

Research Article

## Description of Reproductive System of Indian Water Scorpion, *Laccotrephes maculatus* Fabr. (Hemiptera, Heteroptera: Nepidae)

Babita Khandelwal, Y.C. Gupta and Kanhiya Mahour<sup>1\*</sup>

Department of Zoology, BSA Collage, Mathura-281004, U.P., India.

Experimental Laboratory, Department of Zoology, R.P.P.G. College, Kamalganj, Farrukhabad-209724, U.P., India.

**Abstract:** Water scorpion, *Laccotrephes maculatus* Fabr. is unisexual and exhibits sexual dimorphism. The males are relatively smaller with conspicuous connexival spines and possess distinct external genitalia. The male reproductive organs include a pair of testis, a pair of vasa deferentia, a pair of vesicula seminalis, two pairs of accessory glands and unpaired median ductus ejaculatorious. The female reproductive organs possess a pair of ovaries, a pair of lateral oviducts, a common oviductus communis, a vagina and the spermatheca.

**Keywords:** Testis, Vas efferens, Seminal vesicle, Ductus ejaculatorius, Ovaries, Ovarioles, Terminal filament.

### 1. Introduction

The *Laccotrephes maculatus* Fabr. is most commonly distributed water scorpion in India. They swim below the surface of water and are easily recognized by the shape of their body and their long respiratory filaments. The sexes are separate. The males are smaller in size than the females with distinct connexival spines.

The contribution on the reproductive organs in Heteroptera is mainly due to the studies of Bordas (1905), Hewitt (1906), Rawat (1939), Woodward (1949, 1950), Gupta (1951), Carayon (1950, 1951), Bonhag and Wick (1953), Pendergrast (1957), Khanna (1965), Kaushik (1970), Choi and Lee (1972) etc. *Laccotrephes maculatus* Fabr. is though, common in Indian water but has not been studied for their reproductive organs. The present study first gives a detailed overview of the reproductive system of *Laccotrephes maculatus* Fabr.

### 2. Material and Methods

The water scorpion, *Laccotrephes maculatus* for the present investigation were collected during the month of July to November from various ditches, ponds etc. from district Mathura, Uttar Pradesh. These bugs were killed by chloroform vapours and fixed in Bouin's fluid for about 24 hours and washed through several changes of 70% alcohol with a few drops of glycerine.

Dissections of the specimens were made to study the reproductive organs.


### 3. The male reproductive system (Pl. I & II)

The male reproductive organs consist of a pair of testis, a pair of vasa deferentia, a pair of vesicula seminalis, two pairs of accessory glands and unpaired median ductus ejaculatorious.

#### 3.1 Testis

There is a pair of small oval whitish sac-like testis (TE) lying dorsolaterally one on either side in the third abdominal segment. The testis (TE) are held in their position by a large number of fine tracheal branches which ramify over them. Each testis consists of five long, narrow and highly convoluted testis follicles (TEF), enclosed within a common membranous follicular sheath.

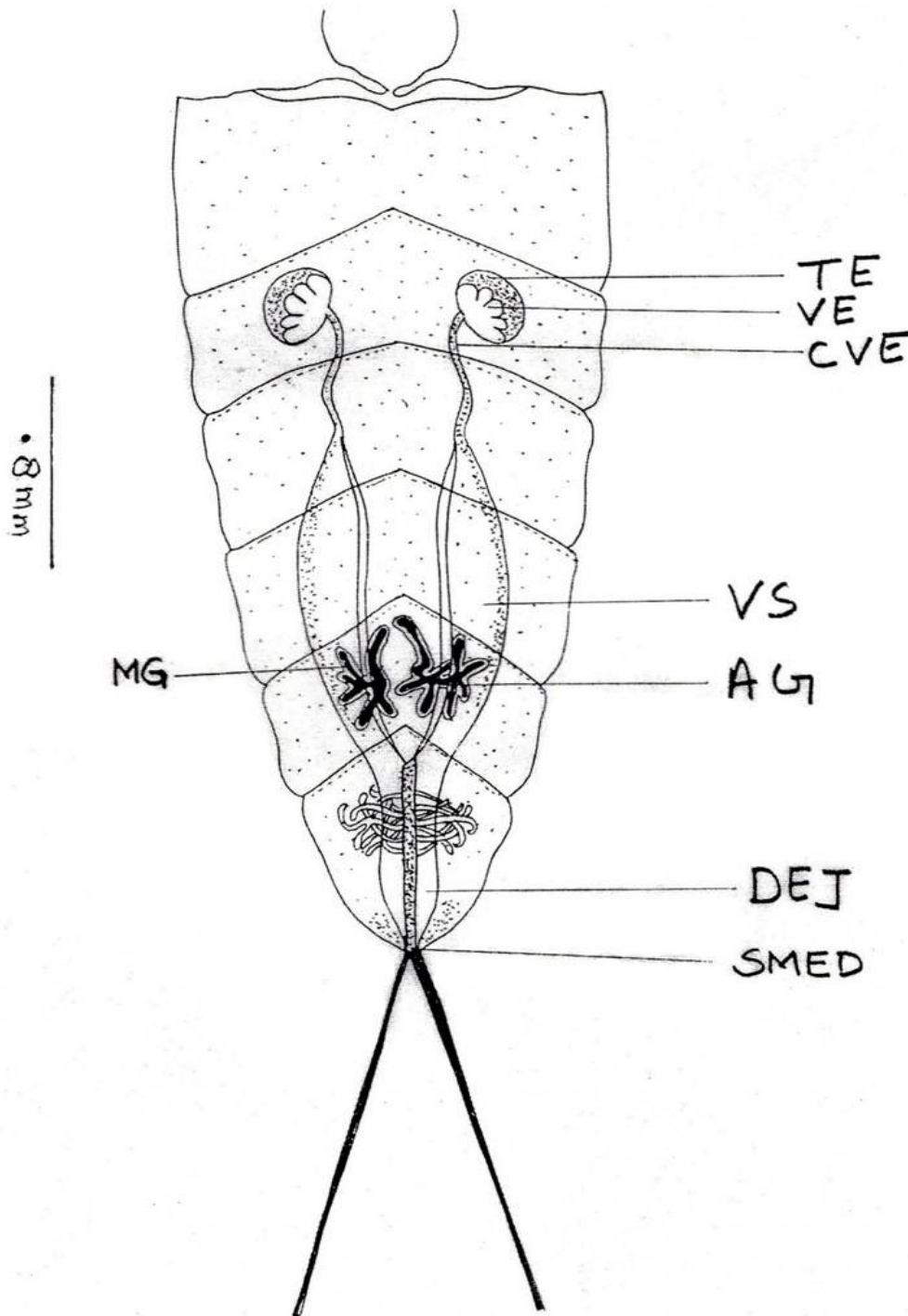
The number of testis follicles or sperm tubes varies in Heteroptera. According to Woodward (1949), Carayon (1950), Pendergrast (1957), Qadri (1949) and Akbar (1958), 4-7 testis follicles have been reported in each testis. In aquatic Heteroptera such as *Belostoma*, *Nepa*, *Sphaerodema* and *Ranatra*, five testis follicles or sperm tubes in each testis have been described by Locy (1884), Hamilton (1931), Presswalla and George (1935) respectively. Water scorpion, *Laccotrephes* Fabr. also has five testis follicles in each testis, confirming a uniformity in their number in aquatic Heteroptera. The

\*Corresponding Author: Dr. Kanhiya Mahour  0000-0001-7059-6274.  
E-mail: kris\_mathura@yahoo.com.  
Phone No.: +91-9412404655.

