OBSERVATION

MALE REPRODUCTIVE SYSTEM OF PSEUDACORION RUBRICEPS SELYS

Male reproductive system of P. rubriceps Selys consists of two parts:

1. Internal genital organs, comprising a pair of testes, a pair of ducts - the vasa deferentia, a sperm sac and a ductus ejaculatorius. Accessory reproductive glands are totally absent.

2. External genital organs, consisting of genital structures and secondary copulatory organs etc.

The true male genital aperture is situated on the ventral side of the ninth abdominal segment partly enclosed between a pair of coxites.
I. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The Testes

The testes are a pair of long cylindrical, translucent (in fresh condition) and multilobular structures, each measuring 3.01 mm. in length and 0.172 mm. in thickness and occupying the posterior half of seventh and the whole of the eighth abdominal segments (Pl. I, fig. 1). The testes of the two sides are present on the dorsal side of the alimentary canal, and remain separate anteriorly but closely apposed to each other posteriorly. The testes are held in position by tracheae, fat-bodies, nerves and suspensory filaments, the last named structure being the anterior prolongation of adipose tissue enveloping each testis.

The Vasa Deferentia

Posteriorly, the testis continues into a narrow duct, the vas deferens measuring 2.29 mm. in length; its diameter being variable (Pl. I, fig. 2). The vas deferens of each side extends from beginning of the ninth abdominal segment up to its middle region, and is morphologically divided into two parts, (a) a short proximal part and (b) a convoluted distal part. The proximal part of the vas deferens consists of a small duct of narrow diameter emerging out from the posterior end of the testis. It is enshrouded by a thick coat of adipose tissue.

The convoluted part of vas deferens is a long duct of variable diameter, narrow proximally and becoming gradually dilated postero-distally. It forms two or three 'U' shaped bends along its course up to the sperm sac.

The Sperm Sac

The two vasa deferentia unite posteriorly below the alimentary canal to form a prominent, median, elongated sac, the sperm sac (Pl. I, fig. 2). The sperm sac measures 0.234 mm.
in length and is constricted in the middle to form two lobes, an anterior and a posterior lobe. The vasa deferentia of the two sides enter into the anterior lobe of the sperm sac from the ventro-lateral side. The sperm sac serves as a reservoir for sperms before their translocation to vesicula seminalis of secondary copulatory apparatus.

In general specimens the sperm sac and vasa deferentia are translucent white. However, with increase in age, the wall of the sperm sac and distal parts of vasa deferentia become reddish-brown which changes to black ultimately.

The Ductus Ejaculatorius

The sperm sac communicates ventrally to the gonopore through a minute ductus ejaculatorius which is formed by a portion of the ventral wall of sperm sac. The ejaculatory duct is supported on a cup-shaped chitinous structure present on the anterior side of the gonopore (Pl. II, fig. 1).

(B) HISTOLOGY

The Testis

The wall of the testis is thin and composed of a single layer of stretched cells forming the peritoneal layer. The peritoneum is surrounded by adipose tissue which forms a definite and regular layer on the outer side. The adipose tissue is a spongy mass consisting of vacuolated fat-cells with highly granular nuclei. Inner to the peritoneal layer are contained a large number of lobules and a common lateral duct (Pl. I, fig. 3).

The Testicular Lobules:

A lobule is almost spherical and solid mass of germ cells bounded by a very thin limiting membrane which is distinctly visible only at places between adjacent lobules. The germ
cells in a lobule are all alike and represent only one stage of spermatogenesis at any time. The different lobules, however, contain germ cells in different stages of spermatogenesis. The testicular lobule is, therefore, not divisible into different zones of a typical insect testicular follicle i.e., germerium, zone of growth, zone of transformation etc. Definite germinal epithelium is absent in lobules in the adult damselfly. Each lobule opens into a common lateral duct by means of a narrow ductule which is visible distinctly in ripe lobules containing fully developed spermatosperm. The ductule is a very delicate structure formed by prolongation of the limiting membrane of the lobule.

The Common Lateral Duct:

The common lateral duct runs sinuously throughout the length of each testis on the outer lateral side. It is, however, not continued into the anterior apical region of the testis. The wall of the duct consists of a thick inner epithelial layer resting on a basement membrane and a thin outer circular muscle layer (Pl. I, fig. 4). The epithelium in the anterior half of the duct is composed of two or three layers of small cells in which the nuclei occupy most of the volume. Each nucleus is provided with a large nucleolus in the centre and several granules at the periphery. The cytoplasm in the epithelial cells is granular and vacuolated. The lumen is narrow and devoid of sperms and secretory material.

The epithelium in the posterior half of the common lateral duct consists of a single layer of large cuboidal cells with distinct cell-membranes (Pl. I, fig. 5). The epithelial cells rest on a thin basement membrane. The cytoplasm of each epithelial cell is densely granular. The nucleus is large in size, oval or elliptical in shape, and highly granular in appearance but devoid of a nucleolus. The epithelial layer on the outer side of the lateral duct is comparatively thin than that of the inner side. The lumen is large and contains few spermatosperm dispersed in a granular secretory material.
The Vas Deferens

The common lateral duct is continued beyond the posterior end of the testis in the form of vas deferens. The wall in the proximal part of the vas deferens is composed of the following layers from periphery inwards (Pl. I, fig. 6):

(i) The Adipose tissue layer:— It is present in the form of a very thick and prominent layer. The adipose tissue consists of a spongy mass of highly vacuolated cells containing large granular nuclei.

(ii) The Muscle layer:— It consists of a thin layer of circular muscle fibres on the inner side of the adipose tissue layer.

(iii) The Epithelial layer:— The epithelial layer consists of a single row of cuboidal cells arranged round a central lumen. Each epithelial cell contains densely granular secretory material in the cytoplasm. The nuclei are large and granular, each measuring 9 micra in diameter. The epithelium rests on a basement membrane. The lumen of the duct is narrow and contains secretory material.

The wall of the convoluted part of vas deferens is thin and composed of following layers from periphery inwards (Pl. I, fig. 7):— (i) Peritoneal layer, (ii) Musculature, (iii) Basement membrane, and (iv) Epithelial layer.

The peritoneal layer is thin and composed of spindle-shaped cells with elongated nuclei. Black pigment granules are present in the peritoneum. The musculature in this part of the vas deferens is well developed and consists of circularly disposed fibres only. The epithelium is very thin and made up of a single layer of small cells. Each cell possesses a prominent spherical nucleus of 6 micra diameter, and granulated and vacuolated cytoplasm. The epithelium rests on a basement membrane and encloses a spacious lumen in the centre. The lumen
of the vas deferens is filled with two types of secretory material, an outer homogeneous material and an inner granular material. The homogeneous secretory material forms a distinct layer on the inner side of the epithelium and seems to be of mucilaginous consistency. The convoluted part of the vas deferens stores spermatozoa.

The Sperm Sac

Histologically, the sperm sac shows a structure almost similar to that of the vas deferens (Pl. I, fig. 8). The epithelium is composed of a single layer of small cells with vacuolated cytoplasm and granular spherical nuclei. The cell boundaries between the epithelial cells are often indistinct. The epithelium is surrounded on the outer side by a thick layer of striated circular muscles forming a strong muscular coat in the wall. There is a thin peritoneal layer on the outermost side of the wall of sperm sac. Black pigment granules are densely packed in the peritoneal cells. The lumen is large and spacious. It contains secretory material and spermatozoa and is not lined by a chitinous intima.

The Ductus Ejaculatorius

The ejaculatory duct shows the same histological structure as the sperm sac except that its epithelium is lined internally by a thin chitinous intima.

2. External Genital Organs

The male external genitalia consist of a pair of supra-anal appendages, a pair of infra-anal appendages, a pair of coxites guarding the gonopore (Pl. II, fig. 1) and a complicated secondary copulatory apparatus situated ventrally on the second and anterior part of the third abdominal segments (Pl. II, fig. 2).
The Supra-anal Appendages

Arising from the postero-dorsal side of the last segment of abdomen above the anus is a pair of black coloured prominent appendages, the supra-anal appendages (Pl. II, fig. 3). Each supra-anal appendage is a stout, hollow, subconical chitinized structure measuring 0.734 mm. in length. The inner margin of the appendage is curved and bears a 0.129 mm. long, robust spine near the base and a 0.044 mm. long spine near the middle region. The appendage is broad at the base and tapers to a blunt apex posteriorly. The surface of each supra-anal appendage is covered with small hair.

The Infra-anal Appendages

In male damselflies, a pair of infra-anal appendages is present lying ventro-lateral to the anus (Pl. II, fig. 4). Each infra-anal appendage is a 0.532 mm. long, hollow, chitinized, ungulate structure which is narrow at the base and comparatively broad at the apex. A small spine projects postero-dorsally from the inner apical side. Bristle-like hair are present on the ventral surface of the appendage.

The Male Genital Aperture

The gonopore is a 0.129 mm. long, elliptical aperture located ventrally in the middle of the ninth abdominal segment (Pl. II, fig. 5). The margin of the genital aperture is strengthened by a chitinous ring which is internally continued anteriorly as the cup-shaped chitinous structure supporting the ejaculatory duct.

The Coxites: The gonopore is flanked by a pair of wedge-shaped, weakly sclerotized, 0.583 mm. long coxites of light blue colour. Each coxite is united by its broad anterior two-third portion with the body-wall which is provided internally with a prominent, heavily sclerotized antero-dorsal spine at the anterior end of coxite. The posterior one-third portion of the coxite lies
separate from the body-wall projecting down as a tapering style-like structure. Hair are sparsely distributed on the surface of the coxites.

The Anterior genital plate:- The anterior genital plate is a 0.532 mm. long, 0.647 mm. broad sclerotized portion of the ninth sternum lying anterior to the gonopore (Pl. II, fig. 5). The surface of the plate is beset with numerous hair and tubercles.

The Post-genital plate:- It is a small rectangular plate situated behind the gonopore, and measuring 0.409 mm. in length and 0.655 mm. in breadth. Its surface is adorned with closely set small tubercles only.

THE SECONDARY COPULATORY APPARATUS

The secondary copulatory apparatus comprises an anterior lamina, a pair of anterior hamules, a lamina batilliformis, a genital sac, supporting framework, a penis and a vesicula spermalis (Pl. V, fig. 2). All the secondary copulatory organs, except the vesicula spermalis which is situated at the anterior end of the third abdominal sternum, are contained in a genital fossa on the ventral side of the second abdominal segment. The posterior pair of hamules is absent in this damselfly.

The Genital Fossa

The genital fossa is a deep bowl-shaped depression on ventral side of the second abdominal segment. It lodges all the organs of the secondary copulatory apparatus except the vesicula spermalis.

The Anterior Lamina

The genital fossa is anteriorly bounded by a 0.562 mm. large, pale blue hood-like chitinous structure, the anterior lamina (Pl. II, fig. 2). The anterior lamina is convex
ventrally, and deeply emarginated posteriorly to form a prominent inverted 'V'-shaped cleft. The cleft is covered dorsally by a membrane forming a sac-like structure, the median laminar sac (Pl. II, fig. 6). The laminar sac measures 0.814 mm. in length and narrows anteriorly extending into the body cavity of the first abdominal segment. A horizontal, internal apophysis demarcates the anterior lamina on the anterior side from the first abdominal sternite. The margins of the cleft bear a few hair which project towards the space.

The Anterior Hamules

The anterior hamules are a pair of prominent structures present on the posterior side of the anterior lamina. A hamule is composed of two plates, an outer plate and an inner plate (Pl. II, fig. 6). The outer plate is quadrate in shape measuring 0.364 mm. in length and 0.345 mm. in breadth, and is antero-laterally attached to the postero-lateral margin of the anterior lamina. On the lateral side the outer plate is joined to ventro-lateral side of the second tergum through a membrane. The inner plate is divisible into a strongly sclerotized vertical part and a horizontal membranous area, which connects the inner plate with the outer plate (Pl. V, fig. 3). The sclerotized part of the inner plate lies above the middle region of outer plate as a vertical structure. The apical end of this vertical structure is curved like a hook. The sclerotized part of the inner plate is hard and its surface is furnished with hair.

The Lamina Batilliformis

The lamina batilliformis is a chitinous structure which forms a part of the postero-dorsal wall of the median laminar sac (Pl. II, fig. 6). It is composed of a large, ventrally convex scoop-shaped plate with a semicircular anterior margin. The posterior margin of the lamina batilliformis is broadly notched to form a pair of limbs. The limbs are heavily sclero-tized on the inner side and possess numerous hair in the
posterior half. The apex of each limb is flexed antero-dorsad and continues as a long process, the cornu, ending as an incomplete loop.

The Genital sac

The second abdominal venter is invaginated to form a large genital sac in the middle one-third of the segment. The wall of the genital sac is membranous and supported anterogradely by the lamina batilliformis, and laterally and posteriorly by components of the framework (Pl. II, fig. 2). In the wall of the sac the antero-proximal portion of penis is incorporated while remaining portion of penis projects out ventro-posteriorwards through opening of the genital sac.

The Supporting Framework

It is a complicated frame of chitinous structures strengthening the wall of the genital fossa and giving support to many organs of the secondary copulatory apparatus. The components of the frame arise by sclerotization of local areas in the sternal membrane. The supporting framework consists of a pair of anterior vertical bars, a pair of lateral longitudinal bars and a posterior median plate (Pl. V, fig. 2).

The Anterior Vertical Bars:

The anterior vertical bars are 0.489 mm. long slender structures incorporated in the lateral wall of the genital sac (Pl. II, fig. 6). Dorsally, each bar extends up to the roof of the sac where it becomes united with basal plate of the penis. The bar ventrally extends posteriorly outwards up to middle region of the anterior hamule.

The Lateral Longitudinal Bars:

The lateral longitudinal bars are 0.345 mm. long structures lying horizontally in the genital fossa on the ventrolateral sides of the genital sac opening (Pl. II, fig. 6). They
extend parallel and lateral to the vertical sclerotized part of
the inner plate of anterior hamule. Anteriorly, each bar
articulates with the lower end of the anterior vertical bar and
posteriorly, with the anterior limbs of the posterior median
plate of frame.

The Posterior Median Plate:-

It is a 0.384 mm. broad chitinous plate situated on the
posterior side of the opening of the genital sac and above the
vesicula spermatica (Pl. II, fig. 7). The posterior median
plate is somewhat 'H'-shaped consisting of a wide middle piece
and two pairs of limbs, one on the antero-lateral side and the
other on the posterior side. The anterior limbs are short
structures, each measuring 0.125 mm. in length and articulating
with the posterior end of the lateral longitudinal bar. The
posterior limbs are 0.143 mm. long structures with rounded
spines. Hair are present on the ventral surface of the plate
and its limbs.

The Penis

The penis is an unsegmented doubly-flexed chitinous
structure which acts as an intromittent organ. Unlike Anisop-
tera, it projects out ventrally from the genital sac and not
from the vesicle. The penis consists of a basal plate and a
distal shaft (Pl. II, fig. 6).

The Basal Plate:-

The basal plate is the antero-proximal region of the
penis which is incorporated in the dorsal wall of the genital
sac. It consists of two sclerites, an anterior sclerite and a
posterior sclerite.

The Anterior Sclerite:- The anterior sclerite is a 0.259 mm.
wide transverse bar situated above the basal end of the posterior
sclerite. The anterior sclerite is supported laterally by the
anterior vertical bars of the framework which maintain it in
position also.

The posterior sclerite:- It is a 0.432 mm. long scoop-like structure with a semicircular apex. The bases of the anterior and the posterior sclerites enclose between them a distinct foramen which leads inside the shaft connecting it with haemocoel.

The Shaft:-

The distally free portion of the penis forms the shaft which is bent ventrally over the basal plate. The shaft is divided into three regions, a proximal region, a middle region and a distal region.

The Proximal region:- It forms the longest region of the shaft which is united anteriorly with the basal plate. The basal and the ventro-lateral areas of the proximal region are heavily sclerotized; its dorsal and lateral walls being membranous.

The Middle region:- The middle region of the shaft is small and distinctly separated from the proximal region by a small pit. It is strongly sclerotized laterally but membranous dorsally and ventrally.

The Distal region:- The distal region measures 0.259 mm. in length and consists of a weakly sclerotized membranous region only. It is composed of a ventral prepuce and a posterior glans, the two structures being united only at the base (Pl. II, fig. 8). The glans is a small lobe-like structure. The prepuce is a large, forwardly directed structure which covers the middle region of the shaft on the ventral side. It consists of a pair of dorso-lateral lobes and an equally large median lobe.

An external median dorsal groove runs prominently along the membranous dorsal side of the shaft (Pl. V, fig. 2). The groove is continued posteriorly upto the base of the distal region.
The Vesicula Spermalis (Vesicle)

The vesicula spermalis is a 0.682 mm. long, vase-shaped structure situated at the anterior end of the third abdominal sternum. It consists of a large bulging body and a narrow anterior neck (Pl. II, fig. 9). The body is elongated and extends anteriorly into the second abdominal segment. The posterior margin of the vesicula spermalis is rounded. The ventral wall of the vesicle is sclerotized and the surface covered with hair. The neck is membranous in the middle of the ventral surface and strongly sclerotized on the lateral sides forming a pair of limb-like structures covered with bristle-like hair. The cavity of the vesicula spermalis communicates to the exterior through an antero-ventral slit-like orifice which is present in the membranous area of the neck. The orifice of the vesicle lies guarded by a pair of lips. The dorsal wall of the vesicula spermalis is membranous and strengthened by an anterior and a posterior apodeme. The apodemes are present in the area between the genital fossa and the third abdominal sternite.

The Anterior Apodeme:— It is a sclerotized transverse bar, thin in the middle and expanded at the ends. The ends are directed dorso-laterally and become attached to the posterior limbs of posterior median plate of frame through a membrane.

The Posterior Apodeme:— It is a prominent transverse bar which is fused with the anterior margin of the third sternite. Lateral ends of the posterior apodeme project dorso-laterad.

The cavity of the vesicula spermalis is filled with a viscous fluid containing sperm masses, and does not communicate either with genital fossa or with the penis.
FEMALE REPRODUCTIVE SYSTEM OF PSEUDAGRION RUBRICEPS SELYS

The female reproductive system of *P. rubriceps* Selys consists of two parts:

1. Internal genital organs
2. External genital organs

1. INTERNAL GENITAL ORGANS

(a) Gross Morphology

The internal organs consist of a pair of ovaries, a pair of oviducts, a short common median oviduct and a highly muscular set of organs termed '8th Complex' (Pl. V, fig. 1). The '8th Complex' comprises a vagina, a bursa copulatrix and a spermatheca, all of which are assembled together in eighth abdominal segment to form a compact structure, the '8th Complex'. A pair of accessory reproductive glands are also present in the ninth abdominal segment which open dorsally in the vagina.

The Ovaries

The ovaries are a pair of large, pale coloured organs measuring 22.42 mm. in length and extending from base of the first abdominal segment upto middle of the seventh abdominal segment. The ovaries of the two sides run close together on the dorsal side of the alimentary canal and are connected mesally by a median dorsal ligament along their length except in the terminal regions. The median ligament continues beyond the ovaries anteriorly and enters into the thorax to become inserted on the tergal wall. At the other end, it is attached to the dorsal body-wall near the end of the ninth abdominal segment. Each ovary consists of a very large number of ovarioles which arise from the dorso-mesal side of a prominent duct termed common lateral duct. The common lateral duct is a long, thin-walled, transparent duct running longitudinally on the ventro-lateral
side of each ovary throughout its length except the anterior tip. It is packed with eggs in a mature ovary.

The ovarioles are arranged in a linear sequence only on the dorso-mesal surface of the common lateral duct, thereby differentiating the dorsal and ventral surfaces of the ovary. Each ovariole is directed anteriorly and dorsally with its apical end drawn out into a tapering thread-like structure, the terminal filament. The terminal filaments of the anterior ovarioles of an ovary together form a thick and stout structure, the apical filament of the ovary which attaches the gonad to the postero-dorsal wall of the thorax. The terminal filaments of the remaining ovarioles of the ovary are attached to the median dorsal ligament. Fat-bodies are abundantly present among the ovarioles but do not form a regular coat round the ovary.

The ovaries are held in position by the apical filaments, the median dorsal ligament, nerves, adipose tissue and also by tracheae which ramify all over the surface.

**The Oviducts**

The common lateral ducts of the ovaries are continued posteriorly as a pair of oviducts, each measuring 2.35 mm. in length. An oviduct is a simple, transparent, thin-walled canal extending from the middle of seventh abdominal segment upto the first quarter of eighth abdominal segment. The oviduct lies latero-dorsal to the alimentary canal in the beginning, but near the posterior end of seventh abdominal segment it turns ventrally and inwards to become ventral to the gut. In mature damselflies, the oviduct is filled up with 5-7 eggs which are arranged in two series.

**The Common Median Oviduct**

The oviducts of the two sides unite beneath the gut near the middle of eighth abdominal segment to form a common median oviduct, the oviductus communis (Pl. III, fig. 1). The oviductus communis is a short and broad duct which lies hidden dorsally by
the eighth abdominal ganglion. It is surrounded by adipose tissue and leads posteriorly into the '8th Complex'.

The '8th Complex'

The '8th Complex' is a prominent structure situated immediately behind the eighth abdominal ganglion in the posterior half of the eighth abdominal segment below the alimentary canal (Pl. III, fig. 2). The '8th Complex' measuring 0.645 mm. in length, is a muscular organ richly supplied by fat-bodies, tracheae, tracheoles and nerves.

The Vagina

The common median oviduct leads posteriorly into a narrow median passage, the vagina, lying on the ventral side of the '8th Complex' (Pl. III, fig. 1). It is morphologically divisible into a long, anterior tubular portion and a short posterior, genital atrium (Pl. III, fig. 3).

(i) The Anterior Tubular Portion:

It forms the main, strongly chitinized part of the vagina. A pair of muscles, one on each side, arising from the lateral wall of the vagina are inserted on the eighth sternite. These are termed sterno- vaginal muscles by the author (Pl. XXXVII, fig. 2). Another pair of powerful muscles originates anteriorly on the vagina and runs along the mesal sides of the oviducts to attach on the seventh sternum. These are termed anterior vaginal muscles by the author.

(ii) The Genital Atrium:

It is the posterior part of the vagina which is chamber-like, thin-walled and wrinkled in appearance (Pl. III, fig. 3). The chamber communicates to the exterior through an aperture, the vulva. The genital atrium serves to store the egg temporarily before its extrusion.

The vagina is antero-dorsally evaginated to form a
prominent structure termed bursa copulatrix. A small roundish structure, the bulbous spermatheca, lies behind the bursa copulatrix, with which it is connected by a duct.

**The Bursa Copulatrix**

The bursa copulatrix is a large, sac-like median structure on the antero-dorsal side of the '8th Complex' (Pl. III, fig. 3). It is nearly spherical in shape and located between eighth ganglion on the anterior side and bulbous spermatheca on the posterior side. The bursa copulatrix conceals the anterior portion of the vagina from dorsal view and communicates with it by a short ductus bursae.

**The Spermatheca**

The spermatheca is an unpaired structure lying underneath the bursa (Pl. III, fig. 3). It is directed postero-dorsally and consists of a distal bulbous portion and a proximal duct, the two portions being termed respectively as bulbous spermatheca and spermathecal duct. The bulbous spermatheca conceals the middle portion of the vagina from dorsal view.

The surface of vagina, bursa copulatrix and spermatheca is whitish in colour, being opaque or semi-transparent depending on the amount of adipose tissue surrounding them.

**The Accessory Glands**

The accessory glands are a pair of white cylindrical structures situated beneath the rectum in the whole of the ninth abdominal segment (Pl. III, fig. 2). Each gland consists of two parts, an elongated saccular portion and a narrow duct. The duct is thin and delicate, and measures about one-fourth of the total length of the gland. It connects the saccular portion of the gland with the postero-dorsal wall of the genital atrium at a point which is very close to the vulvar aperture.
(B) HISTOLOGY

The Ovary

The ovary is composed of a very large number of panistic ovarioles which are arranged in a linear sequence on the dorso-medial side of the common lateral duct (Pl. III, fig. 4). An ovariole is an elongated thread-like organ, broad proximally and tapering to a point at the free end. It contains a chain of developing ova arranged in a single row one over the other, the oldest being situated at the base near the union of the ovariole with the common lateral duct. The following regions of an insect ovariole are clearly differentiated in the damselfly:-

(i) Terminal filament:— The terminal filament is a long, delicate thread-like anterior prolongation of the wall of the ovariole which serves to hold the gonad in its position. The terminal filaments of the remaining ovarioles are embedded in the median dorsal ligament which comprises fat-bodies, connective tissue and a few muscle fibres. The terminal filaments of anterior ovarioles collectively form a cord-like structure, the apical filament of the ovary at the anterior end.

(ii) Germarium:— It is a small region of undifferentiated germ cells situated next to filament near the apical end of the ovariole.

(iii) Vitellarium:— The remaining portion of the ovariole forms the vitellarium in which ova are present in different stages of development.

Each ovariole is surrounded by a very thin cellular membrane forming the epithelial sheath. The cellular nature of the epithelium is clearly evident between the spaces of the adjacent developing ova. In the germarium region, the epithelial sheath is very thin consisting of greatly stretched cells due to which the demarcation from one cell to another is rather difficult. Posteriorly, in the region of the vitellarium, the cellular nature
is prominently exhibited by the epithelial wall, which forms a circular covering round the oocytes. This layer round the developing oocyte is known as the follicular epithelium which secretes chorion. The epithelium of the wall of ovariole is continuous with that of the common lateral duct.

**Structure of an egg:** The egg is an elongated cylindrical body which is obtuse at one end and pointed at the other. It is differentiated into a convex dorsal and a flat ventral side. The egg is surrounded externally by a thick and tough layer, the chorion which possesses an irregular hexagonal pattern on the surface. A delicate canal, placed a little obliquely to one side of the central axis, pierces the chorion at the anterior end. This is micropyle, the passage for the entry of sperm. It contains a large vesicular nucleus in the centre which is surrounded by a large quantity of yolk. The yolk is surrounded by a vitelline membrane. A laid egg is covered over by a thin gelatinous layer which is thickened at the anterior and posterior poles. The anterior thickening is in the form of a conical cap known as the pedicel, by the apex of which attachment is made to the egg string.

**The Common Lateral duct**

Histologically, the wall of the common lateral duct shows following layers, in order, from within outwards: (1) Epithelial layer, and (ii) Musculature.

The thin epithelial layer consists of small cuboidal cells arranged in a single row. Each cell contains a prominent oval nucleus. Musculature forms the outermost layer of the wall of the duct and consists of a layer of muscle fibres arranged longitudinally forming a very thin coat. The outer wall of the duct is nearly smooth while the inner wall shows a large number of irregular folds due to the fact that this side gives rise to ovarioles.
The Oviduct

The histological structure of the wall of the oviduct is similar to that of the common lateral duct except that its musculature is comparatively thick. The musculature comprises a layer of muscle fibres arranged longitudinally outside the epithelial layer. The epithelium consists of small cuboidal cells which are arranged in a row round the lumen. An epithelial cell possesses vacuolated cytoplasm and a distinct roundish nucleus. The chorionic wall of the eggs passing through the duct, has been observed to form a definite lining to the epithelial layer on the inner side especially when the yolk gets removed during sectioning. The adipose tissue is also present as an incomplete layer forming the outermost stratum in the wall of the oviduct. The lumen of the duct is spacious.

The Common Median Oviduct (Oviductus Communis)

The wall of the common median oviduct shows following layers in order, from within outwards:


The epithelium is composed of small cuboidal to columnar cells which are arranged in a single tier round the lumen. The cytoplasm in the epithelial cell is vacuolated and contains a prominent spherical nucleus which possesses 3-4 deeply-staining granules near the nuclear membrane. The bases of the epithelial cells rest on a structureless basement membrane. The musculature consists of an inner thin layer of circular muscle fibres and an outer, comparatively thicker layer of longitudinal muscle fibres. The peritoneum forms the outermost covering of the wall of the common median oviduct and comprises a single layer of greatly stretched cells. The lumen in the centre of the duct is spacious and communicates posteriorly with that of the vagina (Pl. III, fig. 6). It is lined by a very thin chitinous intima which remains closely applied to the inner side of the epithelium. The chitinous lining often contains portions of the chorionic wall.
of the eggs which adhered to it during fixation of the tissue. The dorsal wall of the common median oviduct is depressed along the middle line to accommodate the pair of anterior vaginal muscles in the groove (Pl. III, fig. 5). The two anterior vaginal muscles which run close together, have a common origin on the anterior process of collar. However, the muscles become gradually separated from each other as these proceed anteriorly along the dorsal surface of the oviductus communis. In the specimen, the muscles of the two sides are not equally developed, that of the left side being thinner than the right one.

The Vagina

The vagina consists of an anterior tubular portion and a genital atrium.

(1) The Anterior Tubular Portion

The anterior tubular portion of the vagina is a muscular organ whose lumen is laterally compressed by the presence of thick bands of striated muscles in its side walls (Pl. III, fig. 7). The lumen consists basically of a vertical slit with small lateral evaginations ventrally and a wide cavity antero-dorsally. The lumen is lined by a thick chitinous intima which becomes thickened at places forming specialized cuticular structures. The anterior portion of the vagina possesses a hard and elongated chitinous structure, the collar, projecting vertically in the cavity and marking the junction of oviductus communis, vagina and bursa copulatrix. The collar is made up of a median keeled plate, the posterior surface of which is notched deeply to produce a flattened postero-laterally directed arm on each side. The keel extends as an anteriorly directed process, the anterior process of collar on which the anterior vaginal muscles are inserted. The chitinous lining in the lateral wall of the compressed lumen is thickened to form two broad laminate structures termed lateral plates. The anterior-margin of each lateral plate is smooth and slightly incurved whereas its posterior margin is provided with ridges and grooves. The lateral plates
provide surface for attachment to the fibres of the sternovaginal muscles.

The epithelium in the wall of the vagina consists of cubical to tall columnar cells and is thrown into ridges which correspond to those of the chitinous intima. The epithelial cells are distinctly columnar in the ridges where each cell measures 7 micra in length and contains a 4 micra large spherical nucleus of granular appearance. The cytoplasm is vacuolated. The epithelial layer stands on a basal membrane. Outside the basal membrane are present muscle fibres running in longitudinal, radial and transverse directions. The adipose tissue is also present scattered among the muscle bundles.

(ii) The Genital Atrium:

The wall of the genital atrium is thin and thrown into irregular folds (Pl. IV, fig. 1). Histologically, it shows the following layers arranged, in order, from within outwards:-

The chitinous intima is thick and feebly sclerotised, thereby appearing colourless at places. The epithelium is composed of a single layer of small cuboidal cells in which cell-boundaries are not very distinct. There is a 4 micra large oval nucleus in each epithelial cell. Musculature is poorly developed in the wall and consists of a few muscle fibres which run in all directions. The adipose tissue is also present in scattered masses outside the wall of the genital atrium.

The Bursa Copulatrix

The histological structure of the bursa copulatrix is similar to that of the anterior tubular portion of vagina except that the chitinous intima of bursa is thrown into a complex pattern of ridges and furrows (Pl. III, fig. 8). Beginning from inside, the wall of the bursa copulatrix shows the following layers:-

The innermost layer comprises a chitinous intima which is
strongly chitinised and thrown into a complex pattern of plates and ridges projecting vertically in the lumen. The epithelium is composed of small cubical cells which are arranged in a single layer round the chitinous intima. Each epithelial cell measures 7 micra in length and 5 micra across, and contains a 4 micra large nucleus of spherical shape. The nucleus possesses a prominent nucleolus in the centre and 3-4 deeply-staining granules near the periphery. The cytoplasm of the epithelial cells is faintly-staining and slightly vacuolated. The epithelial layer is surrounded by a thin structureless basement membrane on the outer side. The musculature consists of longitudinal muscle fibres which form a uniformly thin coat outside the basement membrane. External to the muscle layer is present a thick and complete layer of adipose tissue. The lumen of bursa copulatrix is spacious and full of homogeneous secretion in which spermatozoa are scattered, more densely on the periphery than in the centre.

The wall of the ductus bursae shows almost the same structure as that of the bursa copulatrix except that its chitinous lining is provided with small postero-ventrally directed cuticular spines. There is only a single median dorsal ridge projecting into the lumen.

**The Spermatheca**

The histological structure of spermatheca is almost similar to that of the bursa copulatrix with the difference that the epithelial layer of the former is secretory (Pl. III, fig. 8). The wall of the bulbous spermatheca is composed of the following layers:

1. Chitinous intima,
2. Epithelium,
3. Basement membrane,
4. Musculature,
5. Adipose tissue.

The epithelium of spermathecal wall consists of short cuboidal cells which are arranged in a row outside the chitinous intima. Each epithelial cell measures 6 micra in length and possesses granular and vacuolated cytoplasm. The nuclei are oval
in shape, each measuring 4 micra in length and possessing 3-4 deeply-staining granules in the nucleoplasm. The bases of the epithelial cells are supported on a thin basement membrane. Outer to the basement membrane is present a thin layer of muscle fibres which are disposed longitudinally in the wall. The outermost layer in the wall of the spermatheca is composed of a thick coat of adipose tissue. The chitinous intima is thick and shows a lamellate structure. The lumen is large and full of spermatozoa and homogeneous secretion. The structure of the wall of the spermathecal duct is similar to that of the bulbous spermatheca.

The Accessory Glands

The accessory gland is divisible into two regions, a distal saccular region and a proximal duct (Pl. III, fig. 2). Histologically, the two regions of the accessory gland are different.

Saccular portion of accessory gland:

The wall of the saccular portion consists of a prominent epithelial layer which is surrounded by a very thin, transparent chitinous intima on the inner side and a thin coat of musculature on the outer side (Pl. IV, fig. 2). The epithelial layer is composed of a single tier of tall columnar gland cells enclosing a spacious lumen in the centre. The cytoplasm of the epithelial cell is highly granular and vacuolated. The nuclei are densely granular and situated mostly towards the basal end of cells. Numerous large spaces are seen at places in the epithelial layer, which also possesses secretory material towards the inner margin. The epithelium is, therefore, secretory in nature. There is a structureless basement membrane which provides support to the epithelial cells. A thin layer of muscle fibres is circularly disposed outside the basement membrane forming the main muscular coat of the wall. A few longitudinal muscle fibres are also present in the wall outside the layer of circular muscles.
Duct of accessory gland:-

The wall in the duct of the accessory gland is composed of the following layers, in order, from within outwards (Pl. IV, fig. 3):-

(i) Chitinous intima, (ii) Epithelium, (iii) Basement membrane, (iv) Muscle layer, and (v) Adipose tissue.

The lumen of the duct is narrow and lined by a thick layer of chitin. The chitinous intima is surrounded on the outer side by an epithelial layer which consists of a row of tall cubical cells. Each epithelial cell possesses a large darkly-staining nucleus of oval to elongated shape. The cytoplasm is homogeneous and devoid of vacuoles, spaces or secretion droplets. The epithelium of the duct of the accessory gland, therefore, appears to be non-secretory. The epithelial layer is bounded externally by a thin basement membrane. The musculature comprises a thick coat of circular muscle fibres only. The adipose tissue is also seen adhering at some places on the surface of the wall of the duct.

The duct of the accessory gland leads into the genital atrium from the postero-dorsal side to open close to the vulva.

2. **EXTERNAL GENITAL ORGANS**

The female external genital organs of *P. Rubriceps* selys consist of a pair of supra-anal appendages and a well developed ovipositor (Pl. IV, fig. 4). The female genital aperture is situated on the ventral side between the eighth and ninth abdominal segments, but concealed by base of ovipositor.

**The Supra-anal Appendages**

There is a pair of 0.497 mm. long, rod-like tubular supra-anal appendages projecting out posteriorly from the end of the tenth abdominal segment (Pl. IV, fig. 5). Each supra-anal appendage is an ash-coloured organ which is broad in the middle
and tapering towards the distal end. The surface of the anal appendage is covered with numerous small, white hair. The hair present on the ventro-mesal surface of the appendage are, however, longer than those found elsewhere. The posterior edge of the tenth tergite bears a series of small black spines.

**The Female Genital Aperture**

The female genital aperture termed vulva, is a circular orifice situated ventrally at the junction of the eighth and ninth abdominal segments.

**THE OVIPOSITOR**

The ovipositor is present on the ventral side of eighth, ninth and tenth abdominal segments and encloses the vulva. It consists of following five pairs of structures (Pl. V, fig. 4):

1. First valvifers,
2. Second valvifers or Lateral valves,
3. First valvulae,
4. Second valvulae, and
5. Conangula. The second valvulae lie dorsal to the first valvulae and both of these are enclosed by the lateral valves.

(i) **The First Valvifers**

These are a pair of flat, partly sclerotized rectangular plates implanted in the venter behind the eighth abdominal sternite (Pl. IV, fig. 6). Each valvifer bears on the mesal side a process, termed the mesal process which is joined with its fellow of the opposite side by a membrane. The anterior margin of each plate is drawn out anteriorly as a prominent strongly sclerotized structure, the anterior apophysis which provides attachment to the dorso-ventral muscles of the first valvifer.

(ii) **The Second Valvifers (Lateral Valves)**

These are a pair of 1.76 mm. long flap-like cuticular structures which are situated posterior to the first valvifers (Pl. IV, fig. 7). Each lateral valve is a bluish coloured
appendage consisting of a broad basal portion and a terminal style. The basal portion of the lateral valve extends over the whole of the ninth abdominal venter, and the style over the tenth abdominal venter. The antero-lateral margin of the basal portion of each lateral valve is strongly sclerotized to form an apophysis, termed anterior apophysis of lateral valve, for attachment of muscles. A posterior apophysis is also present arising from the postero-lateral edge. The posterior apophysis is stouter than the anterior apophysis and provides attachment to a second set of muscles of the lateral valve. Both the apophyses, anterior and posterior, project into the body cavity. Towards the distal end, the basal portion gives mesally out a cone-like outgrowth, termed gonoplace. The gonoplace of the two sides protect the apical ends of the first and second valvulae by enclosing these structures between them. The basal portion of the lateral valve is attached to the ventral surface of the abdomen by a chitinous bar termed laterotergite (Pl. V, fig. 4). This bar in P. furureceps is tapering at both the ends. The base of the second valvifer bears numerous hair on the outer surface and a series of teeth-like serrations on the ventral border.

The lateral valves are joined together by an intervalvular membrane which bears a small anterior sclerite (anterior intervalvular sclerite) near the front border and a large semicircular sclerite (posterior intervalvular sclerite) at the end of the posterior margin (Pl. XXXVII, fig. 2). The anterior intervalvular sclerite and the posterior intervalvular sclerite give attachment to the two ends of the anterior intervalvular muscles of the ovipositor.

The style of the lateral valve arises terminally from the basal portion and measures 0.361 mm. in length. It is a stout, dark brown coloured organ, the apex of which is densely hairy and directed towards its fellow of the opposite side. The surface of the style is covered with hair which are, however, sparsely distributed. The style appears to be tactile in nature.
(iii) **The First Valvulae**

The first valvulae are a pair of strongly chitinized sword-shaped processes, each measuring 1.364 mm. in length and directed posteriorly in the mid-ventral line (Pl. IV, fig. 6). A valvule consists of a basal ramus and a distal shaft.

The ramus is a small basal portion of the valvule which comprises a plate-like structure bearing a prominent ridge on the dorsal surface. The plate lies horizontally and bears on the lateral side a triangular process termed the lateral process. The two rami of a pair of valvulae are joined together medially to form a common plate-like structure which is acutely pointed at the anterior end. Each valvule is attached to the valvifer of its side by the basal border of the ramus.

The shaft of the valvule is an elongated structure which tapers distally to an acutely pointed apex. Its dorsal surface is provided with a longitudinal groove, and the dorsal edge is strongly sclerotized and continued anteriorly to merge into the dorsal ridge of the ramus. The outer lateral surface in the distal one-third region of the shaft bears numerous denticles, each of which alternates with a transverse ridge. The ventral edges of the two shafts lie opposed together when the ovipositor is not in use.

(iv) **The Second Valvulae**

The second valvulae are also a pair of elongated, sword-shaped, strongly sclerotized processes projecting posteriorwards and lying in the median line (Pl. IV, fig. 7 & 8). Each valvule measures 1.276 mm. in length and consists of a short basal portion termed ramus, and a long distal portion, the shaft. The shaft is three times the length of the ramus. The ramus is a curved plate-like structure placed in a vertical plane. When viewed laterally, it appears somewhat triangular in shape with its apex directed anteriorly. The inner surface of the ramus is concave, to provide surface for attachment of an ovipositor muscle. The
outer surface of the ramus is bulging and covered with small hair. The proximal end of the ramus is attached to antero-basal end of the lateral valve of its side.

The ramus is continued posteriorly as the shaft which is marked with a ventrally placed ridge running throughout the length. The blade of the shaft is uniformly wide, except in the apical region where it tapers acutely. It shows transverse ridges alternating with denticles on the outer lateral surface in the posterior half only.

The ventral ridge of the second valvular shaft fits into the dorsal groove of the first valvular shaft forming a sliding interlocking mechanism, typical of Platygotae Insecta (Matsuda, 1976). The valvulae thus enclose a longitudinal channel, the ovipositor canal for ova to travel out.

(v) The Gonangula

The gonangula are a pair of small bar-like sclerites which are placed transversely and obliquely, one on each side near the anterior end of the ninth abdominal segment (Pl. IV, fig. 4 & 6). It is attached dorsally through a membrane with antero-ventral part of the ninth abdominal tergite near the anterior end of the lateral valve. The ventral end of the gonangulum lies attached to the dorsal side of the lateral process of ramus of the first valvule.
1. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The internal reproductive organs consist of a pair of testes, a pair of efferent ducts - the vasa deferentia, a sperm sac and a median ejaculatory duct. Definite accessory reproductive glands are absent.

