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Original Research Article

A Method of Controlling Pest Population Using Radiation Techniques

Anil Kumar Khare[1] and Archana Khare[2]*

[1]Dr. RadhaBai Govt. Naveen Girls College, Raipur - 492 001, India
[2]College of Dairy Science and Food Technology (CGKV), Raipur - 492 012, India

**Corresponding author*.

A b s t r a c t

The present research relates to a method of controlling a population of pests by way of using radiation techniques. The method comprises collecting a predetermined quantity of pests and treating the said pests with a plurality of radiations at predetermined doses and time to induce sterility. The pests include plurality of species of coleopteran beetles which further include *Raphidopalpa faveicollis, Alphitobius diaperinus* and *Hoplocerambyx spinicornis.* The radiations include UV radiation, X-ray radiation and Cobalt-60 radiation. The radiations induce sterility in said pests by hampering reproductive cells which hinder their growth. The radiation used for hampering the reproductive capabilities. The radiation induces mutation in the germ cells of the pest causes sterility. The radiation gives results in cellular level in chromosomes during spermatogenesis, by lengthening of nuclear division cycle and ultimately, inhibits the mitosis. Moreover, further doses (higher doses) of irradiation leads to stickiness and further clumping of Metaphase and Anaphase stages of cell division cycle and stop its completion. Hence, this method avoids the use of insecticide spray and environmental pollution and avoids a negative effect on the useful insects and other organisms.

K e y w o r d s

Alphitobius diaperinus
Co-60 radiation
Hoplocerambyx spinicornis
Raphidopalpa foveicollis
UV radiation
X-ray radiation

Introduction

The insects have drawn the attention of many entomologists due to their economic importance. These were known to the humans as they cause diseases and also damaged food, fruits and vegetables and control of insects can be accomplished in many ways. The Coleoptera is the largest order in not only the Arthropoda but in the entire animal kingdom consisting about 330000 species. They are adapted to various modes of life, *viz.* terrestrial, aquatic, arial, fossorial, subterranean, cavernicolous, etc. and are mostly concealed in habit. The value of entomology is based upon insect controls which have been developed by entomologists. However, the study of insects is also of great value in increasing our fundamental basic knowledge of general biology and in aiding the understanding of the natural laws governing the development and abundance of plants and animals.

The effects of radiation on male germ cells in insects have been studied by Knipling (1955) in some insects and suggested control measures for mosquito, tse-tse fly, ball worms, weevils cane and corn borers and destructive moths Clark et al. (1957) worked on mature sperm of *Habrobracon*. Muller (1927), Altenburg (1930), Bishap (1942), Spalding et al. (1957), and Catcheside (1948) have studied the effects of radiations on male germ cells of Drosophila. Cork (1957) worked on flour beetle, Mercier (1979) worked on colarad beetles, Rahim and Norimah (1990) worked on stored pulse beetle, Saha and Shahjahan (1998) has studied the effects of neem and radiation on hide beetle. Abdel (1999) has studied the effect of gamma radiation on larval stages of the Khapra beetle. Boshra (1994) has studied the effect of gamma radiation on reproduction mating competitiveness and sperm activity of pulse beetle, *Callosobruchus chinensis*, Roley et al. (1974) have studied the effects of ionising radiation on human testis.

The present research work includes the study of the structure of male germ cells and the effects of irradiation on three species of coleopteran beetles *viz.*, *Raphidopalpa foveicollis*, *Alphitobius diaperinus* and *Hoplocerambyx spinicornis*. The objective of this study is to develop an alternative strategy for controlling the injurious insects-pest through the radiation technology. The method involves rearing male population of Coleopteran beetles under study, *viz.*, Sal heart-wood borer (*Hoplocerambyx spinicornis)* is a Sal-borer destroying Sal (*Shorea robusta*) forests, lesser meal-worm (*Alphitobius diaperinus)* is a poultry pest causing disease in Chicks. Red pumpkin beetles (*Raphidopalpa foveicollis*) destroy leaves and flowers of Cucurbit plants. These insects exposed to various doses of radiations i.e., UV-rays, X-ray and gamma rays from Co-60.