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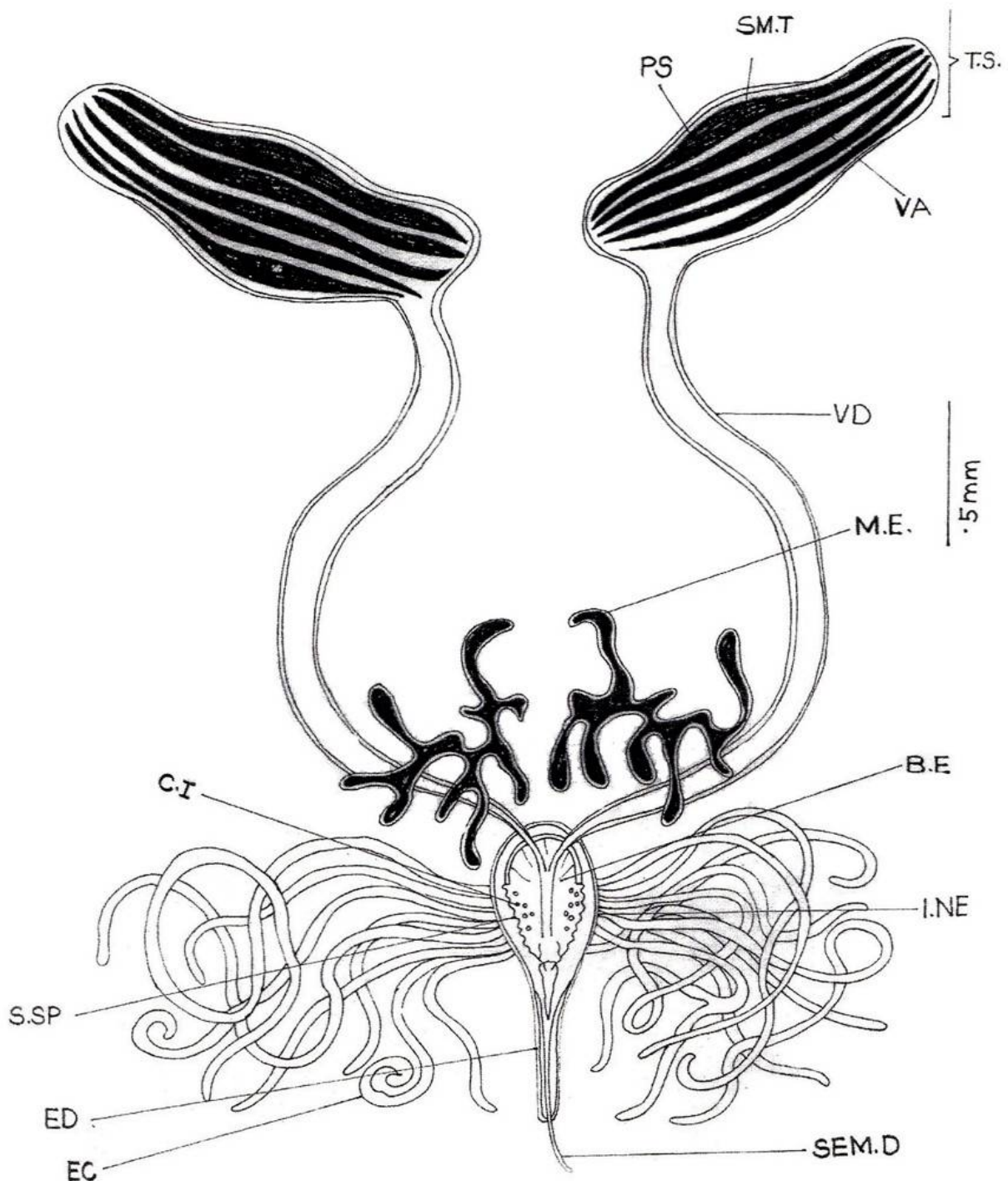
coils of the sperm tubes are so intimate that the whole testis looks like a rounded mass of intermingled and entangled thin tubes. The entire testicular mass is enclosed within a thin peritoneal sheath. Each sperm tube opens into a vasa efferens (VE). All the five vasa

efferentia join to form a common duct the vasa deferens (VD). Each sperm tube terminally coiled in a highly complicated manner on the periphery of the testis to look like a glomerulus. The terminal blind ends of the sperm tubes are relatively somewhat wider.



**Plate 1: Male reproductive organs *in situ*, *Laccotrephes maculatus* Fabr.**

Abbreviations: AG - Accessory Gland; CVE - Common vasa efferens; DEJ - Ductus ejaculatory; TE - Testis; VD - Vasa deferens; VE - Vasa efferens; VS - Vesicular seminalis; SEM.D - Seminal duct.



**Plate II: Male reproductive organs, *Laccotrephes maculatus* Fabr.**

Abbreviations: BE - Bulbous ejaculatory; C.I. - Chitinous intima; EC - Ectoderm; E.D. - Ejaculatory duct; I.N.E - Investing epithelium; ME - Mesadene; P.S. - Peritoneal Sheath; SEM.D - Seminal duct; S.M.T - Spermatic tube; S.S.P - Subcuticular space; TS - Testis; VA - Vasa efferens; VD - Vasa deferens.

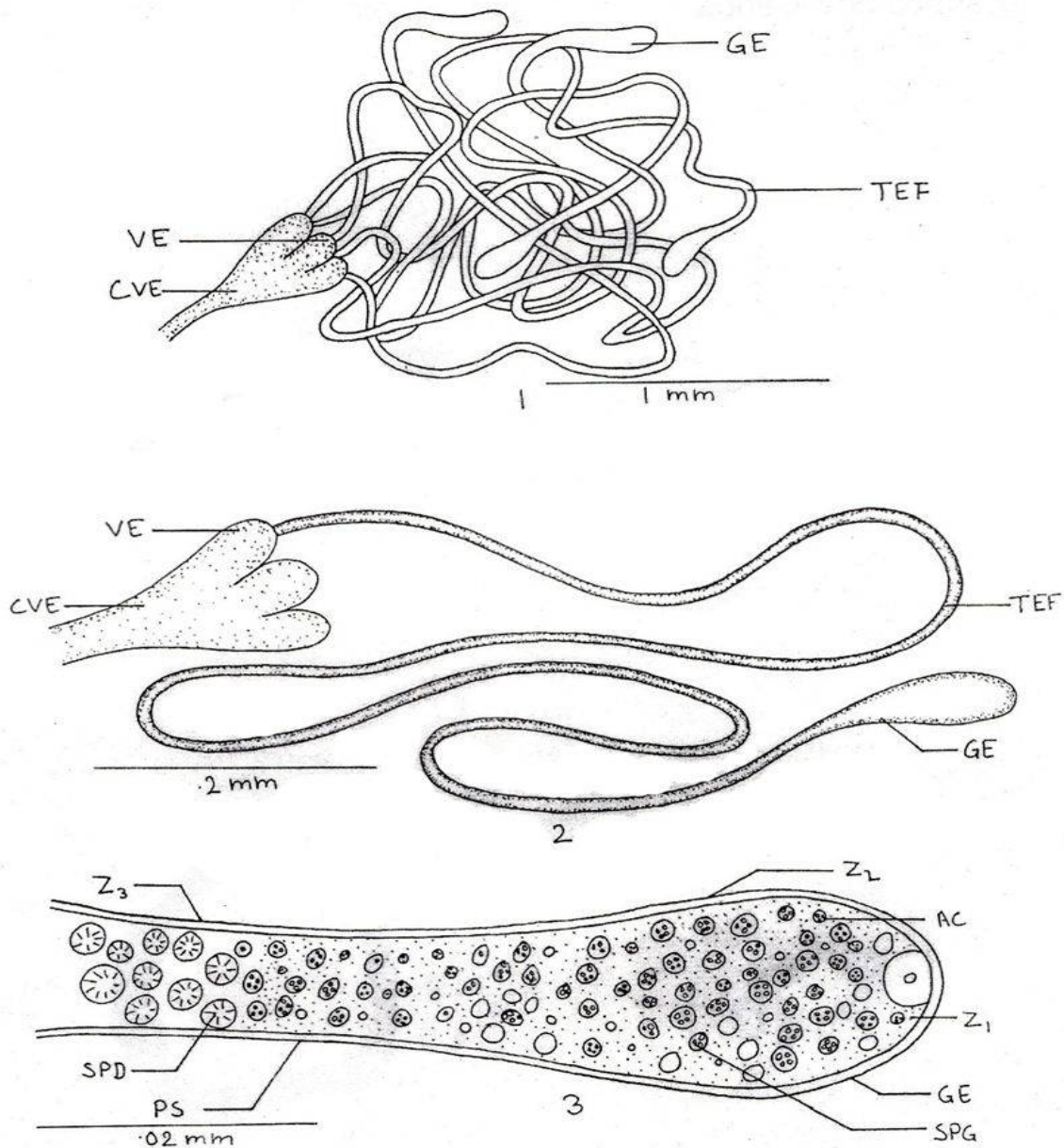
### 3.1.1 Histology (Pl. III, Figs. 1-3; Pl. IV, Fig. 1-5; Pl. V, Fig. 1-4)

