CHAPTER IV

OBSERVATIONS
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The present study includes the study of the morphology of beetles, structure of male germ cells and the effects of irradiation on three species of coleopteran beetles. Viz. *Raphidopalpa foveicollis* (Red pumpkin beetle), *Alphitobius diaperinus* (Lesser mealworm) and *Hoplocerambyx spinicornis* (sal heart-wood borer).

The specimens of coleopteran beetles were collected in different seasons and from various localities of Raipur, Baster, Kavardha districts of Chhattisgarh state and Mandla (Dindori), Shahdol (Amarkantak) districts of Madhya Pradesh state (Fig.5 to 20).

HABITAT

*Raphidopalpa foveicollis* (Red pumpkin beetle) is found inhabiting cucurbit plant (coleoptera), chrysomelidae. Damage to these plants is caused by both grubs and adults of this beetle. Adult beetles feed on the leaves, flowers, flower buds and fruits of cucurbits causing severe damage. It is found feeding on gourd, cucumber and various cucurbits. It causes severe injury specially to young plants. The damage done to young seedling is so severe that the crop has to be re-sown because all the leaves of the young plants are eaten up. The beetles eat and make holes into the leaves. The grub bores into the root and stem of the plant destroying the whole plant, when present in large numbers. The attacked plants wither and die.
They also attack the fruits which become unmarketable. Damage is severe since the beetles are difficult to control (Fig. 16).

*Alphitobius diaperinus* (coleoptera, tenebrionidae) commonly called lesser meal worm lives in the soil and is abundant where floors are used in poultry houses. These beetles were collected from the local poultries all around Raipur district. It is abundant in the dirt floors of poultry houses. These beetles serve as reservoirs of Mark’s disease, virus, Salmonella species, Pasteurella species and other infective agents which are causative or carriers of the disease (Fig. 17).

*Hoplocerambyx spinicornis* (sal heart-wood borer) coleopteran (cereambycidae) is a well known stem borer, infesting the sal trees of forest areas of Madhya Pradesh and Chhattisgarh state. They cause great damage to the forest by boring the stem bark of sal trees. To get rid of this borer, both the State’s have taken extensive drastic measures like deforestation of the infected sal trees and also employing labourers to catch and destroy (manual eradication) the population of these insects. It is a major insect pest of forestry feeding on Xylem sap. This borer has a long recorded history of periodic epidemics from all over the sal growing areas (Fig.19, 20).

**MORPHOLOGY OF THE BEETLES**

The adult *Raphidopalpa foveicollis* (red pumpkin beetle) measures about 7 mm in length and 4 mm in width. The upper surface of the body is bright orange red, while lower surface of the abdomen is entirely black and covered with short whitish soft hairs. The posterior portion of the head is
covered with prothorax. Male beetle is comparatively smaller in size than female individuals and can be easily identified (Fig.21).

*Alphitobius diaperinus* (Lesser mealworm beetle) is small black in colour and rounded on anterior margin. Prothorax wider than long, legs rather short, length 4-5 mm, possesses chewing mouth parts and two pairs of wings. Males are smaller in size than females (Fig.23).

*Hoplocerambyx spinicornis* (sal heart-wood borer) is a dark brown coleopteran beetle which varies greatly in size, length 18.5 to 65.0 mm, width in anterior part of elytra 5-20 mm. The antennae are long 20-33 mm and show clear distinct sexual dimorphism in males and females, long antennae are present in males and comparatively short antennae are present in female individuals (Fig.25,26).

MALE REPRODUCTIVE SYSTEM

In *Raphidopalpa foveicollis* (red pumpkin beetle), the male reproductive organs are found toward the tip of the abdomen. The opening from the reproductive organs is near the posterior end of the body and surrounded by external genitalia, there are claspers, used to hold the female during mating, and the penis. The accumulated sperms are held in the body of the male in dilatations of the vasa differentia known as seminal vesicles. Single testis is dorsally placed at the right side of the fifth abdominal segment. It is externally covered with the fat body and posteriorly it opens into the vasa differentia. The two seminal ducts fuse into a single ejaculatory duct. Accessory glands secrete the fluid with which the sperms are mixed. The follicle is connected with the vas deferens by a relatively well developed
slender tube or vas efferens. The vasa differentia are the paired canals leading from the testes and are mesodermal in origin (Fig.29).

In *Alphitobius diaperinus* (Lesser mealworm beetle), the male reproductive system comprises of a pair of testes, a pair of accessory gland, vasa differentia, single ejaculatory duct and sperm sac. Testes are located at the latero dorsal side of abdomen. They are fixed in groove like structure within the abdomen. The accumulated sperms are held in the body of the male in dilatations of the vasa deferentia, known as seminal vesicles. The two seminal ducts fuse into a single ejaculatory duct (Fig.30).

In *Hoplocerambyx spinicornis* (sal heart-wood borer) the male reproductive system consists a pair of testes on the latero ventral side of the alimentary canal. Testes are oval in shape and muddy in colour, posteriorly, they open in the vasa differentia. The seminal vesicle fuse into a ejaculatory duct, which opens into sperm sac (Fig.31).

**MORPHOLOGY OF TESTIS**

*Raphidopalpa foveicollis* (red pumpkin beetle) possesses a single testis. It is dorsally placed at the right side of the fifth abdominal segment. The testis is round and orange coloured surrounded by a thick fibrous tissue with few nuclei in it. Posteriorly it opens into the vasa differentia. It is externally covered with the fat body (Fig.22, 29).

*Alphitobius diaperinus* (Lesser mealworm beetle) has a pair of testes, cotton like in appearance, dirty white in colour, located at the latero-dorsal side of abdomen. They are fixed in groove like structure within the abdomen (Fig.27, 28, 30).
*Hoplocerambyx spinicornis* (sal heart-wood borer) the paired testes are located on the latero ventral side of the alimentary canal. The testes are oval in shape and muddy white in colour posteriorly, they open in the vasa differentia. They are interiorly broad and posteriorly pointed structures (Fig.31, 32).

**HISTOLOGY OF TESTIS**

Histologically the testis of *Raphidopalpa foveicollis* is covered by a fibrous sheath, inside which are a large number of follicles separated by partitions. Within these follicles stages of spermatogenesis are seen viz. spermatogonia, primary and secondary spermatocytes, spermatids and sperm bundles. The follicles contain many cysts each of which consists of a clone of germinal cells. These cysts are arranged in order of increasing maturity from the periphery to the centre of the testis. The primordial germ cells, spermatogonia and spermatocytes are observed at the periphery. The central lumen is filled with the mature sperms. Spermatogonia are large and seen rarely several of these actively dividing cells are seen in testicular lumen primary and secondary spermatocytes are abundant. Developing spermatocytes generally occupy central part of the cavity. They are round in shape having deeply stained acrosomal granule. The sperms are seen in bundles with deeply stained nucleus (Fig.33).

Histology of testis of *Alphitobius diaperinus* shows four distinct parts within the follicle. A germarium containing primary spermatogonia, a zone of growth where transformation of spermatogonia in to spermatocytes
occurs, a zone of maturation where the spermatocytes are converted into spermatids and the zone of transformation where spermatids change into spermatozoa. A number of follicles are found enclosed within the testicular epithelium. The spermatogonia are large in size, primary and secondary spermatocytes are comparatively small in size having 2-3 vacuoles and clear cytoplasm. The sperms are found both isolated and in bundles. The mature sperm consists of deeply stained filamentous nucleus and lightly stained cytoplasmic tail (Fig.34).

Histologically the testis of *Hoplocerambyx spinicornis* consists of a thick covering of a fibrous sheath in which a number of follicles separated by many partitions are present. Follicle consists of 4 distinct zones viz. a thick germarium, a zone of growth, a zone of maturation and a zone of transformation. All germ cells are enclosed within a layer of non-germinal cells forming cysts. Divisions within cyst appear synchronously. Follicle sheath has two cellular layers outer which is continuous and inner present in germarium. The outer layer of the sheath is a thin lamina and the inner a thicker basal lamina. In the cytoplasm of the outer cells flattened nuclei are present. The cells of inner layer, besides being discontinuous, differs from the outer ones in that their cytoplasm is some what denser. Spermatogonia are large in size and remain separated from each other and exhibit no cytoplasmic connections between them. Spermatocytes are abundant in the zone of maturation. Primary Spermatocytes are large in size and have a distinct nucleus. Secondary Spermatocytes are small in size and contain a prominent nucleus and vacuoles. The sperms are large in size and more
in number. It is remarkable to note that in Sal heart woodborer the elongated sperm nucleus contains a tube like vacuole inside, which is lost with the condensation of chromatin material. The elongation of spermatids takes place and they assume the shape like “Trypanosomes” (Fig.35).

STAGES OF SPERMATOGENESIS

*RAPHIDOPALPA FOVEICOLLIS (RED PUMPKIN BEETLE)*

Spermatogonia: The spermatogonia are spherical in shape. In the resting stage the cytoplasm is clear and non granular while the nucleoplasm is granular in nature. These cells possess only one nucleolus in the nucleus. One or two unstained clear nucleolar vacuoles are seen in the nucleolus (Fig. 36). After their growth phase, some changes are seen in the chromosomal behaviour. In prophase chromosome appear in the nucleoplasm (Fig.37). In metaphase stage chromosome become vary short deeply stained and arranged themselves in the equitorial plate of the cell, nuclear membrane is lost (Fig.38). In anaphase stage, the chromosomes move towards their respective poles (Fig.39). In telophase stage the chromosomes reach at the two poles and appears as deeply stained clumped masses (Fig.39).

Primary spermatocytes: After the repeated divisions of the spermatogonia, the primary spermatocyte are formed, which are more in number. In the resting stage these cells have a clear cytoplasm between the cell membrane and the nuclear membrane. The nucleolus stains well with acetocarmine stain. An unstained nuclear vacuole is present inside the nucleolus of all these cells. A perinucleolar ring is present in these cells (Fig.40).
After a short resting stage the cells become active and enters into leptotene stage of meiosis-I (Fig.40). Here the chromosomes are lightly stained threads in the granular nucleoplasm. The nucleolus is deeply stained. In zygotene stage pairing of chromosomes occurs, chromosomal threads become more condensed and stain deeply. Vacuole inside the nucleolus is also seen here which becomes enlarged in size. An unstained perinucleolar ring is present in this stage. In pachytene stage (Fig.41) condensation of chromosomes continues as a result they become short. In some of the cells, chiasmata are also seen at this stage. In diakinesis stage the chromosomes become more condensed, stain deeply and lie dispersed in the cytoplasm. These chromosomes are dot, rod and ring shaped (Fig.42). The nuclear membrane and the nucleolus disappear. However, during metaphase (Fig.43) of these cells, chromosomes get arranged at the equatorial plate. In anaphase stage (Fig.43) chromosomes moves towards the respective poles. In telophase stage (Fig.44) deeply stained chromosomes are seen at the two poles within the cells connected with the cytoplasmic strains. After cytokinesis the two newly formed cells are the secondary spermatocytes.