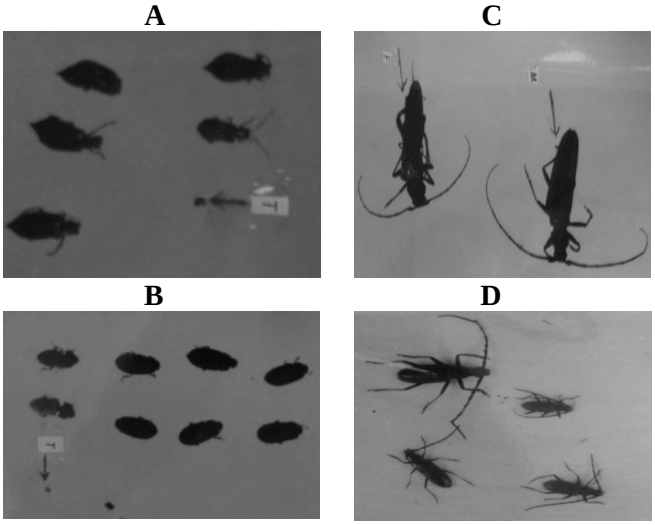
Materials and methods

Collection of insects

The specimens of coleopteran beetles were collected in different season and various localities of Raipur district of Chhattisgarh state and Madhya Pradesh. The study is limited only to males from natural population. The red pumpkin beetles (*Raphidopalpa foveicollis)* were collected from the grass fields, herbs, shrubs and agricultural crop such as cucurbit ground etc. in the agricultural fields of Indira Gandhi KrishiVishwavidyalaya Raipur (C.G.) during the August to December.

The lesser meal-worm (*Alphitobius diaparinus*) coleopteran beetles are abundant where dirt floors are used in poultry houses. These beetles were collected from the local poultries all around the Raipur District, throughout the year. Third and last one beetle i.e. (Sal heart wood borer) *Hoplocerambyx spinicornis* is heavily infested the Sal tree (*Shorea robusta*). It is a major insect pest of forestry feeds on xylem sap. These beetles were collected from Amarkantak, Mandla, Dindori Districts of Madhya Pradesh and Gariabandh, Deobhog, Bustar and Kavardha Districts of Chhattisgarh state, during the last week of May to July (rainy season). The morphology of the insects are given in Fig. 1.

Fig. 1: Morphology of (A) *Raphidopalpa faveicollis,* (B) *Alphitobius diaperinus* and (C & D) *Hoplocerambyx spinicornis* species.



Insects were dissected under the binocular microscope and testis of males were taken out and put in the normal saline solution (0.6%) which is hypotonic saline solution for about 15 to 20 min. for isolating the various germ cells, so that they become discriminate and isolate from one another. Later on these testes were fixed either in acetic alcohol (2:5) or in the aqueous bouins fluid for a day at least. Three types of preparation were taken into accounts *viz*., squash, smear and microtomical sectioning.

The testes were dissected out under the entomological microscope carefully with the help of fine needles and fine scalpels. The squash preparations were made in

acetocarmine stains or orcinocarmine or half carmine stain and half acetocarmine stain. It has been found during various experiments that the half acetocarmine and half orcinocarmine stain is more suitable for discriminating the various stages of germ cells. Smear preparation of testis were made by dissecting them and taken out with the help of fine forceps and needles, in the living condition of the insects. After that these testis were transferred on a very clean plain slide. The smears were prepared by teasing the testicular fibrous sheath under the binocular microscope.

The contents of the testicular lumen were allowed to flow and a uniform film was made, then fixed in acetic alcohol (2:5) immediately before they dried up to avoid postmortem changes. Later on the material was dehydrated and stained with the haemotoxyline and then dehydrated by passing through various grades of alcohol, cleared by xylol and mounted. For the purpose of the study the effects of irradiation on various male germ cells in these coleopteran beetles, we have selected three types of radiation with two different dose i.e. Low dose and high dose. Beetles were exposed with the different duration and dose of exposure to Ultra-violet, X-ray and Co-60 irradiation, and the effects were noted within the germ cells. Irradiation doses selected as follows,

Ultra-violet radiation exposed-

- Low dose - G-15T8/15W for 20 min.
- High dose - G-15T8/15W for 30 min.