The histological studies of the sperm tubes of *Laccotrephes maculatus* Fabr. does not exhibit much differences from the other aquatic Heteroptera. The wider part of the sperm tube is the germarium (GE). It

is followed by three zones viz., zone of growth ( $z_1$ ), zone of maturation ( $z_2$ ), and the zone of transformation ( $z_3$ ). The sperm tubes are enclosed within a thin transparent peritoneal sheath (PS). There are a large number of distinct apical cells (AC) at the blind apical end of the germarium. These apical cells contain

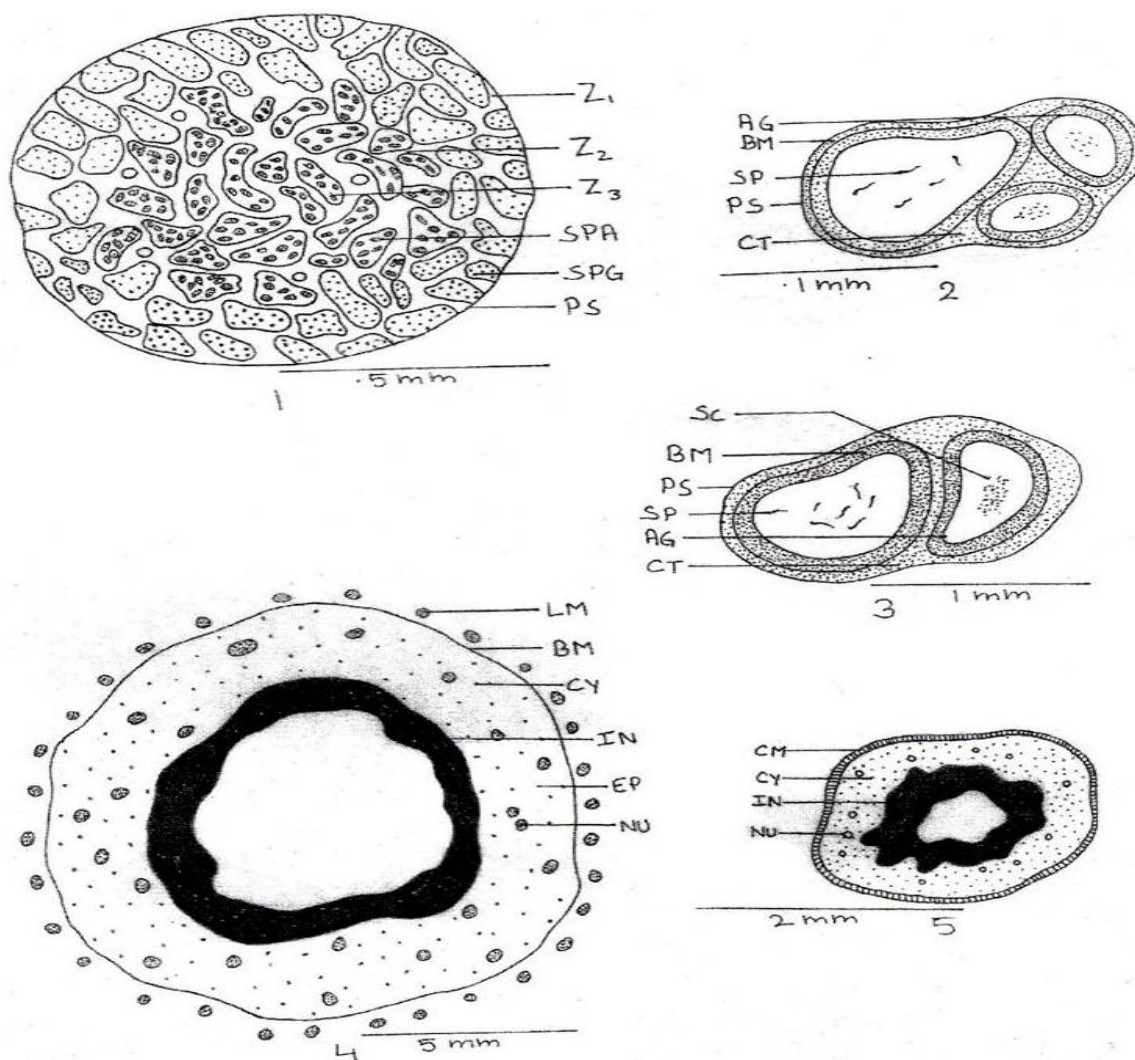
distinctly larger nuclei as compared to that of the surrounding cells, the spermatogonia (SPG). The spermatogonia (SPG) are completely packed up within germarium. Some of the spermatogonia undergo a series of divisions in the zone of growth to form the cysts. The cells within the cyst multiply to form spermatocysts in the maturation zone ( $Z_2$ ). The spermatocysts finally transform into spermatids (SPD) in the zone of transformation ( $Z_3$ ). The spermatids

(SPD) on dissolution of the cyst's wall liberate the spermatozoa (SP) in the posterior part of the testis follicle. The posterior part of the testis follicles is thus always filled with a large number of spermatozoa, arranged in bundles. The heads of the spermatozoa are directed anteriorly and their tails become extremely long and directed posteriorly. Each testis follicle or sperm tube extends backwards for a short distance and then continues as the vasa efferens.



**Plate III: Fig. 1: Testis showing testis follicles. Fig. 2: A single sperm tube or testis follicle. Fig. 3: L.S. of testis**

Abbreviation: AC - Apical cell; CBE - Common vasa efferens; GE - Germarium; PS - Peritoneal Sheath; SPD - Spermatid; SPG - Spermatogonia; TE - Testis; TEF - Testis Follicle; VD - Vasa deferens; VE - Vasa Efferens;  $Z_1$  - Zone of growth;  $Z_2$  - Zone of maturation;  $Z_3$  - Zone of Transformation.