Secondary spermatocytes: The secondary spermatocytes have comparatively short resting period (Fig.46 and having clear cytoplasm and a granular nucleoplasm. These cells are smaller in size as compared to primary spermatocytes. It is remarkable here to note that the secondary spermatocytes are found in groups and packed together. The cells in a group are of the same age and all start dividing at one time. A clear
nucleolar vacuole is visible inside the nucleolus. During metaphase stage (Fig.46) five thread like chromosomes appear inside the nucleoplasm. A perinucleolar ring can also be observed. In metaphase stage chromosomes become very much condensed and stain deeply. These lie in the cytoplasm as the nuclear membrane disappears. In the subsequent anaphase stage (Fig.45) the chromosome moves apart from the equator, so as to reach their respective poles. In telophase (Fig.45) stage the chromosomes reach at their respective poles and appear as deeply stained clumps of the chromatin material. Later after cytokinesis the two spermatids are formed (Fig.47).

The process of transformation of spermatids into sperms called spermiogenesis. The spermatids which are spherical in shape undergo a series of changes to form mature sperms (Fig.48). Initially the spermatids contain condensed (Fig.48) chromatin material. After a short while some changes gradually appear. As a result the chromatin material arranges itself in the innermargin of the nuclear membrane leaving a clear, unstained space at the centre known as the nuclear vesicle. A deeply stained acrosomal granule within the acroblast appears at the margin of the nucleolus (Fig.48). Also the centrioles which are two in number are found at the margin of the nuclear membrane. The spermatids undergo elongation during which condensation of the nuclear material occurs. Acrosomal granule occupies the apex of the tapering end of the elongating spermatids (Fig.48 and 49). This forms the future acrosome of the sperm (Fig.50). One to four vacuoles are seen inside the nucleus of the elongating spermatids. Now the spindle shaped spermatid has a tapering anterior and broad posterior extremity. Vacuoles in the nucleus are still persisting
(Fig.50 and 51). Spermatids undergo further elongation containing one large or two small vacuoles in it (Fig.49). On further elongation an unstained, hollow space i.e. single elongated vacuole is seen inside the sperm nucleus (Fig. 47). To the posterior end of the nucleus joins a tail which is hollow in nature. With further condensation of the nuclear material, this vacuole disappears and the sperm nucleus appears as a deeply stained filament (Fig.46, 48). A lightly stained long cytoplasmic tail joins its posterior end. Further, the sperms aggregate in to bundles (Fig.52-59).

IN ALPHITOBUS DIAPERINUS (LESSER MEALWORM)

Spermatogonia: Spermatogonia are rounded in shape. In the resting stage the cytoplasm is clear and non granular while the nucleoplasm is granular. There is no chromosomal activity. During prophase the chromosomes appear as fine threads in the nucleoplasm having a nucleolus in it (Fig.60). At metaphase deeply stained chromosomes become dispersed in the cytoplasm as the nuclear membrane is lost. These chromosomes appear like 'dots', in polar view (Fig.60). In anaphase the chromosomes move apart from the equitorial plate so as to reach the poles (Fig.60). In telophase darkly stained chromosomes in the form of two clumps are seen at the two poles (Fig.61).

Primary spermatocytes: After repeated divisions of spermatogonia, the primary spermatocytes are formed, which are more in number. These cells have a well stained nucleolus in their nucleoplasm in the resting stage (Fig.63). The activity of chromosomes begins in leptotene (Fig.62) during which they appears as threads. At this stage the nucleolus is also present in the nucleoplasm (Fig.62). In the zygotene stage (Fig.63) the
pairing of the chromosomes occurs, and the nucleolus is still visible (Fig.63). In the pachytene (Fig.62) and diplotene stage (Fig.62) the chromosomes become very much condensed, stain deeply and lie in the cytoplasm, and these appears as 'dots' because the nuclear membrane disappears (Fig.62) In the metaphase of these cells deeply stained chromosomes are arranged at the equatorial region of the cell (Fig.63). In the anaphase stage the chromosomes move towards their respective poles connected by spindles (Fig.64). Finally in telophase (Fig. 64) the chromosomes are seen as well stained clumps at the two respective poles (Fig.64). Later the two daughter cells are formed due to cytokinesis.

Secondary spermatocytes: The newly formed secondary spermatocytes lie for a short period of resting stage. They have a well stained dark nucleolus in their nucleoplasm (Fig.65). As the prophase proceeds, the chromosomal activity begins and the chromosomal threads appear in the nucleoplasm (Fig.66). In the metaphase stage deeply stained and condensed chromosomes get arranged at the equitorial region (Fig.66). In anaphase chromosome move towards their respective poles (Fig. 65, 67) soon in the telophase stage, the chromosomes appear as deeply stained clumped masses at the two poles (Fig.67).

Spermatids: From each secondary spermatocytes, spermatids are formed (Fig.68,69), which are spherical in shape undergo a series of changes to form mature sperms (Fig.70). The chromatin material starts aggregating at the inner margin of the nuclear membrane leaving a clear, nuclear vesicle in the centre (Fig. 71).
Sperms: Acrosome appears as a granule near the nuclear membrane (Fig.72). The spherical spermatids undergo further elongation in which sperm nucleus become curved, and appear like “Trypanosome”. These are broad at the middle having tapering ends (Fig.73). During further elongation the sperm nucleus become more elongated and deeply stained (Fig.72). These continue to condense and elongate to form the sperm nucleus (Fig.73). In a sperm bundle the nucleus stains darkly and the tail stains faintly. Consequently, the isolated sperms also has darkly stained nuclear part and faintly stained cytoplasmic tail part (Fig.73).

**IN HOPLOCERAMBYX SPINICORNIS (SAL HEART-WOOD BORER)**

Spermatogonia: The primordium germ cells describe by their division give rise to spermatogenial cells. These are spherical cells. In their resting stage within the nucleus, a deeply stained nucleus is present which is surrounded by an unstained perinucleolar ring (Fig.74). These cells undergo mitosis. The mitotic dividing stages of spermatogonia are not abundant. In prophase stage a faint network of chromosomes become visible in the nucleoplasm (Fig.74). In metaphase, deeply stained and condensed chromosomes get arranged on the equatorial plate and lie in the cytoplasm as the nuclear membrane disappears (Fig.74). During anaphase, the chromatids move apart so as to reach the opposite poles (Fig.74). At telophase, the chromosomes clump together and appear as deeply stained masses at the two poles (Fig.74). Later, the nuclear division is followed by the cytoplasmic division and two cells are formed.
Primary spermatocytes: The spermatogonia mitotically divide repeatedly and form primary spermatocytes. These cells are abundant in the testis. The cell boundaries of the cells are not clearly distinct because they are found closely packed together. The nucleoplasm appears to be granular while the cytoplasm is quite clear (Fig.74). These cells undergo 1st meiotic division at the onset of the leptotene the chromosomal threads are found scattered in the nucleoplasm. The nucleolus remains attached to the nuclear membrane as a deeply stained body in which a nucleolar vacuole can be clearly seen (Fig.75). In the following zygotene stage, pairing of the homologous chromosomal threads sets in, but it is difficult to trace the paired threads. However, the nucleolar vacuole disappears at this stage (Fig.76). It is now followed by pachytene stage, during which, chromosomal threads become loose and form loops so as to give an appearance of a basket, the "Bouquet" stage (Fig.76). The loops contract and become shorter in the forthcoming diplotene stage. At this stage the nucleolus could not be traced. The homologous pairs do not separate completely but remain attached at certain points (Fig.76). At diakinesis the chromosomes condensed more and stain deeply and lie in the cytoplasm as the nuclear membrane is lost. Subsequently in metaphase, deeply stained and highly condensed chromosomes are seen arranged at the equator (Fig.77). Later in anaphase, chromosomal halves separate and move towards their respective poles (Fig.77). In telophase, the cell becomes elongated and deeply stained. Chromosomal clumps are seen at two poles connected with a strand of spindle in between them (Fig.77).

It is now followed by cytoplasmic division which results in the formation of two secondary spermatocytes.
Secondary spermatocytes: These cells are smaller in size as compared to primary spermatocytes. At their resting stage, the nucleus contains a single nucleolus having an unstained nucleolar vacuole inside it. The chromosomal material of these cells soon reorganises to undergo second meiotic division. A faint network of chromosomal threads appear in the nucleus in prophase stage (Fig. 78). Later in metaphase, the chromosomal threads become very short due to condensation, stain deeply and get arranged at the equatorial region of the cell (Fig. 79). In the following anaphase stage, the two sets of chromosomes separate and move towards their respective poles (Fig. 80). In the telophase stage, these sets of chromosomes reach to their respective poles and become fused together, so as to form compact condensed deeply stained chromatin masses at each pole (Fig. 80). It is now followed by the cytokinesis and two spermatids are formed from each of these cells.

The spermatids now undergo cellular metamorphosis or the spermiohistogenesis two centrioles appear as small dark granules near the margin on the nuclear membrane. In an early spermatid gradual condensation of the chromatin occurs on the inner surface of the nuclear membrane. The nucleus stains deeply at the site of the chromatin condensation leaving an unstainable central cavity, the nuclear vesicle. The spermatids undergo certain morphological changes before forming a mature sperm. The gradually elongate and become oval to fusiform. The nucleus become pointed at the anterior acrosomal end and has a broad posterior end to which the sperm tail attaches (Fig. 82). The middle portion of the
nucleus is slightly broader and contains a single vacuole within it. However, the margins of the spermatid nucleus stains well (Fig.83). The sperm nucleus becomes more condensed and stains deeply in advanced stages (Fig.83). The vacuole finally disappears due to condensation of the elongating nucleus (Fig.84, 85). In the mature sperms the nuclear part stains deeply, and the cytoplasmic tail attached to its posterior part, stains faintly. The sperms are seen in bundles which later on segregate (Fig. 86-91).

EFFECTS OF RADIATION

The effects of radiation on 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 (Fig.92, 93, 94).

On exposure to low dose of ultra-violet radiation all these three beetles do not show any remarkable effects on the testis, histology of testis and on germ cells.

On exposure to high dose of ultra-violet radiation also these three beetles do not show any remarkable change in the histology of testis (Fig.113 - 115).

High doses of X-ray and CO.\textsuperscript{60} radiation affects the germinal epithelium of the testis. The germinal epithelium becomes shrunken. Follicles showed damage, as they shrink and become smaller (Fig. 116 - 121).
EFFECTS OF ULTRA-VIOLET RADIATION

On exposure to low dose ($\frac{G-15T8}{15W}$ for 20 minutes) of ultra-violet radiation, do not show any remarkable change in any of the germ cells is seen (Fig. 104-106).