X-ray radiation exposed-

- Low dose - 60 kv –128 MAs (At 160 station.)(100 Cms. Distance between tube and object)
- High dose - 65 kv –128 MAS-0.8 sec 1 rad (at 160 station) (100 cms. Distance between tube and object)
- Co-60 radiation exposed- 3 rads and 5 rads.

Results and discussion

The effects on radiation exposed male germ cells were observed and compared with normal controls. On exposure to radiation, beetles become hyperactive, their mobility increases. Even high dose of radiation is not lethal for these beetles. On exposure to low dose of Ultra-violet radiation exposure all these three beetles do not show any remarkable effects on the testes and on germ cells.

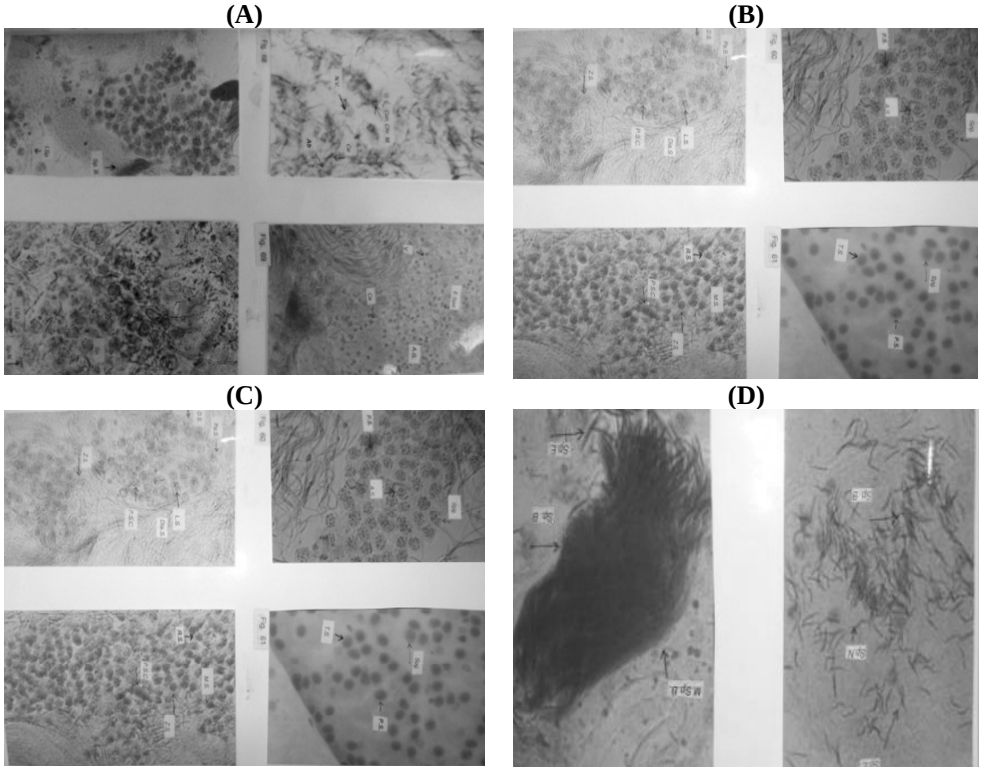
With high dose of Ultra-violet radiation exposure the secondary spermatocytes and sperms show changes in red pumpkin beetle and lesser mealworm. In red pumpkin beetle, secondary Spermatocytes become shrunken. Spermatids change their shape and size, become shorter. In lesser mealworm the secondary Spermatocytes, cell wall distorted. Spermatids condensed their nuclear material. In Sal heart woodborer no remarkable effect is found in any of the germ cells of the testes. With low dose of X-ray radiation, minor changes are observed in the secondary spermatocytes, spermatids and sperms of red pumpkin beetles. The secondary spermatocytes and spermatids shrink, change their shape and sperms reduces their vacuoles. In lesser mealworm the primary spermatocytes, secondary spermatocytes and sperms shrink and become indistinct. In Sal heartwood borer no remarkable change is seen.

