 nights. During 1961, the same traps were placed at 50-foot intervals to a distance of 200 feet and again operated for 13 nights. These were replaced with the baffled 15-watt European chafer beetle survey trap (*9*) and operated for an additional 6 nights. The results of these two tests are also summarized in table 18.

The third site, on the Bagley farm near Newark, N.Y., centered around a small maple tree, about 30 feet tall, that was equally as dense as the maple tree on the Pollot farm. Unlike the other two sites the only illumination at this site came from the BL lamps. The second trap was at least 30 feet beyond the periphery of the outermost branches. Five baffled traps each equipped with two 15-watt BL lamps were placed at 50-foot intervals to a distance of 200 feet and operated for 5 nights. These results are also summarized in table 18.

In every test the trap placed immediately adjacent to the tree trunk captured approximately two-thirds of all the beetles taken. The trap under the periphery of the outermost branches caught from 17 to 28 percent. The first two traps caught more than 80 percent of all the beetles taken in the five traps. Beyond this immediate area of the tree, catches were uniformly low regardless of the distance from the tree and amounted to less than 10 percent at each location. Density of foliage did not alter the response of beetles to the trap next to the trunk or at the periphery of the branches. Other nearby illumination produced no apparent effect on the response of beetles to blacklight. Baffling the traps did not alter the response of beetles to the traps in relation to the trees.

## Location of Trap Entirely Under Canopy of Tree

Even though a trap immediately adjacent to the trunk was a more favorable location than at

TABLE 18.—*Effect of location of trap in relation to trees on attracting and capturing beetles at 3 locations, 1959-61*

| Trap location and lamp wattage | Total beetles captured | Proportion of total captured when trap was at indicated distance (feet) from tree trunk: 0 | 40 | 80 | 120 | 160 |
|---|---|---|---|---|---|---|
| | *Number* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| Phelps Laboratory:[1] | | | | | | |
| 15 watts | 480 | 65 | 23 | 5 | 4 | 3 |
| 30 watts | 811 | 64 | 19 | 4 | 4 | 9 |
| Pollot farm, 15 watts[1] | 432 | 67 | 28 | 2 | 1 | 2 |
| Total or average | 1,723 | 65 | 23 | 4 | 3 | 5 |
| | ......... | 0 | 50 | 100 | 150 | 200 |
| Pollot farm, 15 watts: | | | | | | |
| Without baffle | 2,395 | 77 | 17 | 2 | 2 | 2 |
| With 4-vaned baffle | 5,802 | 69 | 22 | 3 | 3 | 3 |
| Bagley farm, 15 watts[2] | 480 | 66 | 16 | 7 | 6 | 5 |
| Total or average | 8,677 | 71 | 18 | 4 | 4 | 3 |

[1] Trap without baffle.

[2] Trap with 4-vaned baffle.

the periphery of the branches, it was not known whether it would function equally as well if placed away from the trunk but still well under the canopy. By being placed immediately adjacent to the trunk its efficiency may be reduced by being partially invisible from the opposite side of the trunk. Also, the nearness to the trunk exposed it to greater lightning hazards by arcing to the trap and following the extension cord to the source of electricity.

During 1962, five 15-watt BL traps with four-vaned baffles were placed 6½ feet apart in a line from the trunk toward the periphery to a distance of 26 feet. The outermost branches of this tree had a radius of 40 to 50 feet. During the first 5 nights the line extended southwest from the trunk and during the second 5 nights it extended southeast. To eliminate any small differences due to individual lamps or traps, they were rotated daily. The results are given in table 19.

Beginning with the outermost trap in the southwest quadrant, the numbers of beetles captured tended to increase as the traps approached the trunk. With the traps in the southeast quadrant, the numbers tended to increase as the traps approached the periphery. The prevailing westerly winds caused the beetles to congregate in the center and on the east side of the tree and affected the catches at each position accordingly. It was evident that traps need not be placed immediately adjacent to the trunk, but for maximum effectiveness they should be placed well under the canopy of the tree.

## Accidental Catches of Chafers in BL Traps Under Trees

After the beetles settle in the trees for mating, some of the pairs fall to the ground. It has been speculated that many of the beetles captured in BL traps would have fallen into the traps irrespective of the ultraviolet radiation. The possibility of this accidental catch of beetles was studied near the end of the 1961 season.

Two European chafer beetle survey traps (*9*) with 15-watt BL lamps were placed on opposite sides within 3 feet of the trunk of the large maple tree. When one lamp was burned, the opposite trap was completely in the shadow of the trunk. Only one trap was burned each night, al-

TABLE 19.—*Effect of location of trap under tree on capturing beetles, 1962*

| Distance of trap from trunk (feet) | Proportion of beetles captured with traps in— | | |
|---|---|---|---|
| | Southwest quadrant | Southeast quadrant | Average |
| | *Percent* | *Percent* | *Percent* |
| 0 | 20 | 15 | 18 |
| 6½ | 27 | 21 | 24 |
| 13 | 26 | 17 | 22 |
| 19½ | 18 | 23 | 20 |
| 26 | 9 | 24 | 16 |
| | *Number* | *Number* | |
| Total beetles captured | 3,650 | 3,933 | |

ternating between the two. During 6 nights the illuminated trap caught 792 beetles; the nonilluminated trap caught 20 beetles. Even these few may have been captured through stimulation by the opposite trap.

On the following 6 nights one of the traps was removed completely from the site and the remaining trap was burned every other night. During the 3 nights that it burned, it caught 112 beetles. During the 3 nights it did not burn, it caught no beetles even though flight conditions were just as favorable on these nights. This limited study demonstrated that the incidence of accidental catches by beetles simply falling into traps is very low to nonexistent.

## REACTION OF CHAFERS TO BL TRAPS

### Effect of Height of BL Traps on Chafer Catches

Practically all comparisons of BL traps were made by hanging them from standard-length steel rods. This placed the top of the trap at approximately 5 feet. The height at the bottom varied considerably because of differences in length of lamps of different wattage. The 30-watt lamp, the most attractive tested, was the longest and hung nearest the ground. Chandler et al. (*1*) indicated that twice as many May beetles were taken in 15-watt BL traps 2 feet from the ground than at 4 feet. Also, Glick et al. (*6*) found that more pink bollworm moths were taken at 2 feet than at 4 feet.

The relative attractiveness of the 15-watt BL trap at two heights was compared with the attractiveness of the 30-watt BL trap. They were placed around the periphery of a large maple tree for 6 nights in 1960. Two 15-watt traps were hung so the top of the funnel was 42 inches from the ground, the normal height when using standard-length rods. Two others were hung with the top of the funnel at 21 inches. Two 30-watt traps were hung also with the top of the funnel at 21 inches, the normal height when using the standard-length rods. These results are summarized in table 20.

Considerable variation in the density of chafer flights existed during this period. The 30-watt traps caught approximately twice as many beetles as the 15-watt traps at either height. This difference in relative attractiveness of the two corresponded to results of other comparisons. This test demonstrated that the height of the 15-watt traps had little effect on their efficiency, and that the greater efficiency of the 30-watt traps was due to their greater ultraviolet output rather than to their relative height.