With the high dose ($\frac{G-15T8}{15W}$ for 30 minutes) of ultra-violet radiation in *Raphidopalpa foveicollis* (red pumpkin beetle) the spermatogonia become condensed and deeply stained (Fig.134). The primary spermatocytes get reduced and their vacuoles are also reduced (Fig.155). In the secondary spermatocytes, vacuoles are somewhat reduced and are not clear (Fig.176). The spermatids are not much affected (Fig.197). The sperm nucleus become more elongated in shape, size and number of sperms reduced (Fig.218).

In *Alphitobius diaperinus* (lesser meal worm) shrunken spermatogonia are seen (Fig.135). The primary spermatocytes do not show any change (Fig.156). The chromatin material of secondary spermatocytes, become condensed (Fig.177). Spermatids show the distortion effects (Fig.198). Sperm nucleus shows reduced vacuole (Fig.219).

In *Hoplocerambyx spinicornis* (sal heart wood borer) the spermatogonial, primary and secondary spermatocytes are not much affected (Fig.136, 148 and 178) but in some spermatids vacuoles are reduced and elongation affected (Fig. 199) sperm nucleus becomes more condensed and indistinct (Fig.220).
Effects of X-ray radiation

With the low dose (60Kv – 80 MAS (At 160 station) 100 cms distance between tube and object) of X-ray exposure in *Raphidopalpa foveicollis* spermatogonia and primary spermatocytes are not affected (Fig.128,149). Secondary spermatocytes are affected, their morphology changes and they are difficult to identify their chromatin material get condensed (Fig.170). The shape size and number of spermatids get reduced (Fig.191). In sperms, their elongation is affected (Fig.212).

In *Alphitobius diaperinus*, shrunken primary spermatocyte are seen (Fig.150). In secondary spermatocytes, chromatin material get condensed (Fig.171). In spermatids showed shrunken effect (Fig.192). In sperm cells, shape size, number and elongation affected (Fig.213).

In *Hoplocerambyx spinicornis*, the spermatogonia, primary spermatocyte and secondary spermatocytes do not show any remarkable changes (Fig.130, 151 and 172). The spermatids cells show shrunken effect and their number is reduced. Elongation is affected (Fig.193). Sperm cells do not show any remarkable change (Fig.214).

With the high dose (65Kv – 80 MAS (At 160 station) 100 Cms distance between tube and object) of X-ray radiation exposure in *Raphidopalpa foveicollis* the spermatogonia are affected. Their chromatin material become condensed and cells become shrunken. Cell boundaries are obliterated and distorted (Fig.137). In primary spermatocytes the size of the cells reduces and nuclei shrink (Fig.160). The morphology and morphometry of secondary spermatocytes changes. They become indistinct, pyknotic and condensed
(Fig.180). **Necrotic secondary spermatocytes are seen.** In spermatids, chromatin material is condensed, vacuoles disappear, indistinct acrosome and flagellum is very short. Spermatids are reduced in size 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 (Fig.200).

In *Alphitobius diaperinus* high dose (65Kv – 80 MAS (At 160 station) 100 Cms distance between tube and object) of X-ray radiation exposure affects the spermatogonia as they become shrunken and indistinct (Fig.138) chromosomes become abnormal in shape, chromatin material condenses primary and secondary spermatocytes cells become necrotic and their cytoplasm and nuclear material is difficult to identify. Some cells become shrunken and their vacuoles reduced (Fig.159 and 180). Spermatids show distortion effects and elongation of spermatids is affected (Fig.201). In the sperms acrosome appears as a granule near the membrane. Elongation of sperm nucleus is affected. It becomes pointed at the anterior end broad at the middle and almost blunt at the posterior end (Fig. 222).

With the high dose (65Kv – 80 MAS (At 160 station) 100 Cms distance between tube and object) of X-ray radiation in *Hoplocerambyx spinicornis* follicles showed damaged. In the spermatogonia, chromatin material become condensed, and indistinct (Fig.139). In primary spermatocytes nuclei shrink (Fig.160). In secondary spermatogonia chromatin material condenses (Fig.181). In spermatids the size of the vacuole reduces, cell boundaries are shrunken and they are not properly arranged (Fig.202). Elongation of sperms is affected (Fig.223).
Effects of CO.$^{60}$ radiation

With low dose (3 Rads) of CO.$^{60}$ radiation in *Raphidopalpa foveicollis* spermatogonia become deeply stained, chromatin material become condensed and vacuole reduced (Fig.131). The primary spermatocytes are condensed and become pyknotic. They are not clearly distinguishable (Fig.154). Secondary spermatogocyte cells changes, nuclei are deeply stained, vacuoles reduced. Their chromatin material becomes degenerated and necrotic. Cytoplasm and nuclear material is difficult to distinguish from one another (Fig.172). The spermatids are reduced in shape, size, number and flagellum. Acrosome becomes indistinct and centriole disappear (Fig.194) sperms change to aspermia stage in which sperm bundles are not formed. Shape and size of sperm reduces (Fig.215).

With low dose (3 Rads) of CO.$^{60}$ radiation in *Alphitobius diaperinus*, spermatogonia are comparatively more affected. It undergoes abnormal mitosis (Fig.132). In primary spermatocytes chromatin material becomes degenerated and necrotic. It is indistinct (Fig.153). Secondary spermatocytes show distortion effects and become pyknotic and also show necrosis (Fig.174). In spermatids the nucleus become indistinct and cell becomes distorted. Most of the spermatids disappear. Elongation of spermatids is effected (Fig.195). The sperms fail to form sperm bundles and show disturbed physiological state of spermatogenesis which indicates infertility. Shape, size and number of sperms are reduced cell boundaries are shrunken and distorted (Fig.216).
On exposure to low dose (5 Rads) of CO.\textsuperscript{60} radiation in \textit{Hoplocerambyx spinicornis}, spermatogenial and primary spermatocytes do not show any remarkable effects (Fig. 133,154). Secondary spermatocytes showed shrunken effect (Fig.175). Spermatids exhibit distortion. Flagellum of spermatids is very short and acrosome becomes indistinct (Fig.196).

On exposure to high dose (5 Rads) of CO.\textsuperscript{60} radiation in \textit{Raphidopalpa foveicollis}, the follicles are shrunken and damaged. The cell boundaries of spermatogonia become obliterated and distorted (Fig.140). Primary spermatocytes become necrotic. Metaphase clumped and disturbed pachytene stage is observed. Secondary spermatocytes become necrotic and it is not easy to identify their cytoplasm and nucleoplasm (Fig.161 and 182). The vacuoles of the spermatids become fused with one another abnormally and some vacuoles become smaller or disappear (Fig. 203). Sperm nucleus is indistinct and does not take stain properly. Stickiness of chromosomes is observed undergoes abnormal mitosis. Acrosome of spermatids becomes indistinct and flagellum become very short. The sperms become distorted, indistinct and shrunken. Vacuoles disappear. Acrosome not clearly seen showing the partial aspermia state and stickiness of clumping chromosomes. Undergoes abnormal mitosis (Fig.224).

With the high dose (5 Rads) of CO.\textsuperscript{60} radiation in \textit{Alphitobius diaperinus}, the chromosomes of spermatogonia become abnormal in shape and undergoes abnormal mitosis (Fig.141). Chromatin material is condensed due to shrunken effects. Primary spermatocytes become indistinct & necrotic and are not clearly seen (Fig.162). Secondary spermatocytes become
indistinct and necrotic. Chromatin material becomes more condensed (Fig. 183). The elongation of spermatids is affected, their vacuoles are reduced, cells become distorted, shape and size of the sperms reduce. Cell boundaries are shrunken and they are not properly arranged. The sperms fail to form sperm bundles and show disturbed physiological state of spermatogenesis and indicates infertility (Fig. 204 and 216).

High dose (5 Rads) of CO.$^{60}$ radiation in *Hoplocerambyx spinicornis*, follicles showed damage as they shrink and become smaller. Cell boundaries of spermatogonia become distorted (Fig. 142). Secondary spermatocytes showed necrotic effects (Fig. 184). Spermatids nucleus become indistinct. Most of the spermatids disappear (Fig. 205). Number of sperms are reduced and show disturbed physiological state of spermatogenesis and indicate infertility (Fig. 226).

High dose (5 Rads) of CO.$^{60}$ radiation exposure causes 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.
Fig. 1: Photograph showing the equipment used for Ultra-violet radiation exposure facility taken from the Department of Plant Pathology, Indira Gandhi Agricultural University, Raipur (Chhattisgarh).

Fig. 2: Photograph showing the X-ray instrument used for X-ray radiation exposure facility taken from a Private Nursing Home, Raipur (Chhattisgarh).
Fig. 3  Photograph showing the Cobalt Room (Radio-therapy Unit), Department of Radiation and Oncology in Sector-I, Durg (Chhattisgarh).

Fig. 4  Photograph showing the instrument used for photo micrography. The instrument is Leico G MRBE 28/104/MP5/MPS-32 Leico GMBH-Germany. Facility taken from the Department of Plant Pathology, Indira Gandhi Agricultural University, Raipur (Chhattisgarh).
Fig. 5  Showing the Agricultural fields of Indira Gandhi Agricultural University, Raipur (Chhattisgarh) from where the *Raphidopalpa foveicollis* have been collected for experimentation.

Fig. 6  Showing the Horticulture nursery of Indira Gandhi Agricultural University, Raipur (Chhattisgarh) from where the *Raphidopalpa foveicollis* have been collected.

Fig. 7  Showing the location, from where *Alphitobius diaperinus* have been collected. Dirt floor of the poultry houses where they are abundant.

Fig. 8  Showing Sarine poultry farm from where *Alphitobius diaperinus* have been collected. They are found in the dirt floor of poultry farms.
Fig. 9  Showing the dirt floor of the Jaishree Poultry Farm, from where the *Alphitobius diaperinus* beetles have been collected.

Fig. 10  Showing the Sal forest of Pithora, District Mahasamund (Chhattisgarh) from where *Hoplocerambyx spinicornis* beetles have been collected.

Fig. 11  Showing the Sal forest of Amarkantak District Sahadol (Madhya Pradesh)

Fig. 12  Showing the Sal forest of Dindori District Mandla (Madhya Pradesh)
Fig. 13  Showing the Sal forest area of Amarkantak District Sahadol (Madhya Pradesh)

Fig. 14  Showing the Sal forest of Gariabandh, District Raipur (Chhattisgarh)

Fig. 15  Showing the Sal forest of Barnavapara Sanctuary, District Raipur (Chhattisgarh)

Fig. 16  Showing the habitat of the beetle *Raphidopalpa foveicollis*. It is a red coloured pumpkin beetle found on various cucurbits. It feeds on flowers, buds, leaves and fruits. Grubs bore into the root and many reach up to the middle of the stem. They cause severe damage during March to May (Over wintering season).
Fig. 17  Showing the habitat i.e. dirt floor of the poultry farm from where *Alphitobius diaperinus* are found.