**Plate IV:** Fig. 1: T.S. of testis. Fig. 2: T.S. of distal region of vesicula seminalis. Fig. 3: T.S. of proximal region of vesicula seminalis. Fig. 4: T.S. of spermataeca. Fig. 5: T.S. of Vagina.

Abbreviations: AG - Accessory Gland; BM - Basement membrane; CM - Circular muscle; CT - Connective tissue; CY - Cytoplasm; EP - Epithelium; IN - Intima; LM - Longitudinal Muscle; NU - Nucleus; PS - peritoneal Sheath; SC - Viscid substance; SPD - Spermatid; SPG - Spermatogonia; SP - Spermatozoa; Z<sub>1</sub> - Zone of growth; Z<sub>2</sub> - Zone of maturation; Z<sub>3</sub> - Zone of Transformation.

### 3.2 Vas efferens

From each testis arises five vasa efferentia which after running for a short distance open into a wide vas deferens (VD). Each vas deferens extends backwards from the posterior margin of the third abdominal segment up to the anterior margin of fifth abdominal segment. Each vas deferens (VD) is an elongated narrow tube which widens posteriorly to form the seminal vesicle or vesicula seminalis (VS).

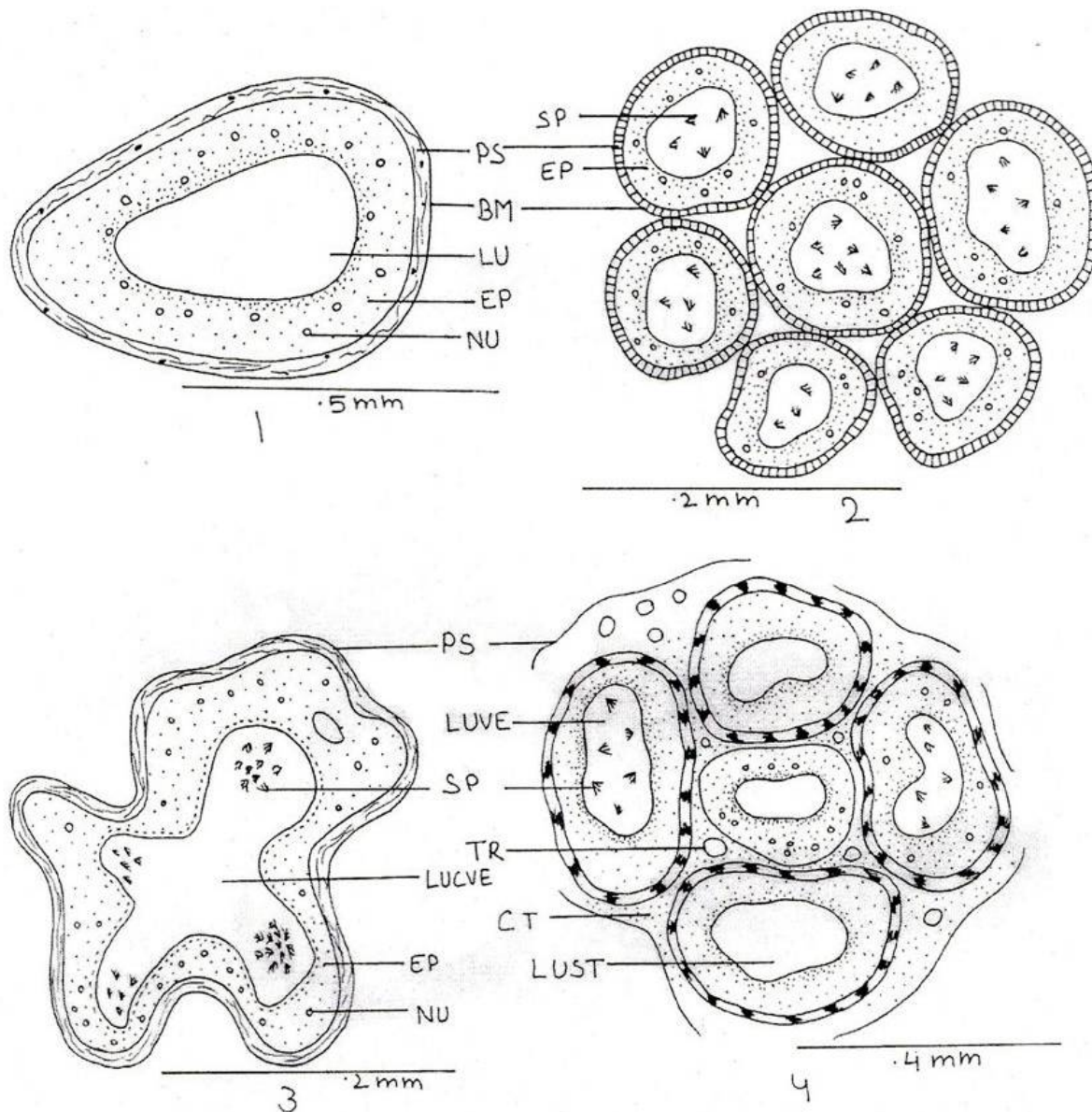
Histologically (Pl. V, Fig. 2), each vas deferens is bounded externally by a thick peritoneal sheath (PS) followed by a thick layer of syncytial epithelium (EP) having undifferentiated cell boundaries and numerous scattered oval nuclei. There is a layer of basement membrane (BM) in between the peritoneum and the epithelium. The epithelium contains numerous coarsely granular cytoplasm. The musculature is absent. The

lumen (LU) of the vas deferens is filled with a large number of bundles of spermatozoa.

### 3.3 Seminal vesicle

Each vas deferens widens posteriorly to form the seminal vesicle which runs as an elongated tube from fifth abdominal segment measuring about 2.96mm in length and 0.42mm in thickness. The seminal vesicles (VS) are narrow anteriorly but have gradually widened up to about their middle and then have again narrowed posteriorly. Both the seminal vesicles (VS) posteriorly unite to open into a common ductus ejaculatorius (DEJ).

Histologically (Pl. V, Fig. 3), the seminal vesicles resemble with the vas deferens in their structure. The lumen of the seminal vesicle is filled with a large number of sperms.



**Plate V: Fig. 1:** T.S. of vasa deferens. **Fig. 2:** T.S. of vasa efferentia. **Fig. 3:** T.S. of common vas efferens. **Fig. 4:** T.S. of testis showing seminiferous tubules.

Abbreviations: BM - Basement membrane; CT - Connective tissue; EP - Epithelium; LU - Lumen; LUCVE - Lumen of common vas efferens; LUST - Lumen of seminiferous tubule; LUCVE - Lumen of vas efferens; NU - Nucleus; PS - peritoneal Sheath; SP - Spermatozoa; TR - Tracheole.

### 3.4 Ductus ejaculatorius

The ductus ejaculatorius (DEJ) is a common duct, formed by the union of both the vesicula seminalis (VS) about in the middle of the seventh abdominal segment. It is wide in front, but gradually narrows up to the posterior end of ninth abdominal segment. It opens to the outside through a male gonopore which is located at the distal extremity of the aedeagus.

Histologically (Pl. VI, Fig. 4), the ductus ejaculatorius (DEJ) is ensheathed by a thick layer of longitudinal and circular muscles. The epithelium is well defined with oval nuclei having distinct nuclear membrane and coarsely granular cytoplasm. There is a distinct basement membrane. The epithelium is lined

internally with a thick layer of intima or cuticle. The histology of ductus ejaculatorius clearly reveals that it is formed as a median ventral invagination of the ectoderm of the ninth abdominal segment which has become connected with the seminal vesicle.