### Response of Chafers to BL Traps Throughout Night

As darkness approaches, the beetles emerge from the ground and fly to nearby trees and shrubs. Response of beetles to ultraviolet radiation during this period has never been noted but commences after they have flown to the trees. Preliminary studies in 1958 (*14*) showed that beetles responded to blacklight at least from 9 p.m. to

TABLE 20.—*Relative attractiveness of 15- and 30-watt BL lamps in traps at different heights on beetle catches, 1960*

| Nights of operation | Total beetles captured | Proportion of total captured at indicated lamp wattage and trap height (inches)[1] | | |
|---|---|---|---|---|
| | | 15 watts | | 30 watts |
| | | 42 | 21 | 21 |
| | *Number* | *Percent* | *Percent* | *Percent* |
| 1 | 29 | 28 | 17 | 55 |
| 2 | 341 | 17 | 31 | 52 |
| 3 | 351 | 18 | 28 | 54 |
| 4 | 589 | 18 | 30 | 52 |
| 5 | 753 | 29 | 24 | 47 |
| 6 | 940 | 26 | 25 | 49 |
| Total or average | 3,003 | 23 | 26 | 52 |

[1] To top edge of funnel from ground.

TABLE 21.—*Response of beetles to BL traps at different intervals of night at 2 locations, 1960-61*

| Trap location and time of night | Proportion of total beetles captured at indicated season | | | | |
|---|---|---|---|---|---|
| | Midseason 1960 | Late 1960 | Midseason 1961 | Late 1961 | Average |
| PHELPS LABORATORY | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| 8-9 | 1 | 19 | 3 | 12 | 9 |
| 9-10 | 27 | 31 | 40 | 43 | 35 |
| 10-11 | 21 | 19 | 18 | 19 | 19 |
| 11-12 | 6 | 3 | 9 | 4 | 6 |
| 12-1 | 3 | 1 | 5 | 2 | 3 |
| 1-2 | 2 | 2 | 4 | 0 | 2 |
| 2-3 | 4 | 0 | 5 | 4 | 3 |
| 3-4 | 7 | 8 | 5 | 2 | 6 |
| 4-5 | 12 | 6 | 7 | 10 | 9 |
| 5-6 | 17 | 11 | 4 | 4 | 9 |
| | *Number* | *Number* | *Number* | *Number* | |
| Total beetles captured | 438 | 170 | 799 | 51 | ........... |
| POLLOT FARM | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| 8-9 | 5 | 7 | 7 | 48 | 17 |
| 9-10 | 63 | 40 | 54 | 19 | 44 |
| 10-11 | 10 | 7 | 17 | 9 | 11 |
| 11-12 | 6 | 7 | 8 | 5 | 6 |
| 12-1 | 3 | 13 | 3 | 5 | 6 |
| 1-2 | 1 | 0 | 1 | 0 | $<1$ |
| 2-3 | 1 | 0 | 1 | 0 | $<1$ |
| 3-4 | 1 | 0 | 3 | 9 | 3 |
| 4-5 | 2 | 6 | 4 | 0 | 3 |
| 5-6 | 8 | 20 | 2 | 5 | 9 |
| | *Number* | *Number* | *Number* | *Number* | |
| Total beetles captured | 1,936 | 15 | 4,638 | 21 | ........... |

about 6 a.m., with a period of low response shortly after midnight. No beetles were captured after 6 a.m. Additional studies were made during the following three summers at different sites and at different periods of seasonal flight. All time recorded is daylight saving time.

These studies were made with 15-watt BL traps under trees at four locations during midseason of all 3 years. Additional studies near the end of the flight season were made during the second and third years.

Beginning at 9 p.m. beetles were removed from the traps once each hour until 6 a.m. The final examinations were made after 8 a.m. Each round of trap visitation required 20 to 30 minutes and was started sufficiently early so that the last trap was emptied by the end of the hour. Each test called for 5 nights' study, but rainstorms reduced it to 4 nights in two of the four tests.

Studies during 1960 included 4 nights during midseason on July 5-8 and 5 nights near the end of the season on July 25-29. Heavy flights were encountered during the first period and very light flights during the second period.

Studies during the 1961 season included 5 nights during the peak flight period of July 10-14 and 4 nights near the end of the season on August 1-7. The results of the four most comprehensive tests are summarized in table 21.

These studies confirmed previous results in that the beetles responded to ultraviolet radiation from shortly before 9 p.m., e.d.t., throughout the night to shortly before 6 a.m. All the catches before 9 p.m. occurred within 10 to 15 minutes of the hour.

From 55 to 86 percent of all the beetles captured for the night were taken before midnight. This was followed by a period of low beetle activity between midnight and 3 a.m., with captures varying from 3 to 14 percent of the total. After this there was a period of slightly increased response until shortly before 6 a.m., with captures varying from 9 to 36 percent. Dawn commenced about 4:15 to 4:30 a.m., and the level of illumination at 5:30 a.m. when all remaining beetles left the trees corresponded to that at 9 p.m. No beetles were ever taken after 6 a.m. From 86 to 95 percent of all beetles taken were captured before midnight and after 3 a.m.

Although large differences in hourly response of beetles occurred on several occasions, the location, density of beetle flight, period of seasonal flight, and year of flight had no consistent effect on the nightly response. The largest deviation occurred before 9 p.m. on the Pollot farm during late 1961 when 48 percent of the nightly catches were taken before 9 p.m. This condition could have been caused by darkness coming earlier in the evening this late in the season. These studies indicated that beetles respond to ultraviolet radiation throughout the night, with the greatest response taking place before midnight.

## Reaction of Chafers Around BL Traps

Numerous attempts were made to observe the reaction of beetles as they flew to BL traps. The BL lamps do not illuminate enough of the surrounding area to make possible following beetles for any appreciable distance as they approach the trap. They are first observed only 3 to 4 feet from the lamp as they are rapidly flying directly toward it. This is in contrast to the reaction of beetles around chemically baited traps, where they dart in and out and may circle the trap several times before they strike it. Around BL traps, however, most of the beetles fly straight into the trap and are deflected into the funnel and captured. A few beetles after once striking the trap may come to rest on its surface. A much greater proportion of beetles that make contact are caught with the BL traps than with the chemical traps.

During periods of heavy flight many beetles have been seen resting near the trap either on the ground or on vegetation, as shown in figure 16. During periods of peak flight as much as 5 pints of beetles (approximately 5,000) have been captured in 1 night in a single trap placed under a large tree where heavy populations congregated.