The Testes

The testes (Pl. VI, fig. 1) are a pair of long, cylindrical, translucent (in fresh condition) structures lying dorsal to the alimentary canal from the middle of the seventh abdominal segment up to the posterior margin of the eighth abdominal segment. The two testes lie separate anteriorly and closely opposed to each other posteriorly. Each testis measures 3.61 mm. in length and 0.445 mm. in diameter near the middle region, and is enclosed within a sheath of adipose tissue. The adipose tissue surrounding the gonad continues anteriorly beyond each testis as a suspensory filament which is attached to the body-wall in the fifth abdominal segment. The suspensory filament, tracheae and fat-bodies serve to maintain the testis in position.

The Vasa Deferentia

The vas deferens emerges as a narrow duct from the posterior end of the testis and extends up to middle of the ninth abdominal segment. Morphologically, the vas deferens is divisible into two parts, a straight proximal region and a convoluted distal region (Pl. VI, fig. 1).

The proximal region of the vas deferens is narrow and lies obliquely on the dorso-lateral side of alimentary canal in the ninth abdominal segment. It is surrounded by a thick coat of
adipose tissue. The convoluted distal region of the vas deferens is dilated and lies ventral to the alimentary canal. It consists of a ventro-anterior limb and a ventro-posterior limb.

The Sperm Sac

The sperm sac is a median, conspicuous, slightly elongated structure lying above the gonopore in the posterior two-third part of the ninth abdominal segment. It measures 0.35 mm. in length and a maximum of 0.16 mm. in diameter. The sperm sac is bulb-shaped, being rounded posteriorly and narrow anteriorly (Pl. VI, fig. 1). The vasa deferentia of the two sides open from the ventro-lateral side into the narrow anterior portion of sperm sac.

In teneral specimens the sperm sac and vasa deferentia are translucent white (Pl. VI, fig. 1). However, in older specimens there develops a gradual blackening in the wall of the sperm sac and the convoluted distal regions of vasa deferentia only, which ultimately become completely black with age (Pl. VI, fig. 2).

The Ejaculatory Duct

The sperm sac opens into the gonopore through a minute postero-ventrally directed duct, the ejaculatory duct. The ejaculatory duct lies above the male gonopore and is supported by an elongated, plate-like chitinous structure. This chitinous structure is continuous with chitinous wall of the gonopore and is concave dorsally.

(H) HISTOLOGY

The Testis

The testis shows the following histological structure beginning from peripherally towards the centre (Pl. VI, fig. 3).

(i) The Adipose tissue:— Fat-bodies are found abundantly in the region of testis in the form of adipose tissue which is present in a regular layer round the organ. The adipose tissue
consists of a spongy mass of large fat-cells, each possessing vacuolated cytoplasm and a highly granulated nucleus. The adipose tissue forms a prominently thick envelope on the outer lateral side of the testis.

(ii) The Peritoneum:— A thin layer of greatly stretched, nearly spindle-shaped cells surround the testis on the external side forming the peritoneal layer (Pl. VI, fig. 4). Each peritoneal cell possesses granular cytoplasm and a nucleus. At places, the peritoneum is distinct due to the presence of prominent nuclei.

The above two layers comprise the wall of the testis which contains inside, a large number of lobules on the inner side of a common lateral duct (Pl. VI, fig. 3). The common duct runs on the outer lateral side of the testis throughout the length except a small region near the anterior end.

(iii) The Common Lateral Duct:— Histologically the common lateral duct is divisible into two regions, an anterior region and a posterior region.

The wall of the lateral duct in the anterior region (Pl. VI, fig. 4) is composed of following two layers from within outwards:—
(a) Epithelium, (b) Muscle layer.

The epithelium consists of a single tier of large columnar cells, each measuring 15 micra in length and 6 micra across. The cytoplasm of the epithelial cells is highly granular and vacuolated. The nucleus is large, spherical to elliptical in shape and measures 5 micra in diameter. There is a conspicuous nucleolus in the centre and numerous deeply-staining granules near the periphery in each nucleus. The cell-walls of the epithelial cells are not visible due to presence of large amount of granular material in the cytoplasm. Musculature of the duct consists of a very thin layer of circular muscle fibres only. The lumen of the duct is small.
The histological structure of the common lateral duct in the posterior region of testis (Pl. VI, fig. 5) differs slightly from that described above. The epithelium of the duct on the outer side is simple and single layered, consisting of small cuboidal cells with large granular nuclei. However, the epithelium on the inner side consists of cuboidal to columnar cells, and shows patches of compactly packed long columnar cells at places. The cytoplasm of the epithelial cells is vacuolated and contains numerous secretory granules and droplets. The cell-membranes are indistinct. The inner margin of the epithelial cells appears fibrillar and irregular. Each epithelial cell contains a highly granular, round nucleus measuring 5 micra in diameter. The epithelium is multilayered also at some places, especially on the inner side of the duct. The musculature comprises a layer of circular muscle fibres only.

The lumen of the common lateral duct is spacious and contains distinctly granular secretory material.

(iv) The Lobules:— The structure of lobules is similar to that described in the previous species. However, the following salient features are noticeable in them.

(a) A lobule is solid and nearly spherical in shape.
(b) All the germ cells in a single lobule are alike.
(c) Each lobule is surrounded by a thin limiting membrane only.
(d) There is no germinal epithelium.
(e) Each lobule opens into the common lateral duct by a separate minute ductule.
(f) The lobules near the common lateral duct contain ripe spermatozoa which are often aggregated into sperm groups.

The Vas Deferens

The vas deferens is the prolongation of the testicular common duct (Pl. VI, fig. 5).
Histologically also, it is divided into two regions, a proximal region and a distal region.

(i) The Proximal region:-- The wall of the proximal region of vas deferens (Pl. VI, fig. 6) consists of a distinct 8 micra thick epithelial layer enclosing a narrow lumen in the centre. The epithelium is composed of a single row of large cuboidal cells. Each epithelial cell contains a large oval nucleus measuring 5 micra in diameter. The nucleus possesses a distinct nucleolus in the centre and 6-8 deeply-staining granules near the periphery. The cytoplasm is granular and vacuolated. The musculature consists of only a thin layer of circular muscle fibres on the outer side of the epithelium. The adipose tissue is well developed and forms a thick coat round the vas deferens. It consists of spongy mass of cells with prominent granular nuclei and large vacuoles.

(ii) The Distal region:-- The wall of the distal region of vas deferens (Pl. VI, fig. 7) is thin and encloses a spacious lumen in the centre. The lumen is filled with secretory material of two kinds, a homogeneous secretion and a granular secretion. The homogeneous secretion forms a thick layer of mucilaginous consistency round the granular secretion which occupies the central region of the duct. The spermatozoa are present mostly in groups in the homogeneous secretion. However, the granular secretion contains mostly scattered spermatozoa, some of which are present in groups also. The wall consists of an inner distinct epithelial layer and an outer muscular layer. The epithelium is composed of a very thin layer of flat cells with elongated granular nuclei. The musculature comprises a layer of circular fibres only. A peritoneal layer is also present outside the muscle layer. The peritoneum possesses numerous brown to black pigment granules which impart black colouration to the wall of this region of vas deferens in older specimens.

The distal region of the vas deferens stores spermatozoa.
The Sperm Sac

The sperm sac shows the same histological structure as is shown by the distal region of vas deferens except that the muscular coat is comparatively strongly developed in the wall of sperm sac. The lumen of the sperm sac is spacious and contains secretory material and spermatosoa. There is no chitinous intima (Pl. VI, fig. 7).

The Ejaculatory Duct

The sperm sac communicates with the gonopore on the ventral side through a microscopic duct, the ejaculatory duct. The wall of the ejaculatory duct possesses the same histological structure as that of the wall of sperm sac except that its lumen is lined by a thin chitinous intima.

2. EXTERNAL GENITAL ORGANS

The external reproductive organs of P. decorum consist of a pair of supra-anal appendages, a pair of infra-anal appendages, a pair of coxites and a secondary copulatory apparatus.

The Supra-anal Appendages

There is a pair of characteristically well developed and upwardly sloped structures, the supra-anal appendages arising out termino-dorsally from the posterior side of tenth abdominal segment (Pl. VII, fig. 1). Each supra-anal appendage is a stout tubular rod-like structure measuring 0.75 mm. in length (Pl. VII, fig. 2). It is coloured light ash on the mesal side, dark ash on the lateral side and black distally. There is a prominent antero-posteriorly directed groove on mesal surface of each supra-anal appendage which also bears three black spines. The basal and middle spines are situated at about one-third and two-third distances from the base of the appendage respectively. The third spine is located subapically and is large, stout and
beak-like in shape. The surface of the appendage is beset with numerous hair which are long and bristle-like.

The Intra-anal Appendages

The intra-anal appendages are 0.23 mm. long, weakly sclerotized paired structures present on the ventral side of the supra-anal appendages and anus (Pl. VII, fig. 1). The intra-anal appendages are dark ash coloured hollow, sac-like structures appearing rounded when seen from the ventral side and rectangular in profile. Each intra-anal appendage is much shorter in size than the supra-anal appendage. It is composed of an outer bulbous portion and an inner flat part (Pl. VII, fig. 3). Each intra-anal appendage bears at the apical end a black posteromesally directed spine of 0.063 mm. length, and numerous bristle-like hair all over the surface.

The Gonopore

The male genital opening is a circular orifice situated between coxites in the middle of the ninth abdominal segment (Pl. VII, fig. 4). It measures 0.136 mm. in diameter. The chitinous wall around the gonopore is heavily sclerotized forming a ring-like structure which is continuous with an internal, elongated plate-like chitinous structure present on the anterodorsal side of the gonopore. The dorsal side of this chitinous structure is concave and lodges the microscopic ejaculatory duct.

The Coxites:—The coxites are a pair of elongated, bean-shaped, light green structures enclosing the gonopore and measuring 0.669 mm. in length. Each coxite is broad and round anteriorly and tapering posteriorly to form a style-like structure. The broad portion of the coxite is fused with the body-wall and the style-like portion which measures one-third of the length of the whole structure, hangs freely from it. Numerous hair are present on the surface.
The Anterior genital plate:— It is a broad rectangular light green plate measuring 0.518 mm. in length and 0.662 mm. in width. The surface is adorned with numerous minute tubercles and posteriorly directed hair.

The post-genital plate:— It is also a rectangular and light green coloured plate measuring 0.339 mm. in length and 0.678 mm. in width. The hair are absent and its surface is beset with numerous minute tubercles only.

THE SECONDARY COPULATORY APPARATUS

A secondary copulatory apparatus is present anteriorly on ventral side of the second and basal part of the third abdominal segments (Pl. VII, fig. 5). It consists of a genital fossa, an anterior lamina, a pair of anterior hamules, a lamina batilliformis, a genital sac, supporting framework, a penis and a vesicula spermalis. The posterior hamules are absent.

The Genital Fossa

The genital fossa housing the copulatory organs has the same description as in the previous species, P. rubriceps Selys.

The Anterior Lamina

The anterior lamina (Pl. VII, fig. 6) is a prominent 0.587 mm. long azure blue plate present in the anterior one-third part of the second abdominal segment. Anteriorly, it is bounded by a transverse apophysis and laterally it is attached through membranes to the ventro-lateral margins of the second tergum. The lateral and posterior regions of the lamina are heavily sclerotized. The posterior margin of the anterior lamina is deeply notched and the cleft reaches nearly upto its anterior margin. The cleft is covered over by a thin membrane. The structure formed by the space of the cleft and the covering membrane is termed median laminar sac. Anteriorly, the median laminar sac is produced into first abdominal segment while
posteriorly it lies attached to lamina batilliformis. The surface of the anterior lamina bears long bristle-like hair.

The Anterior Hamules

A pair of prominent, azure blue hamules are present behind the anterior lamina on the lateral sides in the genital fossa. Each hamule consists of two plates, an outer movable plate and an inner rigid plate (Pl. VII, fig. 6). The outer plate is nearly square in shape measuring 0.396 mm. in length and 0.358 mm. in breadth. It is attached antero-laterally with the anterior lamina, laterally with the ventro-lateral margin of the second tergum and mesally with the inner plate. The inner plate lies immediately dorsal to the outer plate and comprises a large membranous area towards the medial side and a strongly sclerotized vertical part near the middle of the outer plate. The vertical sclerotized part of the inner plate is slightly curved and consists of a posterior basal region which is fused with the membranous part and an anterior apical region. The anterior apical region hangs freely towards the anterior side and is pointed apically forming a hook-like structure.

The Lamina Batilliformis

The lamina batilliformis (Pl. VII, fig. 6) is a chitinous structure located in the middle of the genital fossa. It consists of a large scooped plate which is deeply notched posteriorly forming a pair of prominent limbs. The anterior margin of the scooped plate is semicircular. The margins of the notch are strongly sclerotized, especially near the posterior end where a few bristle-like hair are also present projecting outward. The limbs of the lamina batilliformis are bent at their extremities to form a pair of lateral cornua which are directed anteriorward, upward and outward. The apex of each cornu is slightly curved. The cornua, limbs and margins of the notch provide support to genital sac.
The Genital Sac

The genital sac is a large membranous structure which is situated deep in the central region of the genital fossa. It opens ventrally and houses the antero-proximal portion of the penis. The wall of the genital sac is supported laterally by the anterior vertical bars of the frame, latero-ventrally by the lateral longitudinal bars of the frame and antero-ventrally by the lamina batilliformis. The roof of the sac is formed by the basal plate of penis. Posteriorly, the genital sac is bounded by the anterior margin of the posterior median plate of the frame.

The Supporting Framework

The supporting framework (Pl. VII, fig. 7) consists of (a) a pair of anterior vertical bars, (b) a pair of lateral longitudinal bars, and (c) a posterior median plate.

(a) The Anterior Vertical Bars:

The anterior vertical bars are obliquely present in the lateral wall of the genital sac and measure 0.484 mm. in length. The dorsal end of the bar is united with basal plate of penis and its ventral end is articulated with anterior tip of lateral longitudinal bar of the frame.

(b) The Lateral Longitudinal Bars:

These are 0.369 mm. long structures present horizontally on the lateral margin of the ventral of second abdominal segment. Each bar articulates anteriorly with the anterior vertical bar and posteriorly with anterior limbs of posterior median plate of framework.

(c) The Posterior Median Plate:

It is a large 0.438 mm. wide plate lying horizontally on the posterior side of the genital sac. The lateral margins of the plate are produced anteriorly and posteriorly forming short
pairs of anterior and posterior limbs. The median plate is strongly sclerotized throughout except a distinct antero-medial region which is membranous. There is an antero-mesally directed, ventrad spine at the apex of each anterior limb. Hair are present in patches on the ventral surface of the plate and limbs. The posterior median plate of the frame is connected laterally with second abdominal tergite through membranes.

The Penis

The penis (Pl. VII, fig. 8) is an unsegmented structure acting as the intromittent organ and comprising a basal plate and a shaft.

The Basal plate:-

The basal plate is incorporated in the root of the genital sac and consists of an anterior sclerite and a posterior sclerite.

The Anterior sclerite:- The anterior sclerite is 0.334 mm. broad and lies transversely above the anterior end of the posterior sclerite. It is maintained in its position by the anterior vertical bars of the framework.

The Posterior sclerite:- It is a scoop-like 0.487 mm. long structure which lies united with the basal end of the anterior sclerite.

The Shaft:-

The shaft is a long portion which is continuous proximally with the posterior sclerite. It possesses a narrow lumen in the interior which communicates with the body cavity through a small foramen enclosed by the basal ends of the sclerites of basal plate. The shaft is divisible into three regions, a proximal, a middle and a distal region.
The Proximal region: The proximal region is a long curved rod-like structure which is strongly sclerotised at the base. The sclerotisation gradually diminishes towards the apical side where the distal surface is largely membranous.

The Middle region: The middle region of the shaft is smallest of the three regions. It is heavily sclerotised throughout except the dorsal surface which is membranous.

The Distal region: The distal region is a weakly sclerotised area of the shaft. It is distinctly separated by a line from the middle region of the shaft on which it lies bent over. The distal region is composed of a prepuce and a glans. The prepuce is a large triangular structure tapering to a point apically. The glans is a lobe-like structure situated at the base of the region.

A median groove runs externally along the dorsal membranous area of the penis from near the base of the shaft upto the base of the distal region.

The Vesicula Spermalis

The vesicula spermatica (Pl. VII, fig. 9) is a 0.84 mm long flask-shaped vesicle of deep azure blue colour situated ventral to the posterior median plate of the frame. It consists of a large body and a narrow neck. The ventral wall of the body is strongly sclerotised and shows a median longitudinal depression. The ventral surface of the neck is membranous in the middle and strongly sclerotised on the sides forming a pair of limb-like structures. The apices of the limbus are directed mesad. There is a small, ventral, slit-like orifice in the membranous part of the neck at the anterior end. Small bristle-like hair are sparsely distributed on the sclerotised surface of the vesicle. The dorsal wall of the vesicula spermatica consists of a membrane which is strengthened by two apodemes, an anterior and a posterior apodeme.
The Anterior apodeme: - The anterior apodeme is a thin sclerotized transverse bar expanded at ends and connected with the posterior limbs of the median plate of frame.

The Posterior apodeme: - The posterior apodeme situated behind the anterior apodeme is united with the anterior edge of the third abdominal sternite. The lateral ends of the posterior apodeme are broad and directed postero-dorsally.
FEMALE REPRODUCTIVE SYSTEM OF PSEUDACRION DECORUM (RAMBUR)

1. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The internal reproductive organs consist of a pair of ovaries, a pair of oviducts, a common median oviduct and an '8th complex'. A pair of accessory reproductive glands are also present in the ninth abdominal segment. These open close to the vulva in the postero-dorsal wall of the vagina.

The Ovaries

The ovaries are a pair of prominent yellowish-white organs measuring 23.75 mm. in length and extending dorsally over the alimentary canal from the first abdominal segment up to the middle of the seventh abdominal segment. The two ovaries are joined together for a greater portion of their length by a median dorsal ligament which is attached posteriorly to the dorsal body-wall near the end of the ninth abdominal segment. Each ovary consists of a very large number of panoistic ovarioles opening into a common lateral duct. The dorsal and ventral surfaces of the ovary are well differentiated. The dorsal side bears ovarioles and the ventral side possesses the common lateral duct to which the ovarioles are attached. Each ovariole is an elongated organ which shows a beaded appearance due to presence of eggs in the interior. It is broad at the base and tapers distally to a fine thread-like structure, the terminal filament. The terminal filaments remain embedded in the tissue of the median dorsal ligament. The ovariole encloses a row of developing ova arranged in an acropetal succession, the youngest lying near the apex and the oldest which is largest also, is situated at the base. All the ovarioles are basally attached to the common lateral duct, and apically directed antero-mesally and dorsally. The terminal filamentous ends of anterior
ovarioles are united together to form a cord-like structure, the apical filament of the ovary. The apical filaments of the two ovaries extend anteriorly along with the median dorsal ligament to enter into the thorax where they become attached to the dorsal body-wall. The common lateral duct is a delicate, thin-walled and transparent duct running ventro-laterally almost throughout the length of the ovary. The tracheae and adipose tissue which are abundantly present surrounding each ovary, help to maintain the gonad in position along with its apical filament and the median dorsal ligament.

The Oviducts

The common lateral ducts are continued posteriorly beyond the ovaries as paired oviducts which extend from the middle of the seventh up to nearly the middle of the eighth abdominal segments. Each oviduct is a simple, thin-walled and translucent tube of uniform diameter (Pl. VIII, fig. 1) and measures 2.562 mm. in length. The oviducts turn down the sides of the alimentary canal near their origin and lie ventral to it finally.

The Common Median Oviduct

The two oviducts meet each other below the gut to form a short common median oviduct, the oviductus communis (Pl. VIII, fig. 1). The common median oviduct is surrounded by adipose tissue and lies partly hidden dorsally by eighth abdominal ganglion. It enters posteriorly into the '8th Complex'.

The '8th Complex'

It is a prominent translucent organ (Pl. VIII, fig. 2) situated immediately beneath the alimentary canal in the posterior half of the eighth abdominal segment. The '8th Complex' is situated behind the eighth abdominal ganglion which gives out a pair of nerves running along its dorso-lateral margins. The complex consists of a vagina and a bursa copulatrix. There is no spermatheca in the present species.
The Vagina

The vagina is a muscular duct lying medially on the ventral side of the '8th Complex'. It connects the common median oviduct with vulva. Morphologically, the vagina is divisible into two portions, an anterior tubular portion and a posterior genital atrium.

(a) The Anterior tubular portion:

It is a long tubular and strongly sclerotized structure forming the main part of the vagina. The tubular portion of the vagina is a highly muscular organ which provides surface for attachment to the anterior vaginal muscles in its anterior wall and to the tigo-ternal muscles on its lateral side.

(b) The Genital atrium:

The tubular portion of vagina continues posteriorly into a weakly sclerotized genital atrium. It is a thin-walled chamber showing wrinkled surface. Anteriorly, the genital atrium receives the opening of the tubular vaginal portion and posteriorly it communicates to the exterior through vulva (Pl. VIII, fig. 3). The accessory reproductive glands also open into its postero-dorsal wall through a pair of fine ducts.

The Bursa Copulatrix

The antero-dorsal part of the vagina is evaginated to form a median, dorso-posteriorly directed oval sac, the bursa copulatrix. The apical portion of bursa copulatrix is usually tilted towards one side of the median line and conceals the anterior part of vagina from dorsal view (Pl. VIII, fig. 1). It functions as a copulatory pouch which receives the penis during copulation and stores spermatozoa poured through the penis.

The Accessory Reproductive Glands

There is a distinct pair of white glandular structures
beneath the rectal part of alimentary canal in the ninth abdominal segment. These are the accessory reproductive glands (Pl. VIII, fig. 2) which are seen after careful removal of the alimentary canal. Each accessory gland is composed of a sac-like distal portion and a slender proximal duct. The duct is a delicate tube measuring nearly one-third of the total length of the gland and opening very close to the vulva into the cavity of the genital atrium. The sac-like portion of the gland is an elongated cylindrical organ lying prominently on either side of the median line in the ninth abdominal segment.

(B) HISTOLOGY

The Ovaries

Each ovary consists of a very large number of punciatic ovarioles which arise dorso-mesally from the common lateral duct.

The Ovariole:

An ovariole is surrounded by a thin, delicate, transparent and membranous wall, the epithelium, composed of a single layer of greatly stretched cells. The cellular nature of the wall is clearly seen at the corners of the developing oocytes. The three divisions of a typical insectan ovariole, the terminal filament, the germarium and the vitellarium, are clearly visible in the present species (Pl. VIII, fig. 4). The germarium is a thick mass of undifferentiated germ cells situated next to the terminal filament, which is simply the anterior prolongation of the ovariole wall and surrounding adipose tissue. The vitellarium constitutes a major portion of the ovariole and contains a chain of successively developing ova inside the epithelial wall. The largest egg which is oldest also, lies at the base of the ovariole till its extrusion into the lumen of the common lateral duct. The median dorsal ligament joining the two ovaries, is composed of a loose mass of connective tissue in which fat-bodies and few muscle fibres are also present.
The Common Lateral Duct:

The wall of the common lateral duct is very thin and made up of two layers only, (i) Epithelium and (ii) Muscle layer.

The epithelium is composed of a single layer of small cuboidal cells, each with a large ovoid nucleus and a little amount of cytoplasm. There is a thin layer of longitudinal muscle fibres on the outer side forming the muscular coat of the duct. A spacious lumen is present in the centre of the duct which contains eggs discharged from the ovarioles.

The Oviduct

The wall of the oviduct shows an epithelium on the inner side and a muscle layer on the outer side. The epithelium consists of a single tier of small cuboidal cells, the cell-boundaries of which are indistinct. Each epithelial cell possesses slightly vacuolated cytoplasm and a granular nucleus of oval shape. The muscle layer is comparatively thick but comprises longitudinal muscle fibres only. Adipose tissue is seen attached to the wall of the oviduct at places and forming an incomplete layer round it. The lumen of the oviduct is narrow and serves to transfer the eggs from the common lateral duct to the common median oviduct.

The Common Median Oviduct

The common median oviduct is similar to the oviduct in histological structure except that its lumen is lined by a very thin layer of chitinous intima. The lumen is so spacious that it contains 3 or 4 ova at a time (Pl. VIII, fig. 5). The chitinous intima is surrounded by the epithelium which is composed of a single layer of small columnar cells (Pl. VIII, fig. 6). Each epithelial cell possesses a small amount of vacuolated cytoplasm and a large oval nucleus. The nucleus is provided with a large nucleolus in the centre and 2-3 deeply-staining granules near the periphery. Outside the epithelium is present a very thin basement membrane. The outermost stratum
in the wall is the musculature which comprises two layers, an inner thin layer of circular muscle fibres and an outer thick layer of longitudinal muscle fibres. The adipose tissue is scattered in pieces on the surface of the musculature. A pair of muscles, the anterior vaginal muscles are present on the dorsal side of the common median oviduct. The presence of the single fasciculus of this muscle produces in the wall a small ridge projecting towards the lumen of the oviductus communis. The Oviductus communis opens posteriorly into the vagina of the '8th Complex' through a slit termed the female gonopore (Pl. IX, fig. 1).

The Vagina

(a) The Anterior tubular portion:

Histologically, the wall of tubular portion of vagina consists of the following layers:— (i) Chitinous layer, (ii) Epithelium, (iii) Basement membrane, (iv) Musculature, and (v) Adipose tissue.

The lumen of the tubular portion of vagina is in the form of a narrow vertical slit which is wide dorso-anteriorly and evaginated into a pair of lateral outgrowths ventrally (Pl. VIII, fig. 7). It is lined by a thick chitinous layer which is folded at places showing varying degrees of thickening and chitinization forming specialized cuticular structures. The collar is a small cuticular structure present in the antero-dorsal part of the vagina embracing the orifice of ductus bursae into the lumen. It consists of a median cuticular mass and a pair of lateral arms. The median cuticular mass is strongly sclerotized and blackish-brown in colour lying in the anterior wall of the vagina. The median mass is produced anteriorly into a small process on which the anterior vaginal muscles are inserted. The lateral arms are small and comparatively weakly sclerotized processes, extending along the sides of the lumen as chitinous plates which hang posteriorly towards the lumen. A ductus bursae communicates with the vagina from the dorsal side of the collar whereas the oviductus communis opens into it from
the ventral side. The chitinous layer outlining the vertical part of the lumen is flattened to form a pair of lateral plates (Pl. VIII, fig. 3) on which fibres of the sterno-vaginal muscles are attached.

The epithelium of the vaginal wall is composed of columnar cells which are arranged in a single layer surrounding the chitinous layer. Each epithelial cell measures 9 micra in length and 5 micra in width and possesses a large granular nucleus near the centre. The epithelial cells are supported on a basement membrane. The musculature consists of a pair of thick bands of sterno-vaginal muscles, the fibres of which are attached on the dorsal side, lateral sides and a few on the ventral wall of the vagina. Besides these, a few striated muscle bundles also run longitudinally on the wall of the vagina. In the posterior region of the tubular portion of vagina, strong radial muscles are present in the wall. The outermost coat is formed by adipose tissue which is seen scattered among the muscle bundles.

(b) The Genital atrium:

The structure of the genital atrium is more or less similar to that of the anterior tubular portion of vagina with the difference that the wall of genital atrium is thin and less muscularized. The chitinous lining is also thin, weakly sclerotized, transparent and inpunched at places forming irregular folds. The epithelium consists of a single layer of small cuboidal cells, each measuring 6 micra in length and possessing a prominent nucleus. The adipose tissue is abundantly present outside this region.

The Bursa Copulatrix

The wall of the bursa copulatrix (Pl. IX, fig. 2) is composed of an inner epithelial layer and an outer muscle layer, the two being separated from each other by a thin structureless basement membrane. The epithelium is made up of columnar cells which are arranged in a single tier round the lumen. An
epithelial cell measures 10 micra in length and 6 micra in breadth, and possesses an ovoid nucleus near the base. The nucleus is highly granular and the cytoplasm of the epithelial cell is vacuolated. The epithelium is thrown internally into irregular folds and appears to be distinctly glandular in nature. Externally, it rests upon a basement membrane. The epithelium in the apical portion of the bursa copulatrix possesses large spaces among the granular cytoplasm. The musculature comprises longitudinal muscle fibres only, forming a layer outside the basement membrane. A thick coat of adipose tissue is present on the outermost side of the wall of the bursa. The lumen of the bursa copulatrix is spacious and contains spermatozoa. It is lined by a thin chitinous intima. An interesting observation in the species has been the occurrence of an ovum inside the lumen of the bursa copulatrix (Pl. IX, fig. 3). Ordinarily, the ova do not enter into the bursa.

The ductus bursae (Pl. IX, fig. 1) possesses the same histological structure as described above except that its chitinous intima is greatly folded forming spines and ridges, and the musculature is well developed. The epithelium is simple and non-glandular.

The Accessory Reproductive Glands

The wall of the sac-like portion of accessory gland (Pl. IX, fig. 4) shows the following layers, in order from within outwards:— (i) Chitinous intima, (ii) Epithelium, (iii) Basement membrane, and (iv) Musculature.

The lumen in the sac is large and spacious. It is bounded by a prominent epithelial layer which is irregular in outline. The epithelial layer consists of a single row of tall columnar gland cells, often grouped in patches. The nuclei are large, granular and situated near the basal ends of the cells. The cytoplasm is deeply-staining and vacuolated, and possesses secretory material especially near the inner end of the cells. The epithelium is lined internally by a thin chitinous intima.
There is a basement membrane surrounding the epithelial layer on the outer side. The musculature consists mainly of a layer of circular muscle fibres. A few longitudinal muscle fibres are also present in the wall outside the circular muscle layer. Adipose tissue is absent.

The duct of the accessory gland (Pl. IX, fig. 5) shows the same arrangement of layers as the wall of the sac-like portion. However, following salient features are seen in the duct.

The lumen is narrow and the chitinous intima is thick. The epithelial layer consists of a row of large cuboidal cells, each provided with a prominent deeply-staining nucleus. The secretory material which is characteristically present in the epithelial cells of the saccular portion is, however, absent here. The epithelium of the wall of the duct, therefore, seems to be non-glandular. The muscular coat in the wall of the duct is well developed and consists of a thick layer of circular muscles fibres only. The adipose tissue is present in scattered groups on the surface of the duct.

2. EXTERNAL GENITAL ORGANS

The external genital organs of female \textit{P. decorum} (Rambur) consist of a pair of supra-anal appendages at the end of the tenth abdominal segment and a well developed ovipositor.

The \textit{Supra-anal Appendages}

There is a single pair of bluish-green appendages, the supra-anal appendages arising dorso-terminally from the end of the last abdominal segment (Pl. IX, fig. 6). The appendages are hollow cylindrical organs which are broad at the base and gradually tapering distally. Each supra-anal appendage measures 0.583 mm. in length and is directed postero-ventrally. Numerous
tubercles and posteriorly directed hair are present all over the surface of the appendage. The posterior margin of the tenth abdominal tergite bears a prominent black spine near the base of each supra-anal appendage.

The Female Genital Aperture

The female genital aperture or the vulva lies ventrally at the posterior of the eighth abdominal sternite. It is a simple and more or less circular orifice which lies hidden from external view by the base of the ovipositor (Pl. IX, fig. 6).

THE OVIPOSITOR

A well developed ovipositor is present on the ventral side of the eighth, ninth and tenth abdominal segments (Pl. IX, fig. 6). The ovipositor is composed of five pairs of distinct structures as follows:— (i) Paired first valvifers, (ii) Paired lateral valves or second valvifers, (iii) First pair of valvulae, (iv) Second pair of valvulae, and (v) Gonangula.

The First pair of Valvifers

The first pair of valvifers include two dorso-ventrally flattened, quadrato plates present on the antero-lateral sides of the vulva at the end of the eighth abdominal segment (Pl. VIII, fig. 3). The two plates are joined together along their mesal margin by a chitinous membrane. The anterior margin of each valvifer extends anteriorly as a median sclerotized process, termed the anterior apophysis of the valvifer. The lateral margin of the valvifer also forms a small triangular process which is curved upwards.

The Second pair of Valvifers (Lateral Valves)

The lateral valves are a pair of elongated chitinized structures which hang from the venter of the ninth abdominal segment as leaf-like, bluish-green structures projecting caudad. Each lateral valve (Pl. IX, fig. 7) measures 1.474 mm. in length
and is composed of a broad basal portion and a terminal style. The basal portion is thickly clothed with posteriorly directed hair all over the surface. It is denticulated along the ventral border on the caudal half, where a small flap-like structure termed gonoplac is also present subapically on the mesal side. The gonoplac is depressed lengthwise on one side to house the apex of the aculeus when the ovipositor is at rest. Each lateral valve bears two internal apophyses, an anterior apophysis and a posterior apophysis on the dorso-anterior side, for attachment of ovipositor muscles. The anterior apophysis is a narrow, elongate bar projecting mesad. The posterior apophysis is a comparatively stout process projecting vertically in the body cavity. A bar-like sclerite, the laterotergite which is pointed at the ends, attaches the base of the lateral valve with the ventro-lateral edge of the ninth tergite. The portion of the ninth sternum lying between the base of the lateral valves, is membranous and depressed forming a median groove in the segment to accommodate valvulae. The sternal wall is termed intervalvalular membrane which is strengthened by two intervalvalular sclerites, a small anterior sclerite near the front margin and a large posterior sclerite at the hind edge. The posterior intervalvalular sclerite is a large, transversely elongated, bar-like structure which demarcates the ninth abdominal sternite from the tenth sternite (Pl. IX, fig. 6).

The style is a hollow, stout, palp-like, pale brown organ arising apically from the caudal end of the broad basal portion of the lateral valve and measuring 0.396 mm. in length (Pl. IX, fig. 7). It is curved slightly ventrad and the apices of the two style lie closely apposed to each other. The surface of the style is covered with sparsely distributed hair which, however, form a dense zone at the apex.

The First and Second pair of Valvulae

The first and second pair of valvulae (Pl. IX, fig. 6) are collectively known as 'aculeus' (Matsuda, 1976). The aculeus
consists of two pairs of sword-shaped and heavily sclerotized ventro-medial processes, basally enclosing the vulva and directed posteriorwards. Each valvula is a brownish-black structure which bears a saw-like surface near the distal end. The saw-like appearance is produced by the presence of numerous large tubercles each of which alternates with a transverse pleat. A valvula is made up of a small antero-proximal basal portion termed the ramus and a long distal portion, the shaft. The rami of the first valvulae are situated anterior and ventral to those of the second valvulae. The shafts of the second valvulae are placed above the shafts of the first valvulae and the two shafts of a side are engaged together by a ridge and groove arrangement forming a sliding interlocking mechanism, as in P. rubriceps. The mesal edges of the shafts of valvulae lie apposed to each other, thereby forming an ovipositor canal for the passage of ova from vulva to the exterior. When not in use, the shafts lie ensheathed by the lateral valves in the median groove of the ninth abdominal sternum.

The First Valvulae:

The first valvulae are attached basally with the first valvifers (Pl. VIII, fig. 3), and measure 1.232 mm. in length. The two rami of the first valvulae are joined together to form a broad, dorso-ventrally flattened plate-like structure which bears anteriorly a small median process. The outer lateral area of each ramus is produced into a wing-like lateral process. Besides these structures, each ramus also possesses a prominent longitudinal ridge on the dorsal surface which is posteriorly continued all along the dorsal edge of the shaft. The shaft is acutely pointed at the end.

The Second Valvulae:

The second valvulae measure 1.166 mm. in length and are more slender and curved than the first valvulae. The ramus of the second valvule is attached anteriorly to the inner side of the antero-basal end of the lateral valve of its side (Pl. IX, fig. 7). The ramus is an elongated and scooped plate which lies
in a vertical plane. The convex surface of the ramus bears numerous small hair whereas its mesal surface is concave and provides surface for attachment to a muscle of ovipositor. The rami of the two valvulae are connected by a thin membrane. Each ramus is continued posteriorly into a curved shaft which bears a saw-like edge distally and is pointed apically.

The saw-like edges together with the acutely pointed spines of the first and second pair of valvulae are used for making holes in the plant tissue during oviposition.

**The Gonangula**

A pair of small bar-like, strongly sclerotized structures, the gonangula (Pl. VIII, fig. 3), are placed obliquely and vertically at the junction of the eighth and ninth abdominal segments. Each gonangulum is attached ventrally with the lateral process of the ramus of the first valvule, and dorsally with the antero-ventral part of the ninth abdominal tergite at a point very close to the basal end of the lateral valve of its side.
1. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The male internal reproductive system consists of a pair of testes, a pair of vasa deferentia, a median sperm sac and a ductus ejaculatorius. Accessory reproductive glands are absent.

The Testes

The testes are a pair of 4.41 mm. long and 0.78 mm. thick cylindrical and translucent structures present on the dorsal side of the alimentary canal in the posterior half of the seventh and whole of the eighth abdominal segments (Pl. X, fig. 1). Each testis is composed of numerous rounded bodies, the lobules which impart a beaded appearance to the surface. The two testes are joined with each other by a median longitudinal strand of connective tissue. Adipose tissue surrounds the testis on all sides and extends anteriorly beyond the apex as anterior suspensory filament. The suspensory filament is attached to the tergum of the fifth abdominal segment and serves to hold the gonad in position. The tracheae and tracheoles form a network over the surface of the testis. The testes are held in position by tracheae, fat-bodies and the anterior suspensory filaments. In addition to these structures, the median strand of connective tissue extending between the testes also helps to maintain them in position by posteriorly attaching to the tergum of the ninth abdominal segment.

The Vasa Deferentia

The vasa deferentia emerge out from the posterior end of the testes and lie convoluted in the ninth abdominal segment (Pl. X, fig. 1). A vas deferens measures 2.11 mm. in length when straightened, its diameter being variable. It is a narrow duct in the beginning but becomes distended later on towards
the posterior side. Each vas deferens forms two 'U'-shaped loops along its course, and opens into the sperm sac near its middle region (Pl. X, fig. 2). The vas deferens is, therefore, morphologically divided into following three regions, (i) a proximal region, (ii) a middle region, and (iii) a distal region.

The proximal region of the vas deferens is thin and translucent and represents the narrow beginning part of the duct which lies lateral to the alimentary canal. The middle region forms a prominent part of the vas deferens on the ventro-lateral side of the gut. The distal region connects the middle region of the vas deferens to the sperm sac and is enlarged in size. The adipose tissue forms a thick envelope round the proximal region of the vas deferens. However, in the remaining part of the duct the adipose tissue forms an irregular layer, being attached at places only to the wall of the duct.

The Sperm Sac

The two vasa deferentia join each other in the middle of the ninth abdominal segment to form a large median sac-like structure termed the sperm sac (Pl. X, fig. 2). The sperm sac is a 0.118 mm. long translucent organ, elongated longitudinally and occupying nearly the whole length of the ninth abdominal segment on the ventral side of the alimentary canal. The sac is a dumb-bell shaped structure which is constricted near the middle forming a distinct anterior lobe and a posterior lobe. A portion of the ventral side of the sperm sac is supported on a chitinous structure situated anterior to the gonopore.

The Ductus Ejaculatorius

The ventral wall of the sperm sac is produced ventrally to form a minute ejaculatory duct which opens out to the exterior through the gonopore. The ejaculatory duct is situated in the concavity of a chitinous structure lying anterior to the gonopore.
(B) HISTOLOGY

The Testis

The testis of Ceriagrion shows the following histological structure (Pl. X, fig. 3) beginning from periphery towards the centre:

(i) Adipose tissue:

The adipose tissue forms a thick sheath all round the testis and consists of a spongy mass of large fat-cells, each possessing vacuolated cytoplasm and a highly granulated nucleus. The nucleus is devoid of nucleolus.

(ii) Peritoneum:

It is a very thin layer of greatly stretched cells present within the adipose tissue layer. A peritoneal cell contains only a small amount of cytoplasm and a large spherical nucleus.

The peritoneum and the adipose tissue layer comprise together the wall of the testis which encircles the interior aggregation of lobules.

(iii) The Lobule:

The structure of a lobule shows following important features:

(a) Each lobule is a bead-like structure enclosed by a thin membranous wall, the limiting membrane.

(b) The lobule is a solid and nearly spherical structure packed compactly with germ cells.

(c) The germinal epithelium is absent in each lobule.

(d) The gametes in a lobule are all alike and represent only one stage of spermatogenesis. Different lobules however, contain germ cells in different stages of spermatogenesis.

(e) Spermatocytes are present in groups inside a ripe lobule. The number of sperms in a group is variable.

(f) Each lobule is narrowed to form a minute ductule which opens into a common lateral duct running longitudinally
along the outer lateral border of the testis (Pl. X, fig. 4).

(iv) The Common Lateral duct:

The wall of the common lateral duct is composed of the following layers from within outwards (Pl. X, fig. 4):
(a) Epithelium, (b) Basement membrane, and (c) Muscle layer.

The epithelium is multilayered, consisting of two to three layers of cuboidal cells. Each epithelial cell contains vacuolated cytoplasm near the basal end and densely granular cytoplasm near the apical end. The apical ends of many epithelial cells give out a number of fine processes, thereby making the margin of the epithelium irregular. The nuclei are spherical in shape, each measuring 5 micra in diameter, and possessing a large nucleolus in the centre and 7–8 deeply-staining granules near the periphery. The epithelium is surrounded by a basement membrane on the outer side. The muscle layer is composed of a thin layer of circular muscle fibres only. The lateral duct possesses a narrow lumen in the centre which contains a few spermatids and a small amount of granular secretion.