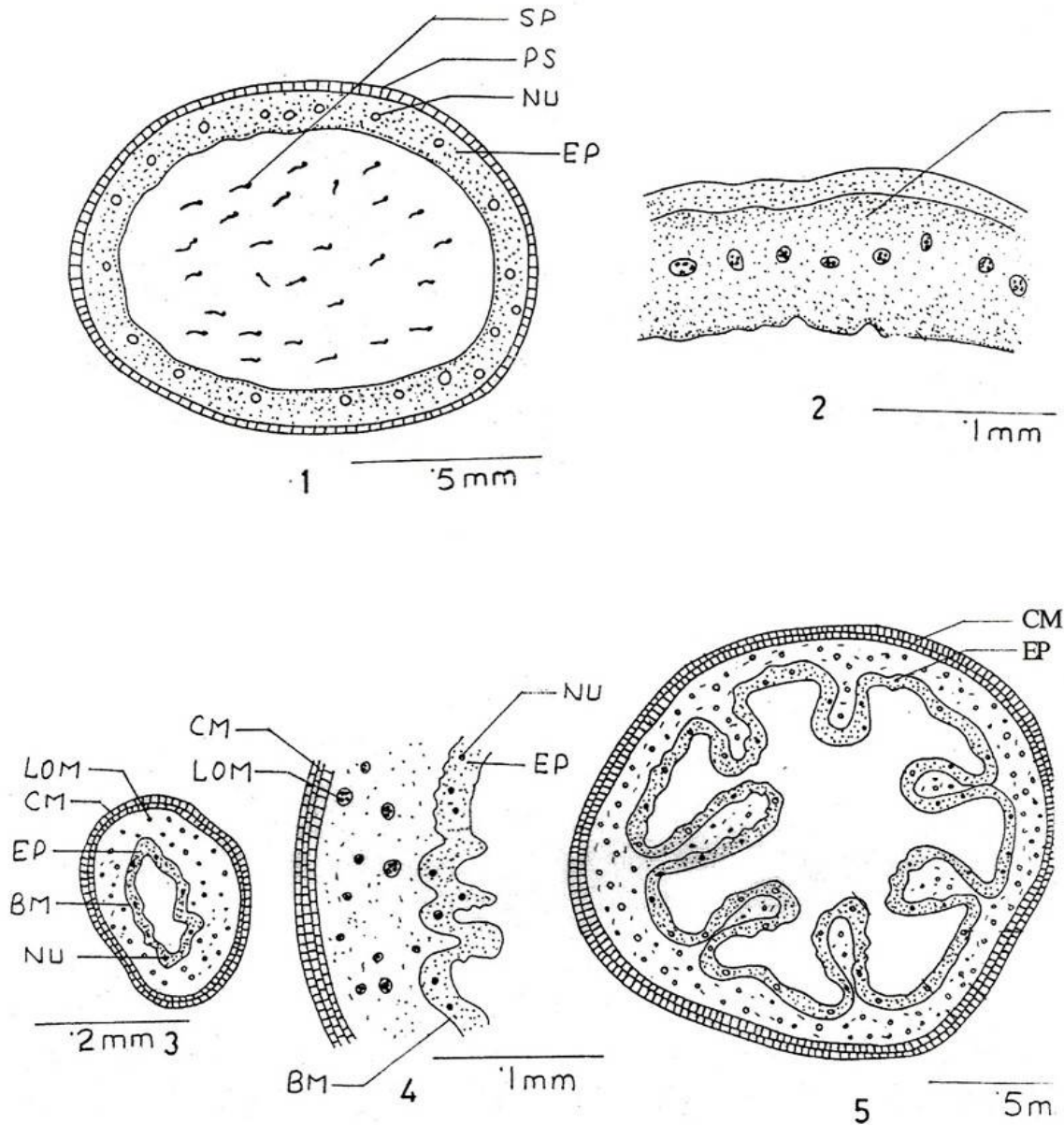
### 3.5 Accessory glands (Pl. VII, Fig. 2)

There are two pairs of accessory glands (AG) which are distinct, transparent, elongated sac-like structures found two on the ventral surface of each seminal vesicle (VS) extending throughout its length and enclosed within a common sheath of connective tissue. Each accessory gland appears like a simple blind tubular structure of about 2.41mm in length and

0.16mm in thickness. The accessory glands open into the anterior part of ductus ejaculatorius (DEJ). The accessory glands secrete a viscid substance (SC) which discharges as a liquid with the spermatozoa to form a covering, the spermatophore.

The histology (Pl. II) of accessory glands reveals that the muscular sheath of accessory glands is continuous with that of the ductus ejaculatorius. The

accessory glands are lined internally with the epithelium (EP) and a thin layer of cuticle which is not continuous throughout. The inner part of the epithelium becomes deeply stained possibly due to the accumulation of secretory products before its release into the lumen (LU). The lining of accessory glands exhibits minute pores at intervals through which the secretion flows into the lumen.



**Plate VI: Fig. 1: T.S. of Seminal vesicle. Fig. 2: T.S. of Seminal vesicle (magnified). Fig. 3: T.S. of lateral oviduct. Fig. 4: T.S. of lateral oviduct (magnified). Fig. 5: T.S. of lateral oviduct.**

Abbreviations: BM - Basement membrane; BEP - Basel zone; CM - Circular muscle; EP - Epithelium; IEP - Inner zone; LOM - Longitudinal muscle; LU - Lumen; NU - Nucleus; PS - Peritoneal sheath; SP - Spermatozoa.