## Sexual Response of Chafers to BL Traps

The normal sex ratio of reared beetles was found to be two males to one female (Gyrisco et al. 7). Chemically baited traps may capture a ratio of 20 or more males to 1 female early in the season. During midseason, the proportion of sexes in flight approaches 1:1; then males continue to increase again to the end of the flight season. Preliminary information on

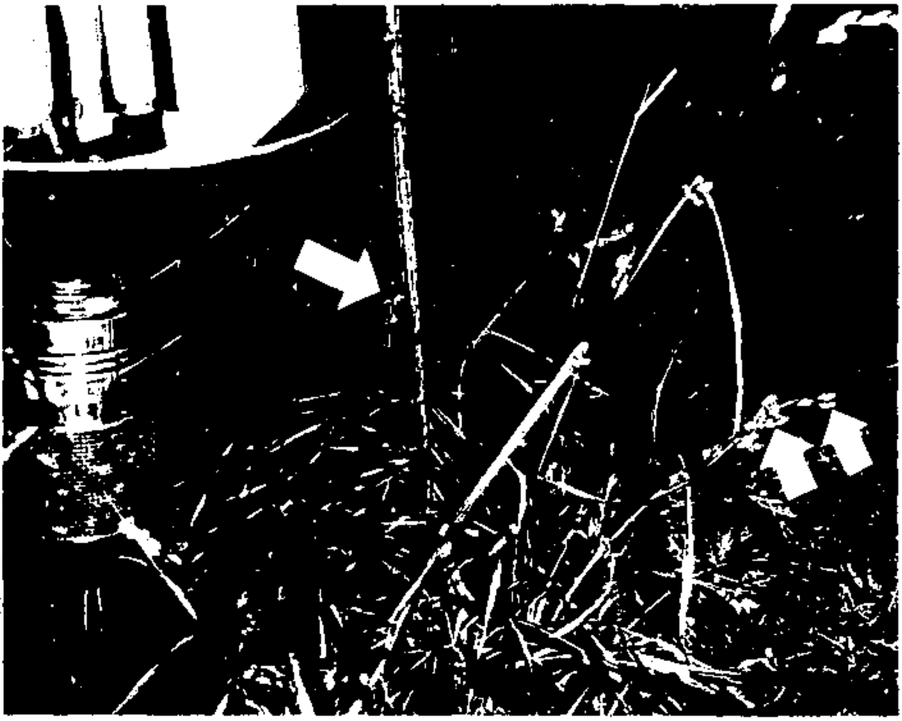

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FIGURE 16.—European chafer beetles resting on vegetation (arrows) around BL trap.

the attractiveness of blacklight to beetles was obtained late during the 1958 season. Of the 357 beetles captured, 62 percent were females. These studies were continued during the following two summers.

Sex ratios of beetles attracted to BL traps were determined during the early, midseason, and late flights at three locations in 1959 and repeated at two of the same locations in 1960. The early-season studies were made prior to peak flights, midseason during peak flights, and late-season studies after peak flights as the beetle populations were diminishing. Traps under large trees in these areas placed there in connection with other studies were emptied daily and beetles were sexed. The results of these determinations are summarized in table 22. During the 1960 midseason flights the sex ratio of beetles was determined at hourly intervals in connection with the study of beetle response throughout the night.

For a given summer, sex ratios varied more between locations than between different periods of the same season. The highest proportion of females was captured in 1959 at the Phelps Laboratory, where it varied from 53 to 66 percent. The lowest proportion was captured at the Pollot farm in 1960, where it varied from 27 to 30 percent. The average percentage of females from all locations was much lower during the second year, with 38 percent as compared with 53 percent in 1959. The time of night had no pronounced effect on sex ratios during the 1960 midseason, but the proportion of females tended to increase after 2 to 3 a.m. The pronounced response of females to BL traps as compared to chemically baited traps has been useful in collecting large numbers of gravid females for use in other investigations.

TABLE 22.—*Sexual response of beetles to BL traps during 3 periods of flight at 3 locations, 1959-60*

| Period in flight and trap location | Total beetles captured | | Proportion of females in total | |
|---|---|---|---|---|
| | 1959 | 1960 | 1959 | 1960 |
| EARLY | | | | |
| | *Number* | *Number* | *Percent* | *Percent* |
| Phelps Laboratory | 116 | 799 | 53 | 52 |
| Pollot farm | 223 | 1,145 | 46 | 27 |
| Abenshene farm | 88 | ... | 45 | ... |
| MIDSEASON | | | | |
| Phelps Laboratory | 382 | 438 | 66 | 44 |
| Pollot farm | 442 | 1,936 | 51 | 27 |
| Abenshene farm | 102 | ... | 52 | ... |
| LATE | | | | |
| Phelps Laboratory | 115 | 204 | 58 | 46 |
| Pollot farm | 157 | 1,271 | 57 | 30 |
| Abenshene farm | 112 | ... | 47 | ... |
| Total or average | 1,737 | 5,793 | 53 | 38 |

# EFFICIENCY OF BL TRAPS

## Relation to Chemical Traps

In preliminary comparisons during 1958, a 15-watt BL trap caught up to 70 times more chafer beetles than the best chemically baited trap on hand. A 3:1 mixture by volume of Java citronella oil and eugenol was the attractant in the latter. Additional comparisons on the efficiency of BL traps over chemically baited traps were made in 1959 and 1960 with two levels of infestation.

During 1959, 15-watt BL traps and chemically baited traps were placed in a 5 by 5 Latin square block in an open field where the

TABLE 23.—*Relative effectiveness of 15-watt BL and chemically baited traps in capturing beetles from infested and noninfested fields, 1959-60*

| Year, trap location, and nights of operation | Total beetles captured | Proportion of total captured | |
|---|---|---|---|
| | | BL trap | Chemical trap |
| *1959* | | | |
| Lightly infested field: | *Number* | *Percent* | *Percent* |
| 1 | 179 | 28 | 72 |
| 2 | 60 | 10 | 90 |
| 3 | 42 | 64 | 36 |
| 4 | 38 | 53 | 47 |
| 5 | 36 | 58 | 42 |
| 6 | 35 | 89 | 11 |
| 7 | 27 | 37 | 63 |
| 8 | 26 | 46 | 54 |
| 9 | 23 | 52 | 48 |
| 10 | 5 | 40 | 60 |
| Total or average | 471 | 48 | 52 |
| Noninfested field: | | | |
| 1 | 74 | 97 | 3 |
| 2 | 58 | 95 | 5 |
| 3 | 47 | 98 | 2 |
| 4 | 35 | 100 | 0 |
| 5 | 23 | 96 | 4 |
| 6 | 18 | 100 | 0 |
| 7 | 16 | 94 | 6 |
| 8 | 10 | 100 | 0 |
| 9 | 7 | 100 | 0 |
| 10 | 7 | 100 | 0 |
| 11 | 8 | 100 | 0 |
| 12 | 4 | 100 | 0 |
| 13 | 2 | 100 | 0 |
| 14 | 2 | 100 | 0 |
| 15 | 3 | 100 | 0 |
| 16 | 2 | 100 | 0 |
| Total or average | 316 | 99 | 1 |

TABLE 23.—*Relative effectiveness of 15-watt BL and chemically baited traps in capturing beetles from infested and noninfested fields, 1959-60*—Continued

| Year, trap location, and nights of operation | Total beetles captured | Proportion of total captured | |
|---|---|---|---|
| | | BL trap | Chemical trap |
| *1960* | | | |
| Lightly infested field: | *Number* | *Percent* | *Percent* |
| 1 | 70 | 26 | 74 |
| 2 | 53 | 87 | 13 |
| 3 | 28 | 43 | 57 |
| 4 | 16 | 50 | 50 |
| 5 | 12 | 67 | 33 |
| Total or average | 179 | 55 | 45 |
| Noninfested field:[1] | | | |
| 1 | 1,386 | 98 | 2 |
| 2 | 446 | 96 | 4 |
| 3 | 310 | 96 | 4 |
| 4 | 96 | 94 | 6 |
| 5 | 18 | 100 | 0 |
| 6 | 15 | 100 | 0 |
| 7 | 2 | 100 | 0 |
| 8 | 1 | 100 | 0 |
| Total or average | 2,274 | 98 | 2 |

[1] Weeks of operation.

chafer population during the spring averaged one grub per 2 square feet. Traps were exposed during midseason for 10 nights. In another test, five chemical traps were placed in single line in the middle of an open field where spring surveys yielded virtually no grubs. Five BL traps were placed under a tree more than 50 feet tall at the edge of the same field. These traps were compared for 16 nights. The results of these tests are summarized in table 23.