The outer wall of the lateral duct possesses almost a uniform structure throughout the length. Its wall on the inner side, however, shows the presence of a comparatively thick epithelium which contains groups of long columnar cells at places.

The Vas Deferens

Histologically, the vas deferens is divisible into only two regions, an anterior region and a posterior region.

The Anterior region:

The anterior region of the vas deferens corresponds to its morphological proximal region and shows the following layers in its wall beginning from within outwards (Pl. X, fig. 5). The lumen is lined by a single layer of columnar cells forming the
epithelial layer in which the cell-boundaries are distinct. The cytoplasm in the epithelial cells is dense and granular, especially towards the inner side. Each epithelial cell also possesses a large rounded nucleus measuring 6 micra in diameter and containing a distinct nucleolus and 7-8 deeply-staining granules. The basal ends of the epithelial cells are supported on a basement membrane. Next to the basement membrane on the outer side is a thin layer of circular muscle fibres comprising the musculature of the wall. A very thin peritoneal layer is also present outside the circular muscle layer. The outermost layer in the wall of the duct is composed of adipose tissue which forms a prominently thick coat. The lumen in the anterior region of the vas deferens is narrow, devoid of sperms and contains a few drops of granular secretion.

The Posterior region:

The posterior region corresponds to the morphological middle and distal regions of the vas deferens. It possesses a histological structure similar to that of the anterior region except that its epithelial wall is thin and lumen is large and spacious. The epithelium consists of a row of small flattened cells, each with indistinct cell-boundaries and a 6 micra large nucleus lacking a nucleolus. The musculature is also well developed in this region of the duct. The adipose tissue forms an incomplete layer and is visible at places only. The posterior region of the vas deferens stores spermatozoa which are present in groups only in a homogeneous mucilaginous secretion filling the lumen.

The Sperm Sac

The sperm sac shows the same histological structure as the posterior region of the vas deferens. However, the musculature in the wall of the sperm sac is thick and consists of a strong coat of circular muscles. The epithelium is distinct in the ventral wall of the sac especially near the origin of the ejaculatory duct. The lumen is large and spacious containing
only the homogeneous secretion in which sperm groups are present (Pl. X, fig. 6). Scattered spermatozoa and granular secretory material are absent. The lumen of the sperm sac is not lined by chitinous intima.

The Ductus Ejaculatorius

The ejaculatory duct (Pl. X, fig. 6) is a minute duct connecting the sperm sac to the gonopore on the ventral side. Its wall consists of following layers, in order, beginning from the innermost side, (i) chitinous intima, (ii) epithelium, (iii) basement membrane, and (iv) musculature. The epithelium is very prominent and consists of a single layer of columnar cells. The cytoplasm of the epithelial cells is non-granular and darkly-staining. The nuclei are spherical and granular, each measuring 4 micra in diameter and possessing 4-5 deeply-staining granules. The epithelium is lined internally by a very thin chitinous lining, the chitinous intima, which surrounds a narrow lumen in the centre. The muscular coat is the wall of the ductus ejaculatorius is well developed and consists of an inner layer of longitudinal muscles and an outer layer of circular muscle fibres.

2. EXTERNAL GENITAL ORGANS

The external genital organs in male Cariangium consist of paired supra-anal and infra-anal appendages, a pair of coxites on either side of the gonopore, and a secondary copulatory apparatus.

The Supra-anal Appendages

There is a characteristically well developed pair of quadrato appendages, the supra-anal appendages arising postero-terminally from the dorso-lateral sides of the tenth abdominal segment. Each supra-anal appendage (Pl. XI, fig. 1) is a 0.338 mm. long and 0.381 mm. broad, sclerotized organ which is
ochreous-coloured and hollow from inside. The postero-mesal corner of the appendage is coloured black and bears a 0.036 mm. long hook directed medially. The surface of the appendage is covered with hair and tubercles.

The Infra-anal Appendages

There is a pair of 0.41 mm. long, cylindrical infra-anal appendages situated beneath the supra-anal appendages on the ventro-lateral sides of the anus. The infra-anal appendages are lemon yellow coloured, hollow sclerotized structures each of which is broad at the base and strongly acuminate distally ending in a blunt spine (Pl. XI, fig. 2). Numerous bristle-like and posteriorly directed hair are present all over the surface except the apex.

The Gonopore

The male gonopore is situated medially in the posterior half of the ninth abdominal sternite (Pl. XI, fig. 3). It is a circular orifice measuring 0.115 mm. in diameter and lying partly hidden by the bases of the coxites. The male genital opening is strengthened by a sclerotized ring which is invaginated to form a nearly triangular, dorsally concave chitinous structure supporting the ejaculatory duct.

The Coxites:

The coxites are a pair of strongly sclerotized rhomboidal structures measuring 0.59 mm. in length which guard the gonopore laterally. Each coxite consists of a large basal portion united with the body-wall and a small style-like terminal portion hanging free.

The portion of the ninth sternite lying anterior to the gonopore is modified to form an anterior genital plate. The anterior genital plate is a broad, greenish yellow structure measuring 0.518 mm. in length and 0.604 mm. in breadth, and provided with numerous tubercles and sparse hair on the ventral surface.
The post-genital plate measuring 0.194 mm. in length and 0.532 mm. in width, is a yellow coloured chitinous plate situated behind the gonopore and formed seemingly by secondary chitinization of the intersegmental membrane between ninth and tenth abdominal segments. The ventral surface of the post-genital plate is beset only with numerous tubercles arranged in transverse rows. Hair are characteristically absent.

THE SECONDARY COPULATORY APPARATUS

In male Ceriaeryx coromandelianum (Fabr.) a very complicated set of secondary copulatory apparatus is present on the ventral surface of the second and a part of the third abdominal segments (Pl. XI, fig. 4). It comprises a genital fossa, an anterior lamina, supporting frame-work, two pairs of hamuli, a lamina batilliformis, a genital sac, a penis and a vesicula spermalis.

The Genital Fossa

The organs of the secondary copulatory apparatus are lodged in a depression termed the genital fossa.

The Anterior Lamina

The anterior lamina (Pl. XI, fig. 5) is a 0.379 mm. long, yellow coloured, inverted 'U'-shaped chitinous hood-like plate lying ventrally in the anterior one-third of the genital fossa. The anterior lamina is concave dorsally and bordered anteriorly by a prominent, strongly sclerotized transverse apophysis whose lateral extremities are directed antero-dorsad. The anterior lamina is divided into two lateral halves or limbs by a deep cleft in the middle. The margin of the cleft is sclerotized and continuous anteriorly with the apophysis. A number of hair project into the space from the sides. The cleft is covered dorsally by a thin membrane forming a 0.381 mm. long sac-like structure, the median laminar sac. The median laminar sac narrows anteriorly and does not project into the first
abdominal segment as observed in most of the Zygoptera studied. Instead, it remains within the precincts of second abdominal segment.

The Hamules

There are two pairs of hamules, one on the anterior side - the hamuli anteriores and the other on the posterior side in the genital fossa - the hamuli posteriores.

The Hamuli Anteriores:

The hamuli anteriores (Pl. XI, fig. 5) are a pair of stout, yellow coloured cutinized structures lying ventrolaterally in the genital fossa near the middle of second abdominal segment. Each hamule consists of an outer plate and an inner plate. The outer plate is a lamellate, quadrate structure measuring 0.43 mm. in length and breadth, and united movably with the postero-lateral margin of the anterior lamina. On the lateral side it is attached to the latero-ventral margin of the second tergum through pleural membrane. The posterior and mesal margins of the outer plate are free and its antero-mesal corner is produced into an acute angle. The antero-mesal angles of the outer plates of the two sides become opposed to each other when the hamuli are held horizontally. The inner plate which is more strongly sclerotized than the outer plate, lies vertically on the dorsal surface near the mesal margin of the outer plate. It is a hook-like organ whose antero-apical portion is free, and the postero-basal portion is curved and united with a membranous structure. This membranous structure connects the inner plate with the mesal border of the outer plate of the hamule.

The Hamuli Posteriores:

A small and simple posterior hamule is carried subapically by each anterior limb of posterior median plate of frame (Pl. XI, fig. 6). The posterior hamules are 0.153 mm. large triangular and laterally compressed outgrowths of chitin projecting ventro-mesad from the genital fossa. The surface of the hamules is furnished with hair.
**The Lamina Batilliformis**

The lamina batilliformis is a 0.378 mm. long heavily sclerotized structure present over the cleft of the anterior lamina and partly in the space enclosed between the two anterior hamuli (Pl. XI, fig. 5). It consists of an anterior plate and two posterior limbs along with their upcurved reflexed cornua. The anterior plate is an elongated tongue-like structure which is concave dorsally and arch-like apically. The outer margin of the anterior plate gives support to the median laminar sac. The posterior limbs are nearly twice as long as the anterior plate and extend posteriorwards with their ends diverging apart and forming a prominent subapical latero-ventral protuberance. The limbs provide support to the antero-ventral wall of the genital sac and bear many long hair on the inner margin. The limbs are bent upwards at their extremities and become continued as cornua. Each cornu extends upto the middle of the limb where its apical end is curved inwards. The apices of the cornua lie close to the pointed ends of the inner plates of the hamuli anteriores.

**The Genital Sac**

It is a large membranous chamber which projects into the cavity of the second abdominal segment. The wall of the genital sac (Pl. XI, fig. 4) is supported antero-ventrally by the lamina batilliformis, ventro-laterally by the lateral longitudinal bars of the frame, and postero-ventrally by the median plate of the frame. The anterior vertical bars of the frame provide support to the lateral wall of the genital sac. The dorsal wall of the sac is, however, strengthened by the basal plate of penis which lies incorporated in it.

**The Framework**

The framework (Pl. XI, fig. 6) is a skeleton of chitinous structures which strengthen the genital fossa and give support to the genital sac, anterior and posterior hamuli and the penis.
The chitinous frame lies posterior to the anterior lamina and consists of a pair of anterior vertical bars, a pair of lateral longitudinal bars and a posterior median plate.

The Anterior Vertical Bars:

These are a pair of 0.586 mm. long, curved, slender bars placed obliquely in the lateral wall of the genital sac. The upper end of each bar is united with the ventro-lateral extremity of the anterior sclerite of the basal plate of penis (Pl. XI, fig. 6). The lower end of the bar is, however, articulated with the lateral longitudinal bar of its side.

The Lateral Longitudinal Bars:

The lateral longitudinal bars are a pair of 0.392 mm. long, straight bars lying horizontally on the ventro-lateral sides of the genital fossa.

The Posterior Median Plate:

It is a 0.475 mm. broad plate which lies horizontally in the posterior part of the genital fossa on the dorsal side of the neck of vesicula seminalis (Pl. XI, fig. 4). The posterior median plate is shaped like a sliced half-egg showing a dark central area and a faint outer border (Pl. XI, fig. 6). The plate is strongly sclerotized and antero-laterally produced into a pair of anterior limbs. Distally, the anterior limbs articulate with the lateral longitudinal bars of the frame. Unlike other species studied, the posterior limbs of the median plate are absent in Carinigrion. Hair are present on the anterior surface of the plate and the bases of the limbs.

The Penis

The penis is an unsegmented stout intromittent organ located ventro-medially in the genital fossa. It is curved at two places, once near the base and later on near the distal end forming a 'S'-shaped structure (Pl. XI, fig. 7). During copulation, the large distal portion (shaft) of the penis projects out
from the genital fossa while the small proximal portion (basal plate) remains incorporated in the roof of the genital sac. The penis lacks an external orifice.

The Basal Plate:-

The basal plate forms the proximal portion of the penis and comprises two sclerites, an anterior sclerite and a posterior sclerite (Pl. XI, fig. 4). The bases of the two sclerites are fused together so as to enclose a foramen, the presence of which separates the shaft from the basal plate.

The Anterior sclerite:- The anterior sclerite is a 0.313 mm. wide, arch-shaped horizontal bar forming a hood-like structure above the foramen. At the two ends it is supported by the anterior vertical bars of the frame (Pl. XI, fig. 6).

The Posterior sclerite:- The posterior sclerite is a 0.483 mm. long structure possessing a shallow groove on the dorsal surface. It constitutes the major portion of the basal plate of penis.

The Shaft:-

The shaft is the long prominent portion of the penis whose anterior part lies enclosed in the genital sac (Pl. XI, fig. 4). A tubular cavity originates from the foramen situated in the basal plate and traverses through the shaft as a narrow tube which is thus connected with the haemocoel. The shaft is divisible into three regions, a proximal region, a middle region and a distal region (Pl. XI, fig. 7).

The Proximal region :- This is a long stout region forming a major part of the shaft. It becomes curved ventro-posteriorly as soon as it arises from the basal plate. A small basal area of the proximal region is strongly sclerotized. The sclerotization is continued posteriorly on the lateral and ventral sides of the shaft while the other surfaces remain membranous. A median groove which is inconspicuous in the beginning but gradually becomes deep and broad posteriorwards, runs externally along
the mid-dorsal side of the shaft.

The Middle region: - The middle region is slightly curved and consists of a narrow anterior half and a broad posterior half. Its dorsal wall is membranous in which the median groove of the proximal region is continued. The groove terminates at the apex of the middle region. The ventro-lateral wall of the middle region is strongly sclerotized and curved at the apex.

The Distal region: - The distal region of the shaft is membranous and consists of a glans and a prepuce. The glans is a short median distensible fold extended posteriorly from the postero-dorsal edge of the shaft. The prepuce is a 0.53 mm. long boat-shaped and dorsally concave plate lying ventrally over the middle region of the shaft.

The Vesicula Spermalis

The vesicula spermalis is a yellow coloured flask-shaped vesicle measuring 0.741 mm. in length and lying behind the second abdominal segment. The vesicle consists of a narrow anterior neck and a bulging hemispherical posterior portion, the body proper (Pl. XI, fig. 8). The neck on the ventral side is composed of a large triangular membranous area in the middle and two heavily sclerotized limbs on the sides. The membranous area bears a prominent, antero-median slit-like orifice which is guarded by a pair of lips. The sclerotized limbs are slightly curved structures which become narrow anteriorly with the apices directed mesad. The body of the vesicle is convex and strongly sclerotized ventrally except a median band-like area which is depressed and weakly sclerotized. Long bristle-like hair are sparsely distributed on the ventral surface of the vesicula spermalis. The dorsal wall of the vesicle is membranous and completely devoid of hair. The vesicula spermalis is attached to the anterior end of the third abdominal sternite by two undermentioned apodemes.
The Anterior Apodeme:—The anterior apodeme is a thin, transversely elongated structure situated behind the second abdominal sternite. The two ends of the apodeme are directed antero-dorsad where they become attached to the postero-lateral side of the median plate of the frame.

The Posterior Apodeme:—The posterior apodeme is a thick, transversely elongated structure lying parallel to the anterior apodeme. Its middle region is united completely with the front margin of the third sternite, and the extremities are produced antero-dorsally.

The vesicula spermatica is not connected with genital fossa and penis.
1. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The internal genital organs include a pair of ovaries, a pair of oviducts, an oviductus communis and a complicated set of organs termed the '8th Complex'. A pair of accessory reproductive glands are also associated with the terminal end of the genital atrium of '8th Complex'.

The Ovaries

The ovaries (Pl. XII, fig. 1) are a pair of 24.01 mm. long, prominent and pale colored organs which are situated dorsal to the alimentary canal. These extend from the base of the abdomen up to the middle of the seventh abdominal segment below the tergum. The two ovaries are joined together by a median dorsal ligament. The ligament is attached anteriorly to the metanotum and posteriorly to the dorsal body-wall of the ninth abdominal segment.

There is a delicate, thin-walled and transparent cylindrical tube running throughout the length of each ovary on the ventro-lateral side. It is termed the common lateral duct which bears numerous ovariolcs on the dorso-mesal side only. The ovary is thus differentiated into dorsal and ventral surfaces. All the ovariolcs of an ovary arise one after another from a longitudinal axis on the common lateral duct. The ovariolcs are placed very close to each other, thereby forming more or less a compact ovary.

Each ovariicle is an elongated thread-like organ broad at the base and tapering apically into a terminal filament. All the ovariolcs are directed antero-mesally and lie more or less parallel to each other. The terminal end of the ovariolcs are
embedded in the tissue of the median dorsal ligament. In the anterior region of the ovary the terminal filaments collectively form a thick, stout suspensory filament, the apical filament of the ovary. The apical filaments of the ovaries are anchored on the metanotum. The apical filaments and the median dorsal ligament maintain the ovary in its position in the abdomen. Fat-bodies and tracheae are ramified densely over the surface of the ovaries.

The Oviducts

A pair of oviducts are present in the posterior half of the seventh and the anterior one-third space of the eighth abdominal segment (Pl. XII, fig. 1). The oviducts are transparent narrow tubes, each measuring 2.76 mm. in length. The oviduct in the beginning lies dorso-lateral to the alimentary canal. It then descends down along the side of the gut and becomes ventral to gut in which position it remains till end. The wall of the oviducts is comparatively thicker than that of common lateral ducts. The lumen of the oviduct usually contains ova which are found in at least two longitudinal rows. Adipose tissue and tracheal ramification is abundantly present around the oviducts.

The Common Median Oviduct (Oviductus Communis)

The oviducts of the two sides come close to each other and ultimately unite together underneath the eighth abdominal ganglion forming a very short oviductus communis. The common median oviduct is a tube of wide dimension which occupies a small space in the middle of the eighth abdominal segment. It is encircled by a complete layer of adipose tissue. There is a single fasciculus of anterior vaginal muscles running anterio-
wards on the mid-dorsal surface of the common median oviduct. This single fasciculus of muscles divides into two fasciculi at the anterior margin of the median oviduct. The oviductus communis opens posteriorly into the '8th complex'.
The '8th Complex'

It is a white translucent organ (Pl. XII, fig. 2) measuring 1.254 mm. in length and situated immediately below the alimentary canal in the posterior half of the eighth abdominal segment. The '8th Complex' is composed of a ventral vagina, a dorsal bursa copulatrix and a tubular spermatheca. The '8th Complex' is richly supplied by tracheae, tracheoles and fat-bodies, and innervated by nerves arising from the eighth abdominal ganglion.

The Vagina

The vagina present on the ventral side forms the main part of the '8th Complex', and consists of an anterior tubular portion and a posterior genital atrium (Pl. XII, fig. 3).

The Anterior Tubular Portion:

It comprises the anterior and distinctly tubular portion of the vagina which is partly concealed on the antero-dorsal side by bursa copulatrix. It receives oviductus communis on the antero-ventral side and ductus bursae on the antero-dorsal side. Posteriorly, the anterior tubular portion communicates with the cavity of the genital atrium.

The anterior tubular portion of vagina is a highly muscular organ. A pair of anterior vaginal muscles originate from the anterior end of the vagina and proceed anteriorwards. A pair of large stumpy sterno-vaginal muscles are inserted laterally and dorsally in the wall of the vagina. The posterior region of the tubular portion is covered by a pair of powerful radial muscles.

The cuticular structures present in the cavity are faintly visible externally through the dorsal wall. There is a small median blackish-brown collar in the anterior region and a pair of lateral plates in the remaining region of the organ.
The Genital Atrium:

The genital atrium is a small, thin-walled chamber situated on the posterior side of the anterior tubular portion of vagina and serves to store the eggs temporarily before oviposition. When empty, the wall of the genital atrium appears wrinkled. The atrium communicates to the exterior through vulva.

The antero-dorsal part of the vagina is evaginated to form a large median organ termed the bursa copulatrix.

The Bursa Copulatrix

The bursa copulatrix is a curved sac-like organ of elliptical shape which lies projecting posteriorly on the dorsal side of the anterior end of vagina (Pl. XII, fig. 3). It is connected with the vagina through a small slender duct-like portion termed ductus bursae. In tenerial and virgin females, the bursa is irregular in shape as its walls are crumpled.

The Spermatheca

The spermatheca is an elongated diverticulum-like structure formed seemingly by the postero-median outgrowth of the basal region of bursa copulatrix (Pl. XII, fig. 3). It is faintly reddish in colour and slightly more narrowed proximally than the distal half which remains pointing towards the bursa copulatrix. The spermatheca lies embedded in a mass of adipose tissue which is continuous with the adipose tissue surrounding the bursa copulatrix.

The Accessory Glands

These are a pair of prominent whitish glands (Pl. XII, fig. 2) located ventrally to the rectum in the penultimate segment of abdomen. An accessory reproductive gland consists of a distal sac-like portion and a proximal ductule portion. The sac-like portion of the gland is an elongated organ of almost uniform diameter throughout and is curved distally. The two glands are directed posteriorly and lie almost parallel and close to each
other. It has been carefully observed that any one of the two glands is always larger than the other. The distal ends of the glands are often joined together by strands of connective tissue. The ductule of the gland is a narrow, delicate, filamentous tube. It opens into the dorso-posterior wall of the genital atrium adjacent to the vulvar aperture.

(B) HISTOLOGY

The Ovary

The ovary comprises a common lateral duct and numerous ovarioles which arise from the dorso-medial side of the duct.

The Ovariole:

The ovariole is a long cylindrical organ which is surrounded by a thin transparent epithelial sheath. The epithelial sheath forms the wall of the ovariole and is composed of a single row of greatly stretched cells. The ovariole encloses a longitudinal chain of developing ova. An ovariole is differentiated into three regions as follows:

(i) Terminal filament:— The wall of an ovariole is produced anteriorly beyond the chain of ova as a delicate thread-like filament, the terminal filament. The terminal filaments of the ovarioles remain embedded within the tissue of the median dorsal ligament from which they seem to derive nourishment.

(ii) Germarium:— The terminal filament is followed by a small region, the germarium. It contains a mass of undifferentiated germ cells which develop into oocytes. When an oocyte is formed it descends down into the vitellarium.

(iii) Vitellarium:— It is the largest region of the ovariole. The oocyte descending down from the germarium, is surrounded by a mass of small cells forming a complete covering over it. Later on, the covering differentiates into a follicular epithelium.
The developing oocytes are contained in separate follicles which form a longitudinal row within the sheath of the ovariole in such a way that the oldest and largest ovum lies at the base near the common duct and the youngest at the top near the germarium. The follicular epithelium is distinctly single layered. There are no nurse cells in between the successive follicles, nor these are present at the apex of ovariole. The ovariole in the damselfly is, therefore, of panostic type.

The median dorsal ligament in which the terminal filaments of the ovarioles remain embedded, is made up of a matrix of adipose tissue in which a few muscle fibres are also present.

The common lateral duct:

Histologically, the wall of the common lateral duct is made up of following two layers:

(i) an inner epithelium, and (ii) an outer muscle layer.

The epithelial layer is thin and consists of small cuboidal cells arranged in a single tier round the central lumen. Each cell possesses a large oval and granular nucleus and a scanty amount of cytoplasm. The muscle layer is very thin and comprises longitudinally placed muscle fibres. In the centre of the duct a large lumen is present in which mature eggs are discharged from the vitellarium of the ovariole.

The oviduct

The wall of the oviduct is comparatively thick showing an epithelium on the inner side and a muscular coat on the outer side. In the centre, there is a lumen containing eggs. The lumen is surrounded by the epithelium which consists of a single tier of cuboidal cells. Each epithelial cell possesses a large oval nucleus, the latter being provided with a few deeply-staining granules in the nucleoplasm. The muscular coat is comparatively thicker than that of the common lateral duct and is made up of longitudinal muscle fibres only. Pieces of adipose tissue are also found adhering on the surface of muscle layer at places.
The Common Median Oviduct (Oviductus Communis)

The common median oviduct differs from the oviduct in possessing a thicker muscular layer and a cutinuous intima in its wall. The wall of the oviductus communis (Pl. XII, fig. 4) shows the following layers from periphery within, (i) Adipose tissue, (ii) Musculature, (iii) basement membrane, (iv) Epithelium, and (v) Cutinuous intima.

The outermost layer in the wall is the adipose tissue which forms a discontinuous layer round the muscular coat. The musculature is well developed in the duct and consists of a thick outer layer of longitudinal muscle fibres and a thin inner layer of circular muscle fibres. Next to the circular muscles on the inner side, is a very thin non-cellular layer of basement membrane giving support to the epithelium. The epithelium is composed of columnar cells, arranged in single layer round the lumen and each measuring 15 micra in length. The cytoplasm in the epithelial cell is granular and contains a 7 micra large, oval nucleus. The cytoplasm is vacuolated. The inner margin of the epithelium is lined by a thin layer of cutinuous intima. The lumen is spacious but allows only one ovum at a time to pass through it.

The dorsal wall of the common median oviduct is provided with a 'V'-shaped outgrowth projecting dorsad. It is present below the fasciculus of the anterior vaginal muscles. The outgrowth is large and more pronounced anteriorly than on the posterior side of oviductus communis.

The Vagina

(i) The Anterior Tubular Portion:

The anterior tubular portion of vagina (Pl. XII, fig. 5) displays the following arrangement of tissue beginning from the inner side: (i) Cutinuous intima, (ii) Epithelium, and (iii) Musculature.
The lumen is laterally compressed and slit-like in appearance. It is placed vertically in the vagina and consists of a broad space antero-dorsally and a pair of prominent lateral evaginations ventrally. The lateral evaginations of the ventral side lie curled upwards and inwards. The lumen is lined by a chitinous intima. The chitinous lining of the lumen in the vertical slit region is thickened to form a pair of sclerotized laminate structures termed the lateral plates (Pl. XII, fig. 3). The two lateral plates are connected dorsally by a thick cuticular layer whereas only a membrane binds them on the ventral side. The chitinous intima in the anterior wall of the tubular vagina is strongly sclerotized to form a collar-like structure embracing the ductus bursae. The collar is a small semicircular structure which consists of an obliquely placed central core and a pair of arms. The central core is produced forward into a small anterior process on which the fasciculus of the anterior vaginal muscles is inserted (Pl. XII, fig. 6). The arms of the collar are flat plate-like structures projecting downward and posteriorward into the lumen. The epithelium in the wall of the anterior tubular portion consists of short cuboidal cells, each measuring 8 micra in length. The cell-boundaries are indistinct. The nucleus in an epithelial cell is 5 micra large and ovoid in shape. It possesses a central nucleolus and many deeply-staining granules in the interior. The base of the epithelium rests upon a very thin structureless basement membrane. The muscular coat is strongly developed and comprises striated muscle fibres which run dorsally and laterally. A pair of sterno-vaginal muscles are attached on the lateral plates. Radial muscles are also present.

(ii) The Genital Atrium:

The wall of the genital atrium is thin and irregularly folded. The innermost layer of the wall is the colourless chitinous intima. It is weakly sclerotized and possesses an irregular outline. The epithelium forms the outer coat and is composed of a single layer of small nearly flattened cells, the
boundaries of which are not very distinct but the nuclei are prominent. Each epithelial nucleus is a 4 micra large spherical structure bearing a centrally located nucleolus and one or two deeply-staining granules. The cytoplasm of the epithelial cells stains darkly. The epithelium is surrounded by adipose tissue which forms a complete layer of varying thickness on the outer side. The adipose tissue is traversed by a few muscle fibres.

The Bursa copulatrix

Histologically, the bursa copulatrix consists of the same layers present in the same sequence as the wall of the anterior tubular portion of vagina (Pl. XII, fig. 5). The innermost layer is chitinous intima which is thick and folded at places to form ridges and grooves. The next layer in the wall of bursa copulatrix which lies outside the chitinous intima is the epithelium. It is composed of a single row of small cuboidal cells each measuring 8 micra in length. An epithelial cell possesses small amount of cytoplasm and a 5 micra large nucleus. The nucleus varies in shape from ovoid to spherical and possesses many deeply-staining granules within it. The nucleolus is absent. The epithelial layer is surrounded by a very thin and structureless basement membrane. Outside the basement membrane there is a thick layer of musculature comprising the longitudinal muscle fibres only. The outermost stratum in the wall of bursa copulatrix is formed by a thin discontinuous layer of adipose tissue. The central lumen of bursa is large and full of spermatocoea.

The ductus bursae which connects the bursa with the vagina (Pl. XII, fig. 6), shows a structure very similar to that of the bursa copulatrix. The chitinous lining of the ductus bursae is very thick and greatly folded to produce numerous small cuticular spines which are directed postero-ventrally.

The spermatheca

The wall of the spermatheca (Pl. XII, fig. 5) is most
similar to that of the bursa copulatrix with certain differences. The epithelium of the spermatheca is single layered and consists of short cuboidal cells each measuring 8 micra in length. The cytoplasm of an epithelial cell is granular and the nucleus is provided with many deeply-staining granules. The nucleus is round to oval in shape measuring 5 micra in diameter and bearing a large nucleolus in the centre. The inner margin of the epithelium is lined by a thin layer of chitinous intima which possesses small ridges and grooves. The epithelium is supported on a thin basement membrane. There is a thin muscular layer of longitudinal muscle fibres on the outer side of the epithelium. It is uniformly thick throughout the length of the organ. The outermost layer in the wall of the spermatheca is composed of an adipose tissue coat which envelops the spermatheca almost completely. The coat of adipose tissue of spermatheca is continuous with that of bursa copulatrix.

The lumen of the spermatheca is tubular and filled with a secretion of homogeneous consistency in which spermatocytes float freely.

The Accessory Gland

The two regions of an accessory gland, the sac-like distal portion and the ductule region are different in histological structure.

The Sac-like portion:-

The wall in the sac-like portion of the accessory gland (Pl. XII, fig. 7) is composed of the following layers, in order, from within outwards: (i) Chitin layer, (ii) Epithelium, (iii) Basement membrane, (iv) Muscle layer, and (v) Adipose tissue.

The lumen of the sac-like portion is spacious and lined by a thin chitinous intima. The chitin layer is irregular in outline and surrounded on the outer side by an epithelial layer which consists of a row of tall columnar cells, each measuring
15 micra in length. The large epithelial cells are aggregated at places forming pad-like thickenings. Each epithelial cell possesses a 5 micra large deeply-staining nucleus of oval to spherical shape. The cytoplasm is granular and vacuolated and possesses a number of empty spaces. In addition to these structures, the cytoplasm shows accumulation of secretion also towards the inner margin of the epithelial cells. The epithelium of the saccular portion of the accessory gland, therefore, appears to be secretory in nature. The epithelial layer is bounded externally by a thin basement membrane. The musculature comprises a thin layer of circular muscle fibres only. Small amount of adipose tissue is also present at places over the surface of the gland.

The Ductule region:

The wall of the ductule of accessory gland (Pl. XII, fig. 6) consists of a prominent epithelial layer which is lined by a colourless chitinous intima on the inner side and a very thick coat of musculature on the outer side. The epithelial layer is composed of a single tier of small cuboidal cells, each measuring 2 micra in length. The cytoplasm of a cell is non-granular and stains faintly. The nucleus is large, ovoid in shape and possesses 3-4 granules. There is a thin and structureless basal membrane providing support to the basal end of the epithelial cells. The musculature comprises a thick layer of circular muscle fibres present outside the basal membrane. The adipose tissue is found in small patches only. The lumen of the duct is comparatively narrow.

2. EXTERNAL GENITAL ORGANS

The external reproductive organs of Ceriaugrion consist of a pair of supra-anal appendages and a well developed ovipositor. The female genital aperture is located ventrally at the end of the eighth abdominal segment. It lies concealed by the base of the ovipositor.
The supranaal Appendages

These are a pair of golden brown appendages arising out terminally from the last segment of abdomen (Pl. XIII, fig. 1). Each supranaal appendage is a posteriorly projected conical organ, hollow from inside and measuring 0.454 mm. in length. It is broad in the middle, comparatively narrow at the base and tapering distally to an obtuse apex (Pl. XIII, fig. 2). The surface of the appendages is covered over by numerous tiny tubercles and hair.

The Female Genital Aperture (Vulva)

The genital atrium of '8th Complex' opens out ventrally on the inter-segmental membrane between the eighth and ninth abdominal segments through an orifice termed vulva (Pl. XIII, fig. 3). It is a small, simple and more or less circular opening which is located above the basal ends of the first valvifers and valvulae of the ovipositor.

THE OVIPOSITOR

The ovipositor is a well developed structure comprising several sclerotized pieces which lie on the ventral side of the eighth, ninth and tenth segments of abdomen (Pl. XIII, fig. 1). The sclerotized pieces include first valvifers, lateral valves or second valvifers, first valvulae, second valvulae and gonangula, all of which are paired.

The First Valvifers

The first valvifers are a pair of sclerites present ventrally between the eighth and ninth abdominal segments. Each valvifer is a dorso-ventrally flattened plate of nearly triangular shape (Pl. XIII, fig. 3). The valvifer plate bears on the mesal side a blunt process termed the mesal process. The two mesal processes are united together by a thin membrane. The anterior margin of each plate is produced anteriorly into a
prominent, anteriorly directed black coloured apophysis, termed the anterior apophysis of the first valvifer. The postero-mesal margin of each valvifer is attached to an elongated sword-like process, the first valvule of ovipositor.

The Lateral Valves or Second Valvifers

The lateral valves consist of a pair of broad, slightly convex, leaf-like, golden brown structures, each measuring 1.386 mm. in length and present underneath the ninth and tenth abdominal segments. A lateral valve is composed of a broad basal portion and a terminal style (Pl. XIII, fig. 4). The basal portion of the lateral valve is attached to the venter of the ninth abdominal segment. The antero-lateral margin of the basal portion is strongly sclerotized to form two stout apophyses, an anterior apophysis and a posterior apophysis. The anterior apophysis is placed horizontally along the antero-lateral margin of the basal portion of lateral valve. It is in the form of a stout bar projecting mesad into the body cavity. The posterior apophysis is also a stout process, which is directed upwards and outwards. The basal portion of lateral valve bears a small conical and membranous outgrowth on the inner side at the distal end. This is termed gonoplac. The gonoplac is provided with a shallow depression on the mesal surface and 3-4 long hair at the apex. There is a lancet-shaped bar, the laterotergite which is placed longitudinally along the lateral margin of the base of the valve. The laterotergite on one hand is attached to the tergum of the ninth segment and on the other hand, is united with the base of the lateral valve. The ventral border of the basal portion is arch-shaped and denticulated in posterior region. The external surface of the valvifer is provided with numerous postero-ventrally directed hair.

The sternal wall between the bases of the two lateral valves is membranous and grooved externally along the median line. It also bears two intervalvular sclerites, an anterior and a posterior sclerite on the inner side. The anterior
sclerite is very small and situated in the middle line behind the ram of the second valvulae (Pl. XIII, fig. 5). The posterior sclerite is transversely placed at the end of the ninth abdominal segment connecting the basal ends of the two posterior apophyses of lateral valves (Pl. XIII, fig. 1).

The style of the lateral valve (Pl. XIII, fig. 4) is a prominent process borne at the apex of the broad basal portion. It is a hard, curved, hollow, blackish-brown, narrow cylindrical structure measuring 0.418 mm. in length and projecting postero-ventrally. The apices of the two style are directed towards each other forming more or less a forceps-like structure. The surface of the style is beset sparsely with short hair.

The Valvulae

There are two pairs of strongly sclerotized sword-shaped processes arising near valve and projecting postero-ventrally. These processes are known as the first and second pair of valvulae which are reddish black in colour. The two pairs of valvulae lie in the median groove of the ninth sternum. Each valvula is composed of a short anterior ramus and a long posterior shaft. The ram of the first valvulae are attached to the postero-mesal margins of the first valvifers, while the ram of the second valvulae are attached to the antero-proximal ends of the second valvifers. The first and the second valvulae of a side are engaged together by a ridge and groove arrangement and the inner surface of each valvula bears a longitudinal groove. The mesal edges of the opposite valvulae of a pair lie closely apposed to each other forming a canal-like structure. The shafts of the second pair of valvulae lie above those of the first valvulae, thus forming a canal through which the eggs are passed out.

(1) The First pair of Valvulae:-

The first valvula measures 1.474 mm. in length. The rami
of the first valvulae are dorso-ventrally flattened plate-like structures lying horizontally behind the first valvifers (Pl. XIII, fig. 3). These are fused anteriorly forming an arch-like anterior margin. Each ramus bears two processes, a lateral process and a dorsal process. The lateral process is a small wing-like extension which supports the ventral end of gonangulum. The dorsal process is a prominent ridge continued posteriorly as the dorsal process of the shaft.

The shaft of the valvule is a curved structure which tapers posteriorly to an acutely pointed apex. The dorsal edge in the blade of the shaft is strongly sclerotized. The distal half of the blade is saw-like in appearance due to the presence of prominent denticles (Pl. XIII, fig. 6).

(ii) The Second pair of Valvulae:

The second pair of valvulae (Pl. XIII, fig. 5) are shorter and more slender than the first valvulae, and each valvule measures 1.364 mm. in length. The ramus of the valvule is a vertically placed spoon-shaped plate which is excavated deeply on the mesal side. It is bulging laterally and provided with a dense zone of short hair on the outer side. The posterior part of the dorsal edge of the ramus is produced mesally into a short triangular process termed the mesal process. The anterior end of the ramus is attached to the antero-proximal end of the lateral valve of its side. The anterior intervalvular sclerite of the ninth abdominal segment is present immediately behind the rami of the second valvulae.

The rami of the two valvulae proceed posteriad and continue as the shafts. The blades of the shaft lie closely apposed to each other forming the roof of the canal through which the eggs are passed out. The distal half of the shaft is serrated due to the presence of prominent ridges and pleats (Pl. XIII, fig. 7).
The Gonangula

The gonangula are a pair of heavily sclerotized bars lying laterad to the vulva one on each side (Pl. XIII, fig. 3). These are placed obliquely in vertical plane. Ventrally, the gonangulum lies attached to the lateral process of the ramus of first valvule. Dorsally, it is attached near the anterior end of the lateral valve with the antero-ventral part of the ninth abdominal tergite.
The male reproductive system of *Ischnura senegalensis* (Hambur) consists of:

1. **Internal genital organs**, that include a pair of testes, a pair of vasa deferentia and a sperm sac from which an ejaculatory duct also comes out.

2. **External genital organs**, comprising two sets of structures, one near the base of abdomen and the other in the apical part of abdomen.

The true male genital aperture is situated on the ventral side of the ninth abdominal segment enclosed between a pair of coxites. However, the functional intromittent organ is situated far anterior, on the ventral side of the second segment of abdomen.

1. **INTERNAL GENITAL ORGANS**

   (A) **GROSS MORPHOLOGY**

   The internal genital organs consist of a pair of gonads - the testes, a pair of efferent ducts - the vasa deferentia, a sperm storage organ - the sperm sac and an ejaculatory duct. Definite accessory glands connected with the male reproductive system of insects have not been found in the damselfly.

   **The Testes**

   There is a pair of elongated, tubular and translucent white (in living condition) testes extending from the middle of the seventh abdominal segment up to the posterior end of the eighth abdominal segment on the dorsal side of the alimentary canal (Pl. XIV, fig. 1). The two testes are loosely joined together throughout their length by a median strand of connective tissue which is attached posteriorly to the termgon of the
ninth abdominal segment. Each testis is a 2.375 mm. long and 0.332 mm. thick organ made up of a large number of lobules. The surface of the testis is, therefore, irregular and beaded in appearance. The testes are maintained in position by the median strand of connective tissue, tracheae, nerves, fat-bodies and suspensory filaments. The suspensory filaments are anterior prolongations of the adipose tissue which surround the testes and are attached to the body-wall in the fifth abdominal segment.

The Vas Deferens

The testis is attached posteriorly to a duct, the vas deferens (Pl. XIV, fig. 1), extending in a convoluted manner from the anterior margin of the ninth abdominal segment up to the middle region. In straightened condition the vas deferens measures 2.11 mm. in length. The duct runs subdorsal to gut for a short distance in the beginning, then turns ventralwards to come to lie below the alimentary canal and finally proceeds posteriorwards up to the sperm sac. Each duct is morphologically divisible into two regions, (i) a proximal region and (ii) a distal region.

(i) The Proximal region:

It is the thin straight portion of the vas deferens which lies close to the posterior end of the testis. Adipose tissue forms an inseparable coat round this region of the duct.

(ii) The Distal region:

It is the long convoluted portion of the vas deferens which lies beneath the alimentary canal. It forms two 'U'-shaped bends before opening distally into the sperm sac (Pl. XIV, fig. 2). The adipose tissue is loosely attached to the wall of the duct and gets separated easily.

The Sperm Sac

There is a small sac-like spherical organ, the sperm sac
measuring 0.462 mm. in diameter and situated beneath the gut in the middle of the ninth abdominal segment. Ventrally, a portion of the sperm sac is supported by a chitinous structure. The sperm sac receives the ends of the distal region of vasa deferentia on the antero-ventral sides and stores spermatozoa (Pl. XIV, fig. 2).

The Ejaculatory Duct

The sperm sac communicates to the gonopore through a small translucent duct, the ejaculatory duct. The ejaculatory duct is a narrow conical structure lodged in the concavity of a chitinous structure present on the anterior side of the male genital aperture.

In teneral specimens the sperm sac and the distal region of vasa deferentia are coloured pinkish white, while in post-teneral specimens these are coloured black.

(B) HISTOLOGY

The Testes

The wall of the testis comprises an outer adipose tissue layer and an inner peritoneal layer. The adipose tissue forms a complete regular coat round the testis and consists of highly vacuolated cells, each possessing a large nucleus with several deeply-staining granules. The peritoneum is thin and single-layered consisting of greatly stretched cells. During microtomy, the peritoneum is often broken. A large number of spherical lobules are packed inside the testis wall (Pl. XIV, fig. 3).