With high dose of X-ray radiation exposure in red pumpkin beetles the spermatogonia chromatin material. Become condensed, and cells become shrunken, cell boundaries are obliterated and distorted. Secondary spermatocytes become necrotic. Spermatids become reduced in size and the chromatin of nucleus becomes condensed at the inner margin of the nuclear membrane. Vacuoles fuse to become reduced sperms and acrosome appears as a granule near the membrane. In lesser mealworm high dose of X-ray radiation exposure affects the germinal epithelium of the testis as it become shrunken. The spermatogonia changes in shape and size becoming indistinct. Chromosomes become abnormal in shape. Secondary Spermatocytes become necrotic and their cytoplasm and nuclear material is difficult to identify. Spermatids show distortion effect. In the Sperms, acrosome appears as granule near the membrane.

With high dose of X-ray radiation in Sal heart woodborer follicles showed damage. In the spermatogonia chromatin material, become condensed and indistinct. In primary spermaocytes, nuclei shrink. In spermatids the size of the vacuole reduces, the cell boundaries are shrunken and they are not properly arranged. Low dose of Co-60 radiation exposure to red pumpkin beetles affects the germinal epithelium of the testis. In spermatogonia, primary spermatocytes, secondary spermatocytes, become deeply stained and vacuole reduced. In lesser mealworm the follicles become smaller. The chromosomes of spermatogonia become deeply stained due to the condensation of nuclear

material. Primary spermatocytes showed shrunken effect. Secondary spermatocytes and spermatids exhibit distortion. In Sal heart woodborer, the testis does not show any remarkable change. Secondary spermatocytes and spermatids showed distortion. Flagellum of spermatids is very short and acrosome becomes indistinct. The effects of radiations on male germ cells of some coleopteran beetles are given in Fig. 2.

Fig. 2: Effects of radiations on male germ cells of some coleopteran beetles: (A) *Raphidopalpa foveicollis,* (B) *Alphitobius diaperinus,* (C) *Hoplocerambyx spinicornis* and (D) *Raphidopalpa faveicollis*



On exposure to high dose of Co-60 radiation in the red pumpkin beetles the germinal epithelium of testis shrinks. Follicles are shrunken and damaged. The cell boundaries of spermatogonia become obliterated and distorted. Primary and secondary spermatocytes become necrotic. Acrosome of spermatids becomes indistinct and flagellum becomes very short. The nucleus is not seen distinctly and does not take stain properly. The sperm becomes distorted, indistinct, vacuoles disappear, acrosome not clearly seen, showing the stickiness and clumping of chromosomes.

In lesser mealworm the germinal epithelium of the testis becomes shrunken. The chromosomes of spermatogonia become abnormal in shape and the chromatin material is condensed, due to the shrunken effect. Primary and secondary spermatocytes are not clearly seen. In Sal heart woodborer, Follicles showed damage as they shrink and become smaller. The cell boundaries of spermatogonia become distorted. Secondary spermatocytes showed necrotic effects. In spermatid the nucleus become indistinct and cell become distorted. Most of the spermatids disappear. Number of sperms was reduced. The sperms fail to form sperm bundles and show disturbed physiological state of spermatogenesis and indicate infertility. It is thus inferred that the affected germ cells by high dose of Co-60 radiation exposure treatment cause interruption of spermatogenesis. This seems significant because discontinuity of spermatogenesis will be the result when all or most of the spermatogonia are damaged and this will lead to permanent sterility. To conclude, the study reveals that Co-60 radiation has a severe effect on the male germ cells in all these three beetles. However, X-ray and Ultraviolet radiation exposure results in interference of spermatogenesis and damage of spermatogonia and sperms.

Conclusion

The application of radiation technology can be helpful to the population of such destructive insect's pests.

Effects of radiation on male germ cells of these coleopteran beetles will help in controlling these insect pests. If other methods of control such as pesticide spray etc. are employed there is a danger of environmental poisoning affecting non-target useful organisms. Hence, the present work is of great agricultural importance.

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