In the open field where an infestation occurred, both types of traps were about equally effective for the entire test although their effectiveness varied considerably from night to night. In the noninfested field the BL traps under the trees caught an average of 99 percent of all the beetles taken in the two types of traps. Equally significant, the BL traps continued to capture beetles for 9 nights after the chemically baited traps discontinued catching beetles.

Both tests were repeated in the same locations during 1960. The population in the open field where traps were compared in a 5 by 5 Latin square block averaged one grub per square foot in the spring. Traps were compared for 5 nights. The test in the virtually noninfested field was conducted for 8 weeks. The results of these tests are given in table 23.

In the open field the nightly catches in the two types of traps again varied considerably, but the average for each type of trap for the entire test approximated and confirmed the results of 1959. The BL traps under the large tree at the edge of the noninfested field captured, on an average, 98 percent of all the beetles in the two types of traps. The chemically baited traps caught beetles for the first 4 weeks only. As the populations of beetles diminished late in the season, the BL traps continued to catch beetles for an additional 4 weeks.

The response of beetles to the two types of traps explains the results obtained. The chemically baited trap sampled the population emerging from the ground in the vicinity of the trap and only during the 30-minute emergence period each evening. Beetles emerging around blacklight traps in the open field must first fly to nearby trees before they are attracted to these traps. The difference in the reaction of the beetles to the two types of traps is a factor to consider in using traps in very lightly infested areas. Since the beetles are attracted to a tall tree from a much larger area than attracted to an individual chemical trap, the chance of capturing a beetle in very lightly infested areas is much greater with the blacklight traps than with the chemically baited traps.

## Relation to Visual Observation

### *Estimates of Chafers in Flight*

During 1958, the density of chafer beetles around four trees was estimated during 12 nights and compared with the numbers captured in 15-watt BL traps. Roughly one-third of the numbers estimated were captured (*14*). Additional estimates were made in 1959 and 1960 in an effort to determine more precisely the efficiency of BL traps.

During 1959, the numbers of beetles in flight were estimated for 8 to 14 nights in one large tree more than 50 feet tall at three locations and compared with the total numbers of beetles actually captured with a single 15- or 30-watt BL unbaffled trap placed under the tree. The results given in table 24 confirmed the estimates made in 1958 that the 15-watt BL traps caught about one-third of the beetles flying to a given tree. A 30-watt BL trap was more efficient and appeared to capture about one-half of the beetles in a given tree.

In spite of the apparent consistency between the estimates and the actual catches, individual estimates of population might be far from accurate. An attempt was made in 1960 to determine the accuracy of estimates. The density of beetle flight in a maple tree approximately 30 feet high

TABLE 24.—*Estimated efficiency of 15- and 30-watt BL traps in capturing beetles, 1959*

| Lamp wattage and nights of operation | Total beetles estimated | Total beetles captured | Estimated efficiency |
|---|---|---|---|
| | *Number* | *Number* | *Percent* |
| 15 watts: | | | |
| 11 | 260 | 88 | 34 |
| 9 | 2,200 | 370 | 17 |
| 14 | 2,600 | 1,103 | 42 |
| 30 watts, 8 | 415 | 229 | 55 |

was estimated for 7 nights. After the beetles had settled, the limbs were shaken to dislodge the beetles onto plastic sheets spread under the tree. The numbers estimated and actually collected were as follows:

| *Estimated* | *Collected* |
|---|---|
| 500 | 231 |
| 250 | 476 |
| 150 | 96 |
| 150 | 87 |
| 100 | 467 |
| 100 | 166 |
| 50 | 46 |

It was evident that estimates could vary considerably from actual counts. Weather conditions appeared to affect flight habits and thus the accuracy of estimates. During warm calm evenings the beetles continued to fly around a tree for several minutes before coming to rest. On cool breezy evenings they came to rest almost immediately after flying to a tree.

In view of these inaccuracies in estimates, another approach was tried to determine the efficiency of BL traps. Two willow saplings about 12 feet high and trimmed to have the same amount of foliage were planted 100 feet apart in an open field where a light infestation was present. Density of beetles flying around these two trees was expected to be similar, and nightly observations indicated that this was generally so. When the beetles had settled, those in one tree were dislodged by vigorous shaking onto a plastic sheet spread under the tree. A BL trap was operated under the other tree throughout the night. In the morning the number captured with the trap was determined. On the following night the same process was repeated in the opposite tree. This was continued until each trap had been in operation for 5 to 10 nights.

Again the 15-watt BL unbaffled trap caught about one-third of the chafers in the tree, as shown in table 25. Addition of baffles doubled its effectiveness. Trap efficiency increased with greater lamp wattage, and the high efficiency of the 30-watt lamp may be due to chafers being attracted from distant trees.

### Actual Counts of Chafers in Flight

A more accurate measure of trap efficiency was considered possible by counting beetles flying to a tree when very few were present and comparing these counts with catches in BL traps under the same trees. Some indication of trap efficiency was evident in 1958 when no beetles

TABLE 25.—*Estimated efficiency of various BL lamps in capturing beetles, 1960*

| Lamp wattage and description of trap | Beetles collected by shaking | Beetles captured by trap | Apparent population captured |
|---|---|---|---|
| 15 watts: | *Number* | *Number* | *Percent* |
| No baffle | 190 | 64 | 34 |
| 4-Winged baffle | 172 | 135 | 78 |
| 30 watts, 4-winged baffle | 329 | 405 | 123 |
| 32 watts,[1] 4-winged baffle | 288 | 261 | 91 |

[1] Circline lamp.

were seen around trees during 3 nights, but BL traps under the same trees caught one, four, and one beetle, respectively, during the 3 nights.

During the next 4 years individual beetles in very light infestations of less than six beetles were counted around individual trees and compared with trap catches under the same trees. An intensive effort was made to observe beetles flying to these trees during the period of maximum activity. This was between 8:50 and 9:10 p.m., e.d.t., on nights following warm sunny days.

In 1959 and 1960, observations were made on 3 nights at the end of the season when beetles were nearly gone. In 1961 and 1962,

TABLE 26.—*Efficiency of 15-watt BL traps compared to visual observation in detecting light populations of beetles at night, 1959-62*

| Year | Total beetles seen | Total beetles trapped |
|---|---|---|
| | *Number* | *Number* |
| 1959 | 5 | 4 |
| | 5 | 3 |
| | 5 | 2 |
| 1960 | 2 | 7 |
| | 4 | 3 |
| | 3 | 2 |
| 1961 | 0 | 1 |
| | 0 | 1 |
| | 0 | 1 |
| | 0 | 1 |
| 1962 | 0 | 3 |
| | 2 | 0 |
| | 0 | 2 |
| | 0 | 1 |
| | 0 | 4 |
| | 1 | 1 |
| | 0 | 1 |
| | 0 | 1 |
| | 0 | 3 |
| Total | 27 | 41 |

similar observations were possible during midseason at the edge of an incipient infestation.