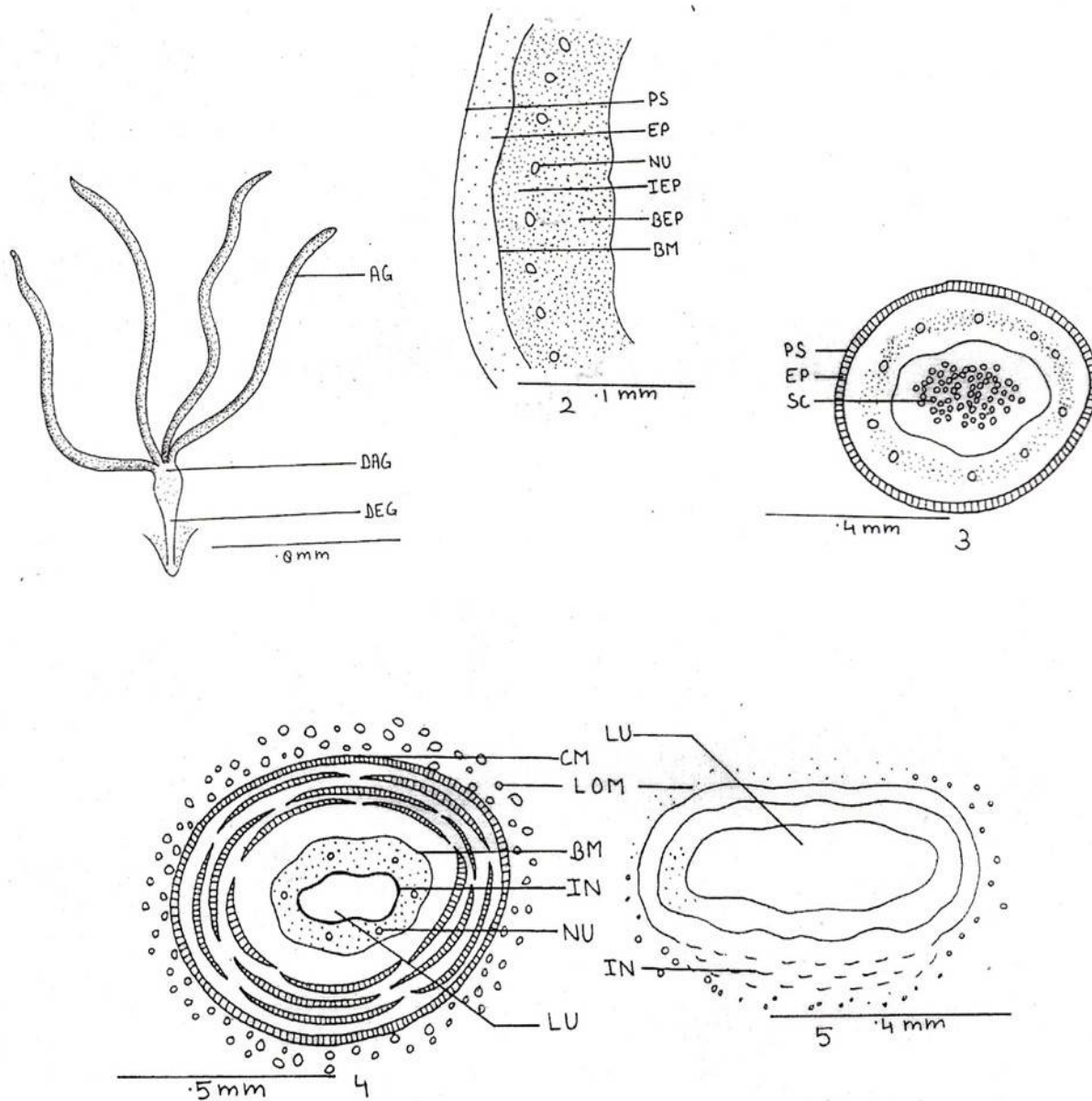


Plate VII: Fig. 1: Accessory gland showing their opening into ductus ejaculatorius. Fig. 2: T.S. of Accessory gland (magnified). Fig. 3: T.S. of Accessory gland. Fig. 4: T.S. of ductus ejaculatorius. Fig. 5: T.S. of median oviduct.

Abbreviations: AG - Accessory gland; BM - Basement membrane; BEP - Basel zone; CM - Circular muscle; DAG - Duct of accessory gland; DEG - Duct of ejaculatorius; EP - Epithelium; IEP - Inner zone; LOM - longitudinal muscle; LU - Lumen; NU - Nucleus; PS - Peritoneal sheath; SC - Viscid substance.

#### 4. Female reproductive system (Pl. VIII & IX, Figs. 1-3)

The female reproductive organs of the water scorpion, *Laccotrephes maculatus* Fabr. consists of a pair of ovaries (OV), a pair of lateral oviducts (LO), a common oviductus communis (COC), a vagina (VG) and the spermatheca (SPT).

##### 4.1 Ovaries

There is a pair of whitish ovaries placed one on either of the ventrolateral sides of the alimentary canal,

extending from about the middle of the mesothorax to the posterior border of the fifth abdominal segment. Each ovary consists of four acrotrophic ovarioles (OVA). The ovaries are profusely provided with fine tracheae and connective tissues. All the four ovarioles of each ovary are united to form a common terminal filament (TE) which is attached to the first phragma by a suspensory ligament (SL) in the anterior part of the mesothorax. The posterior part of the ovariole (PED) the pedicles open into a common wide chamber, the calyx (CAL) which extends behind as the lateral oviduct (LO). Both the lateral oviduct joins medially in



the eighth abdominal segment to form a common oviduct or oviductus communis (COC).

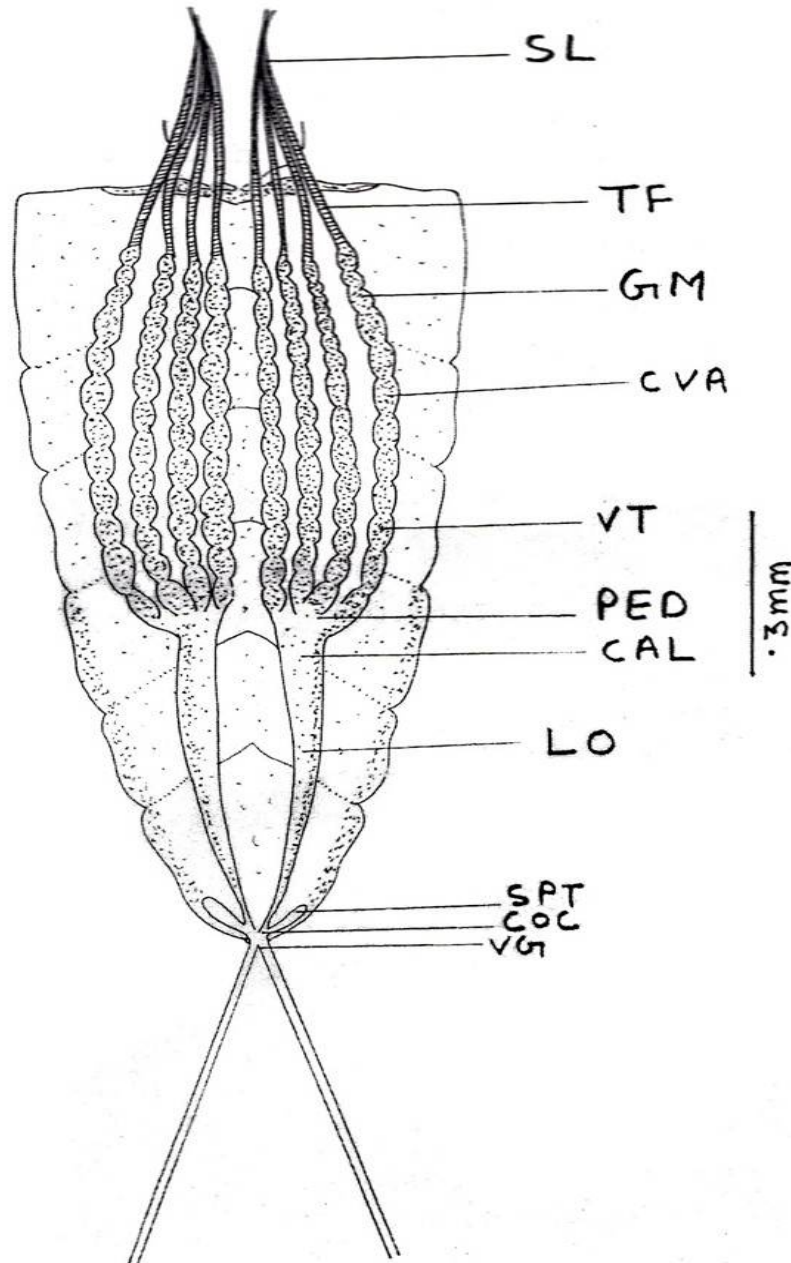
#### 4.2 Ovarioles

Each ovariole is a long, narrow tube of about 6.67mm in length and 0.09mm in thickness having developing eggs disposed one behind the other in a single chain. The oldest oocytes are near their union with the oviduct. Each ovariole is distinguishable into four regions viz, a long terminal filament (TF), a germarium (GR) containing undifferentiated cells, a

relatively wide vitellarium (VT) containing mature oocytes and a short pedicel (PED) or stalk. The outermost covering of the ovariole, the tunica propria is thin, structureless, transparent and membranous.

