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COMBINED EFFECT OF STARVATION AND RADIATION ON FEEDING ACTIVITY OF RED FLOUR BEETLE, TRIBOLIUM CASTANEUM HBST., (COL., TENEBRIONIDAE)

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Abstract. Starved and unstarved red flour beetles were irradiated with doses of gamma radiation ranging from 10 to 100 krad and their feeding activity studied in flour labelled with P^{32}. Feeding activity decreased immediately following irradiation. This decrease was not dose-dependant, but the subsequent rate of recovery was dose-dependant. In control beetles, increasing the starvation period proportionally increased their subsequent feeding activity. Starvation before irradiation increased feeding activity, but to a lesser extent than starvation after irradiation.

There is sufficient data now available on the sterlizing effects of radiation on insects and its use in pest control programmes. However, many of the undesirable side effects also produced by this treatment become important when insects sterilized in this way are required to compete equally for mates in a natural infesting population. Anorexia and lethargy for example are known to be induced by high doses of radiation[1] and in *Drosophila melanogaster* when a dose of 60 krad was given to adults the average food uptake was reduced.[2] A similar reduction in food uptake by radiation treatment has been reported in *Periplanata americana*,[3] *Tribolium castaneum*[4] and in *Ornithodoros tholozani*.[5] Feeding behaviour in insects has been conceived of a complex sequence of responses to a number of stimuli and this sequence is controlled by the physical conditions of the insect and environment. The present studies were undertaken to investigate the effect of pre and postirradiation starvation on the feeding activity of *T. Castaneum*.

Materials and Methods

The culture of *T. castaneum* Hbst. was maintained on whole wheat flour mixed with 5% yeast (w/w) at controlled temperature and humidity of $29 \pm 1°C$, $55 \pm 5\%$ R.H. un der favourable conditions of low crowding and fresh medium. The insects were irradiated in glass vials at room temperature at a dose rate of 3.87×10^5 rad/hr of gamma radiation from Co^{60}. Doses of 10, 25, 50 or 100 krads were given.

Feeding tests were carried out by confining ten insects from each treatment with 1 g p^{32}-labelled flour in 50×25 mm glass vials. The labelling was carried out by thoroughly mixing a suitably diluted P^{32} sodium orthophosphate solution with 60-mesh sieved flour in the proportion of 2 ml/g flour. The resulting paste was freeze-dried for 24 hr, sieved before use and had an initial activity of 25MCi/g. At various time intervals the beetles were removed from the radioactive flour, cleaned of externally adhered flour and counted for radioactivity, by confining the beetles in a small gelatin capsule with a ball bearing and sinking this in scintillation fluid. The beetles were separated from the weight with a small wad of cotton wool. This method gives improved efficiencies over Geiger-Muller detection for low levels of activity. The counts, corrected for decay, were compared as an indication of the feeding rates. Absolute feeding rates could not be determined as a proportion of the ingested P^{32} is lost from the insect in the frass which it was impracticable to recover.

One batch of irradiated beetles was placed on radioactive flour immediately after irradiation and the amount of P^{32} absorbed after 1, 2, 4 and 8 days determined. The second batch was starved for 1 and 2 days after irradiation, and then given radioactive flour for 24 hr after which the insects were counted for radioactivity. In another test, the insects were starved for 1, 2, 4, or 8 days prior to the radiation treatment. The starved irradiated and starved non-irradiated beetles were allowed to feed on labelled flour for 24 hr and ingestion was measured.

Results

Effect of Radiation on Feeding Activity. The rate of feeding immediately following irradiation fell to a minimum level Fig. 1 compared with control insects and this effect was similar at all doses of radiation (cf. Fig. 1). Although the feeding rate decreased with increased dose, the differences were not significant. From this it could be inferred that radiation treatment caused a temporary paralysis of feeding activity which was independent of radiation dose over the range of 10—100 krad. This effect of radiation was not permanent, for the insects recovered after sometime and resumed feeding. The speed of recovery was dependent upon the radiation dose, for beetles irradiated with lower doses recovered earlier than those given higher doses of radiation. At doses up to 50 krad the effect was limited for 24 hr or less, whereas at 100 krad the effect lasted for 2 days.

Pre-irradiation Starvation. In beetles which were not irradiated the feeding activity in the 24 hr. following strarvation increased, reaching a maximum at about 8 days (Fig. 2).

The feeding response of beetles irradiated after starvation differ from that of the normal beetles, and varied with radiation dose and length of starvation. At all doses, the irradiated starved beetles consumed less food than the corresponding untreated but starved insects. The starved irradiated insects consumed more food than unstarved irradiated insects. At doses of 10 krad a proportional increase in feeding activity occurred with an increase in starvation, suggesting that the starved beetles may overcome the