During the 4 years, there were 19 positive nights either by observation or by trap catches, as shown in table 26. There was only 1 night in the 19 when beetles were seen but none were caught. On all other nights at least one beetle was captured when they were seen. At least a single beetle was caught on 11 nights when none were seen in flight.

An intensive effort was made during the 1963 season to compare the efficiency of a 6-watt and a 15-watt BL trap to visual observations in detecting light infestations of beetles. Visual observations were made for 42 nights from June 19 through August 1 to detect the presence of beetles coming to a single tree. Either a 6-watt general-purpose trap or a 15-watt European chafer beetle survey trap was operated on a.c. circuit under the same tree on which visual counts were made each night.

A 20-minute observation was made each evening beginning about 15 minutes before the expected time of peak flight and ending about 5 minutes after it. The expected time of peak flight varied slightly depending on the amount of cloudiness and the season and was determined by the time of peak flight in other areas where a heavy population was present. The numbers of beetles actually seen in flight around the tree during the evening and the beetles captured in the trap on the same night were recorded. The 6- and 15-watt traps were interchanged to expose each to similar population levels. Results for each positive night are given in table 27.

TABLE 27.—*Relative effectiveness of 6- and 15-watt BL traps compared to visual observation in detecting light infestations of beetles at night, 1963*

| Observation versus 6-watt trap | | Observation versus 15-watt trap | |
|---|---|---|---|
| Beetles seen | Beetles caught | Beetles seen | Beetles caught |
| *Number* | *Number* | *Number* | *Number* |
| 4 | 0 | 4 | 1 |
| 4 | 0 | 3 | 0 |
| 2 | 2 | 2 | 3 |
| 2 | 1 | 2 | 2 |
| 2 | 1 | 2 | 1 |
| 2 | 0 | 1 | 1 |
| 1 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| Total........ 19 | 6 | 17 | 10 |

Each pair of entries—beetles seen or beetles caught—represents results on a single night. The data are listed in order of diminishing numbers of beetles observed and not chronologically. There were 20 positive nights for beetles either observed or caught in a trap. Four beetles were the most seen on a given night. The numbers observed in flight were greater than trap catches this year, but the high efficiency of the BL traps was again apparent. The 6-watt trap caught one-third of the total number of beetles observed; the 15-watt trap caught more than one-half of the total number observed. There were 5 negative nights for the 6-watt trap compared with only 3 for the 15-watt trap when beetles were observed but not caught. There were two negative observations when traps revealed the presence of beetles. It can be concluded from these studies over the 5-year period that the BL traps are highly effective in detecting light infestations.

## BATTERY OPERATION OF BL TRAPS

A battery-operated BL trap for European chafer surveys is desired because of several inherent disadvantages in operating the traps from existing a.c. circuits. (1) There are many desirable sites in a given location where traps should be placed, but they are too remote from a source of electricity. (2) It takes a considerable amount of time and effort to contact property owners to obtain permission to tap into their source of electricity. (3) Long lengths of extension cord are often required for placing a trap even relatively near a source of electricity. It has been recognized, however, that reliable equipment for efficient operation of fluorescent lamps with storage batteries was practically nonexistent. Hollingsworth and Briggs (*8*) indicated that vibrator-type inverters have only 40 to 75 percent efficiency and an operating life of 1,000 hours or less. This is in contrast to transistor-type inverters with an efficiency of 70 to 90 percent and a greatly extended life expectancy.

A few exploratory observations in 1960 indicated that if an efficient battery-operated trap became available, it should perform satisfactorily in capturing beetles. Brief operation of 4-, 8-, and 15-watt BL traps with 6- and 12-volt automotive batteries resulted in capturing beetles just as readily as when operated with an a.c. circuit. Vibrator-type inverters were used. They burned the lamps for 2 or 3 nights without recharging the batteries. The 4-watt lamp was also successfully operated for 2 nights on a dry-cell B battery.

## Specifications for Battery-Operated Trap

Specifications for a battery-operated 15-watt blacklight trap were prepared. An input of 12 volts d.c. nominal and an output of 120 volts a.c. at approximately 1,000 c.p.s. through a transistorized inverter were specified. Although Hollingsworth et al. (*9*) stated that from the standpoint of attractiveness to insects they found no advantage in operational frequencies higher than 60 c.p.s., the lamp can be operated more efficiently with the higher frequency. In addition, the specifications called for a photoswitch with an adjustable range for turning the power supply on with the approach of darkness and off with the approach of daylight. It should have the capacity to operate a 15-watt fluorescent lamp for 3 consecutive 10-hour nights, starting from a fully charged condition. An electronics firm was engaged to build such units.

The 15-watt European chafer beetle survey traps (fig. 14) were wired to operate with either an a.c. circuit or a battery. When a 60-cycle a.c. circuit is used, the current flows through a 60-cycle ballast in the trap. When a battery is used as a source of power, the current flows through a 1,000-cycle ballast in the inverter and bypasses the ballast in the trap.

## Preliminary Tests

During 1961, two complete units for battery operation were available. Each was fitted with a 15-watt BL lamp. One of these units was placed under a single large tree and operated nightly for 2 weeks. The photocell activated the lamp between 8:34 and 8:40 p.m. and turned it off between 6:10 and 6:20 a.m., e.d.t. The numbers of beetles captured each night ranged from over 1,000 beetles during the first 3 nights to less than 100 each night near the end of this period as the seasonal populations decreased.

The second unit was used to compare its performance with an identical trap operated from an a.c. circuit. The traps were hung from steel rods placed approximately 30 feet apart beneath a large tree and operated for 14 nights. Beetles were counted each morning. The photocell was darkened, and if the lamp was activated, it was assumed that it had burned all night. The traps were rotated daily. During this period the battery-operated trap captured 42 percent of the beetles taken in the two traps. The numbers taken by this trap equaled or exceeded the numbers taken in the trap operated by a.c. circuit on only 4 nights. It appeared from these results that the battery-operated trap was somewhat less attractive than the one operated on a.c. circuit.

## Performance of Battery-Operated and A.C.-Operated Traps

An attempt was made during 1962 and 1963 to determine whether the apparently lower attractiveness of the 15-watt trap operated with a battery during the previous year was valid. There appeared to be three possibilities: (1) The lamp operated at 1,000 c.p.s. is less attractive, (2) the ultraviolet output is lower with battery operation, and (3) turning the battery-operated lamp on after 8:30 p.m. did not permit sufficient warming of the lamp for maximum ultraviolet output for the earliest flying beetles.