#### 4.3 Terminal filament

It is the slender thread-like filament that forms the anterior part of the ovariole. It is a solid strand of cells ensheathed in the tunica propria. The terminal filaments have united anteriorly to form the suspensory apparatus of the mature ovary in the adult.



**Plate VIII. Internal organs of reproduction, *Laccotrephes maculatus* Fabr. Fig. 1: Female reproductive organs *in situ*.**

Abbreviations: CAL - Calyx; COC - Common oviductus communis; GM - Germarium; LO - Lateral oviduct; OV - Ovary; OVA - Ovariole; PED - Pedicel; SL - Suspensory ligament; SPT - Spermatheca; TF - Terminal filament; VG - Vagina; VT - Vitellarium.

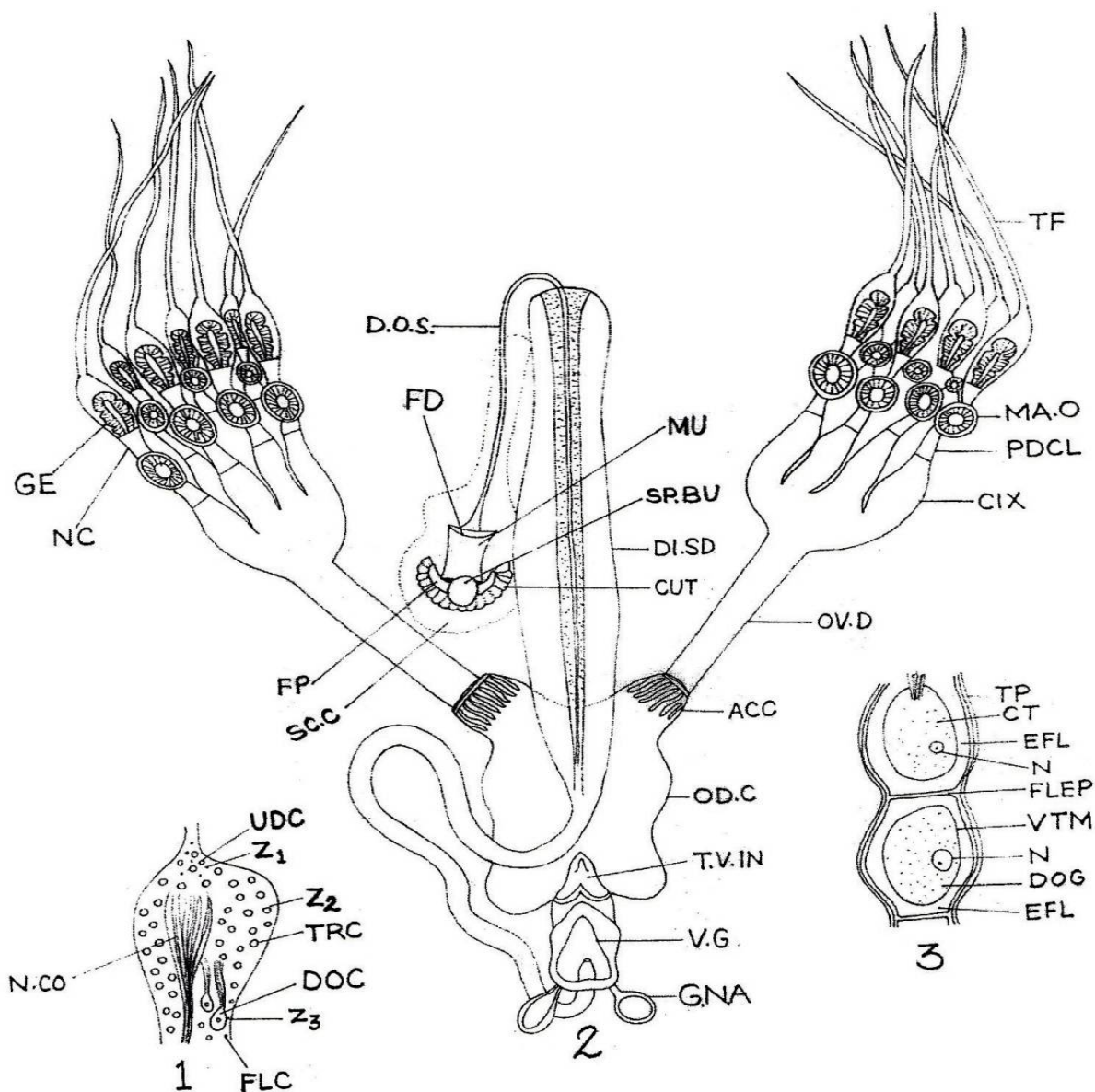


Plate IX. Female reproductive organs, *Laccotrephes maculatus* Fabr. Fig. 1: L.S. of germarium. Fig. 2: Female reproductive organs.

Abbreviations: DOC - Young oocyte; FLC - Follicular cell; N.CO - Nutritive cord; TRC - Trophic cells; UDC - Undifferentiated cells; Z<sub>1</sub> - Zone First; Z<sub>2</sub> - Zone second; Z<sub>3</sub> - Zone Third; ACC - Accessory gland; CIX - Calyx; CUT - Cuticular lining; DL.SD - Dilated portion of spermatheca; D.O.S - Spermathecal duct; FD - Distal flange of pump; FP - Proximal flange of pump; GE - Germarium; GN.A - Genital armature; MA.O - Mature oocytes; MU - Muscle; N.C. - Nutritive cell; OD.C - Oviductus communis; OV.D - Lateral oviduct; PDCL - Pedicel; SC.C - Secretory cell; SP.BU - Spermathecal bulb; T.F. - Terminal filament; T.V.IN - Thickening of vaginal intima; VG - Vagina; CT - Cytoplasm; DOG - Developing oocytes; EFL - Egg follicle; FLEP - Syncytial membrane; N - Nucleus; VTM - Vitelline membrane.

#### 4.4 Germarium (PL. X, Fig. 1)

The germarium (GM) forms the apex of an ovariole, below the terminal filament (TF). It contains trophocytes, young oocytes and follicular epithelium. The trophocytes (TRC) or nurse cells are present in the anterior portion of the germarium. The trophocytes are connected with the primary oocytes by cytoplasmic strands, the trophic cards or nutritive cords (NC). A germarium can be differentiated into three zones. The anterior-most portion of the germarium or zone contains a large number of undifferentiated small cells with

minute nuclei and distinct cell boundaries. The middle portion of the zone comprises more than  $\frac{3}{4}$  of germarium and contains numerous trophocytes (TRC) or nurse cells the trophocytes are relatively larger than the undifferentiated cells of preceding zone with distinct small nuclei and well-defined cell boundaries. The trophocytes are spherical or oval in shape and variable in size. The developing oocytes (OOC) are connected with the trophocytes by small cytoplasmic strands, the nutritive or the trophic cords (NC). The trophic cord serves to pass nourishment from the

trophocytes to the developing oocytes. The posterior portion of the germarium zone<sub>3</sub> is relatively small and contains young oocytes, follicular cells (FLC) and trophocytes. The trophocytes in this zone have completely lost their cell boundaries. The young oocytes may be distinguished from the follicular cells by their round or spherical shape and large size. The follicular cells are small oval, containing relatively less amount of cytoplasm and occupy the posterior lateral parts of the germarium.