Fig. 18  Showing the habitat of *Hoplocerambyx spinicornis* beetles (Sal heartwood borer).

Fig. 19  Showing the habitat of *Hoplocerambyx spinicornis*, the forest area of Deobhog, Raipur (Chhattisgarh) from where beetles have been collected with the help of forest employees.

Fig. 20  Showing the habitat of *Hoplocerambyx spinicornis*. found in the forest area of Gariaband, Raipur (Chhattisgarh) from where beetles have been collected with the help of forest employee.
Fig. 21  Showing the morphology of the *Raphidopalpa foveicollis* (entire insect) showing various views and also showing sexual dimorphism. Female having a broad abdomen and comparatively large in size than male.

Fig. 22  Arrow showing the morphology of the testis in-Situ in *Raphidopalpa foveicollis*.

Fig. 23  Showing the various morphological views of *Alphitobius diaperinus* and sexual dimorphism, males are small in size.

Fig. 24  Showing the morphology of testis in-Situ in *Alphitobius diaperinus*. 
Fig. 25  Showing the sexual dimorphism in *Hoplocerambyx spinicornis* and also showing clear distinct antennae. Long antennae in male and comparatively short antennae in female individual.

Fig. 26  Showing the morphology of the entire insect in various views *Hoplocerambyx spinicornis*.

Fig. 27  Showing the morphology of testis of *Raphidopalpa foveicollis*.

Fig. 28  Showing the morphology of testis of *Alphitobius diaperinus*. 
Fig. 29  Diagram showing the male reproductive system of *Raphidopalpa foveicollis*. 
Fig. 29  Male Reproductive System of
*Raphidopalpa foveicollis*
Fig. 30  Diagram showing the male reproductive system of *Alphitobius diaperinus*. 
Fig. 30  Male Reproductive System of

*Alphitobius diaperinus*
Fig. 31  Diagram showing the male reproductive system of *Hoplocerambyx spinicornis*. 
Fig. 31  Male Reproductive System of
_Hoplocerambyx Spinicornis_
Fig. 32  Showing the morphology of testis of *Hoplocerambyx spinicornis*.

Fig. 33  Showing the histology of testis of *Raphidopalpa foveicollis*.

- Haemotoxylin Stain  10 X 6
- Histological Preparation

Fig. 34  Showing the histology of testis of *Alphitobius diaperinus*.

- Haemotoxylin Stain  10 X 6
- Histological Preparation

Fig. 35  Showing the histology of testis of *Hoplocerambyx spinicornis*.

- Haemotoxylin Stain  10 X 6
- Histological Preparation
Fig. 36  Showing the spermatogonia in resting stage with well stained nucleus in their nucleus having a vacuole inside it. Spermatogonia also contain granular nucleoplasm and clear cytoplasm Raphidopalpa foveicollis. Squash Preparation 1000 X Acetocarmine stain

Fig. 37  Showing the spermatogonia in prophase stage showing appearance of chromosome with a well stained nucleus in their nucleus. Vacuole are also seen (Raphidopalpa foveicollis). Squash Preparation 1000 X Acetocarmine stain

Fig. 38  Showing the spermatogonia in metaphase, deeply stained chromosomes get arranged in the equatorial plate. Nuclear membrane disappears and condensed deeply stained chromosomes is seen in the nucleoplasm (Raphidopalpa foveicollis). Squash Preparation 1000 X Acetocarmine stain

Fig. 39  Showing the spermatogonia in the Anaphase stage and Telophase stage (Raphidopalpa foveicollis). Squash Preparation 1000 X Acetocarmine stain
Fig. 40  Showing the primary spermatocytes in Leptotene stage showing granular nucleoplasm and appearance of chromosomal threads in it. A deeply stained nucleolus contains two very small nucleolar vacuoles. A clear unstained perinucleolar ring is seen around the nucleus (Raphidopalpa foveicollis)  
Squash preparation  
Acetocarmine stain

Fig. 41  Showing the primary spermatocytes in pachytene stage, the nucleus shifts towards the margin and the chromosomes are seen loosely oriented on the other side of it the perinucleolar ring is not visible (Raphidopalpa foveicollis)  
Squash preparation  
Acetocarmine stain

Fig. 42  Showing the primary spermatocytes in Pachytene diakinesis and diplotene stage (Raphidopalpa foveicollis)  
Squash preparation  
Acetocarmine stain

Fig. 43  Showing the primary spermatocytes in metaphase, anaphase and telophase stages and also showing cytokinesis (Raphidopalpa foveicollis)  
Squash preparation  
Acetocarmine stain
Fig. 44  Showing the secondary spermatocytes in prophase stage (active stage) and metaphase (*Raphidopalpa foveicollis*) 1000 X
Squash preparation
Acetocarmine stain

Fig. 45  Showing the secondary spermatocytes in telophase stage (*Raphidopalpa foveicollis*). 1000 X
Squash preparation
Acetocarmine stain

Fig. 46  Showing the primary spermatocytes in resting stage with clear cytoplasm and granular nucleoplasm, and a well stained nucleolus. These secondary spermatocytes are formed from primary spermatocytes through the first meiotic division. These cells are smaller in size as compared to primary spermatocytes. Secondary spermatocytes show a peculiar variable behaviour of their disappearance during the spermatogenesis (*Raphidopalpa foveicollis*) 1000 X
Squash preparation
Acetocarmine stain

Fig. 47  Showing the newly formed spermatids (*Raphidopalpa foveicollis*) 1000 X
Squash preparation
Acetocarmine stain
Fig. 48  Showing the spermatids, condensed chromatin material at the inner margin of nuclear membrane (*Raphidopalpa foveicollis*)
Squash preparation  
Acetocarmine stain  

Fig. 49  Showing the elongation of spermatid nucleus (*Raphidopalpa foveicollis*)
Squash preparation  
Acetocarmine stain  

Fig. 50  Showing the spermatids in germ cells deeply stained acromosal granules and nuclear vesicle and aggregation of chromatin material at the inner surface of the membrane (*Raphidopalpa foveicollis*)
Squash preparation  
Acetocarmine stain  

Fig. 51  Showing the spermatids in groups. Almost all the spermatids in the active stages, which show chromosomal activity and nucleus with acrosomal granules seen, attached to the nuclear membrane (*Raphidopalpa foveicollis*)
Squash preparation  
Acetocarmine stain
Fig. 52  Showing the elongation of spermatids pointed acrosome at anterior end with broad posterior end (Raphidopalpa foveicollis)
Squash preparation  
Acetocarmine stain  1000 X

Fig. 53  Showing the spermatid nucleus showing more condensation and attaining spindle shape expansion of lateral margin can also be seen. Its pointed anterior and contains a granular acrosome at its tip (Raphidopalpa foveicollis)  
Squash preparation  
Acetocarmine stain  1000 X

Fig. 54  Showing the more elongation of spermatids nucleus and the attachment of flagellum (Raphidopalpa foveicollis)  
Squash preparation  
Acetocarmine stain  1000 X

Fig. 55  Showing the further elongation of spermatids (Raphidopalpa foveicollis)  
Squash preparation  
Acetocarmine stain  1000 X
Fig. 56  Showing the sperm nucleus elongation (*Raphidopalpa foveicolli*)
Squash preparation  1000 X
Acetocarmine stain

Fig. 57  Showing the mature sperm bundle. Few mature sperms are seen released in which nucleus become more elongated, vacuole disappear and it is deeply stained (*Raphidopalpa foveicolli*)
Squash preparation  1000 X
Acetocarmine stain

Fig. 58  Showing the few mature sperm clearly. Long hollow tail attached to the posterior broad end of the sperm nucleus are highly stained (*Raphidopalpa foveicolli*)  1000 X
Squash preparation
Acetocarmine stain

Fig. 59  Showing the mature sperm bundles, sperm nucleus seen as deeply stained (*Raphidopalpa foveicolli*)  1000 X
Squash preparation
Acetocarmine stain
Fig. 60  Showing the various stages of spermatogonia; Prophase, Metaphase (polar view) and Anaphase stages (*Alphitobius diaperinus*).  
Squash preparation  1000 X  
Acetocarmine stain

Fig. 61  Showing the spermatogonial cells in prophase state with a well stained nuclei in their nucleus (*Alphitobius diaperinus*).  
Squash preparation  1000 X  
Acetocarmine stain

Fig. 62  Showing the primary spermatocytes in leptotene, diplotene, diakinesis, pachytene and zygotene stages (*Alphitobius diaperinus*).  
Squash preparation  1000 X  
Acetocarmine stain

Fig. 63  Showing the primary spermatocytes in metaphase and zygotene stages (*Alphitobius diaperinus*).  
Squash preparation  1000 X  
Acetocarmine stain
Fig. 64  Showing the primary spermatocytes in Anaphase and Telophase stages (*Alphitobius diaperinus*).  1000 X
Squash preparation
Acetocarmine stain

Fig. 65  Showing the secondary spermatocytes in Prophase stage (active stage), Resting, Anaphase, Early Telophase stages (*Alphitobius diaperinus*).  1000 X
Squash preparation
Acetocarmine stain

Fig. 66  Showing the secondary spermatocytes in Zygotene, Diplotene and Prophase stages (*Alphitobius diaperinus*).  1000 X
Squash preparation
Acetocarmine stain

Fig. 67  Showing the secondary spermatocytes in Anaphase showing clumped chromosomes moving apart to their respective poles and also showing prophase stage having granular nucleoplasm with thread like chromosomes (*Alphitobius diaperinus*).  1000 X
Squash preparation
Acetocarmine stain
Fig. 68  Showing the spermatids, condensed chromatin material at the inner margin of nuclear membrane. The nuclear vesicle, acroblast and centrioles are seen (Alphitobius diaperinus).  
1000 X  
Squash preparation  
Acetocarmine stain

Fig. 69  Showing the elongation of spermatids, condensation of nuclear material with a small granule, the acrosome attached to the tapering end of it, centriole is also visible and unstained vacuoles are seen in the nucleus also showing the spermatids germ cells deeply stained. Acrosomal granule and nuclear vesicle and aggregation of chromatin material at the inner surface of the membrane (Alphitobius diaperinus).  
1000 X  
Squash preparation  
Acetocarmine stain

Fig. 70  Showing the mature sperms in bundle with deeply stained sperm head and tail. The tail is hollow in nature (Alphitobius diaperinus).  
1000 X  
Squash preparation  
Acetocarmine stain