### *Procedures and Results of 1962 Studies*

Three 15-watt BL European chafer beetle survey traps were placed in an equilateral triangle beneath the same large tree used in 1961. Trap 1 was operated with a 12-volt battery through a photocell inverter unit at 1,000 c.p.s. It was activated each evening between 8:45 and 9 p.m., e.d.t., when illumination dropped to 20 foot-candles, and was turned off at the same level of illumination each morning. Trap 2 was operated with a 12-volt battery through a manually operated inverter at 60 c.p.s. and was turned on when the first trap was activated. This was turned off about 8 a.m. when the traps were first visited. Trap 3 was operated from an a.c. circuit and burned continuously. Each morning the beetles were counted and the photocell of the 1,000-cycle unit was activated artificially to ascertain operation throughout the night. The traps were rotated so that each trap occupied each position once every 3 nights. This constituted a series. The batteries were replaced with fully charged ones every 3 nights.

After the first four series had been completed, difficulty was encountered with the photoswitch of the 1,000-cycle unit. Therefore, the two battery-operated units were turned on manually each afternoon about 5 p.m. and turned off the next morning after 8 a.m. The test was continued for five additional series.

The results of the first four series, shown in table 28, indicate that the battery-operated units were less effective than the a.c.-operated trap. Results of the last five series indicate that when the lamps were given a sufficient warming period, the battery-operated traps were equally as effective as the a.c.-operated trap.

### *Procedures and Results of 1963 Studies*

The possible value of sufficient warming of BL lamps for maximum ultraviolet output before beetles start to fly was investigated during the 1963 season.

Three 15-watt European chafer beetle survey traps (fig. 14) were hung about 23 feet apart in an equilateral triangle under the same large tree used the previous 2 years. Trap 1 was operated with a 12-volt battery through an inverter at 1,000 c.p.s., with a photoswitch adjusted to turn the power supply on when the illumination level dropped to 150-170 foot-candles.[1] During midseason this level was reached about 8:15 to 8:20, e.d.t., on clear cloudless

[1] Measured with Weston Illumination Meter Model 756. Sensing cell pointed same direction as photoswitch.

TABLE 28.—*Relative effectiveness of 15-watt BL traps when started at different times and operated with different power sources in attracting beetles, 1962*

| Time battery-inverter traps started and series | Total beetles captured | Proportion of total captured in traps operated with— | | |
|---|---|---|---|---|
| | | 1,000-Cycle inverter | 60-Cycle inverter | 60-Cycle a.c. circuit |
| *8:45-9 p.m.* | *Number* | *Percent* | *Percent* | *Percent* |
| 1 | 1,276 | 28 | 33 | 39 |
| 2 | 1,163 | 29 | 42 | 29 |
| 3 | 645 | 22 | 34 | 44 |
| 4 | 583 | 35 | 23 | 42 |
| Total or average. | 3,667 | 28 | 33 | 38 |
| *5 p.m.* | | | | |
| 5 | 3,279 | 34 | 32 | 34 |
| 6 | 574 | 36 | 33 | 31 |
| 7 | 457 | 33 | 34 | 33 |
| 8 | 380 | 33 | 33 | 34 |
| 9 | 182 | 33 | 33 | 34 |
| Total or average. | 4,872 | 34 | 33 | 33 |

evenings. It was also the level of illumination occasionally reached beneath trees during midday under heavily clouded storm conditions. Trap 2 was also operated on a battery through an inverter with the photoswitch activating the lamp at 14 to 16 foot-candles of illumination, the level reached at 8:45 to 8:50 on clear cloudless evenings. This period generally corresponds to the appearance of beetles flying to the trees in small but noticeable numbers. Trap 3 was operated on 60-cycle 120-volt a.c. circuit and burned continuously.

TABLE 29.—*Effect of warming period of 15-watt BL lamps operated with different power sources on beetles catches, 1963*

| Series | Total beetles captured | Proportion of total captured in traps operated with— | | |
|---|---|---|---|---|
| | | Battery | | A.c. circuit continuously |
| | | Early | Late | |
| | *Number* | *Percent* | *Percent* | *Percent* |
| 1 | 3,532 | 20 | 38 | 42 |
| 2 | 3,227 | 23 | 35 | 42 |
| 3 | 2,256 | 29 | 42 | 29 |
| 4 | 1,910 | 38 | 34 | 28 |
| 5 | 1,265 | 32 | 26 | 42 |
| 6 | 945 | 38 | 37 | 25 |
| 7 | 923 | 25 | 35 | 40 |
| 8 | 592 | 42 | 36 | 22 |
| Total or average. | 14,650 | 31 | 35 | 34 |

These traps were operated for nearly a month. Nightly catches were determined, and the traps were rotated daily so that each trap occupied each position once every 3 nights of flight. This constituted a series. These results are summarized in table 29.

The eight series are arranged according to diminishing catches. There was considerable variation in catches for individual nights and also in individual series. These studies indicated no value in having a preflight warming period with battery-operated traps. Neither did they indicate that the battery-operated traps were less efficient than the a.c.-operated trap.

On the basis of the 3-year study, we concluded that a trap powered with a storage battery is equally as effective in attracting and capturing beetles as a trap powered with an a.c. circuit. In addition, the BL lamp when activated at the onset of flight is equally as attractive to beetles as when activated earlier for a preflight warming period.

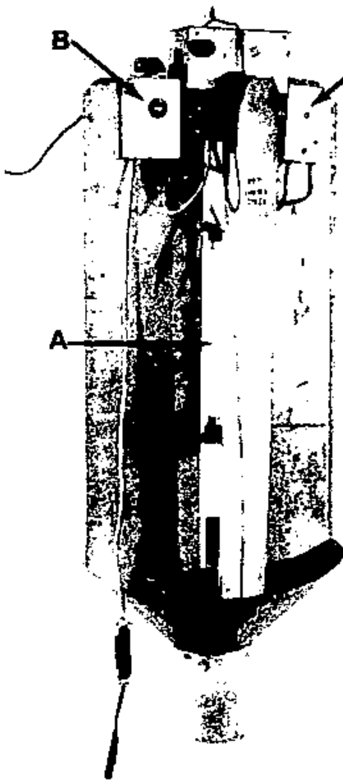


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FIGURE 17.—Six-watt BL lamp (*A*), photoswitch (*B*), and inverter (*C*) mounted on European chafer beetle survey trap.

## Comparison of 6- and 15-Watt BL Battery-Operated Traps

### *Traps in Competition With Each Other*

A 6-watt transistorized inverter unit became available in 1962 and was used to operate a 6-watt BL lamp in the European chafer beetle survey trap, as shown in figure 17. This lamp was compared with a 15-watt BL lamp in an identical trap. Both traps were powered with 12-volt batteries. Both inverters had an output of 120-volt a.c. circuit at 1,000 c.p.s. and were automatically activated with a photocell.

The two traps were hung from steel rods and placed about 7 feet from the trunk of a large tree on opposite sides so that one trap was not seen from the position of the other. Both lamps were started automatically each evening between 8:50 and 8:57 p.m., e.d.t., and operated for 26 nights. The beetles were counted each morning, and the photoswitches were activated artificially to ascertain operation throughout the night. The batteries were recharged as needed to maintain a continuous source of power.

During the first 16 nights the traps were located directly east and west of the trunk. They were rotated each day. A series consisted of 2 nights with each trap in each position once. Prevailing westerly winds tended to force the beetles to congregate on the east side of the tree and increased the catch of beetles in the trap on this side. Therefore, the last five series were conducted with the traps placed north and south of the trunk.