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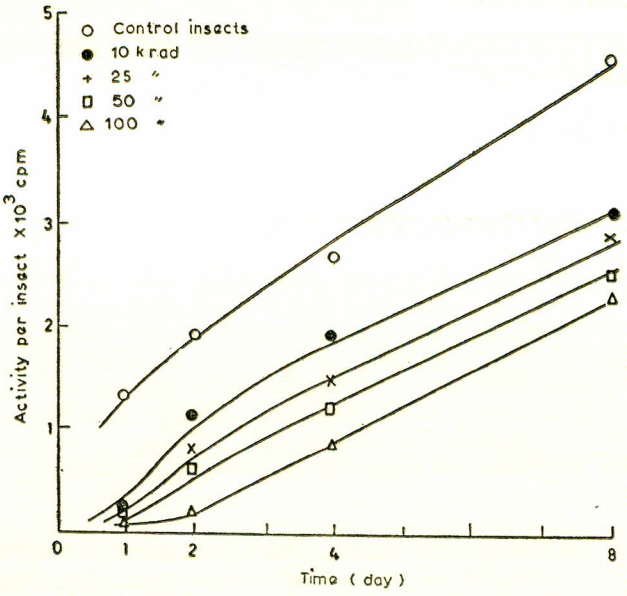

Fig. 1. The effect of four doses of radiation on feeding by *T. castaneum* up to 8 days after irradiation.

radiation syndrome and resume feeding activity.

At higher doses, a similar proportional increase in feeding activity did not occur with an increase in starvation period. At 25 krad day starvation had a very slight effect on feeding activity, whereas 2-day or more increased the feeding activity. At 50 and 100 krad 2-day and 4-day starvation are required to initiate the feeding activity respectively.

Post-irradiation Starvation. The postirradiation starved insects consumed more food than the preirradiation straved beetles. In post-irradiation starvation studies (Fig. 3), the effect of radiation was not so apparent for 1-day of starvation, whereas for 2-day starvation, the effect was dose-dependent. At higher doses the insects consumed less food. At 10 krad the 2-day post-irradiation starvation compeletely masked the effect of radiation and these insects consumed the same amount of food as the control insects starved for 2 days. At higher doses the insects consumed less food than the control insects, though they ate more than the pre-irradiation starved beetles.

Discussion

The mechanism of hunger, food intake and regulation of the quantity of food ingested are not fully understood in insects and it is not certain whether the inhibitory effect of radiation on feeding activity of *Tribolium* is caused by ininhibition in the central nervous system, the neurosecretory system or the sensory system. All these systems play a part in quantity of food ingested. At higher doses, the insects are mumbed and become inactive, a state with which is associated with an inhibition or decline in feeding rates. However, at lower doses the insects remain active and mobile though the feeding is inhibited. It seems probable that radiation treatment may have decreased the general metabolic activity of the beetles. If the metabolic activity is reduced, the insects will require less energy and this will lead to reduced feeding activity.

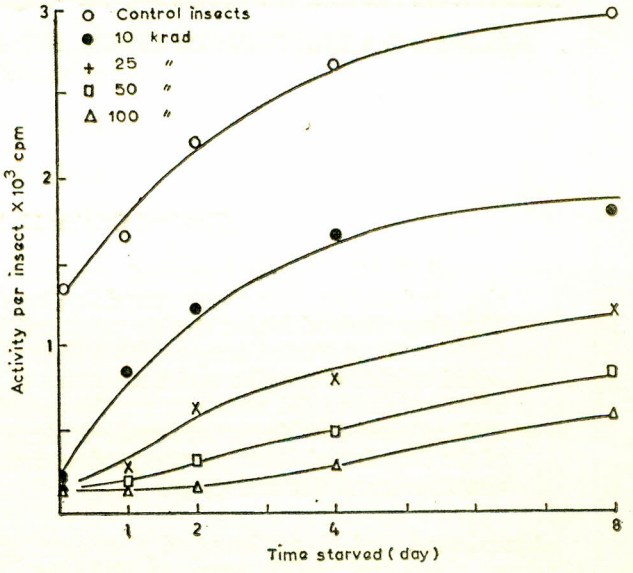

Fig. 2. The effect of different periods of starvation on the feeding activity of *T. castaneum* after irradiation.

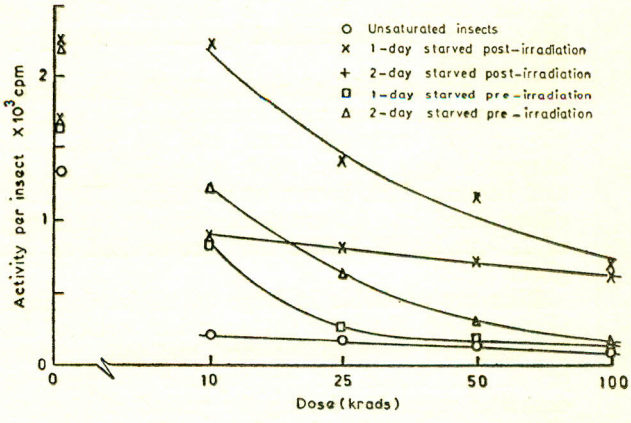

Fig. 3. The feeding activity of *T. castaneum* starved for 1 and 2 days before or after irradiation.

The starvation studies suggested that between doses of 10 and 100 krad, starvation can partially overcome the radiation syndrome inhibiting feeding activity but that more starvation is required for higher doses of radiation. Strictly, the results of pre and post-irradiation starvation are not comparable. In postirradiation starvation, the insects recover from the radiation effects during the starvation period and this treatment becomes more pronounced than the irradiation, whereas in preirradiation starvation, the effect of radiation is more pronounced than that of starvation.

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