Fig. 71  Showing the sperm bundles with fifth elongation of sperm nucleus in which the nucleus become more elongated also (Alphitobius diaperinus).  
1000 X  
Squash preparation  
Acetocarmine stain
Fig. 72    Showing the fully mature sperms. Tail of sperm seen attached to the posterior broad end of the nucleus. Mature sperm bundle with long thread like head and a very thin very long tail (*Alphitobius diaperinus*).
Squash preparation
Acetocarmine stain

Fig. 73    Showing the sperm bundle with sperm nucleus and sperm tail (*Alphitobius diaperinus*).
Squash preparation
Acetocarmine stain

Fig. 74    Showing the spermatogonial cells in early anaphase in which chromosome start and are seen moving towards their respective poles. In the geneial cells the clumped chromosomes are seen at two poles in the telophase showing cytokinesis (*Hoplocerambyx spinicornis*).
Histological preparation
Haemotoxylin stain

Fig. 75    Showing the primary spermatocytes in resting stage clear cytoplasm between cell membrane and the nucleolus is granular the nucleus is deeply stained with a clear nucleolar vacuole within it (*Hoplocerambyx spinicornis*).
Histological preparation
Haemotoxylin stain
Fig. 76  Showing the primary spermatocytes in metaphase showing chromosomes arranged in the equatorial plate (*Hoplocerambyx spinicornis*).
Histological preparation
Haemotoxylin stain

Fig. 77  Showing the primary spermatocytes in anaphase stage, the chromosomes is seen at their respective poles (*Hoplocerambyx spinicornis*).
Histological preparation
Haemotoxylin stain

Fig. 78  Showing the primary spermatocytes in telophase stage, where the deeply stained condensed chromosomes are seen at two poles with in the cell connected with the cytoplasmic strands (*Hoplocerambyx spinicornis*).
Histological preparation
Haemotoxylin stain

Fig. 79  Showing the secondary spermatocytes in prophase stage. The cells contain a well stained nucleolus in the nucleoplasm. Metaphase stage showing deeply stained condensed chromosomes laying in the cytoplasm (*Hoplocerambyx spinicornis*).
Histological preparation
Haemotoxylin stain
Fig. 80  Showing the secondary spermatocytes in anaphase stage showing clumped chromosomes moving a part to their respective poles and telophase stage showing clumped deeply stained chromosomes at the two poles \( (Hoplocerambyx spinicornis) \).  
Histological preparation  
Haemotoxylin stain

Fig. 81  Showing the newly formed spermatids, condensed and deeply stained. Spermatids are showing spermeochistogenesis, the chromatin material aggregates at the inner margin of the nuclear membrane with the result a clear nuclear vesicle is formed with in the nucleus. A deeply stained acrosomal granule appears near the margin of the cell. Centriole is also visible as deeply stained granules in the nuclear membrane \( (Hoplocerambyx spinicornis) \).  
Histological preparation  
Haemotoxylin stain

Fig. 82  Showing the spermatids showing condensed chromatin material at the near margin of the nuclear membrane. The nuclear vesicle acroblast, acrosomal granules and two centriole are seen \( (Hoplocerambyx spinicornis) \).  
Histological preparation  
Haemotoxylin stain

Fig. 83  Showing the elongation of the spermatids showing condensation of nuclear material with a small granule, the acrosome attached to the tapering end of it one to four small unstained vacuoles are seen in the nucleus, centriole is also visible \( (Hoplocerambyx spinicornis) \).  
Histological preparation  
Haemotoxylin stain
Fig. 84  Showing the further elongation of the spermatids nucleus with pointed anterior end and broad posterior end. One or two vacuoles with in the nuclear material still exists (*Hoplocerambyx spinicornis*). Histological preparation 1000 X
Haemotoxylin stain

Fig. 85  Showing the further elongation of the spermatid nucleus first pointed anterior end contains a granular acrosome at its tip while the cutoplasmic tail is seen attached to the broad posterior end the nucleus contains one large or two small vacuoles. In it small flagellum is seen attached to the centriole. (*Hoplocerambyx spinicornis*). Histological preparation 1000 X 45
Haemotoxylin stain

Fig. 86  Showing the sperm nucleus more elongated with a large unstained vacuole with in it. The posterior end appears rounded, where the tail joins. The tail is also hollow in nature (*Hoplocerambyx spinicornis*). Histological preparation 1000 X 45
Haemotoxylin stain

Fig. 87  Showing the isolated sperm with well-stained nucleus in which the vacuoles are totally lost (*Hoplocerambyx spinicornis*). Histological preparation 1000 X
Haemotoxylin stain
Fig. 88  Showing the mature in bundles with deeply stained sperm head and tail. Also the sperm nucleus more elongated enclosing vacuoles in it pointed anterior end the broad posterior end can be well marked. The chromatin of the nuclear material has condensed at the inner margin of the nuclear membrane acrosome appears as a granules near the membrane a clear nuclear vesicle within the nucleus also seen (Hoplocerambyx spinicornis). 1000 X 45
Histological preparation
Haemotoxylin stain

Fig. 89  Showing the sperm elongation, spindle shaped acrosomal end is sharply pointed. Some sperm are curved like trypanosomes, its lateral margin expanded (Hoplocerambyx spinicornis). 1000 X
Histological preparation
Haemotoxylin stain

Fig. 90  Showing the fully mature sperm tail of sperms. Tail of sperm seen attached to the posterior broad end of the nucleus. Mature sperm bundle with long thread like head and a very thin and long tail (Hoplocerambyx spinicornis). 1000 X 45
Histological preparation
Haemotoxylin stain

Fig. 91  Showing the sperm bundle, sperm nucleus and sperm tail (Hoplocerambyx spinicornis). 1000 X
Histological preparation
Haemotoxylin stain
Fig. 92  Showing the effect of high dose of Ultra-violet, X-ray and CO\textsuperscript{60} radiation on morphology of *Raphidopalpa foveicollis*. No remarkable effects are seen.

\[ \text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 30 minutes} \]

\[ \text{X- Ray} = 65 K\gamma-80 \text{ MAS (at 160 station) 100 cms distance between tube and object} \]

\[ \text{CO}^{\text{60}} = 5 \text{ Rad} \]

Fig. 93  Showing the effect of high dose of Ultra-violet, X-ray and CO\textsuperscript{60} radiation on morphology of *Raphidopalpa foveicollis*. No remarkable changes seen.

\[ \text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 30 minutes} \]

\[ \text{X- Ray} = 65 K\gamma-80 \text{ MAS (at 160 station) 100 cms distance between tube and object} \]

\[ \text{CO}^{\text{60}} = 5 \text{ Rad} \]

Fig. 94  Showing the effect of high dose of Ultra-violet, X-ray and CO\textsuperscript{60} radiation on morphology of *Alphitobius diaperinus*. No remarkable effects seen.

\[ \text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 30 minutes} \]

\[ \text{X- Ray} = 65 K\gamma-80 \text{ MAS (at 160 station) 100 cms distance between tube and object} \]

\[ \text{CO}^{\text{60}} = 5 \text{ Rad} \]

Fig. 95  Showing the effect of low dose (3 rads) of CO\textsuperscript{60} radiation on morphology of testis of *Alphitobius diaperinus*. No remarkable changes seen.
Fig. 96  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on morphology of testis of *Alphitobius diaperinus*. No remarkable changes seen.

Fig. 97  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on morphology of *Hoplocerambyx Spinicornis* hyperactive and their mobility increases.

Fig. 98  Showing the effect of high dose of Ultra-violet radiation on morphology of *Hoplocerambyx Spinicornis*. No remarkable changes seen.

Ultra-violet = \frac{G-15T8}{15W} \text{ for 30 minutes}

Fig. 99  Showing the effect of high dose of X-ray radiation on morphology of testis of *Hoplocerambyx Spinicornis*. Germinal epithelium effected.

X- Ray = 65 K\textsubscript{y} - 80 MAS (at 160 station) 100 cms distance between tube and object
Fig. 100  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on morphology of testis of \textit{Hoplocerambyx Spinicornis}. Germinal epitheliums become shrunken.

Fig. 101  Showing the histology of testis of \textit{Raphbidopalpa toveicollis} (Control).
Histological preparation 10 x 45
Haemotoxylin stain

Fig. 102  Showing the histology of testis of \textit{Alphitobius diaperinus} (Control).
Histological preparation 10 x 45
Haemotoxylin stain

Fig. 103  Showing the histology or a portion of testis \textit{Hoplocerambyx spinicornis} (Control)
Histological preparation 10 x 45
Haemotoxylin stain
Fig. 104  Showing the effect of low dose of Ultra-violet radiation on histology of testis of *Raphbidopalpa toveicolis*. No remarkable effects.
Histological preparation 10 x 45
Haemotoxylin stain

Ultra-violet = \( \frac{G-15T8}{15\text{ W}} \) for 20 minutes

Fig. 105  Arrow showing the effect of low dose of Ultra-violet radiation of histology of testis of *Alphitobius diaperinus*. No remarkable effects.
Histological preparation 10 x 45
Haemotoxylin stain

Ultra-violet = \( \frac{G-15T8}{15\text{ W}} \) for 20 minutes

Fig. 106  Showing the effect of low dose of Ultra-violet radiation on histology of testis of *Hoplocerambyx spinicornis*. No remarkable effects.
Histological preparation 10 x 45
Haemotoxylin stain

Ultra-violet = \( \frac{G-15T8}{15\text{ W}} \) for 20 minutes

Fig. 107  Showing the effect of low dose of X-ray radiation on histology of testis of *Raphidopalpa toveicolis*. No remarkable effects.
Histological preparation 10 x 45
Haemotoxylin stain

X- Ray = 60 K, 80 MAS (at 160 station) 100 cms
distance between tube and object
Fig. 108  Showing the effect of low dose of X-ray radiation on histology of testis of *Alphitobius diaperinus*. No effect.  
Histological preparation  
Haemotoxylin stain  
10 x 6

X- Ray = 60 Kv - 80 MAS (at 160 station) 100 cms 
distance between tube and object

Fig. 109  Showing the effect of low dose of X-ray radiation on histology of testis of *Hoplocerambyx spinicornis*. No change.  
Histological preparation  
Haemotoxylin stain  
10 x 6

X- Ray = 60 Kv - 80 MAS (at 160 station) 100 cms 
distance between tube and object

Fig. 110  Showing the effect of low dose (3 rads) of CO\(^{60}\) radiation on histology of testis of *Raphidopalpa foveicolis*. No remarkable change.  
Histological preparation  
Haemotoxylin stain  
10 x 6

Fig. 111  Showing the effect of low dose (3 rads) of CO\(^{60}\) radiation on histology of testis of *Alphitobius diaperinus*. Cell boundaries are shrunken and distorted.  
Histological preparation  
Haemotoxylin stain  
10 x 6
Fig. 112  Showing the effect of low dose (3 rads) of CO$^{60}$ radiation on histology of testis of *Hoplocerambyx spinicornis*. No changes observed.
Histological preparation
Haemotoxylin stain  10 x 6