When populations were high, the 6-watt lamp was only slightly less effective than the 15-watt lamp, but tended to become less effective as the population diminished. This is evident in table 30. About 43 percent of all the beetles caught were taken in the 6-watt trap when they were in the east-west location. In the north-south location, this trap caught 34 percent of the beetles.

Smith et al. (*11*) showed that a small trap with a 6-watt BL lamp was approximately 60 percent as efficient in catching numerous species as a larger trap with a 15-watt BL lamp. During the 1963 season, a 6-watt battery-operated trap designed as a general-purpose survey trap became available. It is fitted with a more elaborate insect-collecting device, which eliminates rain and retains a volatile killing agent. Its overall dimensions are 8¼ by 14½ inches as compared with 12½ by 26 inches for the conventional European chafer beetle survey trap. Both types of traps assembled for battery and photocell operation are shown in figure 18.

These two traps and the Euro-

TABLE 30.—*Relative effectiveness of 6- and 15-watt battery-operated BL traps in attracting beetles when traps were located in different directions from tree trunk, 1962*

| Direction of traps from trunk and series | Total beetles captured | Proportion of total captured in traps with lamps of— | |
|---|---|---|---|
| | | 6 watts | 15 watts |
| EAST AND WEST | *Number* | *Percent* | *Percent* |
| 1 | 3,752 | 48 | 52 |
| 2 | 3,215 | 45 | 55 |
| 3 | 3,013 | 43 | 57 |
| 4 | 1,902 | 37 | 63 |
| 5 | 1,473 | 51 | 49 |
| 6 | 1,054 | 41 | 59 |
| 7 | 995 | 42 | 58 |
| 8 | 288 | 37 | 63 |
| Total or average | 15,692 | 43 | 57 |
| NORTH AND SOUTH | | | |
| 9 | 294 | 37 | 63 |
| 10 | 85 | 45 | 55 |
| 11 | 71 | 33 | 67 |
| 12 | 46 | 21 | 79 |
| 13 | 22 | 32 | 68 |
| Total or average | 518 | 34 | 66 |

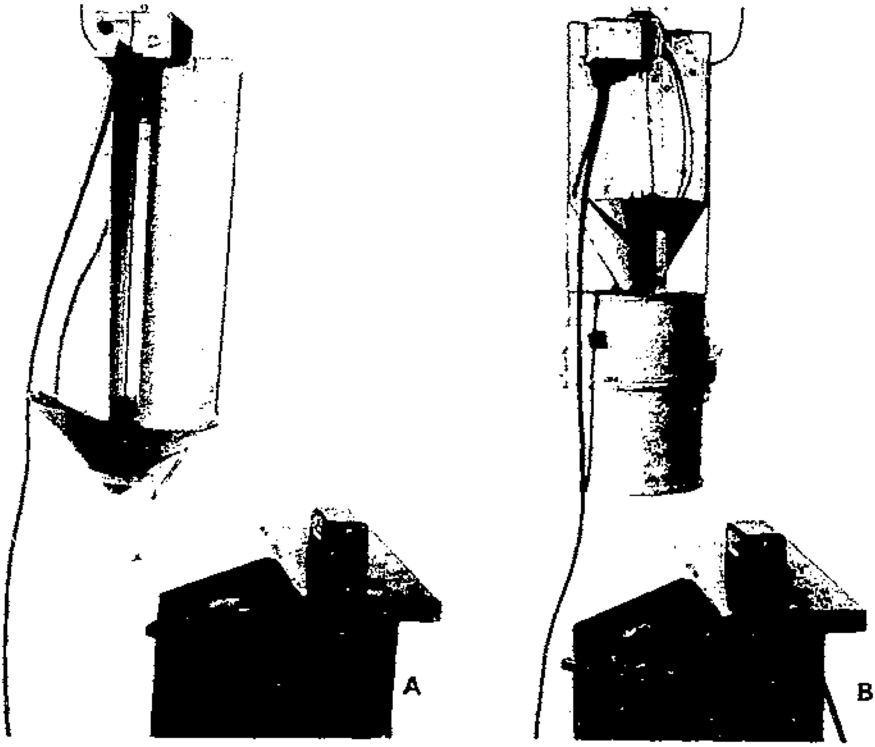


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FIGURE 18. European chafer beetle survey trap with 15-watt BL lamp (*A*) and general-purpose survey trap with 6-watt BL lamp (*B*) equipped for battery operation.

pean chafer beetle survey trap equipped with a 6-watt BL lamp (fig. 17) were hung approximately 20 feet apart in an equilateral triangle under a large tree. All three were operated with batteries, and the photoswitches were adjusted to turn the power supply on at approximately 8:30, e.d.t., on clear cloudless evenings. Nightly catches were determined, and the photoswitches were activated artificially to ascertain operation throughout the night. The traps were rotated daily so that each trap occupied each position once every 3 nights to complete each series. The results of this study are summarized in table 31.

The 6-watt traps were equally effective and each caught approximately half as many beetles as the 15-watt trap. The smaller baffle and funnel of the general-purpose 6-watt trap did not contribute to loss of efficiency. In spite of the lower efficiency of the 6-watt trap, it showed considerable promise for use in survey operations because of the longer battery life that could be expected with this lamp. In addition, the smaller 6-watt trap has a definite size advantage over the larger 6-watt trap.

TABLE 31.—*Comparison of 6-watt BL lamp in small and large trap with 15-watt BL lamp in large trap in capturing beetles, 1963*

| Series | Total beetles captured | Proportion of total captured with— 6-Watt small trap | 6-Watt large trap | 15-Watt large trap |
|---|---|---|---|---|
| | *Number* | *Percent* | *Percent* | *Percent* |
| 1 | 6,654 | 29 | 41 | 30 |
| 2 | 5,064 | 18 | 15 | 67 |
| 3 | 3,833 | 28 | 26 | 46 |
| 4 | 2,705 | 17 | 30 | 53 |
| 5 | 1,063 | 32 | 15 | 53 |
| 6 | 681 | 21 | 25 | 54 |
| 7 | 205 | 12 | 25 | 63 |
| Total or average | 20,205 | 22 | 25 | 52 |

### *Traps Isolated From Each Other*

Previous comparisons on the effectiveness of BL traps in capturing beetles indicated that the differences between larger and smaller lamps were minimized when the traps were operated independently, so that they were not in direct competition with each other. All these studies were made with traps operated on a.c. circuit.

During the 1963 season, a 6-watt BL general-purpose survey trap and a regular 15-watt BL European chafer beetle survey trap, both operated with batteries (fig. 18), were compared when performing independently. The traps were placed under two trees approximately 90 feet tall. One trap was not visible from the location of the other. The trees were separated by approximately 100 yards and an intervening large building, but each tree drew beetles from a common infestation. The beetles were counted, and the traps were rotated daily as long as a single beetle was caught in at least one of the traps. They were operated for 12 nights or six series, each series consisting of each trap occupying each position for 1 night. The results are summarized in table 32.

