Figure 10: Infrared spectrum of hemolymph free amino acids in control and treated insects.
Figure 18: A. Photograph of male *I. limbata*, with external genitalia (EG). B. Light micrograph showing the position of reproductive system in the abdominal cavity and the abdominal segment (AS) of insect. C. The whole reproductive system of *I. limbata* with testes (T), seminal vesicles (SV), vasa deferentia (VD), paired accessory glands (PAG), unpaired accessory gland (UAG) and an ejaculatory duct (ED) (before fixing and staining). D. Reproductive system stained with eosin.
Figure 19: Diagram of the male genital apparatus of *L. limbata*, dorsal view. The paired testes (T) with 7 testes follicles (TF) joined to paired vasa deferentia (VD) with seminal vesicles (SV). The vasa deferentia in the distal region shows adhering paired accessory glands (PAG), the mesadenes, with lobules filled with secretions. The vasa deferentia empty into the sperm duct (SD). The wall of the sperm duct consists of cuticular intima and is surrounded by erection fluid (EF) which has no access to the genital ducts. The erection fluid reservoir (EFR) lies above the unpaired accessory gland (UAG). Scale bar = 100 μm.
Figure 21: Enlarged view of the portions of male reproductive system of *L. limbata*. **A.** Testis (T), seminal vesicle (SV) and vas deferens (VD). **B.** Vas deferens with vesicular paired accessory glands (PAG) and an unpaired accessory gland (UAG). **C.** The unpaired accessory gland which continues into the sperm duct or ejaculatory duct (ED). **D.** The wall of the ejaculatory duct consists of cuticular intima (CI) and externally erection fluid reservoir (EFR). Scale bars: A-C = 30 μm, D = 20 μm.
Figure 21: Unstained phase contrast photomicrographs of sex cells in different stages of development in the testes. A-B. Testis showing zones of sex cell differentiation. C. Elongating spermatocytes (SC) and immature sperm bundle. D. The late stage of spermatids (ST) showing tail region (arrow). E. Spindle-shaped cyst with broad central region. F. Spermatogonial (SGC) and spermatocyte cysts (SCC), and mature sperm bundle (MSB). Moving spermatozoa which were partially separated from the bundle (SB). Scale bars = 10 μm.
Figure 23: The light micrographs of different regions of male reproductive system. 

A. The L.S of testis filled with germ cells in anterior region with spermatogonia (SG), spermatocytes (SC), spermatids (ST) and spermatozoa (SZ) towards the posterior region. 