The Testicular Lobule:-

The testicular lobules are somewhat spherical and solid structures, each bounded externally by a very thin limiting membrane. There is no germinal epithelium. The lobules contain germ cells which are all alike in a single lobule. Different lobules contain germ cells in different stages of spermatogenesis.
It is thus evident that spermatozoa are not produced simultaneously in all the lobules at a time. The testicular lobules are arranged in a definite pattern on the inner side of a common lateral duct. The lobules which are situated near the lateral duct contain mature germ cells and spermatozoa while those situated away from the duct possess germ cells in comparatively earlier stages of spermatogenesis.

The Common Lateral Duct:
There is a duct, the common lateral duct running sinuously from the anterior to the posterior end of the testis on its lateral side. The testicular lobules pass the mature sperms into this duct through minute ductules which appear to be simple prolongations of the limiting membrane (Pl. XIV, fig. 4). The wall of the common lateral duct (Pl. XIV, fig. 5) comprises two layers, an outer musculature and an inner epithelium. The musculature is thin and present immediately outer to the epithelium, and consists of circular muscle fibres only. The epithelium is uniformly single layered on the outer side and one to three layered on the inner side. The epithelial cells are columnar in shape and their size ranges from 13 micra to 18 micra in length. Each epithelial cell possesses granulated cytoplasm and a large, round to oval nucleus in the middle. The nucleus measures 7 micra in diameter and is provided with a conspicuous central nucleolus and about eight peripheral granules. The lumen of the common lateral duct is narrow in the anterior region of the testis but becomes gradually wider in the posterior region. It contains scattered spermatozoa which are dispersed in a granular secretory material.

The Vas Deferens
Histologically also, the vas deferens is divisible into two regions, a proximal and a distal region. The wall in the proximal region of vas deferens (Pl. XIV, fig. 6) consists of the following layers in order commencing from the innermost side, (a) Epithelium, (b) Basement membrane, (c) Circular muscles,
(d) Peritoneum, and (e) Adipose tissue layer.

The epithelium is distinct and consists of cuboidal cells arranged in a single tier round the central lumen. Each cell measures 14 micro in length and possesses granular and vacuolated cytoplasm in which a 7 micro large, spherical nucleus is present. The nucleus contains one distinct central nucleolus and a few indistinct granules. The epithelial cells rest basally on a thin non-cellular basement membrane. The musculature is thin and comprises a layer of muscle fibres placed circularly on the outer side of the basement membrane. The peritoneal layer is indistinct. The adipose tissue forms a thick layer on the outermost side in the wall of the proximal region.

The distal region of the vas deferens (Pl. XIV, fig. 7) shows the same layers in its wall as the wall of the proximal region. However, the epithelium is comparatively thin and consists of flat cells. The cytoplasm of the cells is homogeneous and contains droplets of secretory material. The nuclei are granular and faintly staining. The muscle layer is thick and consists of circular muscle fibres only. The adipose tissue forms an incomplete layer on the outermost side. The peritoneal cells are packed with brownish black pigments which attribute the black colour to the wall of the duct in post-tenal specimens. The lumen is spacious and contains homogeneous secretion in which spermatozoa are present in groups.

The Sperm sac

The histological structure of the sperm sac is similar to that of the distal region of vas deferens except that the lumen is more dilated. The orientation of the tissue in the wall of the sperm sac is as follows:-

(i) Epithelium: - The epithelium is very thin and consists of a single layer of flat cells with indistinct cell-membranes and faintly-staining nuclei. The cytoplasm is vacuolated and very
much reduced in quantity. The inner margin of the epithelium is not lined by chitinous intima. The epithelial cells rest on a basement membrane which is not clearly visible.

(ii) Musculature:— There is a comparatively thick coat of circular muscle fibres outside the basement membrane.

(iii) Peritoneum:— The peritoneal layer forms the outermost coat in the wall of the sperm sac and consists of greatly elongated cells. The peritoneal cells are filled with brownish black pigments.

(iv) Adipose tissue:— The adipose tissue, though present abundantly in the region, does not form a regular and complete covering over the sperm sac.

The lumen of the sperm sac is large and filled up with a secretory material of homogeneous appearance in which spermatozoa are stored in groups only (Pl. XIV, fig. 8).

The Ejaculatory Duct

The histological structure of the ejaculatory duct (Pl. XIV, fig. 8) resembles with that of the sperm sac in the arrangement of the tissue layers. However, its epithelium is lined internally by a very thin chitinous intima. The muscular coat consists of an inner layer of longitudinal muscle fibres and an outer layer of circular muscles. The ejaculatory duct connects the sperm sac with the gonopore.

2. EXTERNAL GENITAL ORGANS

The male external genitalia consist of a pair of supra-anal appendages, a pair of infra-anal appendages, a pair of coxites and a complicated secondary copulatory apparatus. The anal appendages are used for seizing and holding the female during copulation.
The Supra-anal Appendages

These are yellowish-black coloured, hollow appendages coming out terminally from the dorso-lateral margin of the tenth abdominal segment. The two appendages lie basally separated above the anus and measure 0.504 mm. in length. Each appendage consists of a somewhat triangular plate-like basal portion and a curved hook-like terminal process (Pl. XV, fig. 1). The dorsal surface of the basal portion which is more heavily sclerotized than the ventral surface, bears several protuberances and long bristle-like hair. The hair on the ventral surface are sparsely distributed. The hook-like terminal process lies on the inner side with its apex directed mesally. The terminal processes of the two appendages form together a forceps-like organ for a firm grasping of the female during copulation.

The Infra-anal Appendages

Situated beneath the supra-anal appendages and ventro-lateral to the anus are a pair of forcipate infra-anal appendages. The infra-anal appendages are longer than the supra-anal appendages and measure 0.581 mm. in length. Each infra-anal appendage (Pl. XV, fig. 1) is a hollow cylindrical organ having yellowish-black colour at the base and dark black in the remaining portion. The surface of the appendage is uniformly covered with long bristle-like hair which arise from small protuberances.

The Male Genital Aperture

The gonopore is a more or less circular orifice measuring 0.115 mm. in diameter. It is located ventrally in the posterior part of the ninth abdominal segment and lies guarded laterally by a pair of coxites (Pl. XV, fig. 2). The margin of the genital aperture is strengthened by a chitinized ring. The chitinized ring is invaginated to form an elongated, antero-dorsal chitinous structure on the anterior side of the gonopore. This chitinous structure is dorsally concave in the middle where the ejaculatory duct is lodged.
The Coxites:—

The coxites are a pair of elongated bean-shaped, weakly sclerotized, light green structures, each measuring 0.54 mm. in length. The coxite is broad anteriorly but tapers posteriorly to form an obtuse style-like structure (Pl. CV, fig. 2). The broad basal portion of the coxite is fused with the body-wall while the terminal style-like structure hangs free. Numerous hair are present on the surface of the coxite.

The Anterior genital plate:—

The anterior genital plate is a 0.419 mm. long and 0.568 mm. broad sclerotized portion of the ninth abdominal sternum lying anterior to the gonopore. It is attached through membranes with the eighth abdominal sternite anteriorly and the ninth abdominal tergite laterally. The plate is coloured green and its surface is beset with numerous hair and minute tubercles.

The Post-genital plate:—

The post-genital plate is a small, green coloured plate situated behind the male genital aperture and formed by the secondary sclerotization of the intersegmental membrane between the ninth and the tenth abdominal sternites. The plate measures 0.331 mm. in length and 0.549 mm. in breadth. It is attached laterally to the ninth abdominal tergite and posteriorly to the tenth abdominal sternite through membranes. The surface is beset with small tubercles only. Hair are absent.

THE SECONDARY COPULATORY APPARATUS

The secondary copulatory apparatus consists of an anterior lamina, a pair of anterior hamules, a lamina batilliformis, a genital sac, supporting framework, a pair of posterior hamules and a median intermittent organ - the penis. All these structures are lodged in a genital fossa on the ventral side of the second abdominal segment. In addition to these organs, a vesicula spermalis is also present at the anterior end of the venter of third abdominal segment.
The Genital Fossa

The genital fossa is a deep depression on the ventral side of the second abdominal segment housing the organs of the secondary copulatory apparatus, except the vesicula spermatica.

The Anterior Lamina

The ventral shelf of the genital fossa in the anterior one-third part of the second abdominal segment is in the form of a large chitinous plate, the anterior lamina. It is a 0.616 mm. long structure of bluish-green colour. The anterior margin of the lamina is bordered internally by a small, heavily sclerotized transverse apophysis. The posterior margin of the anterior lamina is deeply cleft in the middle to form an inverted 'V'-shaped notch which divides the plate into two lateral halves. Each lateral half is provided with a few hair on the ventral surface and 12-14 hair on the mesal side facing the cleft. The mesal sides of the lateral halves give support to the dorsal membranous, median laminar sac. The anterior end of the median laminar sac is narrowed and confined only within the second segment. The median laminar sac is attached posteriorly to the lamina batilliformis.

The Anterior Hamules

The anterior hamules (Pl. XV, fig. 3) are a pair of well developed sclerotized structures present behind the anterior lamina. Each hamule is composed of a ventral outer plate and a dorsal inner plate. The outer plate is a black coloured and dorso-ventrally flattened structure which is quadrate in shape measuring 0.418 mm. in length and 0.441 mm. in breadth. It is antero-laterally attached to the postero-lateral margin of the anterior lamina. Laterally, the outer plate is connected to the ventro-lateral margin of the second tergite through a membrane. The inner plate of the anterior hamule is divisible into a horizontal membranous part and a vertical heavily sclerotized part. The horizontal membranous part joins the vertical part
of the inner plate to the mesal margin of the outer plate. The vertical part is a laterally flattened, hook-like curved structure directed forward.

The Lamina Batilliformis

The lamina batilliformis (Pl. Xv, fig. 4) is a 0.614 mm. long chitinous structure present medially in the genital fossa and above the cleft of anterior lamina. It is composed of a dorsally concave, scoop-like plate which narrows anteriorly. The posterior margin of this plate is broadly notched up to the middle forming thereby a pair of postero-lateral limbs. Each limb bears a distinct ventro-laterally projecting apical protuberance bearing a few hairs. The two limbs of the lamina batilliformis are flexed antero-dorsad at their extremities and then continue as narrow processes termed cornua. The apex of each cornu is curved to form an incomplete loop-like structure.

The Genital Sac

The central region of the genital fossa is invaginated to form a prominent membranous sac, the genital sac which opens out ventrally by a broad orifice in the middle of the second abdominal segment. The support to the wall of the genital sac is provided by lamina batilliformis on the antero-ventral side, by the bars of the framework on the lateral and latero-ventral sides, and by median plate of the frame on the posterior side. Basal plate of the penis forms the roof of the sac.

The Supporting Framework

The supporting framework consists of (i) a pair of anterior vertical bars, (ii) a pair of lateral longitudinal bars, and (iii) a posterior median plate.

(1) The Anterior Vertical Bars:

The anterior vertical bars are 0.551 mm. long, slender chitinous structures incorporated in the lateral wall of the
genital sac. The dorsal extremities of the anterior vertical bars extend up to the dorsal level of the genital sac. Ventrally, each bar projects posteriorly outwards and terminates near the front margin of the anterior hamule.

(ii) The Lateral Longitudinal Bars:

The lateral longitudinal bars are 0.396 mm. long chitinous structures lying horizontally in the genital fossa above the lateral margin of the outer plates of the anterior hamules. Each lateral bar articulates anteriorly with the ventral extremity of the anterior vertical bar and posteriorly with the anterior limbs of the posterior median plate of frame. The lateral longitudinal bars provide ventro-lateral support to the wall of the genital sac.

(iii) The Posterior Median Plate:

The posterior median plate of the frame (Pl. XV, fig. 5) is a 0.462 mm. broad, strongly sclerotized 'W'-shaped structure situated immediately behind the orifice of the genital sac and dorsal to the vesicula seminalis in the hinder part of the genital fossa. The plate consists of a broad median chitinous structure and a pair of long anterior limbs. The posterior margin of the median chitinous structure is notched in the middle to form a pair of 0.111 mm. long posterior limbs. Anteriorly, the median structure is produced into a prominent spine-like process in the middle line. The anterior limbs arise from the lateral sides of the median chitinous structure and are directed anteriorly. Each anterior limb measures 0.442 mm. in length and articulates with the lateral longitudinal bar of the frame besides bearing the posterior hamule on its subapical side. The anterior part of the plate gives support to the wall of the genital sac on the postero-ventral side.

The Posterior Hamules

The posterior hamules are a pair of small and simple,
strongly sclerotized chitinous outgrowths projecting ventro-laterally from the genital fossa (Pl. XV, fig. 3). Each hamule is a 0.154 mm. long and 0.188 mm. broad, bilaterally compressed hollow structure of rectangular shape situated subapically near the extremity of the anterior limbs of the posterior median plate of frame (Pl. XV, fig. 5). There is a foramen at the base of the hamule which leads into the cavity of the organ. The surface of the posterior hamule is covered with long hair.

The Penis

The penis is a stout tubular unsegmented chitinous organ without an external orifice (Pl. XV, fig. 6). It is situated ventro-medially in the genital fossa and has no connection with the vesicula spermatis. The penis projects out during copulation and acts as an intromittent organ. The penis comprises two parts, a basal plate and a shaft.

The Basal Plate:

The basal plate is a small proximal part of the penis which is incorporated in the root of the genital sac described earlier. The penis is, therefore, firmly anchored and the anchorage helps greatly in its movement and ejection during copulation. Morphologically, the basal plate is composed of two sclerites, an anterior sclerite and a posterior sclerite.

(i) The Anterior sclerite:— The anterior sclerite is a 0.309 mm. wide transverse bar which is placed above the proximal part of the posterior sclerite. Laterally, the anterior sclerite is firmly joined with the dorsal extremities of the anterior vertical bars of the framework. This arrangement works as a mechanical lever because any movement of the vertical bars of the frame causes the movement of the penis also.

(ii) The Posterior sclerite:— The posterior sclerite is a spoon-shaped structure measuring 0.432 mm. in length. It is united basally with the anterior sclerite.
There is a distinct foramen enclosed between the sclerites of the basal plate. The foramen leads into the shaft of the penis and connects the lumen of the shaft with the haemoccel.

The shaft:-

The shaft is the long, free distal part of the penis. It is bent ventrally over the basal plate and proximally enclosed within the genital sac. The shaft is divided into three regions, a proximal region, a middle region and a distal region.

(a) The Proximal region:- The proximal region is the longest portion of the shaft and is united proximally with the basal plate of the penis. It is bent towards postero-ventral side to protrude out through the orifice of the genital sac. This region of the shaft is strongly sclerotized basally and latero-ventrally but is membranous in the remaining area. The apical part of the proximal region bears a transverse row of 1 small and 3 long spines on each side which project postero-laterally (Pl. XV, fig. 7).

(b) The Middle region:- The middle region (Pl. XV, fig. 6) is movably attached to the proximal region, the latter lying distinctly separated from the former by the presence of a small ventral pit. The middle region is membranous dorsally and laterally but heavily sclerotized ventrally. The ventral wall of the region near apex gives out a pair of heavily sclerotized black hook-like prominent processes which project posteriorly and lie closely parallel to each other.

(c) The Distal region:- The distal region of the penis shaft is membranous and comprises a glans and a prepuce. These structures are united at the base. The glans is a relatively short but distinct lobe-like swollen structure directed postero-dorsally. The prepuce is a 0.302 mm. large and ventrally
bent structure which extends nearly up to half of the middle region of the shaft. The prepuce gradually tapers apically where it bears a dumb-bell shaped sclerotized area and a pair of long flagella-like processes.

A median groove runs externally along the membranous dorsal side of the shaft from near its base up to the glans.

The Vesicula Spermatica

The vesicula spermatica (Pl. XV, fig. 8) is a 0.77 mm. long, vase-shaped median structure situated behind the genital fossa in the third segment of abdomen. It is composed of a prominent black bulging body and a narrow anterior neck. The posterior margin of the body is semicircular in outline. Its ventral wall is strongly sclerotized and covered with hair. The neck is membranous in the middle of the ventral surface but strongly sclerotized on the lateral sides forming a pair of limb-like structures. The membranous area of the neck extends posteriorly up to middle of the body as a narrow streak bilobed at the apex. The area is provided anteriorly with a ventro-medial slit-like orifice. The vesicula spermatica communicates to the exterior through this orifice which lies guarded laterally by a pair of lips. The ventral surface of the lips is provided with antero-medial hair. The dorsal wall of the vesicula spermatica is flat and membranous. The vesicula spermatica is supported in position by two apodemes, anterior and posterior apodemes which strengthen its dorsal wall as well (Pl. XV, fig. 3).

The Anterior apodeme:— It is a sclerotized transverse bar whose lateral ends are directed antero-dorsal to get attached to the posterior limbs of the posterior median plate of frame.

The Posterior apodeme:— The posterior apodeme is a prominent transverse bar fused with the basal part of the third abdominal sternite. Laterally, its extremities project antero-dorsally.
The vesicula spermatica stores in its lumen the seminal fluid of mucilaginous consistency containing groups of spermatozoa (Pl. XV, fig. 9) for a temporary period till its transference to the female. The seminal fluid reaches to vesicle through its orifice, from the gonopore by curling of abdomen due to which the gonopore comes in apposition with the orifice.
FEMALE REPRODUCTIVE SYSTEM OF ICHNURA SENEGALENSIS (RAMBUR)

1. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The internal reproductive organs of female I. senegalensis (Rambur) consist of a pair of large ovaries, a pair of small oviducts, a very short common median oviduct, a muscular vagina, a cylindrical bursa copulatrix and a spermatheca. The vagina, bursa copulatrix and spermatheca, together comprise a prominent structure in the eighth abdominal segment which is termed as the '8th Complex'. The '8th Complex' is situated below the alimentary canal in the posterior half of the segment. A pair of accessory glands are also located posteriorly in the ninth abdominal segment. These open in the postero-terminal part of the '8th complex' through a pair of fine ducts.

The Ovaries

A pair of 17.17 mm. long, thick, cord-like ovaries of white colouration are situated, one on either side of the middle line in the abdominal cavity from the base up to the middle of the seventh abdominal segment (Pl. XVI, fig. 1). The ovaries are present on the dorsal surface of the gut, thereby obscuring its view. The two ovaries remain united together up to the end of the fifth segment by a median dorsal ligament which extends posteriorly up to the ninth segment where it is attached to the dorsal body-wall. The median dorsal ligament also extends anteriorly beyond the ovaries and gets attached to the dorsal body-wall of the metathorax. The two ovaries get separated from each other near the beginning of the sixth abdominal segment and run on the dorso-lateral sides of the alimentary canal.

Each ovary is composed of a large number of ovarioles which are attached serially on a longitudinal axis running
dorso-mesally along the whole length of the gonad. In fact, the longitudinal axis lies in the dorso-mesal wall of a longitudinal duct, the common lateral duct. The attachment of the ovarioles only on one surface of the duct differentiates the dorso-ventrality of the ovary. The ovariole is an elongated thread-like and antero-mesally directed structure which possesses a beaded appearance. The interovariole spaces are filled by adipose tissue in which tracheal ramification also penetrates. Each ovariole is prolonged anteriorly into a fine filament, the terminal filament which lies embedded in tissue of the median dorsal ligament. Thus, the terminal filaments of the ovarioles and the median dorsal ligament hold the ovaries in position. The terminal filaments of only the anteriormost ovarioles become united together and form an apical filament at the anterior end of each ovary. The apical filaments of the two ovaries are fastened to the body-wall in the thorax.

The common lateral duct is present on the ventro-lateral side of each ovary and is richly supplied by tracheal network. The ova are produced in the ovarioles and discharged into the lumen of the common lateral duct and are thereafter passed down into the oviduct.

The Oviducts

The common lateral ducts are extended posteriorly beyond the ovaries to form paired oviducts (Pl. XVI, fig. 1). Each oviduct is a 1.933 mm. long, transparent and comparatively thick-walled canal which occupies the posterior half of the seventh and the anterior one-third of the eighth abdominal segments. The oviducts lie dorso-lateral to the gut in the beginning but near the posterior end of the seventh abdominal segment they turn ventralward and inward over the sides of the gut to become ventral to it. The spaces around the oviducts contain an abundance of fat-bodies in the haemocoel.
The Common Median Oviduct (Oviductus Communis)

The posterior ends of the oviducts come close to each other underneath the gut and unite near the middle of the eighth abdominal segment to form a very short tube of wide diameter, the common median oviduct (Pl. XVI, fig. 1). The common median oviduct is covered dorsally by the eighth abdominal ganglion and surrounded all over by adipose tissue. The pair of anterior vaginal muscles is also found running along the median line on the dorsal surface of oviductus communis. The common median oviduct enters posteriorly into vagina of the '8th Complex' (Pl. XVI, fig. 2).

The '8th Complex'

The '8th Complex' is a prominent translucent structure measuring 1.11 mm. in length and situated below the alimentary canal in the posterior half of the eighth abdominal segment (Pl. XVI, fig. 1). It possesses a complicated structure which includes vagina, bursa copulatrix and spermatheca (Pl. XVI, fig. 3).

The Vagina

The ventro-median part of the '8th Complex' is a large passage through which the ova are passed out from oviductus communis to the vulva. Along the dorso-lateral margin of the vagina on each side is present a nerve which originates from the eighth abdominal ganglion and whose branches innervate the '8th Complex'. Morphologically, the vagina is divisible into two portions, a long anterior tubular portion and a short genital atrium.

1. The Anterior Tubular Portion:

It is the main part of the vagina which is strongly chitinized internally and muscularized externally. The internal chitin layer is specially thickened at two places forming a collar and a pair of lateral plates, the presence of the latter
are visible externally through the wall of the vagina. The muscles of vagina comprise a pair of anterior vaginal muscles, a pair of thick sterno-vaginal muscles, radial muscles and a few muscle bands running longitudinally on the wall. The anterior vaginal muscles are in the form of thin filamentous bands arising from the anterior end of the vaginal collar and running forward on the dorsal surface of the oviductus communis (Pl. XVI, fig. 2) to attach on the seventh abdominal sternum.

The sterno-vaginal muscles (Pl. XVI, fig. 4) consist of very thick bands of muscle fibres which are inserted on the lateral, dorsal and latero-ventral wall of the vagina and attach at the other end on the lateral margin of the eighth sternite. The radial muscles form a powerful group of striated muscle fibres which are especially attached on the lateral side of the vagina near the posterior end.

(ii) The Genital Atrium

The posterior part of the vagina is a thin-walled chamber which lies wrinkled when empty. It is termed genital atrium. The genital atrium is continuous with the anterior tubular portion of vagina on the anterior side and communicates with the exterior through vulva on the other side. It serves to lodge eggs temporarily before they are laid out.

The Bursa Copulatrix

The antero-dorsal wall of vagina is evaginated to form a prominent organ, the bursa copulatrix. The bursa copulatrix is a sac-like cylindrical structure which tapers distally forming an acuminate and upwardly directed apex. The bursa lies over the anterior part of the vagina into which it leads through a tubular passage, the ductus bursae.

During copulation, the bursa copulatrix receives the apical portion of penis (Pl. XVII, fig. 7) which reaches there through vagina (Pl. XVII, fig. 5).
The Spermatheca

It is an unpaired median organ arising near the ventro-terminal region of the bursa copulatrix. It is divisible into a proximal ductule and a distal bulb. The bulb of the spermatheca is mango-shaped in appearance, reddish-black in colour and lies posteriorly directed. The ductule of spermatheca measures only half the length of the bulb and lies underneath the bursa copulatrix. The spermatheca and the bursa copulatrix are enveloped in a common mass of adipose tissue.

The Accessory Glands

The accessory glands are a pair of prominent, whitish structures present below the rectum in the ninth abdominal segment. Each gland is divisible into a proximal duct and a distal sac-like portion. The duct is a delicate and slender tube connecting the sac-like portion with the postero-dorsal wall of the genital atrium near the female genital aperture. The sac-like portion is a cylindrical organ which is broader near the base than at the apex. The two accessory glands lie close and parallel to each other in the cavity of the ninth abdominal segment. It has been observed carefully that with age the accessory glands do not undergo any change of shape and size.

(B) HISTOLOGY

The Ovary

Each ovary is composed of a large number of egg-tubes or ovarioles which arise from the dorso- mesal surface of the common lateral duct.

The Ovarioles:

All the ovarioles of the ovary are of primordial type in which nurse cells are absent altogether. The ovarioles are present on dorsal surface of ovary and produce ova. The
developing oocytes are enclosed within an epithelial wall, the
sheath of the ovariole which is thin, delicate and membranous. The
epithelial layer consists of a single row of stretched cells
appearing distinctly at the corners of developing ova. Each
ovariole clearly shows all the three typical regions of an
insect ovariole, i.e. the terminal filament, the gerarium and
the vitellarium. The terminal filaments of the ovariole are
formed by the anterior prolongation of the epithelial wall. The
subapical region of the ovariole comprises the gerarium in which
proliferation of primordial germ cells occur and oogonia are
produced. The last region, the vitellarium forms the largest
part of the ovariole and contains developing oocytes which are
arranged longitudinally in a single row. The arrangement of
oocytes inside the ovariole is in such a way that the oldest and
largest oocyte is situated at the base while the youngest and
smallest oocyte is at the apex of the vitellarium. The terminal
filaments of the ovarioles remain embedded in the tissue of the
median dorsal ligament except those forming the apical filament
of the ovary. The median dorsal ligament is made up of a loose
matrix of connective tissue in which fat-bodies and muscle
fibres are abundantly present.

The Common Lateral Duct:

The wall of the common lateral duct shows an epithelium
on the inner side and a muscle layer on the peripheral side.
The epithelial lining of the lateral duct consists of a thin
layer of short cuboidal cells arranged in a single tier round
the lumen. Each epithelial cell possesses a small amount of
cytoplasm in which a large roundish nucleus is present. On the
outer side of the epithelium occurs a thin layer of longitudinal
muscle fibres forming the musculature of the wall. A spacious
lumen is present in the centre of the duct.

The Oviduct

The wall of the oviduct (Pl. XVI, fig. 5) is thin and
made up of two layers, an epithelium and a musculature. The epithelium is present round a spacious lumen and comprises a single layer of small-sized cuboidal cells which are similar to those of the common lateral duct of the ovary. The cell-boundaries of the epithelial cells are indistinct. Each epithelial cell possesses a scanty amount of cytoplasmic material and a large granular nucleus of spherical shape. The nuclei are mostly located towards the inner margin of the epithelium. The musculature forms a strong muscular coat in the wall and is composed of longitudinal muscle fibres only. The oviduct is not lined internally by a chitinous layer.

The Common Median Oviduct (Oviductus Communis)

The median oviduct (Pl. XVI, ffigs. 2 & 6) shows the same histological structure as the paired oviducts with the difference that its lumen is lined over by a thin chitinous intima. The lumen is spacious and allows only one egg at a time to pass through it. The chitinous intima is surrounded on the outer side by the epithelium which is composed of a row of short cuboidal cells. The cell-boundaries in the epithelial layer are indistinct. Each epithelial cell measures 9 micra in length and possesses a granular and slightly vacuolated cytoplasm. The nuclei are spherical in shape and located near the apical end of the epithelial cells. A nucleus measures 4 micra in diameter and possesses a large nucleolus and a few deeply-staining granules. The basal ends of the epithelial cells are supported on a thin and structureless basement membrane. The musculature consists of circular and longitudinal muscle layers. The circular muscle layer is present immediately outside the basement membrane and forms the inner layer of musculature. The longitudinal muscle layer is placed outside the circular muscles and forms a comparatively thick coat. The outermost stratum in the wall of the oviductus communis is composed of an incomplete layer of adipose tissue.
The presence of the paired anterior vaginal muscles on the dorsal surface produces no ridge in the wall of the common median oviduct. Moreover, the two muscles are unequal also, the right muscle being larger than the left. Posteriorly, the oviductus communis enters the '6th Complex' and opens into its vagina by a wide orifice termed gonopore.

The vagina

(a) The Anterior Tubular Portion:-

The wall of the anterior tubular portion of vagina (Pl. XVI, figs. 4 & 7) shows the following arrangement of layers from within outwards:-

(i) Chitinous intima, (ii) Epithelium, (iii) Basement membrane, (iv) Musculature, and (v) Adipose tissue.

The lumen of the duct is narrow and distensible. It is wide dorsally and evaginated ventrally. The lumen is very spacious and cup-shaped in appearance on the antero-dorsal side of the vagina. The ductus bursae and oviductus communis open into this part on dorsal and ventral side respectively. The chitinous layer in the anterior wall where the aforesaid ducts open, is strongly sclerotized and modified to form a special small structure, the collar. The collar is dorso-ventrally placed in the wall and consists of a middle portion and a pair of lateral arms. The middle portion is produced into a posteriorly directed hook-like process on the dorsal side and an anteriorly directed process on the ventral side. These are termed the hook and the anterior process of collar respectively. The lateral arms of the collar are wing-like chitinous extensions projecting postero-ventrally into the lumen and enclosing the opening of the ductus bursae. It is produced on the ventral side into a pair of lateral evaginations, each directed slightly upwards. The lumen is lined by a chitinous intima which is thick and strongly sclerotized on the dorsal and lateral sides, and thin ventrally. The lateral sclerotization of chitinous intima forms a lateral plate which is connected dorsally with a
similar structure on the other side. Each lateral plate is somewhat oblong in shape and lies vertically and parallel to the longitudinal axis of the organ.

The epithelium is thin and single layered consisting of short cuboidal cells each measuring 9 micra in length. The nuclei are spherical and granular in appearance each measuring 4 micra in diameter and provided with a large nucleolus. The base of epithelial cell rests upon a thin and non-cellular basement membrane. Outside the basement membrane is present the musculature which consists of striated muscle fibres arranged in three sets as follows:

(i) a set of anterior vaginal muscles which are inserted on the collar, (ii) a pair of massive tergo-ternal muscles which are inserted on the lateral plates, and (iii) radial muscle fibres attached on dorsal, lateral and ventro-lateral sides of the anterior tubular portion of vagina. The adipose tissue forms the outermost layer of the wall and consists of a spongy mass of cells with prominent, granular nuclei. It is penetrated among the muscle fibres also.

(b) The Genital Atrium:

The wall of the genital atrium is thin and less muscular than that of the anterior tubular portion of the vagina. Histologically, the wall of the genital atrium comprises a chitinous layer on the inner side, an epithelial layer in the middle and a muscular coat on the outer side (Pl. XVI, figs. 4 & 7). The chitinous intima is thick and weakly sclerotized. A 5 micra thick row of cuboidal cells surrounding the chitinous intima forms the epithelial layer. Each epithelial cell possesses a 3 micra large, oval and granular nucleus occupying most of the space in the interior. The musculature is thin and interspersed with the adipose tissue lying on the surface of the organ. The wall of genital atrium is folded at places forming an irregular outline.
The Bursa Copulatrix

It shows the same arrangement of tissue in its wall as the vagina. The wall is composed of an inner epithelial layer and an outer muscle layer (Pl. XVI, fig. 8). The two layers are separated from each other by a thin basement membrane which is structureless. The epithelium is made up of columnar cells which are arranged in a single row. The epithelial cell measures 14 micra in length and 7 micra in breadth, and contains a granular and vacuolated cytoplasm. The nucleus is oval in shape measuring 5 micra in diameter and possessing 3-4 deeply-staining granules. The muscular layer on the outer side of the basement membrane is thick and composed of longitudinal muscle fibres only. The adipose tissue is present outside the musculature. The lumen of the bursa copulatrix is spacious and filled up with spermatozoa. It is lined by a thick and colourless layer of chitin which is thrown into small intricate folds.

The bursa copulatrix communicates with the vagina through a slender duct, the ductus bursae (Pl. XVI, fig. 2) which is histologically similar to the bursa. However, the lumen of the ductus bursae is lined by a thick and irregularly folded layer of chitin. A prominent median chitinous ridge projects into the cavity from the dorsal wall. Small and inwardly directed cuticular spines are present laterally in the lumen.

The Spermatheca

The bulb of spermatheca (Pl. XVI, fig. 8) shows a histological structure which is similar to that of the bursa copulatrix. The innermost layer in the wall of the spermatheca consists of a thin chitinous intima, often folded internally forming small ridges and grooves. The chitinous layer is lined on the other side by a single tier of columnar cells forming the epithelial layer. Each epithelial cell measures 12 micra in length and possesses a granular cytoplasm. The nucleus is situated near the basal end of the cell. It is oval in shape, 6 micra in diameter and provided with a large nucleolus in the
centre in addition to 2-3 small deeply-staining granules. Next to the epithelium on the outer side is a thin basement membrane which is surrounded by a layer of longitudinal muscles. The adipose tissue is abundant in the region and forms a thick coat over the spermatheca. The bulb of spermatheca is connected with the bursa copulatrix through a ductule.

The Accessory Glands

The wall of the sac-like portion of accessory gland (Pl. XVII, fig. 1) shows the following arrangement of layers from periphery within, (i) Musculature, (ii) Basement membrane, (iii) Epithelium, and (iv) Chitinous intima.

The musculature consists of an outer layer of longitudinal muscle fibres and an inner 3 micra thick layer of circular muscle fibres. Next to the musculature on the inner side is a very thin basement membrane supporting the epithelium. The epithelium is composed of a single layer of columnar gland cells, each measuring 12 micra in length. Some of the cells stain deeply at places due to accumulation of secretory material in them. The nuclei are highly granular and mostly located in the apical region of the epithelial cells. Each nucleus is vesicular, more or less spherical in shape and measures 5 micra in diameter. The outline of the epithelium is irregular and lined internally by a thin chitinous intima. The lumen is spacious and contains a colourless secretion.

The duct of the accessory reproductive gland also possesses the same histological structure as the sac-like portion. However, the muscular coat is well developed and consists of a 12 micra thick layer of circular muscle fibres only. The epithelial layer is composed of a row of cuboidal cells with indistinct cell-boundaries. Each epithelial cell contains a 6 micra large nucleus which is non-granular and stains deeply. The cytoplasm is clear and homogeneous. There is no indication of secretory activity in the epithelium of the duct. The
epithelial layer is lined internally by a chitinous intima which is comparatively thicker than that of the seccular portion of the gland. The chitinous intima surrounds a narrow lumen in the centre of the duct.

2. EXTERNAL GENITAL ORGANS

The female external genitalia of *L. senegalensis* (Rambur) consist of a pair of greyish-black supra-anal appendages and a well developed ovipositor. The base of the ovipositor encircles the female genital aperture or vulva, which is situated between the eighth and ninth sternites. The posterior end of the eighth abdominal sternite projects posteriorly beneath the vulvar aperture and is modified as a subgenital plate.

The Supra-anal Appendages

A pair of 0.403 mm. long supra-anal appendages arise dorso-terminally from the posterior side of the tenth abdominal segment and project horizontally posteriorwards (Pl. XVII, fig. 2). Each appendage is a hollow conical organ which is broad at the base and tapering distally. The surface of the appendage is covered over with numerous small tubercles and posteriorly directed hair.

The Female Genital Aperture

The female genital aperture or the vulva is a simple, more or less circular opening of the '8th Complex' situated ventrally between the eighth and ninth abdominal sternites (Pl. XVII, fig. 3). It is flanked by the rand of the first valvulae and guarded by the subgenital plate.

The Subgenital Plate

The ventral surface of the eighth abdominal sternite is greenish in colour and provided with short tubercles and
posteriorly directed hair. Its posterior portion is modified into an arch-shaped structure termed the subgenital plate (Pl. XVII, fig. 4). The margin of the subgenital plate is attached to the anterior margin of the first valvifers through the thin intersegmental membrane between eighth and ninth abdominal segments. The subgenital plate bears postero-terminally a robust median spine which extends as far back as the anterior one-third region of the ninth abdominal segment. The proximal part of the spine is pale in colour while the distal part is coloured black.

**THE OVIPOSITOR**

The female *I. senegalensis* (Rambur) possesses a well developed ovipositor which is complicated in structure (Pl. XVII, fig. 3). It consists of two pairs of valvifers - the first and second valvifers, two pairs of acutely pointed reddish-brown valvulae - the first and second valvulae, and a pair of gonangula.

**The First Valvifers**

The first valvifers (Pl. XVII, fig. 3) are a pair of dorso-ventrally flattened and weakly sclerotized structures implanted in the venter at the end of the eighth abdominal sternite. Each valvifer is nearly rhomboidal in shape and bears a process on the mesal side. The mesal processes of the two valvifers lie closely apposed and are separated by a narrow ctenidious membrane only. The lateral margin of the valvifer produces a small lateral process which is curved upwards. A strongly sclerotized, black coloured apophysis termed the anterior apophysis, is present at the anterior margin of the valvifer and projects internally into the body cavity.

**The Second Valvifers or Lateral Valves**

These are a pair of large leaf-like processes arising near the vulva and directed posteriorly on the underside of the
ninth and tenth abdominal segments. Each lateral valve measures 1.364 mm. in length and comprises a broad basal portion and a terminal style (Pl. XVII, fig. 5).

The Basal Portion:

The external surface of the broad basal portion is slightly convex and beset with numerous postero-ventrally directed hair. The ventral border of the lateral valve is finely denticulated. The basal portions of the two lateral valves are connected together by a thin inter valvular membrane which bears an anterior sclerite and a posterior sclerite near the anterior and posterior borders respectively. The anterior intervalvalvar sclerite is a small, laterally compressed and strongly sclerotized piece lying nearly in the middle of the anterior half of the intervalvalvar membrane. The posterior intervalvalvar sclerite is a large, transversely elongated, secondarily sclerotized bend of cuticle present between the ninth and tenth sternites. Proximally each lateral valve bears two black coloured and internally directed apophyses termed the anterior apophysis and the posterior apophysis in accordance with their position. The anterior apophysis is a narrow horizontal process which is directed towards the mesal side. Laterally, the anterior apophysis is attached with a weakly sclerotized and lanced-shaped bar, the laterotergite lying along the ventro-lateral border of tergum of the ninth abdominal segment. The posterior apophysis is a comparatively stout and flattened process lying perpendicular at the posterior end of the anterior apophysis and directed vertically dorsad. There is a prominent fold, the gonoplace on the mesal side of the basal portion of each lateral valve (Pl. XVII, fig. 6). The gonoplace is directed postero-dorsally and protects the apex of the valvulae.

The Terminal Style:

The style is a hollow stout palp-like, blackish-brown structure arising terminally from the distal end of the basal
portion of lateral valve and measuring 0.288 mm. in length. The style is directed postero-ventrally and covered sparsely with small hair which are, however, small and bristle-like near the apex.

The First Valvulae

The first valvulae (Pl. XVII, fig. 5) are a pair of 1.323 mm. long, ventro-posteriorly directed processes whose apices are curved upwards. Each valvula is sword-shaped in appearance and comprises a small proximal ramus and a long distal shaft.

The ramus of the valvula is a plate-like structure which is held horizontally. The rami of the first pair of valvulae are joined together by an arc-shaped median process. The outer lateral margin of each ramus is produced into a small wing-like process, the lateral process. A prominent longitudinal ridge termed the dorsal ridge is present on the dorsal surface of each ramus near the basal end of its lateral process.

The ramus is continued posteriorly into the shaft which is provided with a dorsal groove running throughout the length to facilitate the interlocking mechanism of valvulae. The shafts of the first valvulae enclose between their basal ends a space through which the penis is introduced into the vagina during mating. The distal part of each shaft is serrated due to the presence of denticles on the surface.

The Second Valvulae

These are also a pair of sword-like and postero-ventrally directed processes which, however, differ from the first valvulae in being slender and shorter in length, measuring 1.144 mm. only. A valvula is made up of a small antero-proximal basal portion and a long distal portion termed ramus and shaft respectively.

The ramus of the second valvula is an elongated and laterally compressed structure which is comparable with the handle of a sword. It is proximally attached to the inner side
of the antero-basal end of the lateral valve of its side. The
rami of the second valvulae lie above the rami of the first
valvulae and are joined by a thin membrane so as to enclose the
vulvar aperture. It bears a cup-shaped depression on the mesal
side and a bulge on the outer side. The surface of the bulge
is covered with numerous short bristle-like hair. The dorsal
edge of the ramus is modified to form a ventrally directed
hook-like process, the mesal process.

Each ramus continues distally into an elongated shaft
which is comparable to the blade of a sword. Each shaft carries
a longitudinal groove on the inner surface and a longitudinal
ridge on the ventral surface to facilitate the interlocking
mechanism of valvulae. The shaft is serrated distally on the
outer side (Pl. XVII, fig. 6). The serrations consist of nume-
rous pointed teeth, each tooth alternating with a transverse pleat.

The shafts of the second valvulae are placed above the
shafts of the first valvulae in such a way that a tubular canal
is formed from vulva through which eggs are passed out during
oviposition. The serrated edges and pointed apices of the
shafts make holes in the plant tissue in which the eggs are
deposited. It is only during the egg laying that the shafts
of the paired valvulae project out. At rest, however, these lie
covered by the lateral valves.

During copulation, the valvulae and lateral valves are
held apart to facilitate the entry of penis into vagina of the
female (Pl. XVII, fig. 5).

The Gonangula

A pair of small sclerotized structures, the gonangula
are placed obliquely and vertically one on each side on the
venter of the anterior end of ninth abdominal segment (Pl. XVII,
fig. 3). The dorsal end of each gonangulum is directed anterior-
ward and articulated with the ventral margin of the ninth tergum.
The ventral end of the gonangulum rests on the lateral process
of the ramus of first valvule with which it is attached also.
Male reproductive system of *Lechnura rufoctyagma* Selys consists of the same set of organs as described in *L. senegalensis* (Rambur).

I. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The Testes

The testes are a pair of elongated, tubular, cylindrical and almost translucent structures (Pl. XXXVI, fig. 1). They are multilobular organs, each measuring 2.934 mm. in length and 0.412 mm. in breadth in the middle. The testes occupy posterior half of the seventh abdominal segment and whole of the eighth abdominal segment, and lie dorsal to the alimentary canal. These are covered over externally by adipose tissue and tracheae which are easy to remove. A median strand of connective tissue unites the two testes together throughout their length and is attached posteriorly to the tergum of the ninth abdominal segment.