TABLE 32.—*Relative effectiveness of 6- and 15-watt battery-powered BL traps operating independently in capturing beetles, 1963*

| Series | Total beetles captured | Proportion of total captured with— 6-Watt trap | 15-Watt trap |
|---|---|---|---|
| | *Number* | *Percent* | *Percent* |
| 1 | 646 | 43 | 57 |
| 2 | 285 | 56 | 44 |
| 3 | 214 | 38 | 62 |
| 4 | 13 | 45 | 55 |
| 5 | 11 | 35 | 65 |
| 6 | 3 | 33 | 67 |
| Total or average | 1,172 | 42 | 58 |

The 6-watt trap captured, on an average, 42 percent of the total and the 15-watt trap 58 percent. Previous results were confirmed in showing that the smaller lamp was more effective when not in competition with the larger lamp. These results gave further evidence that the 6-watt battery-operated trap shows considerable promise for use in general-survey operations.

### Battery Life With 6- and 15-Watt BL Lamps

Determining battery life with a 6-watt BL lamp was desirable, since this lamp performed well in comparison with the larger 15-watt BL lamp.

During 1962, fully charged 12-volt batteries of 72 ampere-hour rating were hooked up to 6- and 15-watt BL traps equipped with 1,000-c.p.s. inverters and photocell switches. The lamps were burned each night until the batteries were completely discharged.

In the first comparison, when the weather was generally clear, both lamps were activated between 8:30 and 9 p.m., e.d.t., and turned off at approximately 6 a.m. The 6- and 15-watt lamps operated successfully for 11 and 3 nights, respectively.

During the second comparison, it was cloudy most of the time. The traps were activated between 7 and 9 p.m., depending on the cloudiness. They did not turn off until about 7 a.m. on some days. The 6- and 15-watt lamps operated successfully for 10 and 3 nights, respectively.

During 1963, 12-volt batteries with ampere-hour ratings of 60 and 72 were tested for their duration in operating 6-watt BL lamps. A fully charged battery of each capacity was connected to a trap and operated for 10 to 11 hours each night until they ceased to burn the lamp. Then the batteries were recharged and connected to the other trap. The 60 ampere-hour battery operated a 6-watt lamp in both traps for 5 and 4 full nights, respectively. The 72 ampere-hour battery operated a 6-watt lamp in both traps for 9 and 7 full nights, respectively.

Longevity with a single charge of a 72 ampere-hour battery fell short of the 1962 results, but still indicated that the 6-watt trap could be operated with weekly changes of the battery for normal 9-hour nights. The 6-watt BL trap shows much promise of being efficient and practical for general chafer surveys, and we believe that any future increase in traps should be of this size.

## SUMMARY

The outstanding attractiveness of blacklight to beetles of the European chafer (*Amphimallon majalas* (Razoumowsky)) was discovered in 1958. This led to an intensive effort to develop a blacklight trap for survey operations on this quarantined insect.

Blacklight fluorescent lamps, designated as BL, with peak radiation at 3,650 angstroms were by far the most attractive. Lamps with the Philips phosphor, which produce more energy in the blue region, were equally as attractive as those with the conventional phosphor. Traps with the BL lamp caught 1½ times more beetles than with the related BLB lamp, also peaking at 3,650 angstroms, and 3½ times more than the erythemal, the next most at-

tractive lamp peaking at 3,100 angstroms. Argon glow lamps, a source of low-wattage near-ultraviolet radiation, and incandescent lamps were totally ineffective in attracting chafer beetles.

Attractiveness of the BL lamps increased with wattage. When in competition with each other, the 30-watt lamp attracted approximately 16 times more beetles than the 4-watt lamp. When not in direct competition, the 30-watt lamp attracted slightly more than twice as many beetles.

Ultraviolet output of BL lamps depreciates rapidly during the first 100 hours of burning, then slowly over the following several thousand hours. The 15-watt lamps with 0-hour burning and ultraviolet maintenance of 123 percent were slightly more attractive to beetles than lamps burned 100 hours with ultraviolet maintenance of 100, but additional burning up to 4,500 hours did not decrease their attractiveness.

Adding a four-vaned baffle to the 15-watt trap tripled its effectiveness. This increase was not altered when the baffle was made of transparent plastic, sheet aluminum, or galvanized sheet iron (painted or unpainted). Attractiveness of the trap was not altered by painting it green, white, yellow, or red. Extending the funnel 1 inch beyond the outer edge of the baffle did not alter the efficiency of the 15- or 30-watt BL trap.

Placing two 15-watt BL lamps in a trap did not double its effectiveness. Four lamps were required and this was not a practical method of increasing trap efficiency. Under light populations, the 30-watt BL lamp was 4 1/2 times more effective in the vertical position than in the horizontal position. Under heavy populations, its attractiveness in both positions was nearly equal. The 32-watt circline BL lamp was only half as attractive as the 30-watt lamp and only slightly more attractive than the 15-watt lamp.

Sixty-four percent of the extraneous insects caught in the BL traps were eliminated by permitting smaller insects to escape through the 1/16-inch mesh screen bottom and sides of the receptacle. Reducing the funnel opening from 1 1/4 to 3/4 inch excluded about 40 percent of the larger insects. A 6-inch circular disk of 1/2-inch mesh hardware cloth placed horizontally in the funnel reduced the probability of the opening becoming clogged without reducing beetle catches.

Placing BL traps adjacent to the trunks of large trees caught approximately 15 times more beetles than traps in the open within 200 feet of the tree. Traps under the periphery of the outermost branches caught approximately five times more than ones in the open. When the trap was well under the canopy of a tree, its position did not affect the catch. The chances of beetles accidentally falling into an unlit trap under a tree are rather remote, especially in a light infestation.

Beetles were attracted to BL traps from shortly before 9 p.m., e.d.t., to about 6 a.m. From 55 to 86 percent of the total nightly catches were taken before midnight and from 86 to 95 percent before midnight and after 3 a.m.

Beetles generally flew directly into the BL trap with no evidence of circling flights as is true around chemical traps. During periods of heavy flights beetles have been observed resting on nearby objects.

The sexual response of beetles

to BL traps varied more with location than with different seasons, periods of a given season, or time of night. The proportion of females varied from 27 to 66 percent.

In a lightly infested open field, BL traps were no more attractive than the best chemical trap. When placed under a tree in a virtually noninfested field with beetles flying to the tree from various directions and distances, the BL trap under the same tree caught approximately 100 times more beetles than chemical traps nearby.

Approximately one-third of the estimated numbers of beetles congregating in a given tree were captured with 15-watt BL traps. Addition of baffles and larger lamps increased catches. When traps were placed in a lightly infested location, beetles were caught on numerous occasions when none could be seen in flight. The high efficiency of these traps was demonstrated.

The BL traps operated with a battery through a photoswitch-activated inverter at 120 volts and 1,000 c.p.s. were as effective as traps operated with 60-cycle a.c. circuit. A 6-watt battery-operated BL trap caught from one-third to one-half as many beetles as the 15-watt trap. A fully charged 12-volt battery of 72 ampere-hour rating operated the 6-watt lamp from 7 to 11 nights compared with 3 nights for a 15-watt lamp. The 6-watt battery-operated trap showed considerable promise as an efficient and practical tool for conducting European chafer surveys.

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