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# EFFECTS OF GAMMA RADIATION ON THE SURVIVAL PATTERN OF THE CIGARETTE BEETLE, LASIODERMA SERRICORNE (F.) (COLEOPTERA: ANOBIIDAE)[1]

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**The survival of all developmental stages of the cigarette beetle,** Lasioderma serricorne **(F.), exposed to different doses (10 to 100 kr) of gamma radiation was investigated. There was a differential effect on the metamorphic stages and age at any particular stage. Susceptibility of eggs to radiation markedly decreased with age. A dosage of only 10 kr was needed to prevent 1-day old eggs from hatching while 10 kr was required for a similar effect on 4-day old eggs. However, all hatched larvae died without transforming into pupae. First-instar larvae and prepupae were killed before transforming into adult form at all dose levels. The more resistant pupae showed a higher percentage of adult emergence at 70 kr but failed to emerge at 80 and 100 kr. On the other hand, irradiation did not seem to affect the longevity of the adults considerably since at most dosages mortality was comparable with the control group. Using mortality alone as a criterion for measuring the susceptibility of** L. serricorne, **16000 rads which is the recommended dose for control of grain weevils, is ineffective for the control of adult cigarette beetles.**

The cigarette beetle, *Lasioderma serricorne* (F.), is considered the most destructive pest of stored tobacco or tobacco products. It attacks a wide range of commodities mostly of dried plant and animal origin. Howe (1957) enumerated a number of hosts and studied its development on different foodstuffs.

This insect is cosmopolitan although its range is restricted by low temperature and low humidity. It is believed to have been disseminated by trade, especially by shipment of cigars or bales of tobacco. The adults can fly at considerable distances and can live in the field under tropical conditions. In temperate countries, their survival depends upon the warmth of bins, warehouses, and the like. In the Philippines, *L. serricorne* is abundant throughout the year although adults are most frequently found from March to April, the driest and hottest months (Jones 1913).

The injury on tobacco is principally caused by the larvae since there is evidence that the adults do not feed (Runner 1919; Howe 1957). The larvae

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usually bore into the cigars which may extend from one side to the other. Actual loss is not attributed to the amount consumed by the larvae (except when infestation is very high) but to the presence of refuse, dust, and dead insects, which reduces the quality of the product or may render the product unsalable.

During processing and manufacture, tobacco is subjected to high temperature sufficient to kill any insect present in the material. But the problem of keeping tobacco free from reinfestation during storage and shipment is inevitable. Since control of this pest by chemicals and other methods was found to be relatively unsuccessful, the use of ionizing radiation against this insect and other stored-product pests became popular.

Susceptibility of several insects infesting cereals and other commodities to lethal and sterilizing doses of gamma radiation has already been studied by a number of workers. It was shown that there is a differential response of radiation between insect species (Cornwell *et al* 1957) as well as between genera (Park *et al* 1958; Erdman 1962). Differences in response due to sex (Carney 1959; Brown and Tilton 1972; and Rejesus and Lapis 1973), age, and metamorphic stage (Cornwell 1966) have also been demonstrated. As a rule, the amount of radiation sufficient to cause mortality on adults would also kill the other stages. Responses of irradiated adults also differ when post-irradiation temperature is manipulated (Singh and Liles 1927), e.g. mortality of *Rhizopertha dominica* being faster when the temperature is increased. Differences in survival of all the developmental stages and the reproductive potential of adults from irradiated immature stages were also observed (Jefferies 1962). When low dosages of gamma radiation are fractionated, the effect depends on the number of fractions, fractional dose, interval time, and interval temperature. These differences may be attributed to the recovery of the somatic and reproductive cells. However, these manifestations are not achieved at the commercial dose level (16,000 rads.).

This experiment was carried out to study the effects of gamma radiation on the survival of the cigarette beetle, *Lasioderma serricorne* and to evaluate the dose level that could be recommended for control in bulk irradiation.

## MATERIALS AND METHODS

*Life history studies.* Adult cigarette beetles were mass reared in the laboratory on ground corn and yeast with 18:1 ratio by weight. Emerging adults were then allowed to oviposit in pre-sieved flour. Eggs were collected by sieving the medium. They were then incubated and first instar larvae were placed individually in vials with adequate food. They were kept at room temperature averaging 77°F and 67% R.H. and were observed daily.