The testes are held in position by tracheae, fat-bodies, nerves, median strand of connective tissue and also by suspensory filaments which are the anterior prolongations of adipose tissue covering.

The Vasa Daeerentia

The posterior end of each testis is slightly constricted where from a duct, the vas deferens (Pl. XXXVI, fig. 1) comes out posteriorly which measures 1.15 mm. in length. It is a curved, 'Z'-shaped tube which lies enveloped within a sheath of adipose tissue. From the origin at the base of the ninth segment of abdomen on the subdorsal side of the alimentary
canal, the vas deferens extends posteriorly up to the middle of the ninth abdominal segment as a thin translucent tube. Thereafter, it becomes dilated and convolutes down inwards to run ventrally to the gut up to the middle of the ninth segment. Distally, the vasa deferentia of the two sides open into a swollen sac-like organ, the sperm sac. Before opening into sperm sac each duct forms a small 'U'-shaped bend.

The Sperm Sac

The sperm sac is a large, median organ of somewhat oval shape lying ventral to the alimentary canal in the middle of the ninth abdominal segment (Pl. XXVI, fig. 1). The sac measures 0.973 mm. in length and 0.511 mm. across in the middle. It receives the openings of the vasa deferentia on the ventrolateral sides. The sperm sac stores spermatozoa. A nerve passes lengthwise along each dorso-lateral margin of the sperm sac. Ventral a portion of the sperm sac rests on a chitinous structure situated anterior to the gonopore.

The Ejaculatory Duct

There is a small translucent ejaculatory duct arising ventrally from the sperm sac and opening out to the exterior through gonopore. The duct is lodged in the depression of a dorsally concave chitinous structure which provides rest to a portion of the sperm sac as well. The chitinous structure appears to be formed by invagination of the body-wall through the gonopore.

In general specimens, the sperm sac and the distal part of vasa deferentia are pale white. However, in older specimens, these are coloured brownish-black.

Definite accessory glands have not been found in any part of the male reproductive system of the damselfly studied.
The Testis

The testis (Pl. XVIII, figs. 1 & 2) shows a definite and regular adipose tissue layer in the outermost strata of the wall. It consists of a spongy mass of highly vacuolated cells provided with very little cytoplasm and granular nuclei. It is richly supplied with tracheae and tracheoles. The wall of the testis is formed only by a thin layer of peritoneum. It consists of a layer of greatly stretched cells. Each cell is provided with a prominent bulging nucleus in the centre.

The Testicular Lobule:-

A large number of solid and almost spherical lobules are present enclosed by the wall of the testis. They are arranged towards the inner side of a lateral duct into which they open by minute ductules. The ductules are prominently visible in ripe lobules. The testicular lobules contain germ cells in different stages of spermatogenesis. All the germ cells in a lobule are alike and represent only one stage of development. The germ cells of a lobule are enclosed by a thin limiting membrane only. There is no germinal epithelium. It is thus evident that unlike the typical insect testis, the gonad in I. rufostigma is not divided into different zones like germarium, zone of growth and zone of transformation etc. The absence of a germinal epithelium and follicular zones, and the presence of all germ cells in any one stage of spermatogenesis at a time in a lobule show that the structure of the testis in the damselfly is greatly specialized.

The Common Lateral Duct:-

There is a lateral duct running sinuously throughout the length of the testis on its outer lateral side. The lobules open into it through minute ductules. The wall of the lateral duct is made up of following layers from within outwards:-
(i) Epithelium:— The structure of the epithelium towards the outer side and the inner side of the duct is different. The epithelium on the outer side is simple and single layered consisting of cuboidal cells, each measuring 10 micra in length. The epithelial cell contains granular, vacuolated cytoplasm and a nucleus towards the apical side. The nucleus is spherical in shape measuring 4 micra in diameter and containing a nucleolus and 4 to 8 deeply-staining granules. The epithelium on the inner side is thick and multilayered measuring 19 micra in width. The epithelial cells are cuboidal to columnar in shape and lack distinct cell-boundaries. The nucleus is large and the cytoplasm dense and highly vacuolated.

(ii) Musculature:— A very thin layer of circular muscle fibres is present outside the epithelium in the wall of the duct.

The lumen of the lateral duct is spacious and contains secretory material and spermatozoa which are not present in groups.

The Vas Deferens

The vas deferens is histologically divided into a proximal region and a distal region.

The Proximal region:—

The wall of the proximal region is distinct and consists of 6 to 8 micra thick epithelial layer enclosing a spacious lumen in the centre (Pl. XVIII, fig. 3). The epithelium is composed of a single row of small cuboidal cells with indistinct cell-boundaries. Each epithelial cell possesses a 4 to 5 micra large spherical nucleus occupying a large space in the cell. The nucleus is provided with a central nucleolus and many deeply-staining granules near the periphery. The cytoplasm is densely granular. The epithelium is supported on a very thin structureless basement membrane enveloped by a thin layer of circular muscles. The adipose tissue is very well developed.
and forms a thick coat round the vas deferens. The lumen is empty being devoid of the spermatozoa and secretory material.

The Distal region:-

The wall of the distal region of vas deferens is comparatively thin. The lumen is spacious and filled with secretory material of two kinds, one of granular consistency and the other homogeneous (Pl. XVIII, fig. 4). The granular secretion occupies the central part of the lumen and contains mostly scattered spermatozoa. The homogeneous secretory material is present near the periphery of the lumen and mostly contains groups of spermatozoa. The epithelial layer lining the lumen consists of a thin layer of flat cells, each bearing a 4 micra large oval nucleus. The nucleus contains two or three faintly-staining granules only. The bases of the epithelial cells are supported on a basement membrane. Outer to the epithelial layer and the basement membrane is present a thin stratum of circular muscle fibres. The outermost layer in the wall of the duct is formed by peritoneum. It consists of greatly stretched cells, the cytoplasm of which is packed densely with brownish-black pigment. Adipose tissue forms a loose and incomplete envelope round the distal region of the vas deferens.

The Sperm sac

The wall of the oval sperm sac (Pl. XVIII, fig. 5) consists of the same layers as that of the distal region of vas deferens. However, the epithelium of the sperm sac wall is characteristically thin and the lumen large and spacious. The cell-boundaries between the epithelial cells are indistinct. The epithelium measures only 5 micra thick and possesses granular cytoplasm and oval nuclei, each of 2 micra diameter. The epithelium is surrounded by a very thin non-cellular basement membrane. The muscular layer is prominent and composed of circular muscle fibres. The peritoneum is thick and laden with numerous brownish-black pigments which impart blackening to the wall during post-teneral phase. The lumen of the sperm sac is large
and contains scattered spermatozoa. The spermatozoa are dispersed in a highly granular secretory material on the peripheral side and a less granular secretory material in the central part of the lumen. There is no chitinous intima.

The Ejaculatory Duct

The ejaculatory duct shows the same histological features as the sperm sac except that its epithelium is lined internally by a thin chitinous intima and the musculature is comparatively thicker comprising an outer layer of circular muscles and an inner layer of longitudinal muscles. The epithelial nuclei are highly granular.

2. EXTERNAL GENITAL ORGANS

The Supra-anal Appendages

There is a pair of characteristically well developed ciaspere, the supra-anal appendages arising out termino-dorsally from the posterior side of the tenth abdominal segment (Pl. XVIII, fig. 6). These are light orange coloured hollow chitinized appendages, each measuring 0.266 mm. in length. An appendage appears rounded in shape. The ventro-mesal edge of the appendage is produced into a flat, triangular, heavily sclerotized 0.237 mm. long hook which is directed downward (Pl. XIX, fig. 1). Bristle-like hair are present all over the surface of the appendage and the hook.

The Infra-anal Appendages

The infra-anal appendages are a pair of hollow elongated, cylindrical forceps-like structures which are longer in size than the supra-anal appendages (Pl. XVIII, fig. 6). Each appendage measures 0.453 mm. in length and is coloured light orange. The apex of the appendage is strongly sclerotized to form a curved hook-like structure (Pl. XIX, fig. 2). The surface
of the appendage is clothed with hair which are directed posteriorly.

The Gonopore

The male genital aperture is a small elliptical slit measuring 0.101 mm. in length and located ventrally in the centre of the ninth abdominal sternite (Pl. XVIII, fig. 7). The margin of the gonopore is strongly chitinized forming a ring which is forwardly continued into an internal, broad chitinous structure. This structure is bifurcated at the anterior end and bears a prominent lengthwise depression on the dorsal surface.

The Coxites:

The coxites are a pair of pear-shaped, blackish orange structures each measuring 0.575 mm. in length. The two coxites lie on the lateral side of the gonopore which is partly hidden by these structures. The coxites are broad and rounded anteriorly, and tapering posteriorly as a stylus. The tapering part of the coxite hangs free from the body-wall while the remaining part is united with the ninth sternum. The surface of the coxite is covered over with long posteriorly directed hair.

The Anterior genital plate:

It is a broad weakly sclerotized rectangular plate which is light orange in colour and measures 0.605 mm. in width. Surface of the anterior genital plate is beset with numerous long, postero-mesad hair and small tubercles.

The Post-genital plate:

The post-genital plate is also a broad rectangular chitinous plate measuring 0.266 mm. in length and 0.677 mm. in width. The anterior and posterior margins of the plate are straight while the corners are rounded. The ventral surface of the plate bears tubercles only, hair being noticeably absent.
THE SECONDARY COPULATORY APPARATUS

The Genital Fossa

The ventral surface of the second abdominal segment forms a deep depression, the genital fossa. There exists no internal connection between the genital fossa, penis and the vesicula seminalis.

The Anterior Lamina

The anterior lamina (Pl. XIX, fig. 3) is a 0.528 mm, large chitinous hood-like plate of orange colour. It is situated in the anterior part of the genital fossa. The anterior margin of the lamina is strengthened internally by a prominent, heavily sclerotized transverse structure, the apophysis. The lateral margins of the anterior lamina are also strongly sclerotized and attached through pleural membranes to the ventro-lateral edges of the second abdominal tergite. The posterior margin of the anterior lamina is notched so deeply in the middle that the cleft reaches upto the front margin. The cavity of the cleft is covered dorsally by a thin membrane and the composite structure thus formed is termed the median laminar sac which measures 0.638 mm. in length. The median laminar sac tapers anteriorly forming a process which enters into the first abdominal segment. On the posterior side, the median laminar sac lies attached to the lamina batilliformis. Hair are present on the margin of the cleft and the ventral surface of the anterior lamina.

The Anterior Hamules

A pair of chitinous hamules are present behind the anterior lamina, one on either side (Pl. XIX, fig. 3). A hamule is made up of two plates, an outer plate and an inner plate. The outer plate is movably attached to the ventro-lateral margin of the second tergum on one hand and to the anterior lamina on the other hand. This plate is greenish-orange in colour, somewhat quadrate in shape and measures 0.443 mm. long and
0.396 mm. broad. The ventral surface is beset with many long hair. The antero-mesal angle of the outer plate is drawn out to form a small forwardly directed black coloured process. The outer plate is connected along the mesal margin with the overlying inner plate of the hamule. The inner plate comprises a large, weakly sclerotized membranous flat part and a small, strongly sclerotized vertical part. The membranous part lies close to the mesal half of the outer plate and connects the outer plate with the vertical part of the inner plate. The vertical sclerotized part is a laterally compressed hook-like structure hanging towards the genital fossa. Basally, the surface of the inner plate is beset with long and posteriorly directed hair.

The Lamina Batilliformis

The lamina batilliformis is a rigid ventro-median structure located in the genital fossa above the anterior lamina and the anterior hamule (Pl. XIX, fig. 3). It measures 0.596 mm. in length and consists of an elongated spoon-shaped plate which is cleft postero-medially forming a pair of limbs. The plate sits tightly in the cavity of the cleft of anterior lamina. Each limb of the lamina batilliformis bears hair on the mesal side and a tuft of 5-8 long hair on the apical side. The posterior end of the limb is bent dorsally forming a cornu. The cornua are directed anterioward and outward, and run parallel to the mesal margin of the hook of the anterior hamule. The limbs and the cornua of lamina batilliformis provide skeletal support to genital sac.

The Genital Sac

The genital sac is a large membranous sac which is located in the anterior part of the genital fossa. The sac opens ventrally through a large orifice. The genital sac is supported antero-ventrally by the lamina batilliformis, and laterally and posteriorly by the cutinous structures of the
framework. The roof of the sac is strengthened by the basal plate of penis. The genital sac protects the anterior part of the penis shaft by housing it in the space.

**The Framework**

The framework is made up of a pair of anterior vertical bars, a pair of lateral longitudinal bars and a posterior median plate.

**The Anterior Vertical Bars:**

The anterior vertical bars each measuring 0.528 mm. in length, are obliquely present in the lateral wall of the genital sac. A bar is vertically placed in such a way that its upper end is antero-mesally directed and the lower end postero-laterally directed. The upper end of the bar is united with basal plate of the penis, and the lower end articulates with the lateral longitudinal bar of the frame (Pl. XIX, fig. 4).

**The Lateral Longitudinal Bars:**

These are 0.308 mm. long paired structures placed antero-posteriorly in the genital fossa and providing support to the ventro-lateral wall of the genital sac.

**The Posterior Median Plate:**

It is a large chitinous plate lying horizontally on the posterior side of the genital sac. The posterior median plate (Pl. XIX, fig. 5) is a 'W'-shaped structure possessing a maximum width of 0.648 mm. The plate comprises a broad median chitinous structure, a pair of long anterior limbs and a pair of short posterior limbs. The median chitinous structure is broad at the base but narrows gradually towards the anterior side to form a spear-shaped structure. The anterior limbs are a pair of stout, 0.442 mm. long processes which are articulated apically with the posterior ends of the lateral longitudinal bars of framework. The posterior limbs are small blunt processes whose
apical margins are curved upwards. The posterior margin of the median plate is caved in to give an arch-like appearance.

The Posterior Hamules

A pair of simple nearly rectangular structures are present near the subapical side of each anterior limb of the median plate of the frame (Pl. XIX, fig. 5). These are termed posterior hamules. Each hamule is a hollow, 0.132 mm. large structure projecting vertically ventrad. There is a foramen near its base. The surface of the hamule is furnished with numerous long hair.

The Penis

The penis is a long unsegmented, chitinous organ which lacks an external orifice (Pl. XIX, fig. 4). It is situated ventro-medially in the genital fossa and consists of a small basal plate and a long shaft.

The Basal Plate:

The basal plate forms a part of the dorsal wall of the genital sac and comprises an anterior sclerite and a posterior sclerite.

The Anterior sclerite: The anterior sclerite is a 0.23 mm. broad chitinous bar placed transversely above the frontend of the posterior sclerite. Its lateral ends are supported by the anterior vertical bars of the framework, and the basal margin is united with the posterior sclerite.

The Posterior sclerite: It is a spoon-shaped, dorsally concave and apically notched structure measuring 0.367 mm. in length. It composes major part of the basal plate of penis. In the concavity of the posterior sclerite there is a thin membranous glandular cushion ( Ligula-schwellkörper of Pfeau, 1971) which often gets swollen to form a ball-like structure. 
The shaft:-

The shaft of the penis is a stout, tubular, and curved portion which is a continuation of the posterior sclerite of the basal plate. It possesses a narrow lumen in the centre which communicates with the haemocoel through a small aperture enclosed between the shaft and the basal plate. Like other species described previously, the shaft of penis in I. rufostigma is also divisible into three regions.

(a) The Proximal region:- It is a long, curved, rod-like structure emerging posteriorwards from the orifice of the genital sac. The basal, the ventral and the ventro-lateral areas in the wall of the shaft are strongly sclerotized while the remaining portion is membranous. A transverse row of postero-ventrally directed spines counting 3 in number is present on either side at the terminal end (Pl. XIX, fig. 6). The proximal region is movably attached to the middle region of the shaft through membranous connections.

(b) The Middle region:- The middle region is shorter but wider than the proximal region of the penis and is bent dorsally. It is membranous throughout except the ventral surface which is strongly sclerotized. A pair of small, heavily sclerotized, hook-like processes of black colour arise near the terminal end of the ventral wall of the region.

(c) The Distal region:- The distal region is a weakly sclerotized portion of the shaft and consists of two structures, a glans and a prepuce. The glans is a small, distensible, hump-like, posteriorly directed extension of the wall near the base of the region. The prepuce is a large and forwardly directed structure which lies bent over the posterior part of the middle region of the shaft. The apical end of the prepuce is wide and bifurcated to produce a pair of curved flagella-like processes.
The external median dorsal groove of the shaft is present in the proximal and middle regions.

The Vesicula Spermalis

The vesicula spermalis is a flask-like 0.792 mm. long organ hanging from the front end of the third abdominal segment beneath the median plate of frame (Pl. XIX, fig. 7). It is orange-black in colour and consists of a narrow anterior neck and a wide posterior body. The body of the vesicle is plano-convex in shape and twice as long as the neck. The neck is ventrally composed of a large semicircular membrane of light green colour bearing a slit-like aperture, the orifice of the vesicula spermalis. The orifice is bordered by two lateral lips. The latero-ventral sides of the neck are hard and strongly sclerotized like that of the ventral surface of the body of vesicle. Long, bristle-like hair are present along the lateral margins of the ventral surface of vesicle. The dorsal wall of the vesicula spermalis is flat and membranous and lacks completely the hairy clothing. The vesicula spermalis is strengthened by anterior and posterior apodemes which are present between the second and third abdominal segments.

The Anterior apodeme:— The anterior apodeme is a thin sclerotized transverse bar. The lateral ends of the bar are expanded and projected antero-dorsally to abut against the upturned ends of the posterior limbs of median plate of the frame.

The Posterior apodeme:— It is situated behind the anterior apodeme and lies fused with the anterior edge of the third sternite. The posterior apodeme is also a transverse bar with expanded ends which are, however, directed dorso-laterally.
FEMALE REPRODUCTIVE SYSTEM OF LECHNURA RUFOSTIGMA SELYS

1. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The internal genital organs include a pair of ovaries, a pair of oviducts, a common median oviduct and '6th Complex'. The '6th Complex' comprises vagina, bursa copulatrix and spermatheca, all of which are placed together forming the compact structure. A pair of accessory glands are also present opening dorsally into the postero-terminal part of the '6th Complex'.

The Ovaries

The ovaries consist of a pair of 17.37 mm, long pale-mud coloured organs extending from the base of the first abdominal segment up to the middle of the seventh abdominal segment on the dorsal side of the alimentary canal. The two ovaries are united mesally by a common ligament, the median dorsal ligament. Anteriorly, the median dorsal ligament is attached to the metanotum and posteriorly to the dorsal body-wall of the ninth segment of abdomen. The ovaries separate from each other near the posterior end of the sixth abdominal segment and proceed posteriorward being dorso-lateral to the gut.

A delicate, transparent, thin-walled membranous tube runs throughout the length of each ovary on the ventro-lateral side. This is termed the common lateral duct which bears a large number of ovarioles along a longitudinal axis on the dorso-mesal side. The ovarioles are arranged compactly one after another along the length of the ovary and directed obliquely towards antero-dorsal side. The presence of ovarioles only on the dorso-mesal side of the common lateral duct evidently differentiates between the dorsal and ventral surfaces of the ovary. Each ovariole is an elongated tubular structure containing
a single chain of developing ova placed one after another. The eggs are placed in a grading manner from the narrow apex of the ovariole down to its broad base. The basal end of the ovariole lies close to the common lateral duct and possesses the largest and oldest oocyte. The apical end of the ovariole is prolonged into a thin, long filamentous structure, the terminal filament. The terminal filaments of the ovarioles are directed antero-medial to become embedded in the median dorsal ligament. In the anterior region of the ovary, the terminal filaments combine together to form a stout cord-like composite suspensory filament termed the apical filament of the ovary. The apical filaments of the ovaries enter the thorax together to attach on the dorsal body-wall. The median dorsal ligament, the terminal filaments of the ovarioles and the apical filaments of the ovaries serve to maintain the gonads in position. Fat-bodies in the form of adipose tissue are abundantly present all round the apical filaments, in the spaces between the ovarioles and over the surface of the common lateral ducts of the ovaries. The tracheae also form a dense ramification all over the surface of the ovary.

The Oviducts

The common lateral ducts extend posteriorly beyond the ovaries as a pair of oviducts which are present in the posterior half of the seventh and anterior region of the eighth abdominal segments. The oviducts are transparent, membranous tubes measuring 1.969 mm. in length. In the beginning, the oviducts run on the dorso-lateral sides of the alimentary canal. However, each oviduct descends down the side of the gut near the end of the seventh abdominal segment and occupies a ventral position. In mature specimens, the lumen of the oviduct usually contains more than one row of ova at a time.

The body cavity in the seventh and eighth abdominal segments possesses an abundance of fat-bodies which are specially aggregated near the oviducts and the common median oviduct.
The Common Median Oviduct

The oviducts from the two sides come close to each other beneath the gut and unite together to form a very short common median oviduct or the oviductus communis. The oviductus communis is a transparent, thick-walled duct which remains covered on the dorsal side by the eighth abdominal ganglion.

There is a fasciculus of powerful muscle originating from the '8th complex' and running anterior along the mid-dorsal surface of the common median oviduct. This single fasciculus divides into two filament-like fasciculi of muscles at the anterior end of the oviductus communis. The fasciculi then extend anteriorward along the mesal margin of the oviducts and attach themselves on the sternum of the seventh abdominal segment. The oviductus communis lies enveloped within a thick mass of adipose tissue and enters posteriorly into the '8th complex'.

The '8th Complex'

The '8th Complex' (Pl. XX, fig. 1) is a translucent structure of composite nature, named so because it is formed by assemblage of many organs in the posterior half of the eighth abdominal segment below the alimentary canal. The '8th Complex' comprises a ventral tubular vagina, a dorsal saccular bursa copulatrix and a posteriorly directed spermatheca arising from the bursa. It is surrounded by adipose tissue and richly supplied with tracheoles and nerves. The ganglion of the eighth abdominal segment sends a posteriorward nerve running along each lateral side of the '8th Complex'.

The Vagina

The vagina is a prominent tube on the mid-ventral side of the '8th Complex' (Pl. XX, fig. 1). It is composed of two portions, (a) an anterior tubular portion, and (b) a genital atrium.
(a) The Anterior tubular portion:

It is the muscular and tubular region which forms the main part of the vagina. The dorsal surface of the anterior tubular portion lies hidden from view due to the presence of large bursa copulatrix and spermatheca. It receives the openings of the common median oviduct and ductus bursae on the antero-ventral and the antero-dorsal sides respectively, and leads posteriorly into the genital atrium.

Two pairs of muscles are attached on the wall of the vagina, the anterior vaginal muscles and the sterno-vaginal muscles. The anterior vaginal muscles are thin filamentous structures which are attached to the front end of the anterior tubular portion. These extend forwards. The sterno-vaginal muscles are large bundles of muscle fibres attached laterally to the wall of the vagina. The remaining part of the vagina is covered over by a few radial and longitudinal muscles.

(b) The Genital atrium:

The genital atrium is a small thin-walled chamber situated behind the anterior tubular portion of the vagina. It communicates to the exterior through vulvar aperture. When empty, the walls of the chamber are wrinkled. The genital atrium stores the eggs temporarily before oviposition.

The Bursa Copulatrix

The bursa copulatrix is a prominent cylindrical sac-like organ formed as a dorsal outgrowth of the antero-dorsal wall of the vagina (Pl. XX, fig. 1). It lies projecting posteriorly over the anterior part of the vagina, with which it is connected by a small slender duct, the ductus bursae. In teneral and virgin specimens, the bursa copulatrix is present in a wrinkled condition on one side of the '8th Complex'.
The Spermatheca

The spermatheca is a long median, posteriorly directed structure which is attached near the middle of the ventral side of bursa copulatrix (Pl. XX, fig. 2). It consists of a proximal duct and a distal sac which are nearly equal in length. The spermathecal sac is faintly red in colour and oval in shape. The spermathecal duct runs anteriorly along the ventro-medial surface of the bursa copulatrix into which it opens finally. The adipose tissue present in the cavity of eighth abdominal segment surrounds both the structures, the spermatheca and the bursa copulatrix together.

The Accessory Glands

The accessory glands (Pl. XX, fig. 1) are a pair of prominent whitish organs present underneath the rectum in the ninth abdominal segment. The two glands which vary in size, extend posteriorly almost parallel to each other. Each accessory reproductive gland consists of two portions, a proximal ductile portion and a distal sac-like portion. The sac measures nearly twice the length of the duct and is cylindrical in shape. The ductile of the gland is a slender thread-like tube which opens dorso-posteriorly in the hinder part of the genital atrium.

(B) HISTOLOGY

The Ovarioles

The ovary comprises a common lateral duct and a large number of ovarioles. The ovarioles are of panoistic type in which nurse cells are absent. The ovariole is bounded by a thin transparent membranous wall, the epithelial sheath which is composed of a single layer of greatly stretched cells. The epithelial sheath encloses a longitudinal series of developing ova. The three zones of a typical insect ovariole are clearly recognized in the present specimen as follows:-
(i) The Terminal Filament:— The terminal filament is produced apically by prolongation of the wall of the ovariole. It is a long, anteriorly directed thread-like structure in which cellular differentiation is not evident. The terminal filaments of the ovarioles except the anterior ones, join the median dorsal ligament. The median dorsal ligament consists of loose connective tissue which contains an abundance of fat-bodies and only a few muscle fibres.

(ii) The Germarium:— The germarium is a small region between the terminal filament and vitellarium. It consists of a mass of actively proliferating cells which differentiate into primordial germ cells and ova.

(iii) The Vitellarium:— The vitellarium is a large posterior zone of the ovariole which is basally attached to the common lateral duct. The cellular nature of the epithelium is quite distinct in the sheath of the vitellarium at places where it grows inwards in a manner to enclose each differentiated oocyte in an egg-chamber or the follicle. The follicles are arranged in a single longitudinal row in graded succession so that the largest one is situated at the base and the smallest one at the apex of the vitellarium. The follicular epithelial cells later on secrete a hard covering, the chorion round each fully developed egg.

The Common Lateral Duct

The wall of the common lateral duct is composed of an inner epithelial layer and an outer muscle layer. The epithelial layer is thin and consists of cuboidal cells which are arranged in a tier round the central lumen. Each epithelial cell possesses a large oval to spherical nucleus near its apical end and a small amount of clear cytoplasm. The epithelium on the dorso-ventral side of the duct is irregular in outline due to attachment of the ovarioles. Outside the epithelium is present the muscle
layer which is thin and composed of longitudinal muscle fibres only. There is a lumen in the centre of the common lateral duct in which mature ova from the ovarioles are released.

The Oviduct

The wall of the oviduct consists of an inner epithelial layer and an outer muscular layer which is thicker than that of the common lateral duct of the ovary. The lumen of the oviduct is wide and spacious. The lumen is surrounded by cuboidal cells which are arranged in a single row forming the epithelial layer. Each epithelial cell measures 6 micra in length and possesses scanty amount of cytoplasm. A 4 micra large, spherical nucleus bearing a distinct nucleolus and 2-3 deeply-staining granules is also present towards the apical end of the epithelial cell. The musculature is made up of a layer of longitudinal muscle fibres only.

The Common Median Oviduct

The structure of the common median oviduct (Pl. XX, figs. 3 & 4) is histologically similar to that of the oviducts with the difference that (i) the lumen in the median oviduct is wide and lined by a thin chitinous intima; (ii) the musculature is thicker and more powerful than that of the oviduct and comprises an inner layer of circular muscles and an outer layer of longitudinal muscles; and (iii) the adipose tissue forms the outermost coat in the wall of the duct.

The epithelium of the oviductus communis consists of a layer of columnar cells, each cell measuring 3 micra in length and possessing a clear cytoplasm and a spherical nucleus. The nucleus measures 4 micra in diameter and is provided with a nucleolus and a few deeply-staining granules. The epithelial layer is supported on a thin basement membrane and lined internally by a thin chitinous intima.
The wall of the epithelium is depressed along the median line due to the presence of the fasciculi of anterior vaginal muscles on the surface. This results in the formation of a median longitudinal ridge projecting towards the lumen from the dorsal wall of the oviductus communis. The epithelium of the ridge seems to be glandular. The ventral wall of the duct is prominently elevated downwards.

The common median oviduct opens ventrally into the vagina of '8th Complex' through a slit-like orifice, the gonopore (Pl. XX, fig. 5).

The Vagina

(a) The Anterior tubular portion:-

The orientation of the tissue in the anterior tubular portion of vagina (Pl. XXI, fig. 1) is as follows:-

The lumen consists basically of a vertical slit with lateral evaginations ventrally and a broad cavity dorsally. The lateral evaginations are small anteriorly and gradually increase in size towards the posterior side. The lumen is lined by a chitinous layer of varying thickness forming special cuticular modifications. Anteriorly, the lumen receives the openings of the ductus bursae and the common median oviduct, and the junction is marked by the presence of a strongly sclerotized cuticular structure, the collar (Pl. XX, fig. 5). The collar lies in the anterior wall of the vagina and consists of a central part and a pair of arms. The central part is placed vertically and obliquely, and produced forward as an anterior process to provide attachment for the anterior vaginal muscles. The arms of the collar are broad lateral outgrowths of the central part. These are directed postero-ventrally into the lumen of the vagina. The cuticle in the vertical slit-like part of the lumen is modified to form a pair of lateral plates. The two lateral plates are connected together dorsally by a thick chitinous
layer and ventrally by a thin membrane only. The chitinous intima is lined externally by an epithelial layer. The epithelium is composed of a layer of short cuboidal cells, each measuring 5 micra in length and 4 micra in breadth. The nucleus is large, granular and spherical measuring 3 micra in diameter and occupying most of the space in the cell. The epithelial cells are supported basally by a very thin layer of structureless basement membrane.

The musculature of the anterior tubular portion of vagina is composed of striated muscle fibres which are more or less orderly arranged. In the most posterior part, the fibres run latero-ventrally from the dorsal and vertical part to insert on the sternum. A few fibres from the dorsal and lateral parts of the ventral evaginations also attach to the sternum. These comprise the radial muscles. Further anteriorly, these muscles are replaced by two large, longitudinal bow-shaped muscles, one on each side of the vagina. In the posterior part, the bow-shaped longitudinal muscles occupy a ventral position but they bend dorsally as the ventral area becomes occupied by massive sterno-vaginal muscles. Further anteriorly, as the sterno-vaginal muscles decrease the longitudinal bow-shaped muscles again bend ventrally. The dorsal wall of the vagina possesses longitudinal muscle fibres which are attached to the cuticular collar. Another pair of longitudinal muscles, the anterior vaginal muscles, also takes its origin from the anterior process of the collar. The collar is, therefore, a cuticular structure on which a number of muscles are inserted. The contraction of the sterno-vaginal and radial muscles causes the lateral plates to move apart to make sufficient space for the egg to pass through vagina (Pl. XXI, fig. 2). The shape of the eggs is accordingly elongated. Varying amounts of adipose tissue are scattered amongst the muscle fibres.

(b) The Genital atrium:

The wall of the genital atrium is thin and irregularly
folded. Histologically, it consists of a chitinous layer and an epithelial layer. The chitinous intima forms the innermost layer which is colourless and thickened at places. It is surrounded by an epithelium which is a thin layer composed of single tier of short cuboidal cells with indistinct cell-boundaries. The epithelial cell measures 4 micra in length and possesses a large prominent rounded nucleus within a mass of deeply-staining cytoplasm. The nucleus measures 3 micra in diameter and contains a nucleolus in the centre. Large amount of adipose tissue is present in the vicinity of the genital atrium in the young and immature specimens.

The Bursa Copulatrix

The histological structure of the bursa copulatrix is similar to that of the anterior tubular portion of vagina.

The innermost layer in the wall of the bursa copulatrix (Pl. XXI, fig. 2) is composed of a thick layer of colourless chitinous intima which is usually thrown into a complicated pattern of folds projecting into the lumen. The chitinous intima is surrounded by an epithelial layer which consists of a single row of cuboidal cells, each measuring 6 micra in length and possessing a 4 micra large, round nucleus. The musculature is thick and comprises longitudinal muscle fibres only. The outermost stratum in the wall of the bursa copulatrix consists of a complete layer of adipose tissue. The lumen is spacious and full of spermatosoma.

The bursa copulatrix communicates obliquely with the vagina through a narrow duct, the ductus bursae (Pl. XXI, fig. 5). The structure of the duct is similar to that of the bursa copulatrix. However, its lumen is lined by a comparatively thick chitinous layer which possesses a number of postero-ventrally directed spines.
The Spermatheca

The spermatheca is morphologically differentiated into a sac and a duct but histologically, both the parts are similar.

The wall of the spermathecal sac and duct (Pl. XX, fig. 6 and Pl. XXI, fig. 1) is formed by a single-layered epithelium resting on a thin basement membrane. The epithelium is composed of large cuboidal cells, each measuring 9 micra in length and bearing a vesicular nucleus near the basal end. The nucleus is oval in shape measuring 5 micra across and possesses a large nucleolus and 3-4 deeply-staining granules. The cytoplasm is granular and vacuolated. The nature of the epithelium of the spermatheca is glandular. The epithelium is lined on the inner side by a thick layer of chitinous intima which is traversed by numerous fine canals. A thin layer of longitudinal muscle fibres forms the muscularature outside the basement membrane. The spermatheca is surrounded on all sides by large amount of adipose tissue. The lumen of the spermatheca is devoid of spermatosacs in virgin females, but in mated ones it is replete with sperms which come into it from the bursa copulatrix (Pl. XX, fig. 2).

The Accessory Glands

The Sac-like portion:

The following layers are present, in order from within outwards in the wall of the sac-like portion:
(i) Chitinous layer, (ii) Epithelium, (iii) Basement membrane, (iv) Muscle layer, and (v) Adipose tissue.

The sac-like portion possesses a large spacious lumen which is lined by a thin chitinous intima (Pl. XX, fig. 7). The epithelium consists of a single row of columnar cells, each measuring 11 micra in length. The cytoplasm of the epithelial cell is highly granular and vacuolated. The nucleus is vesicular and spherical in shape measuring 5 micra in diameter and containing a prominent nucleolus. Large empty spaces are abundantly seen in between the epithelial cells. The epithelium is secretory
and contains secretion deposits also near the apical ends. The epithelial layer is bounded externally by a basement membrane. The muscle layer is thin and consists of circular muscle fibres outer to the basement membrane. The outermost coat is formed by adipose tissue which is thin and broken at places.

The Ductule portion:-

The wall of the ductule (Pl. XX, fig. 8) is very similar to the wall of the sac-like portion of the gland. However, the epithelium is only 5 micra thick and composed of cuboidal cells, each bearing a 3 micra large darkly-staining nucleus. The cytoplasm is devoid of granules and vacuoles, and stains faintly. The epithelium, therefore, seems to be non-secretory. The chitinous intima is comparatively thick and colourless. The musculature is thick and comprises circular muscle fibres. The adipose tissue is also found scattered among the muscle fibres as well as on the outer side of the wall of the duct.

2. **EXTERNAL GENITAL ORGANS**

The female external genitalia of *Leccnura rufostigma* Selje comprise a pair of supra-anal appendages, a subgenital plate beneath the vulva, and a well developed ovipositor.

**The Supra-anal Appendages**

The supra-anal appendages are 0.316 mm. long, hollow and conical appendages coming out dorso-terminally from the tenth abdominal segment (Pl. XXI, fig. 3). The appendages are coloured orange suffused with black, and covered with numerous posteriorly directed hair and tiny tubercles all over the surface.

**The Female Genital Aperture**

The female genital aperture (vulva) is a small simple and nearly circular orifice situated mid-ventrally on the
intersemental membrane between the eighth and ninth abdominal segments (Pl. XXI, fig. 4). It lies between the bases of rami of the first valvulae and second valvulae of the ovipositor.

**The Subgenital Plate**

The sternum of the eighth abdominal segment is a simple plate bearing hair and tubercles and resembles the sternite preceding it. The posterior end of the eighth sternite is enlarged and produced posteriorly beneath the vulva and base of the ovipositor as an arch-shaped structure, the subgenital plate (Pl. XXI, fig. 5). The subgenital plate is light orange in colour and bears apically a black coloured median tapering process which extends up to the proximal one-third part of the ninth abdominal segment. The subgenital plate guards the vulva and protects the ovipositor.

**THE OVIPOSITOR**

The ovipositor is situated on the vertex of the ninth abdominal segment. It comprises first valvifers, second valvifers or lateral valves, first and second valvulae, and gonangula; all of which are paired.

**The First Valvifers**

The first valvifers are a pair of plates located horizontally in the membranous venter between the eighth and ninth abdominal segments (Pl. XXI, fig. 5). Each valvifer bears two processes, a mesal process and an anterior apophysis. The mesal processes of the two sides are joined together by a membrane. The anterior apophysis is a stout, black coloured and anteriorly directed process at the antero-lateral margin of the valvifer. It projects internally into the eighth abdominal segment and provides attachment to a muscle of the ovipositor. The postero-mesal margin of each valvifer provides attachment to an elongated process, the first valvule.
The Second Valvifers or Lateral Valves

The second valvifers or lateral valves (Pl. XII, figs. 4, 6 & 7) consist of a pair of 1.364 mm. long laminate appendages of orange colour which are attached broadly to the tergo-sternal joint of the ninth segment, one on each side. Each lateral valve comprises a broad basal portion and a terminal style.

A thin membrane joins the basal ends of the two lateral valves and hence termed the intervalvular membrane. There are two sclerites in the intervalvular membrane, the anterior and posterior intervalvular sclerites. The anterior intervalvular sclerite is a small elongated, strongly sclerotized area near the middle of the anterior margin of intervalvular membrane. The posterior intervalvular sclerite forms the posterior border of the membrane and consists of a semicircular bar stretched transversely between the bases of lateral valves at the end of the ninth abdominal segment.

The wall of the basal portion of second valvifer is weakly sclerotized and slightly convex bearing numerous posteriorly directed hair on the surface. The proximal end of the valvifer is strongly sclerotized to form two apophyses, an anterior apophysis and a posterior apophysis. The anterior apophysis is a narrow process placed lengthwise in a horizontal plane along the mesal border. The posterior apophysis is situated laterally at right angles to the posterior extremity of the anterior apophysis and forms a stout process directed vertically upward. The anterior and posterior apophyses project into the body cavity of the ninth abdominal segment and provide attachment to the ovipositor muscles. There is a bar-like laterotergite present between the anterior apophysis and the ventro-lateral border of the ninth tergite. It is a flattened bar which is pointed at the ends. The ventral edge of the basal portion of lateral valve is serrated in the posterior half. The posterior region of the broad basal portion possesses on the mesal side a prominent fold, the gonoplac. The apical margin of the gonoplac
bears 3-4 bristle-like hair which are perhaps sensory in nature.

The style of the lateral valve is a prominent tapering process arising terminally from the distal end of the basal portion. It is a 0.281 mm. long, stout tubular and black coloured structure directed posteriorly, and bearing small hair on the surface. The apical end of the style, however, possesses a dense zone of closely set smaller hair.

The First Valvulae

The first valvifer is postero-medially attached to a 1.166 mm. long and strongly sclerotized process, the first valvule which is directed postero-medially (Pl. XXI, fig. 5). The valvule consists of a small ramus and a long shaft.

The ramus of valvule is a broad, dorso-ventrally flattened plate bearing a lateral process and a dorsal process. The ramus of the two sides are joined together anteriorly forming an arch-shaped structure which lies attached to the first valvifers. The ramus of the valvule is drawn out laterally into a short triangular process, the lateral process which provides attachment to the ventral end of the gonangulum. Near the base of the lateral process the ramus bears on the inner side a prominent ridge-like process termed the dorsal process. The shaft of the valvule is an arch-like curved structure. The dorsal edge of the blade of the shaft is strongly sclerotized and continuous anteriorly with the dorsal process of the first valvifer. The distal one-fourth region of the shaft is serrated on the dorso-lateral side (Pl. XXI, fig. 8).

The second Valvulae

The second valvulae (Pl. XXI, figs. 4 & 6) measure 1.166 mm. in length and resemble the first valvulae in shape and structure. Each valvule consists of a short anterior ramus and a long distal shaft.
The ramus of the second valvule is situated dorsal and posterior to that of the first valvule. Its anterior end is attached laterally to the antero-proximal end of the second valvifer of its side. The ramus is a vertical plate which is deeply concave on the mesal side. The lateral surface is convex and covered with a large number of short hair. The ventral edges of the two rami are connected by a thin membrane. The shaft of the valvule is a posterior continuation of the ramus. The shafts of the two valvulæ are usually closely apposed along their mesal edges. The external surface of the blade of the shaft is furnished with transverse pleats which are very prominent in the distal one-third area. This region is strongly serrated also on the ventro-lateral surface.

The rami of the first and second valvulæ basally enclose the female genital aperture between them. The shafts of the second valvulæ are placed above those of the first valvulæ. The two shafts of a side are also interlocked by a ridge and groove arrangement; the ridge belonging to the second valvule and the groove to the first valvule. Moreover, the mesal edges of the shafts of a pair lie closely apposed to each other, the whole structure thus forming a canal, the ovipositor canal. The eggs are passed from vulva into the plant tissue through this canal during egg-laying. However, during mating, the right and left halves of the valvulæ are separated and held apart to permit the entry of penis into vulva.