Fig. 113  Showing the effect of high dose of Ultra-violet radiation on histology of testis of *Raphidopalpa foveicollis*. No remarkable changes are observed.
Histological preparation
Haemotoxylin stain  10 x 6

Ultra-violet = \( \frac{G-15T8}{15 W} \) for 30 minutes

Fig. 114  Showing the effect of high dose of Ultra-violet radiation on histology of testis of *Alphtobius diaperinus*. No remarkable changes seen.
Histological preparation
Haemotoxylin stain  10 x 6

Ultra-violet = \( \frac{G-15T8}{15 W} \) for 30 minutes

Fig. 115  Showing the effect of high dose of Ultra-violet radiation on histology of testis of *Hoplocerambyx spinicornis*. No remarkable changes are observed.
Histological preparation
Haemotoxylin stain  10 x 6

Ultra-violet = \( \frac{G-15T8}{15 W} \) for 30 minutes
Fig. 116  Arrow showing the effect of high dose of X-ray radiation on histology of testis of *Raphidopalpa foveicollis*. Broken germinal epithelium and damaged follicles are seen. 10 x 6
Histological preparation
Haemotoxylin stain

Ultra-violet = \[ \frac{G\text{-}15T8}{15\text{ W}} \] for 30 minutes

Fig. 117  Showing the effect of high dose of X-ray radiation on histology of testis of *Alphitobius diaperinus*. No remarkable changes are observed. 10 x 6
Histological preparation
Haemotoxylin stain

X- Ray = 65 K\text{-} 80 MAS (at 160 station) 100 cms
distance between tube and object

Fig. 118  Showing the effect of high dose of X-ray radiation on histology of testis of *Hoplocerambyx spinicornis*. Broken germinal epithelium and damaged follicles are seen. 10 x 6
Histological preparation
Haemotoxylin stain

X- Ray = 65 K\text{-} 80 MAS (at 160 station) 100 cms
distance between tube and object

Fig. 119  Showing the effect of high dose (5 rads) of CO\text{60} radiation on testis damaged follicles and broken germinal epithelium seen in *Raphidopapla foveicollis*. 10 x 6
Histological preparation
Haemotoxylin stain
Fig. 120  Showing the effect of high dose (5 rads) of CO$^{60}$ radiation on histology of testis of *Alphitobius diaperinus*. Damaged follicles and broken germinal epithelium are seen.  
Histological preparation  
Haemotoxylin stain

Fig. 121  Showing the effect of high dose (5 rads) of CO$^{60}$ radiation on histology of testis of *Hoplocerambyx spinicornis*. Broken germinal epithelium is seen.  
Histological preparation  
Haemotoxylin stain

Fig. 122  Showing the spermatogonia of *Raphidopalpa foveicollis* (control)  
Squash preparation  
Acetocarmine stain

Fig. 123  Showing the spermatogonia of *Alphitobius diaperinus*.  
Squash preparation  
Acetocarmine stain
Fig. 124  Showing the spermatogonia of *Hoplocerambyx spinicornis*
Histological preparation  
Haemotoxylin stain  

10 x 6

Fig. 125  Showing the effect of low dose of Ultra-violet radiation on spermatogonia of *Raphidopalpa foveicollis*. Shrunken spermatogonia are seen.  
Squash preparation  
Acetocarmine stain  

\[
\text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 20 minutes}
\]

1000 x

Fig. 126  Showing the effect of low dose of Ultra-violet radiation on spermatogonia of *Alphitobius diaperinus*. Shrunken spermatogonia are seen.  
Squash preparation  
Acetocarmine stain  

\[
\text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 20 minutes}
\]

1000 x

Fig. 127  Showing the effect of low dose of Ultra-violet radiation on spermatogonia of *Hoplocerambyx spinicornis*. No change.  
Histological preparation  
Haemotoxylin stain  

\[
\text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 20 minutes}
\]

10 x 6
Fig. 128  Showing the effect of low dose of X-ray radiation on spermatogonia of *Raphidopalpa foveicollis*. No change. Squash preparation 1000 x Acetocarmine stain

\[ \text{X- Ray} = 60 \text{ K}_\gamma - 80 \text{ MAS (at 160 station) } 100 \text{ cms} \]
\[ \text{distance between tube and object} \]

Fig. 129  Showing the effect of low dose of X-ray radiation on spermatogonia of *Alphitobius diaperinus*. No remarkable change Squash preparation 1000 x Acetocarmine stain

\[ \text{X- Ray} = 60 \text{ K}_\gamma - 80 \text{ MAS (at 160 station) } 100 \text{ cms} \]
\[ \text{distance between tube and object} \]

Fig. 130  Showing the effect of low dose of X-ray radiation on spermatogonia of *Hoplocerambyx spinicornis*. No change Microtomical preparation 10 x 6 Haemotoxylin stain

\[ \text{X- Ray} = 60 \text{ K}_\gamma - 80 \text{ MAS (at 160 station) } 100 \text{ cms} \]
\[ \text{distance between tube and object} \]

Fig. 131  Showing the effect of low dose (3 rads) of CO\textsuperscript{60} radiation on spermatogonia of *Raphidopalpa foveicollis*. Condensed chromatin material is seen. Vacuoles reduced. 1000 x Squash preparation Acetocarmine stain
Fig. 132  Showing the effect of low dose (3 rads) of CO\textsuperscript{60} radiation on spermatogonia of *Alphitobius diaperinus* condensed chromatin material is seen. Squash preparation 1000 x Acetocarmine stain

Fig. 133  Showing the effect of low dose (3 rads) of CO\textsuperscript{60} radiation on spermatogonia of *Hoplocerambyx spinicornis*. 10 x 6 No remarkable changes. Histological preparation Haemotoxylin stain

Fig. 134  Showing the effect of low dose of Ultra-violet radiation on spermatogonia of *Raphidopalpa foveicollis* shrunken cells are seen. Squash preparation 1000 x Acetocarmine stain

Ultra-violet = \frac{G-15T8}{15 W} for 20 minutes

Fig. 135  Showing the effect of high dose of Ultra-violet radiation on spermatogonia of *Alphitobius diaperinus*. Shrunken cells are seen. Squash preparation 1000 x Acetocarmine stain

Ultra-violet = \frac{G-15T8}{15 W} for 30 minutes
Fig. 136  Showing the effect of high dose of Ultra-violet radiation on spermatogonia of *Hoplocerambyx spinicornis*. Condensed chromatin material seen but they are not much more affected.
Histological preparation 10 x 6
Haemotoxylin stain

Ultra-violet = \[
\frac{G-15T8}{15 \, \text{W}}
\] for 30 minutes

Fig. 137  Showing the effect of high dose of X-ray radiation on spermatogonia of *Raphidopalpa foveicollis*. Cell boundaries are obliterated and distorted. Shrunken cells are seen and are not so clear, their cytoplasm and chromatin material identify separately.
Squash preparation
Acetocarmine stain

\[X\text{-Ray} = 65 \, K_y - 80 \, \text{MAS (at 160 station)} \, 100 \, \text{cms distance between tube and object}\]

Fig. 138  Showing the effect of high dose of X-ray radiation on spermatogonia of *Alphitobius diaperinus*. Shrunken cells are seen.
Squash preparation
Acetocarmine stain

\[X\text{-Ray} = 65 \, K_y - 80 \, \text{MAS (at 160 station)} \, 100 \, \text{cms distance between tube and object}\]

Fig. 139  Showing the effect of high dose of X-ray radiation on spermatogonia of *Hoplocerambyx spinicornis*. Shrunken cells are seen and chromatin material condensed and indistinct.
Histological preparation
Haemotoxylin stain

\[X\text{-Ray} = 65 \, K_y - 80 \, \text{MAS (at 160 station)} \, 100 \, \text{cms distance between tube and object}\]
Fig. 140  Showing the effect of high dose (5 rads) of CO.\textsuperscript{60} radiation on spermatogonia of \textit{Raphidopalpa foveicollis}. Cell chromosome become abnormal in shape. Squash preparation Acetocarmine stain

Fig. 141  Showing the effect of high dose (5 rads) of CO.\textsuperscript{60} radiation on spermatogonia of \textit{Alphitobius diaperinus}. Cell chromosomes become abnormal in shape. Squash preparation Acetocarmine stain

Fig. 142  Showing the effect of high dose (5 rads) of CO.\textsuperscript{60} radiation on spermatogonia of \textit{Hoplocerambux spinicornis}. The size of the germ cells and nuclei become shinkage. The cell boundaries obliterated and distorted follicles showed damaged. Fused vacuoles are seen. Histological preparation Haemotoxylin stain

Fig. 143  Showing the Primary spermatocytes of \textit{Raphidopalpa foveicollis}. Squash preparation Acetocarmine stain
Fig. 144  Showing the Primary spermatocytes of *Alphitobius diaperinus* (Control).
Squash preparation
Acetocarmine stain

Fig. 145  Showing the Primary spermatocytes of *Hoplocerambyx spinicornis* (Control).
Histological preparation
Haemotoxylin stain

Fig. 146  Showing the effect of low dose of Ultra-violet radiation on primary spermatocytes *Raphidopalpa foveicollis*. No remarkable changes are seen.
Squash preparation
Acetocarmine stain

Ultra-violet = \( \frac{G-15T8}{15 W} \) for 20 minutes

Fig. 147  Showing the effect of low dose of Ultra-violet radiation on primary spermatocytes of *Alphitobius diaperinus*. No remarkable changes are seen.
Squash preparation
Acetocarmine stain

Ultra-violet = \( \frac{G-15T8}{15 W} \) for 20 minutes

1000 X

10 X 45

1000 X
Fig. 148  Showing the effect of low dose of Ultra-violet radiation on primary spermatocytes of *Hoplocerambyx spinicornis*. No changes are seen. Histological preparation 10 X 45
Haemotoxylin stain

Ultra-violet = \( \frac{G-15T8}{15\, W} \) for 20 minutes

Fig. 149  Showing the effect of low dose of X-ray radiation on primary spermatocytes of *Raphidopalpa toveicolli*. No remarkable changes are observed. Squash preparation 1000 X
Acetocarmine stain

X-Ray = 60 kV - 80 MAS (at 160 station) 100 cms
distance between tube and object

Fig. 150  Showing the effect of low dose of X-ray radiation on primary spermatocytes *Alphitobius diaperinus*. Shrunken cells are seen. Squash preparation 1000 X
Acetocarmine stain

X-Ray = 60 kV - 80 MAS (at 160 station) 100 cms
distance between tube and object

Fig. 151  Showing the effect of low dose of X-ray radiation on primary spermatocytes of *Hoplocerambyx spinicornis*. No changes are seen. Histological preparation 10 x 45
Haemotoxylin stain