#### 4.5 Vitellarium (Pl. X, Fig. 2)

The vitellarium (VT) is the longest portion of the ovariole found beyond the germarium (GM) and contains the developing oocytes (OOC) in a linear fashion. The developing oocytes become progressively

larger antero-posteriorly. The vitellarium is covered over by a thin layer or tunica propria (TP). The egg follicle consists of a syncytial epithelial layer. The developing oocytes are spherical in shape with distinct nuclei in their cytoplasm. The developing oocytes can be distinguished from the follicular layer by the thin distinct vitelline membrane (VTM). As the oocytes are large in size, they develop yolk. The vitellarium is closed at the posterior end by a basal plug which disintegrates before the discharge of oocytes. The posterior region of the vitellarium collapses after the ovulation. After the ovulation, the cells of the empty follicle undergo condensation and disorganisation to form a yellowish coloured corpus luteum, which disintegrates before the discharge of the next egg.

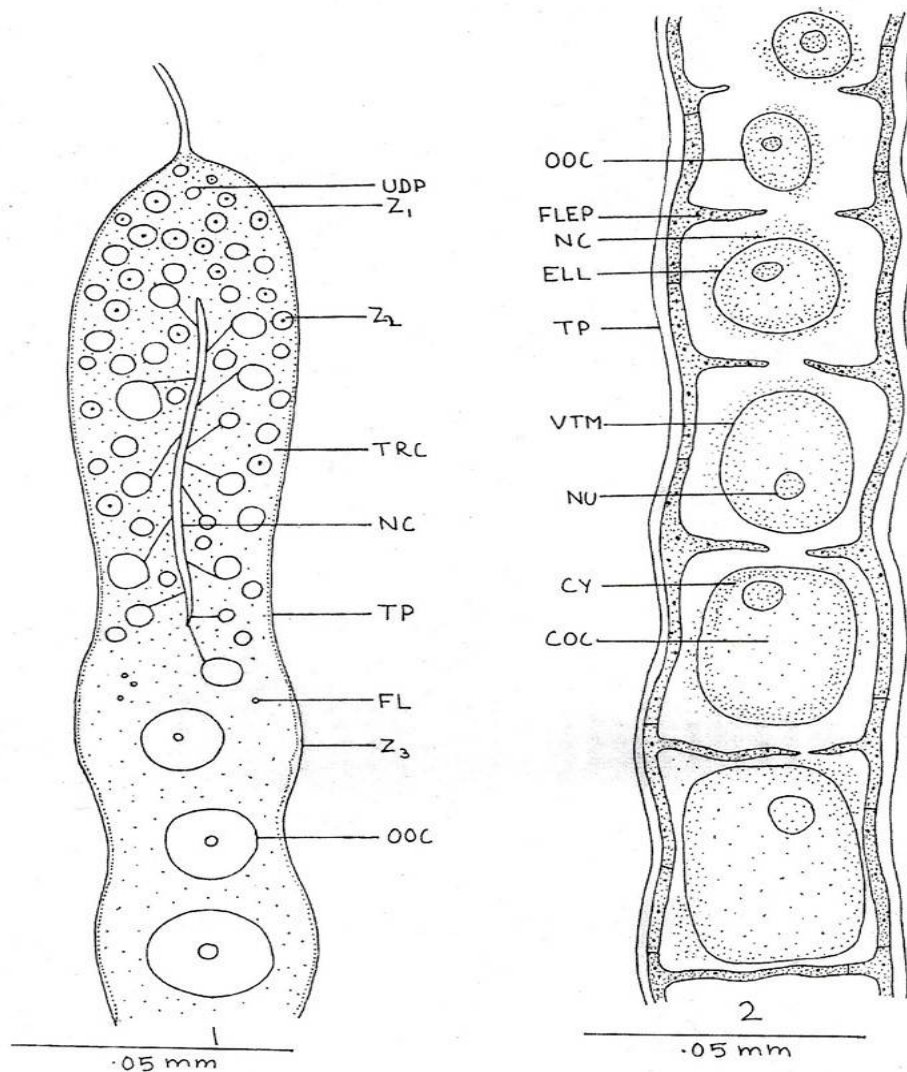


Plate X: Fig. 1: L.S. of germarium. Fig. 2: L.S. of vitellarium.

Abbreviations: CY - Cytoplasm; ELL - Egg follicle; FCL - follicle cell; FLEP - Follicular epithelium; NC - Nutritive cord; OOC - Developing oocytes; NU - Nucleus; TP - Tunica propria; TRC - Trophocytes; UDC - Undifferentiated cells; Z<sub>1</sub> - Zone of growth; Z<sub>2</sub> - Zone of maturation; Z<sub>3</sub> - Zone of transformation; VTM - Vitelline membrane.

#### 4.6 Ovariole pedicel

The pedicles (PED) or stalk of the ovarioles are short ducts. They connect the egg tubes with a lateral oviduct (LO). The walls of the pedicel consist of a simple elastic epithelium which is continuous with that of the oviduct.

#### 4.7 Lateral oviduct

The lateral oviducts (LO) are paired mesodermal tubules of more or less uniform diameter measuring about 2.1mm in length and 0.22mm in thickness leading from the ovaries to the common oviduct, the oviductus communis (COC). They extend from posterior region of fifth abdominal segment to the posterior border of the seventh abdominal segment. The anterior portion of the lateral oviduct is somewhat enlarged to form the broad calyx (CAL) for receiving the mature ova on ovulation. The histology of lateral oviduct reveals that the epithelium is reduced into several deep transverse folds. The epithelium possesses numerous nuclei but no cell boundaries. The syncytial epithelium is surrounded by a thick layer of circular and a thin layer of longitudinal muscle fibres.

#### 4.8 Median oviduct or oviductus communis

The median oviduct or the oviductus communis is an ectodermal tube of about 0.036mm in length and 0.21mm in thickness, located in between the seventh and eighth abdominal segment. It opens into the vagina or the genital chamber through the female gonopore. The female gonopore serves for the discharging of the eggs from the oviduct. It does not play any role in copulation. The median oviduct is lined internally by distinct intima which is relatively thicker on the ventral side. The epithelium is thrown into longitudinal folds along the dorsal and lateral sides. The musculature consists of an inner thin longitudinal and an outer thick circular muscle layer. The circular muscles on the dorsal side are so arranged that they serve as a sphincter and regulate the exit.

#### 4.9 Vagina

The median oviduct or the oviductus communis opens posteriorly into a cup-shaped vagina, which opens to the outside through an opening, the vulva, which is situated in the posterior part of eighth abdominal segment. A spermatheca opens in the anterior region of vagina.

Histologically, the vagina is lined internally by a thick chitinous intima. The epithelial lining of the vagina is poorly developed. The circular muscle layer is poorly developed and the longitudinal muscles are not evident. The vagina serves as copulatory pouch during mating.

#### 4.10 Spermatheca or Receptaculum seminis

There is a pair of spermatheca (SPT). Each spermatheca (SPT) is an elongated pouch or sac-like

structure which is meant for reception and storage of spermatozoa. The spermatheca opens into the vagina from dorsally. Each spermatheca consists of a proximal narrow spermathecal duct and the distal swollen ampulla like spermathecal reservoir. The spermathecal reservoir is lined internally by cuticle, surrounded by a mass of secretory cells and longitudinal muscles. The circular muscle fibres are absent. The discharge of the spermatozoa is controlled by the musculature. On reaching the eggs in the posterior parts of the vagina the sperms are ejected over them from the spermathecal duct by the contraction of the muscles.

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