The Gonangula

A strongly sclerotized bar-like gonangulum (Pl. XXI, figs. 4 & 5) is present ventrally on either side of the median line near the junction of the eighth and ninth abdominal sternites. It is vertically and obliquely situated in such a way that its dorsal end articulates with the antero-ventral border of the ninth tergum. Ventrally, the gonangulum is attached to the dorsal surface of the lateral process of the ramus of first valvule.
MALE REPRODUCTIVE SYSTEM OF AGRIOCHEMIS PYGMAEA (HAMBA)

1. INTERNAL GENITAL ORGANS

The male reproductive system of Agriocnemia consists of internal genital organs and external genital organs. The internal genital organs comprise a pair of multilobular testes, a pair of vasa deferentia, a median sperm sac and an ejaculatory duct.

(A) GROSS MORPHOLOGY

The Testes

The testes (Pl. XXII, fig. 1) are a pair of elongate, tubular, almost translucent organs lying dorso-lateral to the alimentary canal one on each side. The two testes run parallel and very close to each other being joined by a median strand of connective tissue. Each testis is 7.187 mm. long and 0.262 mm. thick, and extends from the middle of the seventh abdominal segment upto the end of the eighth abdominal segment. The testes are held in position by tracheae, nerves, median strand of connective tissue, fat-bodies and also by suspensory filaments which are the anterior prolongations of the adipose tissue surrounding the testes. These filaments are attached to the dorsal body-wall at the end of fifth abdominal segment.

The Vasa Deferentia

Each testis is continued posteriorly into a duct, the vas deferens which is marked off from the former by a prominent constriction (Pl. XXII, fig. 2). The vas deferens is a whitish tube extended from the beginning of the ninth abdominal segment unto the middle. The vas deferens from the side of gut turns ventrally and inwards towards the centre of the segment while covering this distance. It is meanwhile looped at two places so
that the vas deferens can be morphologically differentiated into three regions, a proximal region, a middle region and a distal swollen region. The distal region of the vas deferens opens into anterior lobe of the sperm sac.

The Sperm Sac

The vasa deferentia of the two sides unite posteriorly beneath the alimentary canal to form a greatly dilated white sac-like structure, the sperm sac situated above the gonopore (Pl. XXII, fig. 2). It is a small triangular structure in young insects but becomes greatly distended in sexually mature specimens. However, colour of the sperm sac remains translucent white in both the conditions. When fully developed, the sperm sac is a bilobed organ measuring 0.227 mm. in antero-posterior direction and 0.103 mm. across the broadest part. It is extended lengthwise in almost the whole of the ninth segment and consists of an anterior and a posterior lobe. The anterior lobe of the sperm sac receives latero-ventrally the openings of the vasa deferentia and extends posteriorly up to the level of the gonopore only. The posterior lobe lies behind the gonopore in the posterior half of the ninth abdominal segment. The sperm sac stores spermatosomes.

The Ejaculatory Duct

The sperm sac communicates to the gonopore on the ventral side through a minute translucent ejaculatory duct. The duct arises postero-ventrally from the anterior lobe of the sperm sac. It is lodged in the cavity of a chitinous structure. The ductus ejaculatorius opens out through the male gonopore.

The Accessory Glands

The accessory reproductive glands are totally absent in male Agriocnemis.
(B) HISTOLOGY

The testis

The wall of the testis (Pl. XXII, fig. 3) consists of an outer layer of adipose tissue followed by an inner peritoneal layer. The adipose tissue forms a complete and almost uniform layer round the testis and lies very closely applied to the peritoneum surrounding the organ. It comprises a spongy mass of large cells, each cell with a prominent granular nucleus and highly vacuolated cytoplasm. Fat-bodies form the bulk of this tissue. The peritoneum is represented by a single layer of very thin, stretched cells with large bulging nuclei. Internally, each testis is composed of a very large number of more or less spherical testicular lobules attached to a common lateral duct running sinuously throughout the length of the testis on the dorso-lateral side.

The Common Lateral Duct:

The wall of the lateral duct is composed of an outer muscular layer and an inner epithelial layer. The muscular layer is thin and consists only of the circular muscle fibres. The structure of the epithelial layer is different at places dividing, thereby, the lateral duct into two regions, (i) an anterior region, and (ii) a posterior region.

(1) The Anterior region:— The epithelium of the lateral duct in the anterior region (Pl. XXII, fig. 4) consists of a single tier of cuboidal cells possessing granular cytoplasm and rounded nuclei. The epithelium on the outer side of the duct possesses richly granular nuclei measuring 11 micra long and lacking a nucleolus. The nuclei in the epithelial cells of the inner wall of the duct, are also granular but spherical in shape each measuring 9 micra in diameter and provided with a nucleolus.

(ii) The Posterior region:— The epithelium towards the outer side of the common lateral duct in the posterior region (Pl. XXII,
fig. 3) is simple and consists of a single layer of cuboidal cells. The cytoplasm in the epithelial cell is granular and the nucleus oval in shape measuring 10 micra in length. The adipose tissue layer surrounding the testis is quite thick in posterior region of the common lateral duct than the anterior region. The epithelium towards the inner side of the duct is, however, two layered consisting of columnar cells having densely granular cytoplasm.

The lumen of the duct is large and filled with a granular secretion in which spermatocytes and sperm masses are present, more so in the anterior region. Before emerging from the testis posteriorly the common lateral duct becomes swollen.

The Testicular Lobule:

The testicular lobule is a solid, almost spherical mass of germ cells which is enclosed by a thin limiting membrane. The size of the lobules in a testis vary greatly and the diameter of the largest lobule observed is 0.105 mm. There is no space in the interior of the lobule which is filled with germ cells. All the germ cells in a single lobule are similar and represent only one stage of spermatogenesis. Different lobules, however, contain germ cells in different stages. It means that the germ cells in various stages of spermatogenesis i.e. spermatogonia, spermatocytes, spermatids and spermatozoas do not occur simultaneously at any time in a lobule. It is also interesting to note the absence of a germinal epithelium in the damselfly testicular lobule, which is evidently different in structure from that of other insects. Each lobule narrows towards the lateral duct and forms a very small ductule which opens into the lumen of the duct. The wall of the efferent ductule is seemingly formed by the limiting membrane enclosing the lobule. The lobules present near the common lateral duct possess spermatozoa, often arranged in bundles of more than one per lobule, while the lobules situated away from the duct possess germ cells in younger stages of spermatogenesis.
The Vas Deferens

Histologically the vas deferens is divisible into two regions only, an anterior region and a posterior region.

The wall of the anterior region of vas deferens is made up of 4 layers from within outwards: (i) Epithelial layer, (ii) Basement membrane, (iii) Musculature, and (iv) Layer of fat-bodies. The epithelium consists of a single layer of cuboidal cells, each provided with granular cytoplasm and ovoid nucleus. The nucleus possesses several deeply-staining granules but lacks a nucleolus. The basal ends of the epithelial cells rest on a basement membrane. The musculature is thin and consists of a layer of circular muscle fibres on the outer side of the basement membrane. The fat-bodies are well developed and form a complete envelope of adipose tissue round the duct. The lumen is narrow and filled with a small amount of granular secretory material. A few sperms are also present in the lumen.

The wall of the posterior region of vas deferens is thin and consists of the same layers as in the anterior region. However, the lumen in the posterior region is greatly distended and the epithelium is inconspicuous, discernible at places only by its large granular nuclei. The adipose tissue layer is also incomplete and broken irregularly. The lumen is spacious and filled with granular secretion. The posterior region of the vas deferens principally stores spermatocoe which are present in masses near the epithelial lining on the periphery, whereas in the centre these are scattered irregularly.

The anterior region corresponds to the proximal region while the posterior region corresponds to the morphological middle and distal swollen regions of the vas deferens.

The Sperm Sac

The bilobed sperm sac of a sexually mature specimen shows the following layers in the wall beginning from the inner side:
(i) Epithelium, (ii) basement membrane, (iii) muscular coat, and (iv) peritoneal layer.

The epithelium is thin and consists of a single layer of flat cells, each with an elongated granular nucleus. The epithelial cells rest on a thin basement membrane. There is a well-developed layer of circular muscle fibres on the outer side of the basement membrane. Peritoneum forms the outermost layer in the wall of the sperm sac. The adipose tissue is also present adhering to the wall at places. The lumen of the sperm sac is spacious and stores spermatozoa which are arranged in definite pattern (Pl. XXI, fig. 5). The lumen in the anterior half is filled with a granular secretory material in the centre in which sperms are freely scattered. However, on the peripheral side the spermatozoa are arranged in sperm groups which remain adhering to the epithelial lining. The lumen in the posterior half of the sperm sac is also filled with granular secretory material which forms two zones, an outer zone and an inner zone. The secretion of the outer zone is densely granular, staining deeply and containing a few sperm groups and numerous scattered sperms. The secretion of the inner zone is thin in consistency and very densely packed with scattered spermatozoa but no sperm groups. There is no chitinous intima lining the lumen of the sperm sac.

The Ejaculatory Duct

The ejaculatory duct shows a structure histologically similar to that of the sperm sac except that its epithelium is lined internally by a very thin chitinous intima. The muscular coat is also thick and consists of an inner layer of longitudinal muscles and an outer layer of circular muscles. The ejaculatory duct communicates to the exterior through gonopore.
2. **EXTERNAL GENITAL ORGANS**

The external genital organs consist of paired supra-anal and infra-anal appendages, a pair of coxites, an anterior genital plate and a posterior genital plate, a chitinous invagination of gonopore which lodges the ejaculatory duct, and a secondary copulatory apparatus.

**The Supra-anal Appendages**

There is a pair of characteristically well developed, brownish orange supra-anal appendages arising dorso-posteriorly from the last visible abdominal segment and each measuring 0.309 mm. in length. The supra-anal appendages are hollow cylindrical structures which diverge apart from each other distally. The appendage appears triangular in shape when seen from the dorsal side (Pl. XXIII, fig. 1) and subquadrate when viewed in profile. On the ventro-mesal side, each appendage gives out near its base a prominent black hook-like process measuring 0.136 mm. in length. At the distal end, the appendage is produced into an obtuse papilla. Numerous bristle-like hair are found on the surface of the supra-anal appendage. A tuft of long hair is also present on the dorso-mesal surface in the posterior half of the appendage.

**The Infra-anal Appendages**

The infra-anal appendages are smaller in size than the supra-anal appendages, and measure 0.223 mm. in length and lying ventral to them. Each infra-anal appendage (Pl. XXIII, fig. 2) is a hollow conical, grey coloured structure broad at the base and comparatively narrow distally. The apex of the appendage is serrated due to the presence of 4-5 black tooth-like processes. Small bristle-like hair are present on the surface. The tenth abdominal segment is furnished with 4 spines at the base of the appendage.
The Gonopore

The male genital aperture is a circular orifice situated in the middle of the ninth abdominal segment (Pl. XXII, fig. 6). It measures 0.137 mm. in diameter and is strengthened by a chitinous ring. The gonopore is guarded laterally by a pair of strongly sclerotized pieces, the coxites. The anterior genital plate is situated on the anterior side of the gonopore and the posterior genital plate is situated on its posterior side.

The Coxites:

The coxites are 0.387 mm. long light green, pear-shaped structures partly concealing the gonopore. These are united broadly with the body-wall and become narrowed posteriorly. The style-like portion observed in the coxite of earlier species is absent in the present species.

The Anterior genital plate:

The anterior genital plate measuring 0.202 mm. in length and 0.526 mm. in width, is formed by the modification of the portion of the ninth sternum lying ahead of the gonopore. It is light green in colour, and attached anteriorly to the eighth sternite and laterally to the ninth tergites through membranes. The ventral surface of the anterior genital plate is beset with minute tubercles and numerous small hairs.

The Posterior genital plate:

The post-genital plate lies behind the genital aperture and measures 0.19 mm. in length and 0.384 mm. in width. The posterior genital plate is coloured greenish-yellow and bears on the ventral surface numerous minute tubercles only.

The chitinous ring of the gonopore is drawn up anteriorwards inside the body cavity to form a small, dorsally concave plate like structure (Pl. XXII, fig. 6) which supports the
ejaculatory duct. At the time of sperm translocation to vesicula spermalis, the chitinous plate erects resulting into the formation of a small tubular structure on the ventral wall of the ninth segment carrying the gonopore at its apex.

**The Secondary Copulatory Apparatus**

A very complicated set of copulatory organs is situated on the ventral side in the whole of the second abdominal segment and anterior part of the third abdominal segment (Pl. XXIII, fig. 3). The secondary copulatory apparatus consists of a genital fossa, an anterior lamina, a pair of anterior hamules and a pair of posterior hamules, a lamina batilliformis, genital sac, supporting framework, penis and vesicula spermalis.

**The Genital Fossa**

All the secondary copulatory organs except the vesicula spermalis are lodged in a depression, the genital fossa formed on the ventral side of the second abdominal segment (Pl. XXIII, fig. 3). The genital fossa is strengthened by a skeleton of chitinous structures forming the supporting framework.

**The Anterior Lamina**

The genital fossa is bounded anteriorly by a 0.439 mm. long greenish chitinous plate, the anterior lamina lying ventrally in the anterior one-third part of the second segment (Pl. XXIII, fig. 3). The anterior margin of the lamina is bordered by a strongly sclerotized transverse, internal apophysis. The posterior margin of the anterior lamina is emarginated in the middle to form an inverted 'V'-shaped cleft and two limbs. The mesal side of each limb is furnished with 11-13 antero-mesally directed hair. The space of the cleft is covered dorsally by a translucent membrane forming a 0.59 mm. long sac-like structure, the median laminar sac in the interior of the genital fossa. The anterior end of the median laminar sac narrows into a pointed
process which projects into the first abdominal segment. On the posterior side the sac is attached to the lamina batilliformis.

The Anterior Hamules

The anterior hamules are a pair of chitinous dull-white structures situated laterally in the genital fossa near the middle of the second segment and movably united with the ventro-lateral margins of the second tergite through pleural membranes (Pl. XXIII, fig. 3). Each hamule consists of two plates, a large outer and a small inner plate. The outer plate is quadrate in shape measuring 0.288 mm. long and 0.295 mm. broad, and united anteriorly with the limb portion of the anterior lamina. The antero-mesal angle of the outer plate is extended into a small black, anteriorly directed spine-like process. The inner plate is a prominent structure lying on the dorsal surface of the outer plate. It is composed of a membranous mesal part which connects it with the outer plate, and a strongly sclerotized lateral part. The sclerotized part which bears hair on the surface is divisible into two regions, a basal posterior region and an apical anterior region. The basal region is slightly curved and continuous with the membranous part while the anterior region is free and directed anteriorward forming a hook-like structure.

The Posterior Hamules

Each posterior process of posterior median plate of the framework carries a simple small and hollow knob-like chitinous structure near the apical end. These are the posterior hamules (Pl. XXIII, fig. 4) which project antero-ventrally from the genital fossa. The surface of the posterior hamules is richly clothed with hair.

The Lamina Batilliformis

The lamina batilliformis (Pl. XXIII, fig. 5) is situated ventro-medially in the genital fossa above the cleft of anterior lamina. It measures 0.446 mm. in length and consists of a
dorsally concave, scoop-like plate which is notched in the middle forming a pair of postero-lateral limbs. Each limb is strongly sclerotized on the mesal side and furnished apically with a cluster of postero-mesal hair. The posterior end of the limb is bent towards the antero-dorsal side forming a cornu. The two cornua attenuate apically and end into a curved structure. A distinct ventro-lateral protuberance is present on each side at the union point of limbs and cornua. The lamina batilliformis provides support to the median larnar sac and genital sac.

The Genital Sac

The genital sac (Pl. XXIII, fig. 3) is a large membranous translucent sac which projects deep into the cavity of second abdominal segment and opens out on the ventral side by a wide aperture. The genital sac is supported anteriorly by the lamina batilliformis, laterally by the chitinous bars of the framework and posteriorly by the median plate of the frame.

The Supporting Framework

It is a system of skeletal chitinous structures which provide support to the genital fossa, the anterior and posterior hamules, and to the proximal part of the penis. The supporting framework consists of a pair of anterior vertical bars, a pair of lateral longitudinal bars and a posterior median plate.

The Anterior Vertical Bars:

These are a pair of 0.453 mm. long bars lying dorso-laterally in the membranous wall of the genital sac (Pl. XXIII, fig. 3). Each bar is placed obliquely in such a way that its upper end is mesally directed and the lower end is postero-laterally directed. The lower end of the bar is attached to the front end of lateral longitudinal bar.
The Lateral Longitudinal Bars:

The lateral longitudinal bars are a pair of 0.289 mm. long structures running along the lateral margins of the genital fossa and providing ventro-lateral support to the membrane of the genital sac. The lateral longitudinal bars are horizontally placed, antero-posteriorly directed structures lying in the middle of the second abdominal segment and attached to the anterior vertical bars at one end and to the posterior median plate of the frame at the other end.

The Posterior Median Plate:

It is a 0.388 mm. large, heavily sclerotized, 'H'-shaped plate (Pl. XXIII, fig. 4) lying dorsal to the vesicula spermalis in the posterior part of the genital fossa. The plate is slightly convex on the dorsal side and is produced on the antero-lateral sides into a pair of 0.288 mm. long anterior limbs. The apical end of the anterior limb is slightly notched and articulated with the posterior end of the lateral longitudinal bar of its side. The posterior hemule is lodged in the notch. Posteriorly, the angles of the median plate are drawn out as bluntly rounded processes which represent the posterior limbs. The processes abut against lateral ends of the anterior apodeme of vesicula spermalis.

The Penis

The penis (Pl. XXIII, fig. 6) is a stout unsegmented intro- mittent organ lacking an external orifice. It is 'S'-shaped being curved at two places, once near the anterior end and later on near the posterior end. The penis is situated ventrally in the genital fossa and projects out during the copulation only. It consists of a basal plate and a shaft. There is a foramen at the junction of the two portions which leads into haemocoele on the one side and into a narrow tubular cavity inside the shaft on the other.
The Basal Plate:

The basal plate is a small proximal part of the penis forming partially the roof of the genital sac. It comprises two sclerites, an anterior and a posterior sclerite.

The Anterior sclerite:—The anterior sclerite is a 0.237 mm. wide, arch-shaped horizontal bar forming a hood-like structure above the earlier mentioned foramen. Laterally, it is supported by the anterior vertical bars of the frame. Basally, it is united with the posterior sclerite.

The Posterior sclerite:—This is a 0.331 mm. long, dorsally concave, scoop-shaped structure comprising the major portion of the basal plate of penis.

The Shaft:—

The shaft is the long tubular part of the intromittent organ united proximally with the basal plate and free apically. On the basis of sclerotization of the wall it is morphologically divisible into three regions, a proximal region, a middle region and a distal region.

(i) The Proximal region:—The proximal region is the longest region of the shaft which is curved postero-ventrally near its origin. The anterior portion of the proximal region is heavily sclerotized and lies protected in the genital sac. The remaining portion is also sclerotized heavily but on the ventral and lateral surfaces only. The dorsal surface is membranous. The proximal region is separated from the middle region by a shallow pit located ventrally.

(ii) The Middle region:—The middle region is shorter and wider than the proximal region of the shaft and is directed postero- dorsally. The wall of the middle region is membranous except on the ventral side where heavy sclerotization is seen. The sclerotized area widens posteriorwards and divides into two
posterolaterally directed processes near the middle of the region.

An external median groove runs along the membranous dorsal surface of the proximal and middle regions of the shaft. The groove is shallow and narrow in the basal part but deep and broad in the middle region of the shaft.

(iii) The Distal region:—The distal region of the shaft measures 0.289 mm. in length and consists of a complicated set of three membranous folds, an accessory basal fold, a glans and a prepuce. The accessory basal fold is distinctly present on the ventral surface near the base of the distal region. The glans is a small distensible fold situated at the posterior extremity of the shaft. The prepuce is a large dorso-ventrally compressed structure which lies bent over the ventral surface of the middle region of the shaft. It thus hides the accessory basal fold from ventral view. The apical margin of the prepuce is deeply emarginated forming a pair of wing-like lobes directed antero-dorsally.

The Vesicula Spermalis

The vesicula spermalis (Pl. XXIII, fig. 7) is a 0.552 mm. long, median flask-like structure lying behind the genital fossa. The vesicula spermalis is divisible into a narrow anterior neck and a wide posterior bulging body. The body is twice as long as the neck. The ventral portion of the neck is composed of a large 'U'-shaped membranous area bearing anteriorly a small slit-like aperture, the orifice of the vesicula spermalis. The orifice is bordered by two prominent lips. The ventral bulging surface of the body of the vesicle is hard and heavily sclerotized. Hair are sparsely present on the ventral surface of vesicle. The dorsal wall of the vesicula spermalis is thin and membranous. It is strengthened behind the neck by two apodemes, an anterior apodeme and a posterior apodeme.
The Anterior apodeme:- The anterior apodeme is a transverse bar-like structure situated at the apical end of the second abdominal sternite. The lateral ends of the anterior apodeme are curved dorso-anteriorly and attached to the posterior processes of the median plate of the frame.

The Posterior apodeme:- The posterior apodeme is stouter than the anterior apodeme and lies postero-ventral to it. In the middle the posterior apodeme is united with the anterior border of the third sternite. On the sides, it is expanded only at the ends which are directed forwards and upwards.
1. **INTERNAL GENITAL ORGANS**

(A) **GROSS MORPHOLOGY**

The internal reproductive organs include a pair of ovaries, a pair of oviducts, a short common median oviduct and the '8th Complex'. A pair of accessory reproductive glands are also present opening through ductules into the postero-terminal part of the '8th Complex'.

The **Ovaries**

The ovaries (Pl. XXIV, fig. 1) are a pair of yellowish-white, cord-like elongated organs, each measuring 13.75 mm. in length. These are situated conspicuously in the body cavity, one on either side of the median line above the alimentary canal and extend from the base of the first abdominal segment up to the middle of the seventh abdominal segment. The two ovaries run very close to each other up to the end of the sixth abdominal segment and are united together by a median dorsal ligament. Afterwards, they become a little separate and lie on the dorso-lateral sides of the gut. The median dorsal ligament arises from the metanotum in the thorax and extends medially up to the ninth abdominal segment where it is attached to the dorsal body-wall.

A longitudinal duct is present on the ventro-lateral side of each ovary throughout its length. It is termed the common lateral duct. A large number of antero-mesally directed ovarioles are situated on the dorsal side of the ovary. The ovarioles which open into the common lateral duct are elongated cylindrical structures of beaded appearance. Its terminal free end is drawn out into a filamentous structure which is attached to the median dorsal ligament. The terminal filaments of the ovarioles in the anterior region of each ovary unite together to form a stout
structure, the apical filament. The apical filaments of the two ovaries enter into the thorax and become attached to the dorsal body-wall. Fat-bodies in the form of adipose tissue are present abundantly amongst the ovarioles and on the surface of the ovary along with the tracheal ramifications. The ovaries are held in their position by the apical filaments, the median dorsal ligament and the tracheal network.

The Oviducts

The common lateral duct running throughout the length of the ovary extends posteriorly beyond the gonad in the form of an oviduct (Pl. XXIV, figs. 1 & 2). Each oviduct is a 1.39 mm. long, transparent and comparatively thick-walled tube which arises near the middle of the seventh abdominal segment. It lies dorso-lateral to the gut in the beginning but soon bends over the lateral side of the alimentary canal to become ventral to it, in which position it continues posteriorly up to the end of the proximal quarter of the eighth abdominal segment. The oviducts are narrow slender tubes when the ova are not present inside their lumen. However, when full of eggs the lumen of the oviduct contains 2-3 longitudinal rows of ova in the anterior region and only a single chain of ova in the posterior region of the duct. In that condition the oviduct appears to be broad anteriorly and narrow posteriorly. The oviducts are enveloped within adipose tissue.

The Common Median Oviduct

The two oviducts converge posteriorly and join each other beneath the alimentary canal to form a common duct, the common median oviduct or oviductus communis (Pl. XXIV, fig. 2). It is a very short but thick-walled duct of wide dimension situated anterior to the '8th Complex' and is obscured from view dorsally by the large eighth abdominal ganglion. The oviductus communis is surrounded completely by adipose tissue which is specially thick on the sides. A pair of muscle bundles are present running
eighth sternum on the other hand. These are termed sterno-
vaginal muscles. Further posteriorly, fibres run latero-ventrally
from the vertical part of vaginal lumen to insert on the sternum.
A few fibres from the dorsal wall and ventro-lateral side of the
vagina also attach to the sternum. A band of longitudinal muscle
fibres extends over the dorsal surface of the vagina. A large
muscle runs longitudinally on each ventro-lateral side of the
vagina. It is termed the longitudinal muscle of the first
valvifer because its one end is inserted on the first valvifer
of the ovipositor and the other end is attached to the ante-
costal ridge of the eighth abdominal segment. This muscle does
not form part of the vaginal musculature but due to close
proximity with the vagina it has been described here. The anterior
tubular portion leads posteriorly into the genital atrium.

The Genital atrium:

The genital atrium is a small pocket-like structure
whose wall is thin and membranous. It lies wrinkled when empty
and connects the anterior tubular portion of vagina to the
exterior through the aperture termed vulva.

The Bursa Copulatrix

The bursa copulatrix is a large, median sac-like ellipti-
tical organ which lies posteriorly directed on the dorsal side
of the vaginal anterior portion (Pl. XXIV, fig. 2). The bursa
copulatrix leads into the antero-dorsal part of the vagina
through a small and narrow tubular passage, the ductus bursae.
In recently mated females the bursa is distended considerably
forming a very prominent part of the '8th complex'.

The Spermatheca

The spermatheca is a translucent and unpaired impercep-
tible organ lying immediately ventral to the bursa copulatrix
for the most part (Pl. XXIV, fig. 2). In fact, it is situated
between the dorsal wall of the vagina and the ventral wall of
the bursa. It is elongated diverticulum-like in shape which is slightly broad in the middle and tapering distally (Pl. XXIV, fig. 4). It is connected proximally to the ventro-basal region of the bursa copulatrix. The spermatheca and the bursa copulatrix are embedded in a common mass of adipose tissue.

The Accessory Glands

The accessory glands are a pair of milky-white structures lying distinctly beneath the rectum and above the base of the second valvifers in the ninth abdominal segment (Pl. XXIV, fig. 3). Its proximal portion consists of a slender ductule and the distal portion is sac-like in appearance. The ductule is much shorter than the length of the saccular portion and serves to connect the latter with the postero-dorsal end of the genital atrium near the female genital aperture. The saccular portion of the accessory gland is shaped like a distended cylinder which occupies nearly the whole of the ninth abdominal segment. Slight variation in size has been observed in the saccular portions of the two sides. Usually the right gland is longer and stouter hence curved, than the left one. But vice-verse is also true. Moreover, the accessory glands do not undergo any change in their shape or size with the age of the insect. It is, therefore suggested that the two glands function alternately in an active manner.

(B) HISTOLOGY

The Ovariole

The ovariole (Pl. XXIV, fig. 5) is a thread-like structure which is placed obliquely in an antero-mesal direction on the dorso-mesal surface of the common lateral duct. The ovarioles are arranged one after the other in a linear sequence along the whole length of the ovary. Each ovariole is an elongated tubular structure in which ova are produced. It is surrounded by an epithelial sheath consisting of greatly stretched cells. The sheath of the ovariole is anteriorly
prolonged into a short terminal filament. The germarium lies in the subapical region of the ovariole where active division and differentiation of the cell results in the production of oogonia. The oogonia then descend down into the vitellarium, which forms the largest region of the ovariole. The developing ova are arranged in a row in an acropetal succession within the vitellarium. Each ovum is enclosed within a follicle formed by invagination of the epithelial sheath at the corners of the eggs. The nurse cells between successive ova are altogether absent. There is no nutritive zone at the apical end of the ovarioles too. The ovarioles in the damselfly are, thereby, panoistic. The epithelial sheath of the ovariole is continuous with the epithelium of the common lateral duct. The median dorsal ligament to which the terminal filaments are attached, is made up of a loose mass of connective tissue in which fat-bodies, muscle fibres and tracheoles are interspersed.

The Common Lateral Duct

Histologically, the wall of the common lateral duct consists of an inner epithelial layer and an outer muscle layer, the two being separated by a basement membrane. The epithelial layer is composed of a single stratum of short cuboidal cells, each bearing a large oval and granular nucleus. The nucleus is surrounded by a small amount of cytoplasm. The muscle layer is very thin and comprises longitudinally arranged muscle fibres. The dorso-mesal surface of the duct wall is irregular in outline as it provides attachment to the ovarioles. In the centre of the duct there is a spacious lumen which receives the ova from the vitellaria of ovarioles.

The Oviduct

The oviduct shows a structure which is histologically similar to that of the common lateral duct of the ovary. The epithelium consists of short cuboidal cells arranged in a single layer round the lumen. The cell-boundaries between the epithelial
cells are indistinct. The nuclei of the cells vary in shape from ovoid to roundish. The muscle layer surrounding the epithelium is thicker than that of the common lateral duct and consists of longitudinal muscle fibres.

**The Common Median Oviduct**

The common median oviduct possesses an additional layer of chitinous intima on the inner side of the epithelial layer. The epithelial layer is composed of a row of large cuboidal cells with indistinct cell-boundaries. The cytoplasm in the cell is sparsely granular and vacuolated. The nuclei are also granular, and nucleolated. The epithelium is surrounded by a thin inner layer of circular muscles and an outer thick coat of longitudinal muscles. A basement membrane lies between the circular muscle layer and the epithelium. The adipose tissue forms the outermost coat in the wall of the oviductus communis. The common median oviduct possesses a spacious lumen through which only one egg is let out at a time. During microtomic sectioning, the egg often gets broken due to the presence of hard yolk. The yolk is dispersed leaving behind the chorionic wall which has generally been found attached to the inner side of the epithelium. The oviductus communis communicates posteriorly with the antero-ventral region of the vagina through a slit-like aperture.

**The Vagina**

The Anterior tubular portion:-

The following arrangement of layers is seen in the wall of the anterior tubular portion of the vagina (Pl. XAIV, fig. 6) beginning from within outwards - (i) Chitinous intima, (ii) Epithelium, (iii) Basement membrane, (iv) Musculature, and (v) Adipose tissue.

The lumen in the antero-dorsal part of the vagina is wide and cup-shaped where it receives dorsally and ventrally the openings of the oviductus communis and the ductus bursae
respectively. In the remaining part the lumen is a vertical slit being compressed laterally. On the ventral side the lumen is evaginated to form a pair of lateral outgrowths. The lumen of the anterior tubular portion is lined by a chitinous layer which is weakly sclerotized ventrally and in the lateral evaginations. It is very thick and strongly sclerotized on the lateral sides of the vertical slit-like part where it forms a pair of bright coloured lateral plates. The lateral plates of the two sides are connected dorsally by chitinous membrane and project vertically into the lumen. Each lateral plate (Pl. XXV, fig. 1) is oblong in shape and bears a few longitudinal ridges on the inner side. The anterior wall of the vagina possesses a prominent strongly sclerotized structure, the collar guarding the openings of the oviductus communis and the ductus bursae. The collar consists of a median keeled portion from which a pair of lateral arms arise. The median keeled portion is forwardly directed to form a short pointed process termed the anterior process of the collar. The lateral arms of the collar are flat, postero-laterally directed wing-like transverse extensions from the median keeled portion.

The epithelium of the anterior tubular portion is thin and lies outside the chitinous layer. Near the middle region, the epithelial layer forms 2 or 3 folds which correspond with those of the chitinous layer. The epithelium is composed of a single row of short cuboidal cells in which the cell-boundaries are not clearly visible. Each epithelial cell measures 8 micra in length and possesses a prominent spherical nucleus near the apical side. The nucleus measures 4 micra in diameter and contains 2-3 deeply-staining granules in the nucleoplasmin. The cytoplasm is homogeneous and non-vacuolated. The outer side of the epithelium rests on a thin and structureless basement membrane. The musculature lies outside the basement membrane and consists of striated muscle fibres which are arranged in three definite sets as follows: (a) a set of paired anterior vaginal muscles inserted on the collar, (b) a pair of massive tergo-ternal muscles inserted on the lateral walls of the
vagina, and (c) a band of longitudinal muscles on the dorsal wall. Besides these, muscle fibres also run latero-ventrally from the dorsal, lateral and latero-ventral sides of the vagina to insert on the sternum. Large amounts of fat-bodies and tracheal ramifications are found scattered among the muscle fibres.

The Genital atrium:-

Histologically, the wall of the genital atrium consists of a colourless and weakly sclerotized chitinous layer on the inner side of an epithelial layer. The wall is thrown internally into small folds. The epithelial layer consists of a tier of 5 micra large cuboidal cells. Each epithelial cell possesses a scanty amount of dense cytoplasm and a 3 micra large nucleus of oval shape. A thin muscle layer is present on the outer side of the epithelial layer. The adipose tissue is also present in patches.

The Bursa Copulatrix

The wall of the bursa copulatrix (Pl. XXIV, figs. 4 & 7) shows the same histological structure as the vaginal wall which, in fact, evaginates to produce it. The epithelial layer is made up of a single tier of 12 micra long cuboidal cells. The cytoplasm is densely granular and vacuolated in each cell which also contains an 8 micra large vesicular nucleus. The nuclei are oval in shape and possess several deeply-staining granules in the nucleoplasm. The epithelium is lined internally by a chitinous intima which is thick and produced into intricate folds projecting into the lumen. The epithelium rests on a basement membrane. The outermost muscular coat comprises a thin layer of longitudinal muscle fibres only. It is covered over by an irregular layer of adipose tissue which is specially thick in the posterior part. The bursa copulatrix stores scattered spermatoxoa in its spacious lumen. The ductus bursae possesses a structure similar to that of the bursa except that its lumen is narrow and lined by a comparatively thick cuticular layer bearing several postero-ventrally directed spines.
The Spermatheca

The wall of the spermatheca (Pl. XXIV, figs. 4 & 7) is very similar to that of the bursa copulatrix and shows the following arrangement of the tissue beginning from the centre towards the periphery:— (i) Chitinous intima, (ii) Epithelial layer, (iii) Basement membrane, (iv) Muscle layer, and (v) Adipose tissue layer.

The innermost layer in the wall of the spermatheca is the chitinous intima which is thin and thrown into small ridges and grooves. The chitinous layer is surrounded by a layer of cuboidal cells which compose the epithelial layer. Each epithelial cell measures 9 micra in length and possesses granular and vacuolated cytoplasm and a 5 micra large oval nucleus. The nucleus is nucleolated and granular. The epithelium of the spermatheca is quite distinct and appears to be glandular. The epithelium is lined externally by a thin basement membrane outside which is present the musculature. The musculature is made up of longitudinal muscle fibres only. The wall of the spermatheca is surrounded by adipose tissue which is thick on the lateral sides and conjoins the spermatheca with the bursa copulatrix. The spermatheca opens into the lumen of the bursa near its base and both organs possess spermatозоа in their cavities.

The Accessory Glands

The accessory glands which are present in the ninth abdominal segment consist of a pair of elongated saccular portions joined to the postero-dorsal wall of the genital atrium by a narrow ductule. The two portions of the accessory gland are histologically different in structure.

The saccular portion:

The wall of the saccular portion of accessory gland (Pl. XXV, fig. 2) consists of the following layers beginning from within outwards:— (i) Chitinous intima, (ii) Epithelium, (iii) Basement membrane, and (iv) Musculature.
The lumen of the saccular portion is spacious and lined by a chitinous intima which is very thin and colourless. The chitinous intima is surrounded externally by a tier of tall columnar cells forming the epithelial layer. Each epithelial cell measures 9 micra in length and stains darkly due to heavy accumulation of the secretory material in the cytoplasm. The cytoplasm is prominently vacuolated and filled with secretory granules, especially near the apical region. The nuclei are roundish to ovoid in shape and mostly present towards the basal ends of the cells. Each nucleus measures 6 micra in diameter and possesses a nucleolus in the centre and many deeply-staining granules in the nucleoplasm. The epithelial cells are, thus, secretory in nature. A very thin and structureless layer encircles the epithelium and forms the basement membrane. The musculature lying outside the basement membrane is thin and consists of two layers, a layer of circular muscle fibres on the inner side and a few strands of longitudinal muscles on the outer side.

The Ductule:

The duct of the accessory gland shows the same arrangement of layers in its wall as found in the saccular portion but the two structures differ in histological details. The musculature of the duct is thick and comprises circularly disposed muscle fibres only, the longitudinal muscles being absent altogether. The epithelial layer is comparatively thin measuring 6 micra in thickness and consists of a layer of cuboidal cells in which cell-boundaries are not visible. The nuclei are large vesicular and spherical, each measuring 4 micra in diameter. The cytoplasm is clear and devoid of vacuoles. The epithelium of the duct, therefore, seems to be non-secretory in nature. It is also lined internally by a colourless but discernible layer of chitinous intima. The outline of the chitinous intima is characteristically smooth in the present species.
2. EXTERNAL GENITAL ORGANS

The external genital organs of female *Agricnemis* consist of a pair of supra-anal appendages and an ovipositor.

The Supra-anal Appendages

A pair of 0.274 mm. long supra-anal appendages arise latero-dorsally from the end of the abdomen. They are horizontally placed and posteriorly directed organs lying almost parallel to each other. Each supra-anal appendage (Pl. XXV, fig. 3) is a short yellowish-green organ hollow from inside. The appendage appears rectangular in profile, conical in dorsal view and terminates into an obtuse apex. The surface of the appendage is thickly clothed with white hair and minute tubercles.

The Genital Aperture

The vulva (Pl. XXV, fig. 1) is a circular aperture located mid-ventrally on a membrane between the eighth and ninth abdominal segments. The vulva lies concealed and guarded by the base of the ovipositor.

THE OVIPOSITOR

The robust ovipositor consists of paired chitinized and sclerotized structures termed first valvifers, second valvifers or lateral valves, first and second valvulae, and gonangula. Both the pairs of valvulae enclose an ovipositor canal between them through which the eggs coming from vulva are passed out.

The First Valvifers

These are a pair of triangular plate-like structures situated beneath the posterior end of the eighth abdominal sternite (Pl. XXV, figs. 1 & 4). Each bears a mesal process on the mesal side and an apophysis on the anterior side. The mesal process is short and tapering and conjoined with that of the opposite side by a narrow membrane. The anterior margin of the
Valvifer plate gives out a stout, black coloured anteriorly directed sclerotized process, the anterior apophysis. The lateral margin of each valvifer is slightly upturned.

The Second Valvifers (Lateral Valves)

The second valvifers are a pair of elongated leaf-like processes hanging from the venter of the ninth abdominal segment and directed posteriorwards, each reaching distally up to the terminal end of the abdomen. These are yellow coloured, slightly convex structures measuring 1.166 mm. in length and provided with posteriorly directed hair on the surface. Each lateral valve is divided into a broad basal portion and a cylindrical terminal style (Pl. XXV, figs. 5 & 6).

The Basal Portion:

It attaches the lateral valve to the ventro-lateral side of the ninth abdominal segment. Proximally, it bears two strongly sclerotized and black coloured apophyses which project inside the body cavity. These are termed the anterior apophysis and the posterior apophysis according to their position. The anterior apophysis is a narrow hood-like structure lying in the horizontal plane and extending from the anterior end up to the posterior apophysis. The posterior apophysis is a dorso-laterally directed and gradually tapering process arising near the end of the ninth abdominal segment. The basal portion is attached laterally to a weakly sclerotized bar, the laterotergite which is pointed at both the ends. The laterotergite helps in the attachment of lateral valve to the ninth abdominal tergite.

The ventral border of the basal portion is arch-shaped and its posterior half is tuberculated. The ventral margins of the basal portions of lateral valves of the opposite sides are connected together by a thin intervalvular membrane which is grooved medially on the external side. The intervalvular membrane is attached posteriorly at the end of the ninth segment to a sclerite, the posterior intervalvular sclerite. Anteriorly,
the membrane possesses an anterior intervalvular sclerite near the border. The anterior sclerite is a small median, laterally compressed sclerite situated immediately posterior to the ramus regions of the second valvulae. There is a membranous fold, the gonoplace on the mesal side of the distal end of the basal portion of each lateral valve. The gonoplace of the two sides protect the apices of the shafts of the valvulae.

The Terminal Style:

The apex of the basal portion of lateral valve bears a prominent posteriorly directed and ventro-mesally curved structure termed the style. It is a stout, unjointed and hollow organ of light grey colour near the proximal end and dark brown distally. The style measures 0.167 mm. in length and bears a blunt apex which is flattened on the ventro-mesal side forming a distinct circular area. Short and sparsely distributed hair are present all over the surface of the style except the apical end where the circular area possesses a dense zone of cilia-like hair.

The First Valvulae

The first valvulae (Pl. XXV, fig. 4) are a pair of 0.968 mm. long, ventro-posteriorly directed and strongly sclerotized processes lying medially in the ventral external groove of the ninth abdominal segment. Each valvule is coloured brownish-black and composed of two parts, a small antero-proximal ramus and a long postero-distal shaft.

The ramus of the valvule is a dorso-ventrally flattened plate-like structure which is joined anteriorly with its counterpart of the opposite side forming a common arch-like structure. This structure articulates with the first valvifers anteriorly and provides attachment to the ventro-terminal wall of the genital atrium. On the lateral side each ramus forms a small wing-like process, the lateral process near the base of which a prominent ridge-like dorsal process is also present on
the upper surface. The ramus is continued posteriorly as a slender elongated process, the shaft. The shaft is a gently curved and apically pointed process. Its dorsal edge which is continuous with the dorsal process of the ramus, is strongly sclerotized. The distal region of the shaft is denticulated with sharp black teeth.

The Second Valvulae

The second valvulae measuring 0.924 mm. in length, are slightly shorter, more slender and strongly curved than the first valvulae. These are brownish-black and posteriorly directed processes which lie medially in the external groove of the ninth sternite but above the first valvulae. Each valvula consists of a ramus and a shaft (Pl. XXV, fig. 5).