X-Ray = 60 kV - 80 MAS (at 160 station) 100 cms
distance between tube and object
Fig. 152  Showing the effect of low dose (3 rads) of CO$^{60}$ radiation on primary spermatocytes of *Raphidopalpa foveicollis* condensed and pyknotic cells are seen. Squash preparation Acetocarmine stain

1000 X

Fig. 153  Showing the effect of low dose (3 rads) of CO$^{60}$ radiation on primary spermatocytes of *Alphitobius diaperinus*. Degenerated chromatin material is seen. Squash preparation Acetocarmine stain

1000 X

Fig. 154  Showing the effect of low dose (3 rads) of CO$^{60}$ radiation on primary spermatocytes *Hoplocerambyx spinicornis*. No remarkable changes are seen. Squash preparation Acetocarmine stain

10 X 45

Fig. 155  Showing the effect of high dose of Ultra-violet radiation on primary spermatocytes of *Raphidopalpa foveicollis*. In some cells reduce vacuoles are found. Squash preparation Acetocarmine stain

Ultra-violet = $\frac{\text{G-15T8}}{15 \text{ W}}$ for 30 minutes

1000 X
Fig. 156  Showing the effect of high dose of Ultra-violet radiation on primary spermatocytes of *Alphitobius diaperinus*. No remarkable changes are seen. Squash preparation Acetocarmine stain

\[
\text{Ultra-violet} = \frac{G-15T8}{15 W} \text{ for 30 minutes}
\]

Fig. 157  Showing the effect of high dose of Ultra-violet radiation on primary spermatocytes of *Hoploceramblyx spinicornis*. No remarkable changes are seen. Histological preparation Haemotoxylin stain

\[
\text{Ultra-violet} = \frac{G-15T8}{15 W} \text{ for 30 minutes}
\]

Fig. 158  Showing the effect of high dose of X-ray radiation on primary spermatocytes of *Raphidopalpa foveicollis*. Some shrunken Cells are seen. Squash preparation Acetocarmine stain

\[
\text{X- Ray} = 65 K_{0} - 80 \text{ MAS (at 160 station) 100 cms distance between tube and object}
\]

Fig. 159  Showing the effect of high dose of X-ray radiation on primary spermatocytes of *Alphitobius diaperinus*. The size of cells and nuclei become shrinkage. Squash preparation Acetocarmine stain

\[
\text{X- Ray} = 65 K_{0} - 80 \text{ MAS (at 160 station) 100 cms distance between tube and object}
\]
Fig. 160  Showing the effect of high dose of X-ray radiation on primary spermatocytes of *Hoplocerambyx spinicornis*. Some shrunken cells are seen.
Histological preparation
Haemotoxylin stain

X-ray = 65 Kγ - 80 MAS (at 160 station) 100 cms
distance between tube and object

Fig. 161  Showing the effect of high dose (5 rads) of CO.\textsuperscript{60} radiation on primary spermatocytes of *Raphidopalpa foveicollis* shrunken cells, chromatin material degenerated and condensed, clumped metaphase, disturbed pachytene stage, necrotic cells and smaller follicles are seen.
Squash preparation
Acetocarmine stain

Fig. 162  Showing the effect of high dose (5 rads) of CO.\textsuperscript{60} radiation on primary spermatocytes of *Alphitobius diaperinus*. Indistinct, necrotic cells and chromatin material not seen clearly.
Squash preparation
Acetocarmine stain

Fig. 163  Showing the effect of high dose (5 rads) of CO.\textsuperscript{90} radiation on primary spermatocytes of *Hoplocerambyx spinicornis*. Condensed chromatin material is seen
Histological preparation
Haemotoxylin stain
Fig. 164  Showing the secondary spermatocytes of *Raphidopalpa foveicollis*  
(Control)  
Squash preparation  
Acetocarmine stain

Fig. 165  Showing the secondary spermatocytes of *Alphitobius diaperinus*  
(Control)  
Squash preparation  
Acetocarmine stain

Fig. 166  Showing the secondary spermatocytes of *Hoplocerambyx spinicornis* (Control)  
Histological preparation  
Haematoxylin stain

Fig. 167  Showing the effect of low dose of Ultra-violet radiation on secondary  
on secondary spermatocytes of *Raphidopalpa foveicollis*. No remarkable changes are seen.  
Squash preparation  
Acetocarmine stain

Ultra-violet = \( \frac{G-15T8}{15\text{ W}} \) for 20 minutes
Fig. 168  Showing the effect of low dose of Ultra-violet radiation on secondary spermatocytes of *Alphitobius diaperinus*. No remarkable changes are seen. Squash preparation Acetocarmine stain

\[
\text{Ultra-violet} = \frac{G-15T8}{15 W} \text{ for 20 minutes}
\]

Fig. 169  Showing the effect of low dose of Ultra-violet radiation on secondary spermatocytes of *Hoplocerambyx spinicornis*. No remarkable changes are seen. Microtomical preparation Haemotoxylin stain

\[
\text{Ultra-violet} = \frac{G-15T8}{15 W} \text{ for 20 minutes}
\]

Fig. 170  Showing the effect of low dose of X-ray radiation on secondary spermatocytes of *Raphidopalpa foveicollis*. The morphology of the cells affected, difficult to identify. Their chromatin material condensed. Squash preparation Acetocarmine stain

\[
\text{X-Ray} = 60 K\gamma - 80 \text{ MAS (at 160 station) 100 cms distance between tube and object}
\]

Fig. 171  Showing the effect of low dose of X-ray radiation on secondary spermatocytes of *Alphitobius diaperinus*. Condensed chromatin material seen. Squash preparation Acetocarmine stain

\[
\text{X-Ray} = 60 K\gamma - 80 \text{ MAS (at 160 station) 100 cms distance between tube and object}
\]
Fig. 172  Showing the effect of low dose of X-ray radiation on secondary spermatocytes of *Hoplocerambyx spinicornis* cells with condensed chromatin material seen.  
Histological preparation  
Haemotoxylin stain  

\[ X-\text{Ray} = 60 \text{ K}_\nu \times 80 \text{ MAS (at 160 station) 100 cms} \]

distance between tube and object

Fig. 173  Showing the effect of low dose (3 rads) of CO\(^{60}\) radiation on secondary spermatocytes of *Raphidopalpa foveicollis*. Nuclei of the cells deeply stained the vacuoles reduced, showing the degenerated chromatin material and necrotic cells therefore cytoplasm and nuclear material is difficult to distinguish from one to another.  
Squash preparation  
Acetocarmine stain

Fig. 174  Showing the effect of low dose (3 rads) of CO\(^{60}\) radiation on secondary spermatocytes of *Alphitobius diaperinus*. Some cells showing distortion and pyknotic effect.  
Squash preparation  
Acetocarmine stain

Fig. 175  Showing the effect of low dose (3 rads) of CO\(^{60}\) radiation on secondary spermatocytes of *Hoplocerambyx spinicornis*. Shrunken cells are seen.  
Histological preparation  
Haemotoxylin stain
Fig. 176  Showing the effect of high dose of Ultra-violet radiation on secondary spermatocytes of *Raphidopalpa foveicollis*. Vacuoles are somewhat reduced and not clear. Size of the follicles affected. 1000 X
Squash preparation
Acetocarmine stain

Ultra-violet = \( \frac{G-15T8}{15W} \) for 30 minutes

Fig. 177  Showing the effect of high dose of Ultra-violet radiation on secondary spermatocytes of *Alphitobius diaperinus*. Chromatin material has been condensed at the inner margin of the nuclear membrane. 1000 X
Squash preparation
Acetocarmine stain

Ultra-violet = \( \frac{G-15T8}{15W} \) for 30 minutes

Fig. 178  Showing the effect of high dose of Ultra-violet radiation on secondary spermatocytes of *Hoplocerambyx spinicornis*. Chromatin material condensed. 10 X 45
Histological preparation
Haemotoxylin stain

Ultra-violet = \( \frac{G-15T8}{15W} \) for 30 minutes

Fig. 179  Showing the effect of high dose of X-ray radiation on secondary spermatocytes of *Raphidopalpa foveicollis*. Morphology and morphometry of the cells affected. They become indistinct, pyknotic and condensed. 1000 X
Squash preparation
Acetocarmine stain

X-Ray = 65 Kv - 80 MAS (at 160 station) 100 cms distance between tube and object
Fig. 180 Showing the effect of high dose of X-ray radiation on secondary spermatocytes of *Alphitobius diaperinus*. Some cells become necrotic and therefore cytoplasm and nuclear material difficult to identify separately. Vacuoles reduced. 1000 X
Squash preparation
Acetocarmine stain

X-Ray = 65 K - 80 MAS (at 160 station) 100 cms
distance between tube and object

Fig. 181 Showing the effect of high dose of X-ray radiation on secondary spermatocytes of *Hoplocerambyx spicicornis*. They showed distortion effect and chromatin material condensed. 10 X 45
Histological preparation
Haemotoxylin stain

X-Ray = 65 K - 80 MAS (at 160 station) 100 cms
distance between tube and object

Fig. 182 Showing the effect of high dose (5 rads) of CO$_{60}$ radiation on secondary spermatocytes of *Raphidopalpa foveicollis*. The morphology of the cells changed, pyknotic and necrotic cells are seen, not easy to identify cytoplasm and nuclear material. 1000 X
Squash preparation
Acetocarmine stain

Fig. 183 Showing the effect of high dose (5 rads) of CO$_{60}$ radiation on secondary spermatocytes of *Alphitobius diaperinus* of the morphology of cells changed. Pyknotic and necrotic cells are seen, not easy to identify cytoplasm and nuclear material. 1000 X
Squash preparation
Acetocarmine stain
Fig. 184  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on secondary spermatocytes of *Hoplocerambyx spinicornis* cells showed necrotic effect.
Histological preparation
Haemotoxylin stain

10 X  45

Fig. 185  Showing the spermatids of *Raphidopalpa foveicollis* (Control)
Squash preparation
Acetocarmine stain

1000 X

Fig. 186  Showing the spermatids of *Alphitobius diaperinus* (Control)
Squash preparation
Acetocarmine stain

1000 X

Fig. 187  Showing the spermatids of *Hoplocerambyx spinicornis* (Control)
Squash preparation
Acetocarmine stain

1000 X
Fig. 188  Showing the effect of low dose of Ultra-violet radiation on spermatids of *Raphidopalpa foveicollis*. No remarkable changes are seen.
Squash preparation 1000 X
Acetocarmine stain

\[ \text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 20 minutes} \]

Fig. 189  Showing the effect of low dose of Ultra-violet radiation on spermatids of *Alphitobius diaperinus*. No remarkable changes are seen.
Squash preparation 1000 X
Acetocarmine stain

\[ \text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 20 minutes} \]