*Irradiation studies.* Immature stages of the laboratory strain of the cigarette beetle to be irradiated were obtained by incubating batches of eggs at room temperature in vials containing milled yellow corn plus yeast. At the time of

irradiation the larvae, pre-pupae, and pupae were first instar, 1 day old and 2 days old, respectively, while adults were 1 to 2 days old after emergence from the cell.

Two age groups (0 to 1-day old and 4-day old) of the eggs were irradiated in 50 dram vials at doses of 10, 15, 20, 25, 30, 40, 50, 60, 70, 80 and 100 kr from a Co-60 source (Gamma-Cell 220 built by the Atomic Energy of Canada Ltd.), with an original strength of 7770 Ci. The unirradiated groups served as control.

*Post-irradiation technique.* The adults were transferred to vials with sufficient food immediately after irradiation. The irradiated larvae were transferred to fresh food immediately after constructing the pupal cells. Observations were made at a 3-day interval for the irradiated adults. Mortality of the larvae, prepupae, and pupae was assessed by counting the emerging adults. Counts on the number of adults emerging from the irradiated immature stages were started three days after adults began to appear. The emerging adults were then transferred weekly to fresh food. The same handling procedure was done on irradiated adults.

## RESULTS AND DISCUSSION

The total developmental period (from hatching to adult emergence) of the cigarette beetle reared in a mixture of ground corn and yeast ranges from 18 to 32 days with an average of 24.5 days. There were 4 larval instars observed but Jones (1913) reported that there may be from 4 to 6 instars. This may be attributed to the difference in rearing medium used as well as on the temperature and humidity during the experiment. Ruangopas (1966) found that the cigarette beetle completes its life history faster in coarse medium than in fine powder-like medium.

When the larva is full grown and ready to pupate, it constructs a cell or cocoon where transformation takes place. The pupal cell is ovoid, measuring about 4 mm long and 3 mm wide. It is made of small food particles and refuse cemented together by a secretion of the larva. On other ocassions the cells are formed along the midrib or in the folds of the tobacco leaf, on the sides of cigar boxes, and also between closely packed cigars or cigarettes. After transformation to the adult the insect lies inactive within the pupal cell and emerges in about 4 days.

There was 33% mortality at the larval stage usually during the first instar. The larva died of starvation if unable to penetrate the medium. Disturbance of the last larval instar also delayed construction of the pupal cell and in some cases the larva never succeeded in constructing the cell and eventually died. Additional information on the life history of the cigarette beetle is presented in Table 1.

TABLE 1. **Development of** L. serricorne **on corn + yeast medium at room temperature.**

| | Range (days) | Average (days) |
|---|---|---|
| 1. Incubation Period | 5-8 | 6.15 |
| 2. 1st Instar Larvae | 3-6 | 3.50 |
| 3. 2nd Instar Larvae | 3-7 | 4.35 |
| 4. 3rd Instar Larvae | 5-9 | 7.06 |
| 5. 4th Instar Larvae | 2-6 | 3.00 |
| 6. Pre-pupa | 2-4 | 2.79 |
| 7. Pupal Period | 3-5 | 3.83 |
| 8. Adult's escape from pupal cell | 3-6 | 3.96 |
| 9. Total developmental period (from egg to adult) | 23-45 | 30.68 |
| 10. Adult longevity (from time of escape from pupal cell) | 5-26 | 18.11 |
| 11. Sex Ratio | | Males — 48<br>Females — 52 |

TABLE 2. **Cumulative hatches (per cent) of eggs irradiated when 4-day old.**

| Dose | Days After Irradiation | | | | |
|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 |
| 0 | 71 | 87 | 96 | 99 | 99 |
| 10 | 18 | 38 | 45 | 48 | 50 |
| 15 | 4 | 28 | 34 | 38 | 40 |
| 20 | 7 | 16 | 24 | 28 | 28 |
| 25 | — | 15 | 25 | 30 | 30 |
| 30 | — | 2 | 10 | 15 | 17 |
| 40 | — | — | 4 | 4 | 5 |
| 50 | — | — | — | — | 0 |

*Mortality.* Zero to one-day-old eggs were completely prevented from hatching in all dosages used while 96% in the control hatched. This suggests that mortality of the insect occurred during the development of the embryo which was attributed to "lack of organizational rather than lack of differentation of tissues" (Areekul 1966). However, eggs exposed 4 days after oviposition showed resistance to gamma radiation at doses up to 40 kr where there was 5% larval production, although hatching was delayed for 3 days (Table II) All of the larvae died before pupation. This response would thus indicate that mortality due to irradiation occurred both before and after hatching.