The base of the valvula forms the ramus which arises from the antero-proximal end of the second valvifer of its side. The anterior ends of the two rami provide attachment to the dorso-terminal wall of the genital atrium. The ramus is a triangular plate-like structure lying in the vertical plane and comparable with the handle of a sword. It is spoon-shaped and bears a concavity on the mesal side. The outer side is convex and provided with short bristle-like hair. The two rami of the second valvulae are conjoined dorsally by a thin membrane. The ramus is distally continuous with the shaft which is comparable with the blade of the sword. The shaft of the second valvula bears transverse pleats in the distal half and is denticulated on the lateral surface (Pl. XXV, fig. 6).

The shaft of the first valvula bears a length-wise dorsal groove and the shaft of the second valvula bears a lengthwise ventral ridge. Valvulae of each side are thus interlocked by a sliding ridge and groove mechanism. All the valvulae together form an aculeus or terebra and enclose a common canal throughout their length. One end of this canal opens into the vulva and the other end to the exterior. The first and second valvulae
are covered laterally by the lateral valves when the ovipositor is not in use.

The Gonangula

The gonangula are a pair of small strongly sclerotized bars situated one on each side near the junction of the eighth and ninth abdominal segments (Pl. XXV, figs. 1 & 4). These are placed obliquely in the vertical plane. Its ventral portion is broad and attached to the dorsal surface of lateral process belonging to the ramus of first valvule. The dorsal portion of the gonangulum is comparatively narrow and articulates terminally with the antero-ventral edge of the tergum of the ninth abdominal segment of its side in the vicinity of the anterior end of the second valvifer.
1. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The internal genital organs consist of a pair of testes, a pair of ducts - the vasa deferentia, a median sperm sac and an ejaculatory duct. Definite accessory glands connected with the male reproductive system of insects have not been found in the damselfly.

The Testes

There is a pair of elongated, tubular, translucent testes comprising a very large number of lobules. The surface of the testis is studded with the lobules and appears a little wrinkled at the first sight. Each testis (Pl. XXVI, fig. 1) is a 2.902 mm. long and 0.396 mm. thick organ occupying the posterior two-thirds of the seventh and the whole of the eighth abdominal segments. These are placed slightly obliquely on the subdorsal side of the alimentary canal and the two testes are loosely connected together by a median strand of connective tissue. In the seventh abdominal segment, this tissue is usually attached to the left testis. The testes are maintained in position by tracheae, nerves, fat-bodies and by suspensory filaments which are the anterior prolongations of the adipose tissue surrounding the testes. The filaments are attached to the body-wall in the posterior part of the fifth segment of abdomen.

The Vasa Deferentia

Each testis is attached posteriorly to the basal end of a duct, the vasa deferens (Pl. XXVI, fig. 1) extending from the anterior margin of the ninth abdominal segment up to its middle region and measuring 1.48 mm. in length. The vasa deferens in
the beginning lies dorso-lateral to the gut but later on curves downward to become ventral to the gut forming two 'U'-shaped loops along its course. The vas deferens is morphologically divided into two regions, a proximal region and a distal region.

The Proximal region:

It is the thin and straight beginning part of the vas deferens lying close to the posterior end of the testis from which it is separated by a constriction. The proximal region occupies only the anterior one-third part of the ninth abdominal segment.

The Distal region:

It is the posterior looped part of the vas deferens which lies ventral to the gut. The duct swells gradually as it proceeds postero-mesally to open into a median sperm sac. In young specimens the distal region is faint red in colour which changes to dark black in mature and older individuals.

The Sperm Sac

There is a large sac-like structure, the sperm sac, situated in the posterior half of the ninth abdominal segment (Pl. XXVI, fig. 1). The sperm sac is a pear-shaped distensible organ of variable size. A portion of the ventral wall of the sperm sac rests in the depression of a saucer-shaped chitinous structure at the posterior end of which is situated the male gonopores. The sperm sac is coloured faint red in younger specimens but is dark black in older specimens. It stores spermatozoa coming from vasa deferentia until their transference to the vesicula spermalis situated on the venter of third abdominal segment.

The Ejaculatory Duct

The portion of the ventral wall of the sperm sac lying in immediate contact with the chitinous depression is produced
to form a microscopic ejaculatory duct, which connects the sperm sac to the gonopore postero-ventrally. The ejaculatory duct is visible only in microtomic sections of the sperm sac.

(B) HISTOLOGY

The Testis

The wall of the testis (Pl. XXVI, fig. 2) is composed of an outer adipose tissue layer and an inner peritoneal layer. The adipose tissue forms a complete coat of varying thickness all around the testis and consists of a mass of fat-bodies. It is made up of highly vacuolated cells bearing large granular nuclei. The peritoneum is single layered and forms the true covering of the testis. It is a very thin and delicate layer which breaks up at places during microtomic sectioning. A very large number of solid lobules all of which are arranged on one side of a common lateral duct, fill the interior of the testis.

The Common Lateral Duct:

The lateral duct runs sinuously on the dorso-lateral side of the testis within the peritoneal layer. It is present throughout the length of the gonad except the anterior apical region. The wall of the lateral duct (Pl. XXVI, fig. 3) is composed of two layers, an inner epithelium and an outer muscular coat.

The epithelial layer is thick and composed of columnar cells which are arranged in two tiers in the wall on the outer side of the duct. The epithelium of the wall on the inner side is, however, three to four cells thick. An epithelial cell measures 10 micra in length and contains richly granular cytoplasm in which a large spherical nucleus is present near the apical end. The nucleus measures 5 micra in diameter and possesses a distinct nucleolus in the centre and numerous deeply-staining granules near the nuclear membrane. The muscle coat of the wall of lateral duct is very thin and consists of a
layer of circular muscle fibres on the outer side of the epithelium. A non-cellular basement membrane is also present between the muscle layer and the epithelial layer. The lumen of the lateral duct is spacious and contains scattered spermatozoa in a granular secretory material.

The Testicular Lobule:

The interior of testis is filled up with a large number of lobules which vary greatly in size and in the structure of the germ cells contained within. A testicular lobule is a somewhat spherical mass of germ cells bounded externally by a very thin limiting membrane which is seen with difficulty. A definite germinal epithelium layer is lacking in each lobule and all the germ cells of a lobule are alike representing only one stage of spermatogenesis at a time, i.e., they may all be either spermatogonia, spermatocytes, spermatids or spermatozoa. Moreover, the different lobules contain germ cells in different stages of sperm formation. It is interesting to note that the lobules which are situated near the common lateral duct possess mostly mature germ cells, or spermatozoa aggregated often in groups. Each lobule when ripe, opens into the lateral duct through a minute ductule whose structure is similar to that of the wall of the lobule. The mature sperm pass from the lobule into the lateral duct through this ductule.

The Vas Deferens

The wall of the vas deferens is composed of the following layers in order from within outwards:— (i) Epithelium, (ii) Basement membrane, (iii) Musculature, (iv) Peritoneal layer, and (v) Adipose tissue.

The epithelium is 2-3 cells thick in the wall of the proximal region of vas deferens and consists of columnar cells with distinct cell-boundaries (Pl. XXVI, fig. 4). An epithelial cell is 10 micra in length and replete with granular secretory material in the cytoplasm. The nuclei are oval to rounded in
shape, each measuring 4 micra in diameter and bearing a central nucleolus and several deeply-staining peripheral granules. The bases of the epithelial cells rest on a basement membrane. External to it is a thin layer of circular muscle fibres forming the musculature. A peritoneal layer is also present outer to the musculature. The adipose tissue is seen attached at places to the wall of the vas deferens although present all around. There is a narrow lumen in the centre of the duct.

The wall in the distal region of vas deferens (Pl. XXVI, fig. 5) is thin and consists of a single layer of cuboidal cells forming the epithelium in which cell-boundaries are indistinct. The cytoplasm of the epithelial cells is granular and stains more deeply in the apical part of the cell than at the base. There is a 4 micra large spherical nucleus in each epithelial cell bearing a nucleolus in the centre and 2-5 deeply-staining granules near the periphery. The epithelial layer is surrounded on the outer side by a basement membrane which is very thin.

Outer to the basement membrane is present a circular muscle layer. The outermost stratum in the wall is formed by peritoneal layer which is heavily laden with brownish-black pigment granules. The lumen is wide and spacious containing secretory material of two kinds. There is a very thin layer of homogeneous secretory material in the peripheral part of the lumen adjacent to the inner margin of the epithelium. The central part of the lumen is, however, filled with a secretory material of granular consistency. Scattered spermatozoa and groups of spermatozoa are also present in the centre of the lumen.

The Sperm Sac

The orientation of tissue in the wall of the sperm sac (Pl. XXVI, fig. 6) is as follows:

(1) Epithelium:— The epithelium is 6 micra in thickness and visible at places only. It consists of small flat cells provided with granular nuclei of oval shape and indistinct cell-boundaries.
The cytoplasm of the epithelial cells is granular and devoid of vacuoles.

The base of the epithelium is supported on a thin basement membrane.

(ii) Musculature:— The musculature is well developed and composed of a layer of circular muscle fibres only present outside the basement membrane.

(iii) Peritoneum:— The outermost layer in the wall of the sperm sac is the peritoneum which consists of greatly elongated cells with rounded nuclei. The cytoplasm of the peritoneal cells is heavily laden with brownish-black pigment granules giving black colouration to the wall.

(iv) Lumen:— The cavity of the sac is spacious and contains secretory material of granular type only. The lumen is not lined by a chitinous intima and stores spermatozoa.

The Ejaculatory Duct

The microscopic ejaculatory duct arises from the ventral side of the sperm sac and communicates to the exterior through the gonopore (Pl. XXVI, fig. 6). Its epithelial cells possess darkly-staining granular cytoplasm and highly granulated nuclei of oval shape. The epithelium is lined by a thin layer of chitin. The musculature in the wall of the ejaculatory duct is well developed and consists of an inner layer of longitudinal muscle fibres and an outer layer of circular muscle fibres. There is a thin layer of peritoneum also on the outermost side which is laden with brownish-black pigment granules.

2. EXTERNAL GENITAL ORGANS

The external genitalia in E. malaynum Selys comprise paired supra-anal and infra-anal appendages, a pair of coxites
and a complicated and well developed secondary copulatory apparatus.

**The Supra-anal Appendages**

There is a pair of well developed, black coloured supra-anal appendages arising dorso-terminally above the anus from the last visible segment of abdomen. Each appendage is a stout organ measuring 0.34 mm. in length. The two supra-anal appendages are quite apart from each other at the base and project posteriorward in a divergent manner. Each appendage comprises a plate and a spine (Pl. XXVII, fig. 1). The plate is broadly conical in superior view and flat in profile. The surface of the plate is beset with long bristle-like hair and small tubercles. The spine is a stout 0.18 mm. long hook-like ventro-mesal structure arising near the middle of the plate. The spine is broad at the base and narrows gradually towards the apex forming a small, strongly sclerotized, incurved, black hook at the end. The surface of the spine is covered with hair.

**The Infra-anal Appendages**

These are a pair of very small and simple appendages situated ventro-lateral to the anus and directed upward towards the supra-anal appendages (Pl. XXVII, fig. 1). Each appendage is a weakly sclerotized 0.158 mm. long, hook-like structure of light blue colour. It consists of two parts, a soft basal portion and a hard spur-like portion. The basal portion is weakly-sclerotized, cylindrical and swollen distally. The spur-like portion is strongly sclerotized, measuring 0.036 mm. in length and coloured black at the tip. Small hair are present all over the surface of the appendage except the spur.

**The Genital Aperture**

It is a small oval orifice measuring 0.101 mm. in diameter which is situated centrally on the venter of the ninth abdominal segment between a pair of appendages, the coxites (Pl. XXVII,
Fig. 2). The rim of the aperture is strengthened by a strongly sclerotized ring. The wall of the gonopore is invaginated to form an anteriorly directed, elongated chitinous structure. The chitinous structure is saucer-shaped, bearing a depression on the inner surface to give support to a portion of the sperm sac and the ejaculatory duct. During sperm translocation from the ninth to the second abdominal segment, the body wall around the gonopore forms a small temporary tube carrying the gonopore apically. This phenomenon is accompanied with the lateral displacement of coxites.

The Coxites:

The coxites are a pair of elongated, kidney-shaped and strongly sclerotized structures. Each coxite consists of a large, broad basal portion and a small, tapering apical portion. The basal portion which is rounded anteriorly, remains fused with the ninth sternum. The apical portion is free from the body-wall and projects caudally as a stylus-like structure. Each coxite is deep azure blue in colour and 0.461 mm. in length. The surface of the coxites is covered with numerous posteriorly directed bristle-like hair.

The Anterior genital plate:

A band-like anterior genital plate of light blue colour measuring 0.151 mm. in length and 0.475 mm. in width is present anterior to the gonopore in the ninth abdominal segment. The anterior genital plate is more strongly sclerotized on the anterior and lateral margins than the remaining part. Surface of the plate is adorned with numerous minute tubercles and hair.

The Post-genital plate:

It is a blue coloured plate lying behind the gonopore and developing as a result of secondary sclerotization of the intersegmental area between the ninth and tenth abdominal sternites. The plate measures 0.331 mm. in length and 0.489 mm. in breadth. The surface of the plate bears numerous tiny tubercles only, the hair being absent altogether.
THE SECONDARY COPULATORY APPARATUS

The secondary copulatory apparatus in the present species is formed by the modification of the sternum of the second and third abdominal segment and comprises a set of several structures associated with the copulatory act. These structures include anterior lamina, lamina batilliformis, genital sac, framework, hamuli posteriores, an intromittent organ (penis) and a vesicula spermalis.

The Genital Fossa

The genital fossa is a deep cavity formed by the invagination of the ventral surface in the second abdominal segment. It accommodates all of the secondary copulatory structures except the vesicula spermalis. The fossa is bounded anteriorly by anterior lamina, ventro-laterally by hamuli anteriores and laterally and posteriorly by framework. The fossa does not communicate with the cavity of the vesicula spermalis.

The Anterior Lamina

The anterior lamina (Pl. XXVII, fig. 3) is a 0.562 mm. long, black coloured convex chitinous plate forming the antero-ventral shelf of the genital fossa. The anterior margin of the lamina is strengthened by an internal apophysis which lies transversely with its extremities curved antero-laterally. The anterior lamina is notched deeply on the posterior side by a 'V'-shaped cleft dividing the plate into two lateral halves. A few hair are present projecting into the cavity of the cleft. Dorsally, the cleft is covered over by a thin membrane. The structure thus formed is an elongated sac, the median laminar sac which narrows anteriorly and measures 0.648 mm. in length. Anteriorly, the sac projects beyond the apophysis into the first abdominal segment in the form of a small triangular process. Posteriorly, the median laminar sac incorporates in its wall another structure, the lamina batilliformis.
The Hamuli Anteriores

The hamuli anteriores (Pl. XXVII, fig. 3) are a pair of chitinous structures placed laterally and projecting ventromedially from the genital fossa. Anteriorly, these are united with the postero-lateral margins of the lateral halves of anterior lamina and laterally, with the ventral margins of the second tergite through pleural membranes. A hamule consists of a large outer ventral plate and a small inner dorsal plate. The outer plate measuring 0.352 mm. in length and 0.331 mm. in width, is coloured bluish-green on the ventral surface except on the mesal margin which is black in colour. The inner plate of the hamule consists of a weakly sclerotized mesal part and a strongly sclerotized lateral part. The mesal part connects the prominent lateral part of the inner plate with the outer plate of the hamule. The lateral part is a black vertical plate-like structure which lies curved apically forming a hamular hook. Hair are present only in the basal region of inner plate of the anterior hamule.

The Lamina Batilliformis

The lamina batilliformis is present in the middle of the genital fossa above the cleft of the anterior lamina and enclosed between the two anterior hamules (Pl. XXVII, fig. 3). It is a triangular bluish-black structure measuring 0.462 mm. in length. The lamina batilliformis consists of a scoop-like, dorsally concave plate which is notched posteriorly forming a pair of limbs. The limbs lie near mesal sides of the hamular hook and are provided with a row of ventrally directed hair in the posterior half. Each limb bears a prominent hairy protuberance on the ventro-lateral side near the apex. The distal end of the limb is reflexed towards the antero-dorsal side to form a cornu. The cornua are curved apically into a semi-circular loop.

The limbs of the lamina batilliformis provide support to anterior end of the genital sac and the cavity of its notch allows the penis to pass through.
The Genital Sac

It is a large membranous chamber projecting into the body-cavity of second abdominal segment. The genital sac is laterally supported by the two pairs of chitinous bars of supporting framework. The sac opens ventrally in the centre of the genital fossa through a large orifice which is bounded by the lamina batilliformis, hamuli anteriores and median plate of the framework.

The Framework

The supporting framework (Pl. XXVII, fig. 4) comprises a system of chitinous structures located in the posterior half of the genital fossa and providing skeletal support to the fossa. The system includes a pair of anterior vertical bars, a pair of lateral longitudinal bars and a posterior median plate.

The Anterior Vertical Bars:

These are a slender pair of 0.332 mm. long, straight bars slanting vertically upward towards the median line to become firmly attached to the basal plate of penis. Ventro-posteriorly, the anterior vertical bars are articulated with the lateral longitudinal bars near the middle of the hamuli anteriores on the dorsal side. The bars lend support to lateral wall of the genital sac in which these are incorporated.

The Lateral Longitudinal Bars:

The lateral longitudinal bars are a stout pair of 0.328 mm. long bars situated laterally in the genital fossa and providing support to the ventro-lateral wall of the genital sac. Each bar is placed horizontally in antero-posterior direction in a manner that its anterior two-third part lies over the outer plate and lateral to the hook of the anterior hamule. The lateral bars connect the anterior vertical bars with the posterior median plate.
The Posterior Median Plate:

It is a large, strongly sclerotized plate-like piece situated behind the orifice of the genital sac. Laterally, the posterior median plate is attached to the ventral margins of the second abdominal tergite through pleural membranes. The median plate is a rectangular structure which gives out a pair of limbs extending anteriorly (Pl. XXVII, fig. 5). The rectangular plate is 0.334 mm. in length and 0.482 mm. in width, and is provided with a small, pointed process in the middle of the anterior margin. The postero-lateral angles of the plate abut against the lateral extremities of the anterior epodeme of vesicle (Pl. XXVII, fig. 4). The anterior limbs are stout structures each bearing a small mesal process at the apex. The apical ends of the limbs articulate with the lateral longitudinal bars of frame. A few long hair are present on the ventral surface near the apical region of the anterior limbs.

The Hamuli Posteriore:

The hamuli posteriores are a pair of simple, strongly sclerotized structures hanging ventrally from the apices of the limbs of posterior median plate of the frame (Pl. XXVII, fig. 5). Each hamule is a small, knob-like, hollow structure projecting antero-laterad. A small foramen situated at the base leads into the cavity of each hamule. The surface is beset with 3-5 long hair directed anteriorly.

The Penis:

The penis (Pl. XXVII, figs. 6 & 7) is a prominent unsegmented organ located ventrally in the genital fossa and curved near the proximal and distal ends. At rest, the penis is held horizontally in an antero-posterior direction in the genital fossa between the median plate of frame and vesicula spermalis. The proximal one-third portion of the penis is lodged inside the genital sac. Morphologically, the penis is divisible into a small basal plate and a long shaft.
The Basal Plate:-

It is the antero-proximal part of penis which lies deep in the genital fossa and comprises an anterior sclerite and a posterior sclerite. The two sclerites enclose a small foramen between them which leads into the cavity of the shaft.

(a) The Anterior sclerite:-

The anterior sclerite is a 0.252 mm. wide transverse plate-like structure projecting as a hood above the foramen. Its ventro-lateral ends are supported by the anterior vertical bars of the framework.

(b) The Posterior sclerite:-

The posterior sclerite of the basal plate is a 0.345 mm. long, spoon-shaped sclerite with its cavity facing dorsad. It is narrow at the base, wide in the middle and rounded at the apex.

The Shaft:-

The remaining part of the penis is termed shaft which is a tubular rod-like organ. The shaft is divisible into three regions, a proximal region, a middle region and a distal region.

(i) The Proximal region:-

The proximal region forms the longest region of the shaft and extends postero-ventrally as a deeply curved, bow-shaped rod. It emerges out of the genital sac through the notch of the lamina batilliformis. The proximal region of the shaft is sclerotized heavily on the ventral and lateral surfaces but is membranous dorsally. A row of around 15 small spines is present on each ventro-lateral side in the apical part of the region (Pl. XXVII, fig. 7).

(ii) The Middle region:-

It is wider than the proximal region but smallest of the three regions of the shaft. The wall of the middle region is membranous on all sides except the ventral side which bears
an elongated, slightly curved and strongly sclerotized plate.

There is a narrow duct running inside throughout the proximal and middle regions of the shaft and opening into the haemocoel through the foramen situated between the two sclerites of basal plate. An external groove also runs medially along the dorsal surface of proximal and middle regions of the shaft. This groove is shallow and narrow at the beginning but deep and broad later.

(iii) The Distal region:-

The distal region of the shaft consists of a complicated set of three membranous folds, an accessory basal fold, a glans and a prepuce. The accessory basal fold is present at the base of the region as a small narrow fold across the ventral surface. The glans is situated transversely at the posterior end of the shaft as a large distensible fold directed posteriorward. The prepuce is a 0.316 mm. large folded plate lying ventral to the middle region of the shaft. The prepuce becomes broad distally and embraces the shaft of penis near the junction of the proximal and middle regions. The apical margin of the prepuce is concave and laterally provided with a pair of wing-like lobes which taper distally.

The penis does not communicate with the vesicula spermatica nor there is any external orifice in the organ.

The Vesicula spermatica

The vesicula spermatica (Pl. XXVII, fig. 4) is a 0.814 mm. long scrotiform receptacle for temporary storage of sperms. It lies behind the genital fossa and is borne by the front edge of the third abdominal sternite. The dorsal wall of the vesicle is thin, flat and membranous. The vesicula spermatica consists of an anterior neck and a large posterior body. The neck is strongly sclerotized along the ventro-lateral margin forming a pair of curved, bluish-black limbs which taper anteriorly. The
limbs enclose between them a large 'V'-shaped bluish membranous area on the exposed surface in which a small slit-like longitudinal orifice is located anteriorly. The orifice is guarded by a pair of prominent ventrally bulging lips. The body of the vesicle is hard and strongly sclerotized on the ventral surface. It is bluish-black in colour and bears a median depressed longitudinal area. The ventral surface of the body is covered over with sparsely distributed small hair. The vesicle is attached to the body-wall by two transversely placed apodemes.

(i) The Anterior apodeme:- It is a thin, curved, sclerotized rod-like structure which widens apically. Its ends are directed antero-dorsally.

(ii) The Posterior apodeme:- The posterior apodeme is a stout bar fused for the most part with the anterior border of the third sternite. Its extremities are curved and directed dorso-laterad.

The lumen of the vesicula spermatis communicates neither with the haemocoel nor with the penis, or genital fossa.
FEMALE REPRODUCTIVE SYSTEM OF ENALLAGMA MALAYNUM SELYS

1. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The internal reproductive organs consist of a pair of ovaries, a pair of oviducts, a short common median oviduct and a translucent white '8th Complex' (Pl. XXVIII, fig. 1). A pair of accessory reproductive glands opening into the dorso-terminal part of the '8th Complex' are also situated in the ninth segment of abdomen.

The Ovaries

A pair of 16.75 mm. long, compact cord-like whitish ovaries are situated in the abdomen extending from the first upto the middle of the seventh abdominal segments. The two ovaries lie dorsal to the alimentary canal, covering it completely upto the end of the sixth abdominal segment. In the seventh abdominal segment, the ovaries become dorso-lateral to the gut. The two ovaries are united in the mid-dorsal line by a ligamentous structure, the median dorsal ligament. Anteriorly, the median dorsal ligament is anchored on the metanotum, while posteriorly it is fixed to the dorsal body-wall in the distal region of the ninth abdominal segment.

There is a large delicate, thin-walled and transparent duct on the ventro-lateral side of each ovary extending throughout its length. It is termed the common lateral duct in which the ova are discharged from the ovarioles. The ovarioles are situated longitudinally, one after another on an axis on the dorso-mesal side of the common lateral duct and are directed antero-medially. The ovarioles are long cylindrical structures bearing a longitudinal chain of developing ova within them. Each ovariole is broad at the base and tapers apically forming thereby a slender filamentous structure, the terminal filament.
when the ovaries are dissected, the terminal filaments are broken off from the ovarioles and are found attached to the median dorsal ligament. The terminal filaments of the anterior ovarioles do not join the median dorsal ligament. Instead, these combine together in the first abdominal segment to form a stout filamentous structure, the apical filament of the ovary. The apical filaments are fastened anteriorly on the dorsal body-wall of thorax and hold the ovaries in position together with the median dorsal ligament. The tracheal ramifications and the fat-bodies which are present on the surface of the ovary and in the spaces between the ovarioles also help to maintain the ovary in its position.

The Oviducts

The oviducts are posterior prolongations of the common lateral ducts beyond the posterior limit of the ovaries. Each oviduct occupies the posterior half of the seventh and the anterior one-third of the eighth abdominal segments and is located on the dorso-lateral side of the gut. It then, descends down from the side of the alimentary canal and finally comes to lie ventral to it in the region of the eighth abdominal segment. The oviduct is a 1.5 mm. long, simple and comparatively thick-walled tube of almost uniform diameter throughout. In young specimens, the oviducts are completely enveloped in thick adipose tissue.

The Common Median Oviduct (Oviductus Communis)

The two oviducts meet posteriorly in the anterior part of the eighth abdominal segment to form a common median oviduct on the ventral side of the alimentary canal. This is a very short tube connecting the oviducts with the '8th Complex'. The oviductus communis is hidden dorsally by the eighth abdominal ganglion which lies over it. Large amounts of fat-bodies are loosely attached on the surface of the common median oviduct. The oviductus communis opens posteriorly into the vagina of the '8th Complex'.
The '8th Complex'

The '8th Complex' is an assemblage of vagina, bursa copulatrix and spermatheca in the posterior half of the eighth abdominal segment. The vagina forms the ventro-medial portion of the '8th Complex' whereas the bursa copulatrix and the spermatheca contribute its dorsal part.

The Vagina

It is a prominent ventro-median tube lying laterally compressed between massive bands of striated muscles and comprises an anterior tubular portion and a posterior genital atrium.

(a) The Anterior Tubular Portion:

The anterior tubular portion forms the main part of the vagina (Pl. XXVIII, fig. 2) extending from the middle of the eighth abdominal segment nearly up to the posterior margin. It possesses a small but prominent, chitinous collar in its anterior region where the openings of the oviductus communis and the ductus bursae are present. Posteriorly, there is a pair of strongly sclerotized, large lateral plates in the lumen of the duct. The musculature of the vagina is extensive and consists of the following sets of muscles:— (i) the anterior vaginal muscles, (ii) the sterno-vaginal muscles, and (iii) the radial muscles. The arrangement of the muscles has been described in later pages under the histology of the organ.

(b) The Genital Atrium:

The anterior tubular portion of vagina opens posteriorly into a small chamber, the genital atrium whose wall is thin, membranous and wrinkled in appearance. It is surrounded by large amounts of adipose tissue in young and immature specimens. The wall of the genital atrium is posteriorly attached to the antero-proximal ends of the first and second valvulae of the ovipositor (Pl. XXIX, fig. 4).
The Bursa Copulatrix

The bursa copulatrix is a blind elongated sac-like organ present on the antero-dorsal side of the vagina and directed posteriad (Pl. XXVIII, fig. 2). It is much shorter than the vagina with which it communicates also by a narrow duct, the ductus bursae. In virgin specimens, the bursa copulatrix lies in a wrinkled condition on any one side of the vaginal tube. However, in mated females it forms a very prominent structure on the dorsum of the '8th Complex'.

The Spermatheca

The spermatheca is a small, median and posteriorly projected organ which arises from the ventral side of the bursa copulatrix near the distal end (Pl. XXVIII, fig. 2). It consists of a proximal ductus spermathecae and a distal bulbous spermathecae, both of which are nearly equal in length. The bulbous spermathecae is a sac-like, red-coloured structure lying postero-ventral to the bursa copulatrix. The ductus spermathecae is a slender tube which connects the bulbous spermathecae with the ventro-medial wall of the bursa copulatrix. The spermatheca and the bursa are characteristically enclosed together within a common thick sheath of adipose tissue.

The Accessory Glands

A pair of prominent whitish accessory reproductive glands is present above the base of the lateral valves of ovipositor and underneath the rectal part of the gut (Pl. XXVIII, fig. 1). The two glands run posteriorwards and close to each other in the ninth abdominal segment. Each gland is made up of a proximal duct and a distal sac. The saccular portion is an elongated cylindrical structure which is swollen basally. The duct of the accessory gland is a slender filamentous structure which measures nearly half the length of the saccular portion. The two ducts open separately on the dorso-lateral wall of the genital atrium in the region lying very close to the genital aperture.
(B) HISTOLOGY

The Ovariole

The ovaries are composed of a very large number of ova of different sizes from apex downwards. The terminal filament, the germarium and the vitellarium are also seen in the present case. The terminal filaments of most of the ovarioles are embedded in the tissue of the median dorsal ligament which consists of a matrix of loose connective tissue containing an abundance of fat-bodies and a few muscle fibres.

The Common Lateral Duct

The wall of the common lateral duct is made up of two layers, an epithelial layer on the inner side and a muscular layer on the outer side. The epithelial layer of the duct is continuous with the sheath of the ovariole and consists of a tier of small cuboidal cells in which the cell-boundaries are indistinct but the nuclei are prominently seen. The nucleus is large and spherical and occupies most of the space in the interior of the cell. The cytoplasm is homogeneous and present in a small amount. The musculature surrounds the epithelial layer externally and comprises a layer of longitudinal muscle fibres only. The lumen of the duct is spacious and contains mature ova which are greatly elongated in shape.

The Oviduct

The wall of the oviduct consists of an inner epithelial and an outer muscular layers. The epithelial layer encircles the lumen which is more spacious than that of the common lateral duct. It is composed of a single layer of small cuboidal cells, each measuring 6 micra in height and possessing a large spherical
nucleus in a mass of clear cytoplasm. The nucleus which occupies most of the space in the cell is granular and measures 3 micra in diameter. The musculature is composed of a thin layer of longitudinal muscle fibres only. A thick layer of adipose tissue surrounds the oviduct on the outermost side.

The Oviductus Communis

The oviductus communis (Pl. XXVIII, fig. 3) shows the same histological structure as the oviduct except that its lumen is lined by a thin chitinous intima and the muscular coat is well developed. The epithelium is composed of a layer of 8 micra large cuboidal cells, each possessing granular cytoplasm and a prominent nucleus. The nucleus is 4 micra large, spherical, granular and provided with a nucleolus.

The pair of anterior vaginal muscles running along the mid-dorsal surface of the common median oviduct produces a small linear ridge of the epithelium projecting towards the lumen from the dorsal wall. The musculature consists of an inner circular muscle layer and an outer longitudinal muscle layer. The posterior end of the oviductus communis opens into the vagina through a longitudinal slit-like gonopore.

The Vagina

(1) The Anterior Tubular Portion:

The orientation of tissue in the wall of the anterior tubular portion of vagina is as follows:

There is a vertical and lengthwise extended lumen in the centre of the vagina which is guarded laterally by chitinous lateral plates (Pl. XXVIII, fig. 4). Antero-dorsally, the lumen is wide but ventrally it is produced into a pair of outgrowths, the ventral evaginations. The ventral evaginations of the lumen are narrow and indistinct in the anterior region, but large and prominent in the posterior region of the vagina. The lumen is lined by a strongly sclerotized layer of chitin which is
modified at places forming special cuticular structures. These structures include a collar and a pair of lateral plates. The collar is situated in the anterior wall of the vagina near the openings of the ductus bursae and the oviductus communis which communicate with the vagina from the dorsal and the ventral sides respectively (Pl. XXVIII, fig. 3). The collar consists of a central part and a pair of lateral arms. The central part lies in dorso-ventral plane in such a way that its antero-ventral margin is prolonged forward into a small anterior process. On the lateral sides, the collar gives out lateral arms which are wing-like and directed postero-ventrally. The lateral plates are present vertically in the lateral wall of the vagina and each comprises a broad laminate structure of brightly shining cuticle. The two plates are pressed closely against each other except in the anterior region where these enclose a wide cup-shaped lumen. The lateral plates are connected to each other on the superior side forming a median sclerotized ridge projecting dorsad. On the lower side, the plates are joined together by a chitinous membrane only.

The epithelium of the tubular portion of vagina consists of a single layer of cuboidal cells, each measuring 9 micra in length and 6 micra in breadth. The cells possess only a small amount of clear cytoplasm and round to ovoid nuclei located mostly towards the basal sides. The nucleus measures 5 micra in diameter and contains 2-4 deeply-staining granules. The basement membrane supporting the epithelium is very thin. The musculature of the vagina consists of striated muscle fibres which are arranged in definite order as follows:

The anterior vaginal muscles are thin filamentous muscles which are inserted on the anterior process of the collar at one end and to the seventh sternum at the other end. The collar also provides attachment on its lateral arms to a pair of thick radial muscles which are attached posteriorly on the dorsal side of the lateral plates. The sterno-vaginal muscles are massive muscles running transversely from the anterior
region of the vagina to attach on the eighth sternum. A few muscle fibres also run from the ventro-lateral part of the lateral plates to attach on the eighth abdominal sternite. The adipose tissue does not form a complete layer but is found scattered among the muscles.

(ii) The Genital Atrium:

The epithelial layer in the wall of the genital atrium (Pl. XXIX, fig. 1) is thin but the chitinous intima is quite thick and irregular in outline. The chitinous intima is colourless, weakly sclerotized and surrounded externally by small cubical cells arranged in a row forming the epithelial layer. The muscle fibres and adipose tissue are sparsely present in the wall of the genital atrium.

The Bursa Copulatrix

Beginning from the inner side the wall of the bursa copulatrix (Pl. XXVIII, fig. 5) is composed of chitinous intima, epithelium, basement membrane, musculature and adipose tissue. The chitinous intima is thick, colourless and produced into an intricate pattern of transverse ridges. The epithelial layer consists of 6 micra long cuboidal cells which are arranged in a single tier round the intima. Each epithelial cell possesses a 4 micra large vesicular nucleus surrounded by a small amount of vacuolated cytoplasm. The epithelium is bounded on the outer side by a structureless basement membrane. The muscular coat is conspicuously present and comprises a thick layer of longitudinal muscle fibres only. The adipose tissue forms a thick and complete layer on the outermost side and encloses the spermatheca also within it. The lumen of the bursa is laterally compressed in virgin females which distends to become large in mated individuals in order to accommodate maximum amount of spermatozoa (Pl. XXVIII, fig. 4). The chitinous intima in the ductus bursae bears a number of postero-ventrally directed spines.
The spermatheca

The bulbous spermathecae (Pl. XXVIII, fig. 6) and the ductus spermathecae (Pl. XXVIII, fig. 4) are histologically similar in structure. Moreover, the spermatheca bears a close resemblance with the histological structure of the bursa copulatrix and seems to arise by evagination of the latter.

The wall of the bulbous spermatheca consists of a row of 9 micra large cuboidal cells surrounding the lumen and forming the epithelial layer. The cytoplasm of epithelial cells is highly granular and vacuolated towards the apical side. A large ovoid nucleus measuring 5 micra in diameter is situated near the base of each cell. The epithelial cells appear to be glandular in nature and rest basally on a structureless basement membrane. A thick layer of longitudinal muscles on the outer side of the basement membrane forms the muscular coat. The longitudinal muscles are surrounded externally by a uniformly thick layer of adipose tissue. There is a lumen in the centre of the spermatheca which contains free spermatozoa and not sperm groups. The lumen of the bulbous spermathecae is wider than that of the ductus spermathecae. The lumen is lined by a thick layer of chitinous intima which is irregularly folded in the bulbous portion and nearly smooth in the ductus region.

The Accessory Gland

The sacular portion:

The wall of the sacular portion of the accessory gland (Pl. XXIX, fig. 2) is composed of the following layers, in order beginning from within outwards:-(i) Chitinous layer, (ii) Epithelium, (iii) Basement membrane, and (iv) Musculation.

There is a spacious lumen in the centre of the sac. The lumen is lined by a very thin chitinous intima. The chitinous intima is surrounded by epithelium which is made up of a layer of columnar cells. Each epithelial cell measures 11 micra in length and possesses a large nucleus embedded in cytoplasm. The cytoplasm of the cell is vacuolated and granular besides
possessing large deposits of secretion. The nucleus of the glandular epithelium is vesicular, ovoid in shape and located near the middle of the cell. The nucleus measures 5 micra in diameter and contains 6-8 deeply-staining granules within it. The epithelial cells are mostly arranged in groups which make the outline irregular. The basal support to the epithelial cells is provided by a basement membrane. Next to the basement membrane on the outer side is the muscle layer which consists of a thin and conspicuous layer of circularly disposed muscle fibres.

**The Duct:**

The wall of the duct is composed of the same histological layers as are found in the saccular portion of the accessory gland. However, the epithelium of the duct is non-glandular, and the chitinous intima and the muscular coat are well developed. The duct opens postero-dorsally into the cavity of the genital atrium.

2. **EXTERNAL GENITAL ORGANS**

The female external genitalia of *E. malaynum* Selys comprise a pair of brownish-black supra-anal appendages, a subgenital plate and a robust ovipositor on the underside of the ninth abdominal segment.

**The Supra-anal Appendages**

There is a pair of 0.41 mm. long supra-anal appendages arising dorso-laterally from the posterior end of tenth abdominal segment. Each anal appendage is a short conical organ hollow from inside and projecting postero-ventrally (Pl. XXIX, fig. 3). The surface of the appendage is covered with numerous minute tubercles and hair.
The Genital Aperture

The female genital aperture is a simple, somewhat circular orifice situated mid-ventrally between the eighth and ninth abdominal segments (Pl. XXIX, fig. 4). It is surrounded and protected by the valvifers and valvulae of the ovipositor.

The Subgenital Plate

The sternum of the eighth abdominal segment is brownish-orange in colour covered with hair and tubercles. Posteriorly, it bears a black coloured, heavily sclerotized median area which is enlarged into an arch-shaped structure. This forms the subgenital plate which is directed posteriorward and lies beneath the basal one-third region of the first valvulae (Pl. XXIX, fig. 5). The subgenital plate is produced posteriorly into a robust median process which is coloured brown proximally and black distally. The subgenital plate protects the vulva and the base of the ovipositor.

THE OVIPOSITOR

The ovipositor consists of paired sclerotized structures namely the first valvifers, second valvifers or lateral valves, first valvulae, second valvulae and gonangula. Each shaft of the second valvula carries a ventrally placed ridge which fits into a groove on the dorsal surface of the first valvule of corresponding side. The valvulae enclose an ovipositor canal.

The First Valvifers

These are a pair of dorso-ventrally flattened plates lying horizontally beneath the apical region of the eighth abdominal segment (Pl. XXIX, figs. 4 & 5). Each valvifer gives out three processes, a mesal process, an anterior apophysis and a lateral process on the mesal, anterior and lateral sides respectively. The mesal processes of the two valvifers are closely apposed to each other and connected together by a membrane. The anterior apophysis of the valvifer is strongly
sclerotized and projects into the cavity of the eighth abdominal segment. The lateral process is a small and semicircular process which is turned slightly upwards.

The Second Valvifers (Lateral Valves)

The second valvifers are a pair of blue coloured large processes, each measuring 1.342 mm. in length. The base of lateral valve is inserted into the venter of the ninth abdominal segment (Pl. XXIX, fig. 4). Each lateral valve is composed of a broad basal portion and a terminal stylius. The basal portions of the two lateral valves are connected in the anterior half by an intervalvular membrane which is grooved longitudinally on the external side. The intervalvular membrane bears anterior and posterior intervalvular sclerites in the anterior and posterior regions respectively. The anterior intervalvular sclerite is a small, somewhat rectangular structure located nearly in the centre of the ninth abdominal venter. The posterior intervalvular sclerite is a narrow, semicircular bar stretching transversely between the two lateral valves at the posterior extremity of the ninth sternum (Pl. XXIX, fig. 5).

The external surface of the broad basal portion is convex and covered with numerous whitish hair. The proximal end of the lateral valve is situated mesally along the ventro-lateral border of the ninth abdominal tergite. There is a weakly sclerotized lancet-shaped bar, the laterotergite situated between the proximal margin of the lateral valve and the ventro-lateral margin of the ninth tergite. The basal end of the lateral valve is strongly sclerotized to form an anterior apophysis which lies almost parallel to the laterotergite. The anterior apophysis is directed mesally and projects into the haemocoel. At the posterior end of the anterior apophysis there is another stout and strongly sclerotized process, the posterior apophysis which is directed dorsad into the haemocoel. A membranous fold present on the mesal side of the valvifer is developed terminally into a gonoplic. The gonoplic bears a
longitudinal groove on the inner side and 4-5 hair at the apex.

The stylus is an unjointed palp-like tubular organ originating at the distal end of the basal portion of the second valvifer and projecting underneath the tenth abdominal segment. It lies ventro-lateral to the gonopac and measures 0.288 mm. in length. It is coloured brown proximally and black distally. The surface of the style is covered with short hair which are abundantly present at the apical end.