Fig. 190  Showing the effect of low dose of Ultra-violet radiation on spermatids of *Hoplocerambyx spinicornis*. No remarkable changes are observed.
Histological preparation 10 X 45
Haemotoxylin stain

\[ \text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 20 minutes} \]

Fig. 191  Showing the effect of low dose of X-ray radiation on spermatids of *Raphidopalpa foveicollis*. Shape, size and number of spermatids reduced.
Smear preparation 1000 X
Acetocarmine stain

\[ \text{X-Ray} = 60 \text{ K}_{\gamma} - 80 \text{ MAS (at 160 station)} 100 \text{ cms distance between tube and object} \]
Fig. 192  Showing the effect of low dose of X-ray radiation on spermatids of *Alphitobius diaperinus*. Showing shrunken effect.  
Squash preparation  
Acetocarmine stain

\[ X - \text{Ray} = 60 \text{ K}_\text{v} - 80 \text{ MAS (at 160 station)} \ 100 \text{ cms} \]
\[ \text{distance between tube and object} \]

Fig. 193  Showing the effect of low dose of X-ray radiation on spermatids of *Hoplocerambyx spinicornis*. Showing shrunken effect.  
Squash preparation  
Acetocarmine stain

\[ X - \text{Ray} = 60 \text{ K}_\text{v} - 80 \text{ MAS (at 160 station)} \ 100 \text{ cms} \]
\[ \text{distance between tube and object} \]

Fig. 194  Showing the effect of low dose (3 rads) of CO.\textsuperscript{60} radiation on spermatids of *Raphidopalpa foveicollis*. Spermatids reduced in their shape size and number.  
Squash preparation  
Acetocarmine stain

Fig. 195  Showing the effect of low dose (3 rads) of CO.\textsuperscript{60} radiation on spermatids of *Alphitobius diaperinus*. Elongation of spermatids affected, vacuoles reduced and cells become distorted.  
Squash preparation  
Acetocarmine stain
Fig. 196  Showing the effect of low dose (3 rads) of CO$_{60}$ radiation on spermatids of *Hoplocerambyx spinicornis*. Shows distortion effect.  
Histological preparation  
Haemotoxy stain

Fig. 197  Showing the effect of high dose of Ultra-violet radiation on spermatids of *Raphidopalpa fooveicolli*. No changes are seen.  
Squash preparation  
Acetocarmine stain

Ultra-violet = \(\frac{G-15T8}{15 W}\) for 30 minutes

Fig. 198  Showing the effect of high dose of Ultra-violet radiation on spermatids of *Alphitobius diaperinus*. Showing distortion effect.  
Squash preparation  
Acetocarmine stain

Ultra-violet = \(\frac{G-15T8}{15 W}\) for 30 minutes

Fig. 199  Showing the effect of high dose of Ultra-violet radiation on spermatids of *Hoplocerambyx spinicornis* cells. Reduced vacuoles are seen and elongation affected.  
Histological preparation  
Haemotoxy stain

Ultra-violet = \(\frac{G-15T8}{15 W}\) for 30 minutes
Fig. 200  Showing the effect of high dose of X-ray radiation on spermatids of Raphidopalpa foveicollis. Chromatin material condensed, vacuole disappear, indistinct acrosome and short flagellum seen.
Squash preparation  
Acetocarmine stain  

X- Ray = 65 Kv - 80 MAS (at 160 station) 100 cms 
distance between tube and object

Fig 201  Showing the effect of high dose of X-ray radiation on spermatids of Alphitobius diaperinus. Showing distortion effect and elongation of spermatids affected.
Squash preparation
Acetocarmine stain  

X- Ray = 65 Kv - 80 MAS (at 160 station) 100 cms 
distance between tube and object

Fig. 202  Showing the effect of high dose of X-ray radiation on spermatids of Hoplocerambyx spinicornis. Vacuoles shorter or disappear, indistinct acrosome, flagellum seen very short and cell boundaries become shrunken.
Histological preparation
Haemotoxy stain  

X- Ray = 65 Kv - 80 MAS (at 160 station) 100 cms 
distance between tube and object

Fig. 203  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on spermatids of Raphidopalpa foveicollis. The number and size of the spermatids reduced. Vacuoles are fused abnormally. Some vacuoles become shorter or disappear.
Squash preparation
Acetocarmine stain

1000 X
Fig. 204  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on spermatids of *Alphitobius diaperinus*. Elongation of spermatids cease, distorted cells are seen. Squash preparation Acetocarmine stain

Fig. 205  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on spermatids of *Hoplocerambyx spinicornis*. Nucleus become indistinct and distorted cells are seen. Squash preparation Acetocarmine stain

Fig. 206  Showing the sperms of *Raphidopalpa foveicollis* (control) Squash preparation Acetocarmine stain

Fig. 207  Showing the sperms of *Alphitobius diaperinus* (control) Squash preparation Acetocarmine stain
Fig. 208  
Showing the sperms of *Hoplocerambyx spinicornis* (control)  
Squash preparation  1000 X  
Acetocarmine stain

Fig. 209  
Showing the effect of low dose of Ultra-violet radiation on sperms of *Raphidopalpa foveicollis*. No changes are observed.  
Squash preparation  1000 X  
Acetocarmine stain

Ultra-violet = \( \frac{G-15T8}{15\ W} \) for 20 minutes

Fig. 210  
Showing the effect of low dose of Ultra-violet radiation on sperms of *Raphidopalpa foveicollis*. No changes are observed.  
Squash preparation  1000 X  
Acetocarmine stain

Ultra-violet = \( \frac{G-15T8}{15\ W} \) for 20 minutes

Fig. 211  
Showing the effect of low dose of Ultra-violet radiation on sperms of *Alphitobius diaperinus*. No remarkable changes are observed.  
Squash preparation  1000 X  
Acetocarmine stain

Ultra-violet = \( \frac{G-15T8}{15\ W} \) for 20 minutes
Fig. 212  Showing the effect of low dose of X-ray radiation on sperms of *Raphidopalpa foveicollis*. Shape, size and number of the sperms decreases. Elongation affected. 1000 X
Squash preparation
Acetocarmine stain

\[ X - \text{Ray} = 60 \, K_v - 80 \, \text{MAS (at 160 station)} \, 100 \, \text{cms} \]
\[ \text{distance between tube and object} \]

Fig. 213  Showing the effect of low dose of X-ray radiation on sperms of *Alphitobius diaperinus*. Shape, size and number of the sperms decreases. Elongation affected. 1000 X
Squash preparation
Acetocarmine stain

\[ X - \text{Ray} = 60 \, K_v - 80 \, \text{MAS (at 160 station)} \, 100 \, \text{cms} \]
\[ \text{distance between tube and object} \]

Fig. 214  Showing the effect of low dose of X-radiation on sperms of *Hoplocerambyx spinicornis*. No effects are seen. 1000 X
Squash preparation
Acetocarmine stain

\[ X - \text{Ray} = 60 \, K_v - 80 \, \text{MAS (at 160 station)} \, 100 \, \text{cms} \]
\[ \text{distance between tube and object} \]

Fig. 215  Showing the effect of low dose (3 rads) of Co\(^{60}\) radiation on sperms of *Raphidopalpa foveicollis*. Shape, size of the sperms reduced, cell boundaries shrunken, sperm bundles are going to Aspermic stage in which the sperm bundles are not found or decreases. 1000 X
Squash preparation
Acetocarmine stain
Fig. 216 Showing the effect of low dose (3 rads) of CO\textsuperscript{60} radiation on sperms of \textit{Alphitobius diaperinus}. Shape, size and number of the sperms reduced, cell boundaries are shrunken.

Squash preparation
Acetocarmine stain

Fig. 217 Showing the effect of low dose (3 rads) of CO\textsuperscript{60} radiation on sperms of \textit{Hoplocerambyx spinicornis}. Indistinct acrosome is seen.

Squash preparation
Acetocarmine stain

Fig. 218 Showing the effect of high dose of Ultra-violet radiation on sperms of \textit{Raphidopalpa foveicollis}. Shape, size and number of sperms reduced.

Squash preparation
Acetocarmine stain

\[ \text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 30 minutes} \]

Fig. 219 Showing the effect of high dose of Ultra-violet radiation on sperms of \textit{Alphitobius diaperinus}. Remarkable changes are found. Showing a reduced vacuole within it. Sperm nucleus still more elongated, condensed and stains deeply.

Squash preparation
Acetocarmine stain

\[ \text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 30 minutes} \]
Fig. 220 Showing the effect of high dose of Ultra-violet radiation on sperms of *Hoplocerambyx spinicornis*. Sperms nucleus become more condensed and indistinct. Histological preparation
Haemotoxylin stain

\[
\text{Ultra-violet} = \frac{G-15T8}{15 \text{ W}} \text{ for 30 minutes}
\]

Fig. 221 Showing the effect of high dose of X-ray radiation on sperms of *Raphidopalpa foveicollis*. They become shrunken, more condensed. An elongation of the sperm nucleus affected. It become pointed at the anterior end and broad at the middle and almost blunt at the posterior end. Acrosome appear as granule near the nuclear membrane. Chromatin material condensed.
Squash preparation
Acetocarmine stain

\[
\text{X- Ray} = 65 K_{\gamma} - 80 \text{ MAS (at 160 station) 100 cms distance between tube and object}
\]

Fig. 222 Showing the effect of high dose of X-ray radiation on sperms of *Alphitobius diaperinus*. Condensed chromatin nuclear material at the inner margin of nuclear membrane, acrosome appears as a granule near the membrane and elongation of sperm nucleus affected.
Squash preparation
Acetocarmine stain

\[
\text{X- Ray} = 65 K_{\gamma} - 80 \text{ MAS (at 160 station) 100 cms distance between tube and object}
\]

Fig. 223 Showing the effect of high dose of X-ray radiation on sperms of *Hoplocerambyx spinicornis*. Shape, size, number and elongation of sperms affected.
Histological preparation
Haemotoxylin stain

\[
\text{X- Ray} = 65 K_{\gamma} - 80 \text{ MAS (at 160 station) 100 cms distance between tube and object}
\]
Fig. 224  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on sperms of *Raphidopalpa foveicollis*. Sperms become more condensed and become indistinct. Vacuoles are totally reduced. Acrosome not clearly seen. Showing aspermia state and stickiness of chromosomes.

Squash preparation  
Acetocarmine stain  1000 X

Fig. 225  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on sperms of *Alphitobius diaperinus*. Most of the sperms become distorted. Shrunken and indistinct vacuole disappear, acrosome not seen clearly. Sperms showing partial. Aspermia state and stickiness of chromosomes, undergoes abnormal mitosis.

Squash preparation  
Acetocarmine stain  1000 X

Fig. 226  Showing the effect of high dose (5 rads) of CO\textsuperscript{60} radiation on sperms of *Hoplocerambyx spinicornis*. Reduced sperms are seen.

Histological preparation  
Haemotoxylin stain  1000 X