About 94% of the first instar larvae held as control emerged as adults. There was 100% mortality in the treated larvae at all dosage levels since none reached the adult stage. Irradiated prepupae were also completely controlled by gamma radiation while 95% in the control emerged into adults. Construction of the pupal cell was delayed and dissection of the cell revealed some de-

formation in the insect's structure. Some pupae were unable to transform fully into adults; their wings were short and not fully developed.

The more resistant pupae showed a higher percentage of emergence as 56% of the insects emerged into adults even at 40 kr (Table III). At higher doses emergence was delayed and reduction in adult emergence was high reaching 100% at 80 and 100 kr (Fig. 1). The response of the surviving adults from the irradiated pupae was comparable with the control as the survivors lived as long as the control.

All irradiated adults died 30 days after irradiation while control adults lived up to 20 days after emergence (Table IV). Irradiation did not significantly affect the longevity of the adults. This information is very evident at most dosages where mortality was comparable with the control. Similiar observations were encountered by Tilton, *et al* (1966). Pendlebury, *et al.* (1966) reported that the inefficiency of radiation on the life span of the moths may be attributed to their short life expectancy and that they die from normal causes before the manifestations of radiation dosage become evident. On the other hand, 100% mortality of the adults was achieved 15 days after exposure to 100 kr.

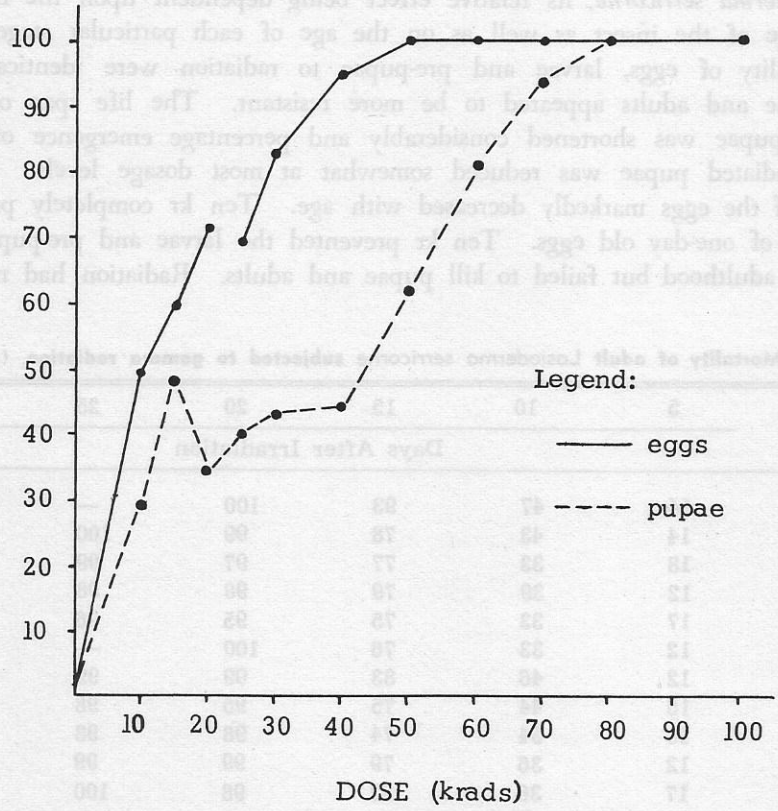


**Fig. 1. Percent reduction in hatchability and emergence of 4-day old eggs and pupae, respectively.**

TABLE 3. **Pupal emergence and mortality of adults from gamma-irradiated pupae of** L. serricorne.