B. C.S of vasa deferentia filled with spermatozoa. 

C. T.S of the vas deferentia showing epithelial cells (EC) and internally filled with spermatozoa. 

D. The C.S of paired (PAG) and unpaired (UAG) accessory gland. Sections were stained with eosin/hematoxyline. Scale bars = 30 μm; C = 20 μm.
Figure 24: Semi-thin sections of testes. A-B. T.S. of testis showing spermatogonial cyst (SGC), spermatocyte cyst (SCC), spermatid cyst (STC) and spermatozoa (SZ), which is covered by basement membrane (BM). C. T.S. of the testis of treated insects showing no visible change. D. L.S. of the testis showing follicular epithelium (FL) separates the germ cells and an outer covering of tunica externa (Te). Sections were stained with toludene blue. Scale bars = 10 μm.
Figure 25: A. The C.S. of unpaired accessory gland (UAG). The erection fluid reservoir (EFR) lies above the unpaired accessory gland. The secretion of the unpaired accessory gland is released in to the glandular lumen (LAG). The epithelial cells showing nucleus (N). B. The lobules (L) of paired accessory gland (PAG) showing dense secretions. C. The T.S. of unpaired accessory gland showing secretions in the centre. The secretion (S) of the unpaired accessory gland is released in to the glandular lumen which continues into the sperm duct or ejaculatory duct (SD). D. The C.S. of the sperm duct (SD) with spermatozoa (arrow) showing cuticular intima and is surrounded by erection fluid (EF). Sections were stained with eosin/hematoxyline. Scale bars: A-B = 20 μm; C-D = 30 μm.
Figure 26: Semi-thin sections of mesadenes. A-B. Semi-thin section of mesadenes showing lobules filled with secretions with outer epithelial cell (EC) with nucleus (N). C. Section of mesadenes showing secretions (S) in the lobules and the lumen (Lu) of the vas deference (VD). D. The section of mesadenes of treated insect showing no visible change. E. Lobule of mesadenes secretions and outer secretory epithelial cells. F. Lobule of the treated insect mesadenes showing large number of vacuoles (V) in the outer secretory epithelial cells and enlarged nucleus. Sections were stained with toludene blue. Scale bars = 10 μm.
Figure 27: The germ cells in the testes. **A.** Section of the testis showing spermatocyte cyst (SCC) with spermatocytes connected with cytoplasmic bridges. **B.** Treated insect testis showing spermatocyte cyst with small cytoplasmic vacuoles (arrows) and early spermatid (ST). **C.** Meiotic division of spermatogonia showing stages of cell division, cells in metaphase, alignment of chromosomes (C) in the same plane (arrows). **D.** Meiotic division of spermatogonia of treated insect with no observable difference. **E.** Spermatocytes (SZ) of testis in the distal region. **F.** Spermatocytes of testis showing clumped sperm heads (arrows) in the treated insect. Sections were stained with eosin/hematoxylin. Scale bars = 20 μm.
Figure 28: Semi-thin section of testis. A. Early spermatid cyst with compact arrangement. B. The treated insect showing loose arrangement of spermatid in the testis. C. Mitotic prophase of spermatogonial cell with well formed polygonal nuclei (arrows). D. Prophase spermatogonial cells, ring formation and broken ring formation (C-shaped) (arrows). E. The testis wall with tunica externa (Te), tunica interna (Ti) and clearly visible nuclei (N) and long spermatozoa (SZ) with conical shaped head. F. Wall of testis of treated insect showing vacuoles and become reduced in size, and the nucleus not clearly visible. Sections were stained with toludene blue. Scale bars = 10 μm.
**Figure 29:** Semi-thin sections of testes. A. Differentiation of spermatocytes into early spermatids (small cyst) and late spermatids (ST) with large number of cells. B. Elongated spermatid cyst showing spherical nuclei. C. The vas efferens showing unbundled spermatozoa with slightly prominent head region (arrow) and long tail region. D. Treated insect showing clumped spermatozoa in the vas efferens. Sections were stained with toludene blue. Scale bars = 10 µm.
Figure 30: Ultrastructure of mesadenes. A. Muscle layer (ML) and basement membrane (BM) surround the secretory epithelium of the paired accessory gland. The secretory cells contain scattered mitochondria (M). B. Newly formed secretory vesicles (SV) of secretory cell with dense irregular plaques are scattered at the surface of the vesicle. C. The apical edge of the secretory cells of AG showing tracheoles (Tr). The secretory granules (SG) are packed tightly in the apical region. D. The tracheoles with cuticle in the secretory cell. Scale bars = 0.5 μm.
Figure 31: A. The tracheoles (Tr) in the mesadenes of normal insect. B. Tracheoles in the mesadenes of treated insect. C. The basal region of the mesadenes showing abundant mitochondria (M) in normal insect. D. The basal region of the secretory cells showing vacuoles (arrows) in the treated insect. Scale bars = 0.5 μm.
Figure 32: A. The secretory cells of mesadenes showing dense nucleus (N) with distinct nuclear membrane (NM) in the normal insect. B. The nucleoplasm appear more dissociated or condensed with slight obliterations in treated mesadenes cell nucleus. Scale bars = 0.5 μm.
Figure 33: Transverse section of testes wall. A. Testis wall of normal insect showing 2 layers of testis, Te-Tunica externa, structureless envelope and Ti-Tunica interna with presumptive mitochondria (PrM). The testis is internally filled with spermatozoa showing axoneme (Ax) and mitochondrial derivative (Md). B. Transverse section of testis wall of treated insect showing degradation of tunica interna with large vacuoles (V) and lipid droplets (Ld). Scale bars = 0.5 μm.
Figure 34: Scanning electron micrographs of spermatozoa in the vasa deferentia. A. spermatozoa of normal insect. B. spermatozoa of treated insect.
Figure 35: A. Scanning electron micrograph of spermatozoa in the vasa deferentia of normal insect showing triangle shaped head and long tail (arrows). B. Spermatozoa of treated insect with no visible difference.
Figure 36: A. Scanning electron micrograph of spermatozoa in the vasa deferentia showing biflagellarity (arrow). B. Spermatozoa of treated insect with no visible difference.
Figure 37: Different stages of spermatogenesis. A. Early stages of spermatogenesis with a large spherical nucleus (N) and proctosac (PV). B. Acrosomal vacuole (AV) on anterior pole of bean shaped nucleus of spermatid. Two axonemes (arrow) are visible in the C.S. of spermatid. C. Horse shoe shaped acrosome cap in the posterior region of late spermatid, large round nucleus, centriole adjucle (CA), an axonemal (Ax) and mitochondrial basis (Md), which migrates into an indentation at the posterior pole of the nucleus and the nuclear surface with unique arrangements. D. Treated insect with vacuoles towards the posterior region (arrows). E. Elongation of spermatid during spermiogenesis, chromatin condensation, the elongation of nucleus and acrosomal vacuole during spermiogenesis. F. Elongated spermatozoon (SZ) with cylindrical shape. Scale bars = 0.5 μm.
Figure 38: A. Longitudinal section of the spermatid in the testis. B. C.S. of the sperm showing mitochondrial derivative (Md) and axoneme (Ax). C-D. L.S of the treated insect spermatozoa with large number of vacuoles (small arrows) and lipid droplets (large arrows), the fish bone like pattern of mitochondrial (Md) crystalline material is visible. E. Presence of crescent shaped mitochondrial derivative with axoneme in the centre portion of normal insect sperm. F. The C.S of the sperm showing large number of vacuoles (small arrows) and lipid droplets (large arrows) in the outer most matrix of treated insect. The two axonemes (biflagellarity, BF) are clearly visible. Scale bars = 1.0 μm.
Figure 39: A. L.S. of the posterior region of spermatozoa with mitochondrial derivative (Md) with crystallisation (arrow), axoneme (Ax) and sperm surface (S). B. C.S. of sperm showing crescent shaped mitochondrial derivative (mirror image) and axoneme of 9+9+2 organisation. C. L.S. of tail region towards the posterior of the sperm showing two axoneme (small arrows). D. C.S. of the sperm showing cross bridge between axoneme and mitochondrial derivatives. Notice the cross bridge (arrow). Scale bars = 0.25 μm.
Figure 40: Ultrastructure of head region of spermatozoa. A. L.S. of sperm showing mitochondrial derivative (Md) and axoneme (Ax). B. L.S. of spermatozoa of treated insect with vacuoles in the outer surface (arrows). C. C.S. of the sperm head showing tubular thick ring shaped acrosome vacuole (AC), round nucleus (N), axoneme and two mitochondrial derivative in the normal insect. D. Round nucleus, mitochondrial derivatives and clearly visible axoneme of spermatozoa in the normal insect. Scale bars = 1.0 μm.