| Dose (kr) | % Emergence | % Mortality Days After Emergence | | |
|---|---|---|---|---|
| | | 7 | 14 | 21 |
| 0 | 100 | 25.00 | 36.00 | 99.00 |
| 10 | 61 | 26.23 | 27.87 | 96.72 |
| 15 | 52 | 25.00 | 44.23 | 100.00 |
| 20 | 66 | 33.33 | 46.97 | 100.00 |
| 25 | 60 | 28.33 | 36.67 | 100.00 |
| 30 | 57 | 26.32 | 64.91 | 100.00 |
| 40 | 56 | 26.79 | 58.93 | 100.00 |
| 50 | 38 | 15.79 | 39.47 | 100.00 |
| 60 | 19 | 52.63 | 57.89 | 100.00 |
| 70 | 6 | 16.67 | 33.33 | 100.00 |
| 80 | 0 | — | — | — |

Based on the data obtained, several conclusions may be derived. Gamma radiation reduces the percentage of adult emergence and shortens the survival of *Lasioderma serricorne*, its relative effect being dependent upon the metamorphic stage of the insect as well as on the age of each particular stage. The susceptibility of eggs, larvae and pre-pupae to radiation were identical while the pupae and adults appeared to be more resistant. The life span of larvae and pre-pupae was shortened considerably and percentage emergence of adults from irradiated pupae was reduced somewhat at most dosage levels. Susceptibility of the eggs markedly decreased with age. Ten kr completely prevented hatching of one-day old eggs. Ten kr prevented the larvae and pre-pupae from reaching adulthood but failed to kill pupae and adults. Radiation had no effect

TABLE 4.**Mortality of adult** Lasioderma serricorne **subjected to gamma radiation (percent).**

| Dose (kr) | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|
| | Days After Irradiation | | | | | |
| 0 | 14 | 47 | 93 | 100 | — | — |
| 10 | 14 | 43 | 78 | 99 | 100 | — |
| 15 | 18 | 33 | 77 | 97 | 99 | 100 |
| 20 | 12 | 39 | 79 | 98 | 98 | 100 |
| 25 | 17 | 33 | 75 | 95 | 96 | 100 |
| 30 | 12 | 33 | 76 | 100 | — | — |
| 40 | 12 | 46 | 83 | 99 | 99 | 100 |
| 50 | 15 | 44 | 75 | 95 | 98 | 100 |
| 60 | 10 | 34 | 74 | 98 | 98 | 100 |
| 70 | 12 | 36 | 79 | 99 | 99 | 100 |
| 80 | 17 | 36 | 82 | 98 | 100 | — |
| 100 | 22 | 42 | 100 | — | — | — |

on the survival of adults compared with that of immature stages. Irradiated adults lived as long as the control except those at the highest dose (100 kr) where 100% died 15 days after irradiation. The same survival pattern was exhibited by adults emerging from the treated pupae.

The present work was unable to determine the survival rate of each of the immature stages since the emergence of adults was used as the criterion for measuring their susceptibility. Using mortality alone as an index, a dose of 16,000 rads (the dose evaluated for control of grain weevils) seems to be ineffective for the control of adult *L. serricorne*. Further studies on the reproductive potential and differential susceptibility of the sexes at 16,000 rads might establish the desirable dose level for control.

## SUMMARY

1. The cigarette beetle, *L. serricorne*, when reared in a mixture of ground corn and yeast undergo 4 larval instars and completes its development (hatching to adult escape from the pupal cell) in an average of 24.5 days.

2. One-day-old eggs were completely killed by irradiation at all dosages. Doses up to 40 kr did not inhibit larval production in 4-day-old eggs but prevented the larvae from transforming into pupae.

4. Irradiated first-instar larvae and pre-pupae were also totally controlled by gamma radiation. Although immediate kill was not attained, the pupae failed to emerge into adults.

4. About 56% of the irradiated pupae transformed into adults even at 40 kr. Higher doses reduced and delayed adult emergence, with 100% mortality attained at 80 and 100 kr. All adults irradiated at 100 kr died 15 after irradiation. All other dosages seem to have no considerable effect on the adults.

5. The results of the study do not give a firm basis for recommending 16 kr for *L. serricorne* control.

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