**The First Valvulae**

The first valvulae are a pair of 1.145 mm. long structures directed posteriorward (Pl. XXIX, fig. 5) and located ventro-medially in the ninth abdominal segment. These are attached to the postero-mesal sides of the first pair of valvifers. Each valvule is made up of a small ramus and a long shaft. The ramus is plate-like and forms the antero-proximal part of the valvule. The two rami of the first pair of valvulae are joined together at the anterior margin forming an arch-shaped structure. Each ramus is expanded laterally into a small wing-like lateral process. There is a dorsal process also on the dorsal side in the form of a ridge situated near the base of the lateral process. The shaft of the valvule is a slender, needle-like structure, suitably adapted for penetration in soft tissue. The ventro-mesal borders of the two shafts lie opposed to each other. The dorsal edge of the shaft is very strongly sclerotized and continuous anteriorly with the dorsal ridge of the ramus. The dorso-lateral surface of the posterior one-third of the shaft is serrated by the presence of posteriorly directed teeth. Each tooth alternates with a transverse pleat on the external surface of the blade.

**The Second Valvulae**

The second valvulae consist of a pair of 1.122 mm. long structures which are directed posteriorly and located ventro-medially but dorsal to the first valvulae. Each valvule is
attached near the antero-proximal end of the lateral valve of its side and composed of a ramus and a shaft like the first valvule.

The part of the valvule which is attached to the second valvifer is distinguished as the ramus (Pl. XXIX, fig. 4). The ramus is an elongated, vertical plate excavated deeply on the mesal side and convex on the lateral side. The convex surface is adorned with a tuft of short hair. The two rami are joined together along their ventral borders by a thin membrane. A hood-like structure is formed horizontally towards the mesal side by the dorsal edge of the ramus in its posterior half. The shaft of the valvule is a curved slender needle-like process. Distally, the external surface of the blade of shaft is provided with several transverse pleats, each alternating with a laterally projecting tooth and thus forming a saw-like structure (Pl. XXIX, fig. 6).

The gonangula

The gonangulum is a bar-like sclerotized structure which is situated obliquely at the distal end of the eighth abdominal sternite. Its dorsal end is articulated with the drooping antero-lateral border of the ninth tergite (Pl. XXIX, fig. 4) and the ventral end rests on the dorsal surface of the lateral processes of the first ramus (Pl. XXIX, fig. 5).
1. INTERNAL GENITAL ORGANS

The male E. parvum exhibits the same organs both in the internal and external genitalia as present in the male E. malayanum.

(A) GROSS MORPHOLOGY

The Testes

The testes are a pair of 2.773 mm. long and 0.165 mm. thick whitish cylindrical gonads present on the dorsal side of the alimentary canal in the posterior half of the seventh and the whole of the eighth abdominal segments (Pl. XXXVI, fig. 2). The testes may differ slightly in size and position. Each testis is a multilobular organ consisting of numerous rounded bodies called lobules. The testes are completely enveloped by adipose tissue which is prolonged anteriorly as suspensory filaments. The filaments attach to the tergum in the anterior part of the fifth abdominal segment. The two testes are also joined together by a median longitudinal ligament which is attached posteriorly to the tergum of the ninth abdominal segment. The tracheae and tracheoles form a dense network over the surface of the testis.

The Vasa Deferentia

A vas deferens emerges out from the posterior end of each testis and measures 1.75 mm. in length. It lies convoluted in a zig-zag manner within the ninth segment of abdomen (Pl. XXXVI, fig. 2). The vas deferens changes its position from the dorso-lateral side of the alimentary canal in the beginning part to the ventral side along its course. Distally, the two vasa deferentia open into a median sperm sac.

The vas deferens is morphologically divided into two regions, a proximal region and a distal region. The proximal
region of the vas deferens is a narrow translucent duct of uniform diameter arising from the posterior end of the testis and running straight posteriorwards. The distal region of the vas deferens becomes gradually thicker and lies prominently convoluted below the gut.

In teneral specimens the distal region of the vas deferens is faintly red in colour and possesses a narrow lumen of uniform diameter. In post-teneral specimens, however, this region is black in colour and possesses a spacious lumen whose diameter gradually increases distally onwards. Moreover, it forms prominent loops also one of which enters sometimes anteriorly into the eighth abdominal segment as well.

**The Sperm Sac**

The vasa deferentia from the two sides join each other below the alimentary canal in the middle of the ninth abdominal segment to form a large median, distensible sperm sac (Pl. XXXI, fig. 2). The sperm sac is a large organ measuring 0.339 mm. in antero-posterior direction and 0.228 mm. across and occupying posterior two-third part of the ninth abdominal segment. When fully distended the caudal end of the sperm sac projects into the tenth abdominal segment. In teneral specimens it is a flattened, wrinkled and heart-shaped structure of faint red colour. However, in post-teneral specimens it is black and swollen considerably but still retaining the cordate outline.

**The Ductus Ejaculatorius**

The sperm sac continues ventrally into an inconspicuous, microscopic translucent duct, the ejaculatory duct which communicates to the exterior through the genital aperture.

**HISTOLOGY**

**The Testes**

The testis shows the following histological structures beginning from the outermost side, (a) Adipose tissue,
(b) Peritoneum, (c) Lobules, and (d) Common lateral duct (Pl. XXX, fig. 1).

Adipose Tissue:— The adipose tissue forms almost a complete layer of varying thickness round the testis. It is composed of a spongy mass of highly vacuolated cells with distinct cell-boundaries and prominent nuclei. The anterior suspensory filament of each testis is composed exclusively of adipose tissue whereas the median ligament includes other connective tissue as well.

Peritoneum:— Next to the adipose tissue layer on the inner side is present a peritoneal layer consisting of a single row of small stretched cells. The peritoneum encircles the lobules and the lateral duct.

The wall of the testis surrounds a very large number of lobules of different size. All the lobules are compactly packed together in the testis on the inner side of a lateral duct.

The Common Lateral Duct:—

The wall of the lateral duct is composed of the following layers from within outwards:— (i) Epithelium, (ii) Basement membrane, and (iii) Muscle layer.

The epithelium is multilayered consisting of small cuboidal cells arranged in 2 or 3 rows. Each epithelial cell possesses a granular cytoplasm and a large spherical nucleus near the apical region of the cell. The nucleus measures 5 micra in diameter and possesses a large central nucleolus and many deeply-staining granules. On the outer side, the epithelium is surrounded by a very fine basement membrane. The muscle layer of the lateral duct is composed of a thin layer of circular muscle fibres only.

The lateral duct runs sinuously throughout the length of the testis except the anterior end. Its lumen is wide and
contains scattered spermatozoa dispersed in a granular secretory material.

The Testicular Lobules:

Each testicular lobule is almost a spherical and solid structure composed of a large number of germ cells filling the interior of the lobule. A lobule is bounded externally by a thin limiting membrane only. The germinal epithelium is absent. All the germ cells in a lobule represent at a time only one stage of spermatogenesis, but different lobules contain germ cells in different stages of spermatogenesis. Although all the germ cells in a lobule are alike yet they differ slightly in their chromosomal structure and behaviour. The lobules display a characteristic mode of arrangement inside the testicular wall. The lobules situated away from the lateral duct contain germ cells in comparatively younger stages of spermatogenesis than those situated near the duct which possess mature germ cells i.e. spermatids and spermatozoa.

The lobules are attached to the lateral duct through very fine ductules. Histologically, each ductule possesses the same structure as the lobule. The ductules are distinctly seen connected to lobules containing spermatids or spermatozoa.

The Proximal Region of Vas Deferens

The proximal region of the vas deferens shows an arrangement of tissue similar to that of the lateral duct of testis.

The lumen is lined by a multilayered epithelium which is composed of cuboidal cells with indistinct cell-boundaries. The cytoplasm of the epithelial cells is densely granular and accumulated mostly near the base. There is a large rounded nucleus measuring 5 micra in diameter and situated in the apical part of the cell. The nucleus possesses numerous deeply-staining small granules and a large nucleolus. The basal ends of the epithelial cells are supported on a basement membrane. Outside
the basement membrane is a thin layer of circular muscle fibres comprising the musculature of the wall. The lumen in the centre of the duct is narrow and contains granular secretory material in which a few scattered sperms and sperm groups are present.

The Distal Region of Vas Deferens

The histological structure of the distal region (Pl. XX, fig. 2) differs greatly from that of the proximal region of vas deferens. The wall is made up of the following layers in order commencing from the outer side:

(a) Adipose tissue
(b) Peritoneum
(c) Musculature
(d) Basement membrane
(e) Epithelium

The adipose tissue consists of masses of fat-bodies attached on the surface of the duct at places only. The peritoneum is thick and consists of a row of flat cells. The cytoplasm of the peritoneal cells is packed with brownish-black pigment granules. Inside the peritoneal layer is present a thin muscular coat which comprises circular muscle fibres only. The epithelium forms the innermost layer of the wall and is composed of small cuboidal cells measuring 8 micra in length arranged in a single row round the central cavity. The cell-boundaries of the epithelial cells are indistinct. There is a 4 micra large nucleus of spherical shape situated in the apical part of each cell. The nucleus possesses a prominent nucleolus and numerous deeply-staining granules. The cytoplasm of the epithelial cells is granular and deeply-staining. A thin structureless basement membrane provides support to the base of the epithelial cells. The lumen is large and spacious and contains spermatosozoa and secretory material arranged in two zones. In the peripheral zone, the secretory material is dense and granular in nature in which the spermatosozoa are present in isolated groups. In the central zone, the secretion is more or less homogeneous and the spermatosozoa are scattered.
The Sperm Sac

The sperm sac shows the same histological structure as the distal region of the vas deferens except that it lacks adipose tissue completely, and the peritoneum and muscular coat are well developed. The cytoplasm of the peritoneal cells is full of brownish-black pigment granules. The epithelium is very thin consisting of small cuboidal cells measuring 5 micra in length. The cytoplasm of the cells is granular and stains deeply. The nuclei are large and oval measuring 3 micra in diameter and each possessing several deeply-staining granules only, the nucleolus being notably absent. The lumen is very spacious and filled with granular secretion only, in which scattered spermatozoa are present. The lumen is not lined by chitinous intima.

The Ductus Ejaculatorius

The ejaculatory duct is a microscopic ventral prolongation of the sperm sac wall. Therefore, it shows a histological structure which is similar to that of the sperm sac. However, the epithelium of the ductus ejaculatorius is lined internally by a thin chitinous layer and the muscular coat consists of two layers, an inner layer of longitudinal muscle fibres and an outer layer of circular muscle fibres.

2. EXTERNAL GENITAL ORGANS

The Supra-anal Appendages

There is a pair of characteristically well developed black coloured appendages, the supra-anal appendages arising dorso-terminally from the tenth abdominal segment (Pl. XXX, fig. 5). Each appendage is pistol-shaped in appearance comprising a handle and a barrel-like portion (Pl. XXX, fig. 3). The handle-like portion is a hollow, 0.321 mm. long structure which is slightly compressed dorso-ventrally. Its apical part is curved towards the ventro-mesal side. The handle-like portion
is continued into an equally long, stout rod, the barrel-like portion of the supra-anal appendage. The apex of the portion is bilobed and the postero-mesal margin is concave. There is a small trigger-like spur also on the mesal side. The appendage is strongly sclerotized all over except a small area on the postero-mesal side. The surface of the supra-anal appendage bears many long bristle-like hair.

The Intra-anal Appendages

There is a pair of 0.288 mm. long, conical intra-anal appendages directed in a horizontal plane and situated beneath the supra-anal appendages on the ventro-lateral sides of the anus (Pl. XXX, fig. 5). The intra-anal appendage is bluish-black coloured, weakly sclerotized hollow structure broad at the base and attenuating distally to an acute apex (Pl. XXX, fig. 4). Numerous bristle-like and posteriorly directed hair are present all over the surface of the appendage except on the dorso-mesal side.

The Gonopore

The male gonopore (Pl. XXX, fig. 5) is situated in the middle of the ventral side of ninth abdominal segment. It is a circular aperture measuring 0.109 mm. in diameter and lying hidden by coxites. The rim of the aperture is strengthened by a chitinized ring which is forwardly continued inside the body to form a narrow, elongated, dorsally concave and strongly sclerotized chitinous structure. The chitinous structure is bifurcated at the far end and provides support to the ejaculatory duct in its concavity.

The Coxites

The coxites are a pair of weakly sclerotized elliptical structures, each measuring 0.378 mm. in length and lying lateral to the gonopore. The coxite is deep azure blue in colour and consists of two parts, a basal portion and a tapering apical portion. The basal portion is large and broadly united with
the body-wall. The terminal portion is small measuring only one-fifth of the total length of the coxite. It is style-like in appearance and possesses an obtuse apex which hangs freely in the postero-ventral direction. At the front margin of each coxite there is a distinct heavily sclerotized process projecting inwards in the body cavity. The exposed surface of the coxites is adorned with numerous long hair.

The Anterior genital plate:

The portion of the ninth abdominal sternite lying in front of the genital aperture is modified into an anterior genital plate. It is a broad, light azure blue coloured structure measuring 0.224 mm. in length and 0.486 mm. in width. There is a black band of strongly sclerotized area near the front margin of the anterior genital plate. The surface of the plate is beset with numerous hair and minute tubercles.

The Post-genital plate:

The post-genital plate measures 0.275 mm. in the antero-posterior direction and 0.499 mm. across. The plate is formed by secondary sclerotization of intersegmental membrane present behind the gonopore. The surface of the post-genital plate bears numerous small tubercles only, there being no hair.

THE SECONDARY COPULATORY APPARATUS

The Genital Fossa

The genital fossa is a wide and deep pit on the ventral side of the second abdominal segment.

The Anterior Lamina

The anterior lamina is a hood-like 0.361 mm. long, deep azure blue coloured plate at the anterior end of the genital fossa (Pl. XXX, fig. 6). The dorsal surface of the anterior lamina is concave and strengthened anteriorly by a strongly
sclerotized black apophysis placed transversely. The lateral extremities of the apophysis are free and directed laterally anteriorly. A deep median cleft divides the posterior edge of the lamina into two lateral halves or limbs. The margin of the cleft is thick and strongly sclerotized and extends anteriorly upto the apophysis. It bears a few small bristle-like hair projecting postero-ventrally. Dorsally, the cavity of the cleft is covered over by an ash-coloured membrane which is densely tuberculated. The structure thus formed is a 0.604 mm. long sac-like structure termed the median laminar sac which projects in the first abdominal segment. The median laminar sac incorporates the lamina batilliformis in its wall and opens ventrally between the lateral halves of the anterior lamina.

The Hamules

There are two pairs of hamules, the hamuli anteriorese and the hamuli posteriores located anteriorly and posteriorly respectively in the genital fossa.

The Hamuli Anteriorese:

The hamuli anteriorese are a pair of chitinous structures lying laterally in the anterior part of the genital fossa behind the anterior lamina and projecting ventro-mesally (Pl. XXX, fig. 6). Each hamule is deep azure blue in colour and composed of a ventral outer plate and a dorsal inner plate. The outer plate is a lamellate structure of quadrate shape measuring 0.295 mm. in length and 0.281 mm. in breadth. It is attached anteriorly with the postero-lateral margin of the anterior lamina and laterally with the latero-ventral edge of the second tergite through membranes. Posteriorly, the outer plate remains unattached. The inner plate is stout and laterally compressed hook-like organ whose antero-apical portion is free and the postero-basal portion is curved. The surface of the hamular hook is adorned with several posteriorly directed hair. The outer plate is connected mesally with the basal portion of the inner plate by a membranous structure.
The Hamuli Posteriorese:-

The posterior hamules are a pair of small, hollow, imperceptible, simple knob-like chitinous outgrowths situated at the apex of the anterior limbs of posterior median plate of framework (Pl. XXX, ii, 7). Each posterior hamule measures 0.154 mm. in diameter and projects ventrally from the genital fossa. The cavity of the hamule communicates with a prominent foramen situated at the base of the organ.

The Lamina Batilliformis

The lamina batilliformis is a 0.453 mm. long chitinous structure which lies enclosed between the two anterior hamules in the floor of the genital fossa. It consists of an anterior plate and two posterior limbs ending in upwardly curved cornua. The plate is an elongated tongue-like structure situated above the cleft of the anterior lamina. It possesses a semicircular front margin and a concavity on the dorsal side. The postero-lateral angles of the plate are prolonged posteriorwards into a pair of limbs. A prominent black papilla directed ventro-laterally and furnished with bristle-like hair, is present subapically near the posterior end of each limb. Hair are also present on the inner margin of the limbs. The extremities of the limbs are bent anteriorly dorsad to form loop-like cornua which are as long as the limbs.

The limbs of the lamina batilliformis provide antero-ventral support to the wall of the genital sac besides forming an inverted 'V'-shaped space through which the penis protrudes out. The plate of lamina batilliformis protects the base of the penis.

The Genital Sac

A membranous genital sac is present in the cavity of the genital fossa. The wall of the sac is attached antero-ventrally to the limbs of lamina batilliformis, laterally to the longitudinal bars and postero-ventrally to the posterior median plate
of framework. The genital sac opens out ventrally through a large orifice in the middle of the second abdominal segment. The dorsal wall of the genital sac incorporates the proximal portion of the penis only and its remaining portion protrudes out through the large orifice of the sac.

The Supporting Framework

The supporting framework is a system of sclerotized chitinous pieces which provide skeletal support to the wall of the genital fossa, genital sac, both the pairs of hamuli and the penis (Pl. XXX, fig. 6). The framework consists of a pair of anterior vertical bars, a pair of lateral longitudinal bars and a posterior median plate.

The Anterior Vertical Bars:

These are a pair of 0.612 mm. long, slender and almost straight bars lying embedded in the lateral wall of the genital sac in an obliquely vertical manner, one on each side of the median line. The dorsal end of each bar is directed antero-mesad and united with the ventro-lateral extremity of the basal plate of penis. The ventral end of the vertical bar is, however, directed postero-laterally to articulate with the lateral longitudinal bar of framework of its side.

The Lateral Longitudinal Bars:

The lateral longitudinal bars are a pair of 0.245 mm. long, stout and straight bars lying horizontally above the outer plate of hamule and running parallel to the hamular hook. The posterior extremities of these bars rest on the anterior limbs of the posterior median plate of framework.

The Posterior Median Plate:

The posterior median plate of the framework (Pl. XXX, fig. 7) is a 'N'-shaped structure measuring 0.411 mm. in length and situated horizontally behind the genital sac in the posterior
part of the second abdominal venter. It consists of a small median inverted 'V'-shaped plate and two pairs of lateral limbs directed anteriorly and posteriorly respectively. The anterior margin of the plate is semicircular and its posterior ends are produced to form the posterior limbs which articulate with the anterior apodeme of vesicula seminalis. The anterior limbs are longer than the posterior limbs and each limb measures 0.238 mm. in length. The apices of the anterior limbs are wide and truncated and bear hamuli posteriores besides articulating with the lateral longitudinal bars of the framework.

The Penis

The functional intromittent organ i.e. the penis in E. parvum is a prominent chitininous rod-like structure situated ventro-medially in the genital fossa. It is curved near the ends forming a more or less 'S'-shaped structure which lacks an external orifice (Pl. XXX, fig. 8). At rest, the penis is held straight and its distal portion lies supported on vesicula seminalis beneath the posterior median plate. During copulation, most of the penis is exerted out ventrally except the anterior part which remains in the wall of the genital sac. The penis is divided into a small basal plate and a long shaft.

The Basal Plate

The basal plate is the heavily sclerotized proximal structure of the penis which forms the roof of the genital sac by being incorporated into it. The plate comprises two sclerites, an anterior sclerite and a posterior sclerite. The bases of the two sclerites are fused leaving a small foramen in the centre.

The Anterior sclerite— The anterior sclerite is a transversely elongated bar measuring 0.173 mm. and placed as a hood-like structure above the foramen. The lateral ends of the anterior sclerite are supported by the dorsal extremities of the anterior vertical bars of the framework.
The Posterior sclerite:- The posterior sclerite is a 0.216 mm. long, dorsally scooped structure forming major portion of the basal plate of penis. Its margins are upturned and the apex notched in the middle.

The Shaft:-

The shaft is a long distal part of the penis lying partly enclosed in the genital sac and connected basally with the basal plate. The shaft possesses two bends, the first near the plate of lamina batilliformis and the second bend near the vesicula spermatica. The shaft is divisible into three regions, a proximal, a middle and a distal region. Of these, the middle and the distal regions are nearly equal in length while the proximal region is very long. The shaft possesses a narrow duct internally which communicates with the haemocoel through the foramen located at its basal end.

(i) The Proximal region:- It is a simple stout rod-like structure protruding ventrally out through the orifice of the genital sac. The proximal region is curved ventro-posteriorly near its origin from the basal plate. A small area at the base measuring one-fourth of the total length of proximal region, is strongly sclerotized. The sclerotization is continued posteriorly on the ventro-lateral and ventral sides of the shaft also. The remaining portion of the region is membranous. The apex of the region is adorned on each side with 6-7 spines on the lateral wall (Pl. XXX, fig. 9). A median groove which is indistinct in the beginning near the base but becomes deep and broad posteriorwards, runs externally along the membranous wall on the mid-dorsal side of the shaft.

(ii) The Middle region:- The middle region of the shaft is curved and strongly sclerotized except on the dorsal side where the wall is membranous. The sclerotized area is divided posteriorly into two ventro-lateral processes which enclose between them a small membranous ventral area. The median external
groove on the dorsal side of the proximal region is continued along the dorsal membranous wall of the middle region also up to its distal end.

(iii) The Distal region:— The distal region of the shaft is membranous and consists of a glans, a prepuce and an accessory basal fold. The glans is a small imperceptible fleshy fold across the surface situated at the posterior end of the shaft. The wall of the glans is distensible. The prepuce is a 0.238 mm. long, rigid plate which superimposes the middle region of the shaft. It is narrow at the ends and wide in the middle. The lateral margin of the middle portion of the prepuce is drawn out into a prominent tapering dorsal process on each side. The apex is also feebly notched forming two small lobe-like lateral extensions which are directed forward. The accessory fold is present on the ventral wall at the base of the region as a prominent fold stretched transversely and directed forwardly.

The Vesicula spermalis

The vesicula spermalis is an elongated scrotiform vesicle measuring 0.77 mm. in length and situated at the junction of the second and third abdominal venter (Pl. XXX, fig. 6). The vesicle consists of a narrow anterior neck and a long posterior bulging body. The neck region of the vesicula spermalis projects into the genital fossa and the body is situated at the base of the third sternite. The ventral surface of the neck is composed of a large triangular, azure blue membranous area flanked laterally on either side by a black sclerotized limb. The membranous area possesses two prominent folds, the lips which project ventrad and guard the slit-like orifice of the vesicle. The lips are provided with a few hair. The ventral bulging surface of the body of vesicula spermalis is black and heavily sclerotized, and continues laterally into the limbs of the neck. There is a weakly sclerotized band-like azure blue area in the median line of the body. The lateral sides of the body are furnished with
long and stiff hair. The dorsal wall of the vesicle is thin, plain and membranous. It is supported by two strongly sclero-
tized apodemes which are situated one behind the other near the anterior end of the third sternite.

The Anterior apodeme:- The anterior apodeme is a thin, trans-
versely elongated structure situated at the posterior margin of the genital fossa. The lateral ends of the apodeme are directed antero-dorsad.

The Posterior apodeme:- The posterior apodeme is a thick, transversely elongated structure whose middle portion is fused completely with the basal margin of the third sternite. The lateral ends of the apodeme are directed postero-dorsally.
FEMALE REPRODUCTIVE SYSTEM OF ENALLAGMA PARVUM SELYS

1. INTERNAL GENITAL ORGANS

(A) GROSS MORPHOLOGY

The internal genital organs of female Enallagma parvum Selys consist of the same set of organs as found in the Enallagma malaynum Selys described previously.

The Ovaries

The ovaries are a pair of 14.37 mm. long, pale-mud coloured organs extending above the alimentary canal from the base of the abdomen upto the middle of the seventh abdominal segment. The ovaries are united together by a median dorsal ligament which is attached at the extremities to the metanotum and the dorsal body-wall of the ninth abdominal segment.

A large delicate membranous common lateral duct runs longitudinally on the ventro-lateral side of the ovary. It provides attachment to the ovarioles on the dorso-mesal side. The ovarioles are situated one after another in a linear sequence. Each ovariole is an elongated and cylindrical structure, tapering at distal end to form a thread-like terminal filament. The terminal filaments are directed antero-dorsally and lie embedded in the tissue of the median dorsal ligament. The terminal filaments of the anterior ovarioles unite together to form a stout common structure, the apical filament which is attached to the metanotum. The adipose tissue and ramifications of tracheoles are abundantly present among the ovarioles and on the surface of the ovaries. These structures serve to hold the ovaries in position along with the apical filaments and the median dorsal ligament.
The Oviducts

The common lateral ducts emerge out posteriorly from the ovaries and turn immediately downwards and posteriortwards to continue as oviducts. The oviducts become ventrad to the alimentary canal and reach upto the anterior one-fourth of the eighth abdominal segment. Each oviduct is a 1.375 mm. long and comparatively thick-walled tube of almost uniform diameter throughout. The oviducts are surrounded on all sides by fat-bodies.

The Common Median Oviduct

The two oviducts converge posteriorly and join each other to form a very short common median oviduct. It is a translucent membranous tube of comparatively wider dimension and thicker wall than the oviduct. The adipose tissue completely ensheathes the oviductus communis which posteriorly leads into the vagina of the '8th Complex' through a slit-like gonopore.

The '8th Complex'

The '8th Complex' (Pl. XXXI, fig. 1) is a large and prominent structure situated beneath the alimentary canal in the posterior half of the eighth abdominal segment. The '8th Complex' includes a vagina, a bursa copulatrix and a spermatheca, all of which are translucent white in colour.

The Vagina

The vagina comprises the ventro-medial component of the '8th Complex' and is morphologically divisible into a long anterior tubular portion and a short genital atrium.

The Anterior Tubular Portion:

It is characterized by the development of heavy chitini- sation internally facing the lumen and strong musculature on the external side. The muscle fibres are arranged in an orderly way forming definite muscle bundles as follows:
(1) A pair of anterior vaginal muscles
(2) A pair of sterno-vaginal muscles
(3) Longitudinal muscles
(4) Radial muscles

The Genital Atrium:

The genital atrium is a small pocket-like structure situated in the terminal part of the '8th Complex'. It is a thin-walled structure which receives the opening of the anterior tubular portion of vagina on the anterior side. Posteriorly, the genital atrium communicates to the exterior through the vulvar orifice encircled by the bases of valvulae of the ovipositor.

The Bursa Copulatrix

The bursa copulatrix is a large median sac-like translucent structure possessing an elliptical shape (Pl. XXXI, fig. 1) and lying posteriorly directed over the anterior portion of the vagina. The bursa copulatrix is greatly distended so as to obscure the view of the vagina especially in recently mated females. Its proximal part is comprised of a narrow duct termed ductus bursae. The ductus bursae is directed postero-ventrally and enters dorsally into the anteriormost swollen region of the vagina.

The Spermatheca

The spermatheca is a small, club-shaped indistinct organ lying compressed between the bursa copulatrix and the vagina. It arises ventrally from the base of the bursa copulatrix and runs nearly parallel along the ventral surface (Pl. XXXI, fig. 1). The apex of the spermatheca, which is reddish in colour, projects slightly upwards near the subapical region of the bursa copulatrix.
The Accessory Glands

A pair of pale-white accessory reproductive glands are present in the ninth abdominal segment. The two glands lie beneath the terminal part of the gut and above the muscles of the ovipositor. Each gland consists of a sac and a ductule. The proximal portion of the gland comprises the ductule which opens into the dorso-lateral wall of the genital atrium. The ductule enlarges distally and forms the sac of the accessory gland which measures twice the length of the ductule. Usually, the sac of any of the two glands is larger than the other.

(B) HISTIOLOGY

The Ovary

The ovary consists of a large number of ovarioles in which the nurse cells are totally absent. The ovariole is clearly differentiated into three regions as follows:-
(a) Terminal filament, (b) Germarium, and (c) Vitellarium.

Each ovariole is an elongated tubular structure which is broad at the base and narrow apically. It is surrounded by a membranous epithelial sheath. The sheath is composed of greatly stretched cells which are arranged in a single row. It is drawn out anteriorly into the terminal filament which lies embedded in the tissue of the median dorsal ligament. The interior of the terminal filament consists of a syncytial core. Near the terminal filament is situated the germarium in which the cell-boundaries are slightly distinct. The cells of the germarium remain in active phase of proliferation in order to produce oocytes. The vitellarium is the prominent part of the ovariole which is divided into several chambers or follicles, each chamber possessing a single developing oocyte. As soon as an ovum becomes mature it is extruded into the lumen of the common lateral duct. The epithelial sheath of the ovariole is pushed inwards between the two adjoining oocytes to form a cellular envelope, the follicular epithelium. The cells of the follicular epithelium are glandular and secrete the chorion of the egg.
The wall of the common lateral duct is composed of the following three layers from within outwards:— (i) Epithelium, (ii) Musculature, and (iii) Adipose tissue. The epithelium consists of a single tier of short cuboidal cells, each possessing clear cytoplasm and a large spherical nucleus. The nuclei are granular and located towards the apical side. Outer to the epithelium is present a thin layer of longitudinal fibres. The outermost layer is broken at places and comprises the adipose tissue. There is a large lumen in the centre.

The Oviduct

The wall of the oviduct shows a histological structure which is similar to that of the common lateral duct. The lumen of the oviduct is narrow and possesses 2-3 ova placed side by side. It is lined by an epithelium which consists of a single layer of short cuboidal cells with indistinct cell-boundaries. The cytoplasm in the epithelial cells is clear and the nuclei roundish and granular. The muscular layer is well developed and comprises longitudinal muscle fibres only. The layer of the adipose tissue which is present on the outermost side is separated easily during sectioning.

The Common Median Oviduct

The layers that compose the wall of the common median oviduct (Pl. XXXI, fig. 2) are adipose tissue, musculature, basement membrane, epithelium and chitinous intima.

The chitinous intima is very thin and present on the inner margin of the epithelium. The epithelium consists of a single tier of 7 micro large cuboidal cells whose cell-boundaries are indistinct. The cytoplasm of the epithelial cells possess some deeply-staining granules. The nuclei are ovoid in shape, each measuring 4 micra in length and situated near the middle region of the cell. The nucleus bears a central nucleolus and several deeply-staining peripheral granules. The epithelial
cells in the dorsal wall of the oviductus communis are, however, columnar in shape and each measures 12 micra in length. The epithelium is encircled by a thin layer of basement membrane. The musculature is present outside the basement membrane and consists of an inner thin coat of circular muscles and an outer thick coat of longitudinal muscles. The adipose tissue forms a regular and complete layer outside the musculature. There is a lumen in the centre of the duct which is triangular in outline.

A common fasciculus of the paired anterior vaginal muscles is present on the mid-dorsal line of the oviductus communis. This single fasciculus divides into two separate fasciculi near the junction of the oviducts and the oviductus communis.

The Anterior Tubular Portion of Vagina

The orientation of the tissue in the wall of the anterior tubular portion of vagina is as follows:— (i) Chitinous intima, (b) Epithelium, (c) Basal membrane, (iv) Musculature, and (v) Adipose tissue.

The lumen of the anterior tubular portion is cup-shaped anteriorly, wide dorsally and narrow ventrally. It is developed into a pair of small lateral evaginations on the ventral side. The lumen is lined by a chitinous intima which is thin and membranous in the ventral region and the lateral evaginations. However, it is thick and strongly sclerotized on the lateral sides forming a pair of bright coloured lateral plates. The lateral plates of the two sides are connected together dorsally by a thick chitinous layer and ventrally by a membranous layer. Each lateral plate is a vertically placed laminate structure of oblong shape whose anterior margin is concave (Pl. XXXI, fig. 1). In the anterior wall of the vagina there is a heavily sclerotized structure, the collar. The collar is an inverted 'V'-shaped structure which consists of a median, spine-like anterior process and a pair of wing-like lateral arms. The
The wall of the genital atrium is composed of a single layered epithelium which is lined by a chitinous intima. The chitinous intima is thick, colourless and thrown into small folds projecting into the lumen. The epithelial layer comprises a row of small cuboidal cells, each measuring 4 micra in length. The nucleus is quite large and roundish and measures 3 micra in diameter. The cytoplasm is scanty in amount and stains deeply. The muscle layer is extremely thin and surrounded externally by an incomplete layer of adipose tissue.
musculature of the bursa copulatrix consists of a regular coat of longitudinal muscles outside the epithelial layer. A thin wavy layer of basal membrane separates the musculature from the epithelium. The epithelial layer consists of a single tier of cuboidal cells, each measuring 12 micra in length. In the middle of the cell there is a large vesicular nucleus measuring 7 micra in diameter. The nucleus is somewhat ovoid in shape and contains 3-5 deeply-staining granules near the periphery. The cytoplasm is vacuolated and loaded with granules. The chitinous intima is thin and thrown into intricate transverse furrows and ridges. The lumen of the bursa copulatrix is wide when replete with spermatozoa, and compressed when devoid of these. The bursa copulatrix is covered by a thick layer of adipose tissue, especially in young specimens.

The ductus bursae connecting the bursa copulatrix with the vagina, is histologically similar to the bursa except for narrow lumen and cuticular spines projecting ventro-posteriad in the lumen from chitinous intima.

The Spermatheca

The structure of the spermatheca (Pl. XXXI, figs. 1 & 5) is also similar to that of the bursa copulatrix. The lumen is likewise spacious when filled up with spermatozoa, and much reduced when empty. The chitinous intima is very thin, colourless and irregular in outline. The epithelium is composed of large cuboidal cells, each measuring 9 micra in length. The cytoplasm of the epithelial cells is granular and vacuolated. Some of the vacuoles are as large as the cell. The nucleus is also granular, and spherical measuring 5 micra in diameter and usually located nearly in the centre of the cell. The epithelium is glandular and surrounded by a very thin basement membrane. The musculature comprises a thin layer of longitudinal muscle fibres only. The adipose tissue is also present but forms only a thin coat outside the musculature.
The Accessory Glands

The Sac:

The lumen of the sac is spacious and irregular in outline because the epithelial cells are especially grouped in glandular patches (Pl. XXXI, fig. 6). The epithelium is lined internally by a thin colourless chitinous intima and externally by a thin structureless basement membrane. The glandular epithelial cells are columnar in shape, each cell measuring a maximum length of 13 micra and so arranged as to form only a single layer of the epithelium. The secretory granules are accumulated in the apical region of the cells due to which the cytoplasm there assumes a deeper stain. Large empty spaces are often seen in the epithelium. The nuclei of the epithelial cells are granular and oval to spherical in shape, each measuring 5 micra in diameter. The musculature in the present species is composed of an inner layer of circular muscles and an outer layer of longitudinal muscles. The adipose tissue is notably absent.

The Ductule:

The wall of the ductule is covered over by a thick coat of adipose tissue. The muscle layer which is very thick consists of circular muscle fibres only. The epithelium is thin and composed of a row of 6 micra large cuboidal cells which form a layer round the lumen. The cytoplasm of the epithelial cells is totally devoid of granules and vacuoles, a fact indicating non-glandular nature of the epithelium of the ductule. The nuclei are, however, deeply-staining and each measures 3 micra in diameter. The chitinous intima is thick and easily discernible. The lumen is narrow.

2. External Genital Organs

The female external genital organs of E. parvum are similar in structure to those of the E. malaynum described previously.
The Supra-anal Appendages

There is a pair of short, hollow and bluish-green appendages, the supra-anal appendages arising dorso-lateral to the anus from the end of the last abdominal segment (Pl. XXXI, fig. 7). Each appendage is a 0.317 mm. long conical organ provided with a blunt and posteriorly directed apex. The surface of the appendage is covered fully with minute, acutely pointed tubercles and posteriorly directed, long, whitish hair.

The Vulva

The genital atrium opens posteriorly through an aperture, the vulva (Pl. XXXI, fig. 7) located medially at the end of the eighth sternite and surrounded by the antero-proximal ends of the valvulae of ovipositor.

The Subgenital Plate

The posterior border of the eighth abdominal sternite is prolonged caudad beneath the vulva and base of the ovipositor as an arch-shaped structure termed the subgenital plate (Pl. XXXI, fig. 8). It is a prominent, green coloured organ which protects the base of the ovipositor. Apically, it bears a stout, median black spine which extends posteriorly upto the anterior quarter of the ninth abdominal segment.

THE OVIPOSITOR

The First Valvifers

These are a pair of weakly sclerotized triangular plates situated beneath the distal end of the eighth abdominal sternite (Pl. XXXI, figs. 3 & 7). The mesal process of the valvifer is small and connected to that of the other side by a thin membrane. The anterior apophysis of the valvifer is borne at the antero-lateral edge and projects internally.
The Second Valvifers or Lateral Valves

The whole of the ninth abdominal venter is occupied by the base of a pair of large flattened structures, the lateral valves (Pl. XXI, figs. 7). The lateral valves are pale-blue coloured weakly sclerotized processes, each measuring 1.232 mm. in length and composed of a basal portion and a style.

The Basal portion:-

It is the broad portion of second valvifer which is provided with hair on the external surface, denticles on the ventral border and two heavily sclerotized apophyses near its base. The anterior apophysis is a narrow hood-like structure projecting mesally on the internal side. On the lateral side, the anterior apophysis is attached to the ninth tergite through a lancet-shaped laterotergite. The posterior apophysis is a hard vertical process provided with a small curved spine at the apex.

The basal portions of the second valvifer of each side are connected together in the anterior half by a thin inner-valvular membrane which forms the ventral wall of the ninth abdominal segment. Externally, the intervalvular membrane bears a median groove which is bounded on the sides by the second valvifers. The intervalvular membrane is attached posteriorly to a transversely elongated and curved sclerite, the posterior intervalvular sclerite. The anterior intervalvular sclerite is a small chitinized piece present near the anterior margin of the membrane on the inner side.

The basal portion extends posteriorly beneath the tenth segment as an elongated cylindrical structure which bears apically a hollow membranous fold, the gonoplac. The gonoplac is directed posteriorwards. It is provided with a longitudinal shallow groove in which the valvulae are safely placed at rest. The apex of the gonoplac bears a group of 2-4 long hair directed poste-riard.
The Style:

The style is a hollow, stout, curved bristle-like unjointed organ measuring 0.252 mm. in length and arising from the distal end of the basal portion of lateral valve. It is a prominent process which lies ventro-lateral to the gonoplace. The proximal quarter of the style is coloured greenish-yellow while the remaining portion is blackish-brown. The surface of the style is furnished with sparsely distributed short hair. There is a small oval area on the ventro-mesal side of its apex where small, cilia-like hair are densely present. The style is directed postero-mesally and regarded sensory in nature.

The First Valvulae

The first valvulae (Pl. XXXI, figs. 3 & 7) are a pair of strongly sclerotised processes, each measuring 1.056 mm. in length and consisting of an anterior ramus and a posterior shaft. The rami are horizontally placed plates which meet each other anteriorly to form an arch-like structure. Each ramus also bears a small wing-like lateral process and a prominent dorsal process. The shaft is an elongated, slender extension of the ramus. It is slightly curved and sharply pointed at the distal end. The distal one-third region of the shaft is serrated on the external surface.

The Second Valvulae

The second valvulae are situated slightly posterior and dorsal to the first valvulae (Pl. XXXI, fig. 7). Each valvule measures 0.964 mm. in length and consists of a basal ramus and an apical shaft. The ramus comprises a vertical plate which is concave mesally and convex laterally. The lateral surface bears a prominent dense patch of short hair. Each ramus extends posteriorly into an elongated, slender shaft which is acutely pointed at the extremity. The distal one-third area of each shaft is denticulated on the external surface. The denticulate area is produced by the presence of numerous small, forwardly
directed teeth, each alternating with a transverse pleat. This forms the cutting edge of the valvule.

Both the pairs of valvulae are interlocked together enclosing a narrow lengthwise canal.

The Gonangula

The gonangula in *E. parvum* Selys do not show any variation in position and structure from that of the previously described species, *E. malaynum* Selys. Each gonangulum has the usual dorsal and ventral articulation with the ninth tergum and the ramus of the first valvule respectively (Pl. XXXI, fig. 7).
1. **INTERNAL GENITAL ORGANS**

(A) **GROSS MORPHOLOGY**

The internal genital organs consist of a pair of testes, a pair of vasa deferentia, a median sperm sac and a minute ejaculatory duct. Accessory glands are totally absent.

The Testes

There are two testes in *Copera* which are present in the posterior one-third of the seventh and whole of the eighth abdominal segments on the dorsal side of the alimentary canal. The testes of the two sides remain conjoined by a thin median strand of connective tissue throughout their length. The strand of connective tissue attaches itself posteriorly to the tergum of the ninth abdominal segment. Each testis is an elongated, cylindrical, multilobular organ measuring 3.45 mm. in length and appearing translucent white in living insects. The length and position of the testes vary in different specimens but within limits described earlier. The testes are enveloped in a sheath of adipose tissue which is produced anteriorly beyond the gonads as suspensory filaments. The suspensory filaments attach the testes anteriorly to the tergum of the sixth abdominal segment. The testes are held firmly in position by suspensory filaments, tracheae, fat-bodies and the median strand of connective tissue.

The Vasa Deferentia

The testis is continued posteriorly as a vas deferens (Pl. XXXII, fig. 1) which runs on the dorso-lateral side of the alimentary canal for some distance in the beginning and becomes latero-ventral to it later on. Finally, the vas deferens comes to lie on the ventral side of the alimentary canal in the middle
of the ninth abdominal segment. The vas deferens is a convoluted tube measuring 1.87 mm. in length in straightened condition. It is divisible morphologically into three regions, a proximal tubular region, a middle distended region and a narrow distal region. The proximal tubular region consists of two limbs, a descending limb connecting it with the testis and an ascending limb opening into the distended middle region of the vas deferens. The descending and ascending limbs of the vas deferens are situated dorso-lateral and ventro-lateral to the alimentary canal respectively. Adipose tissue forms a regular covering over this region of the duct.

The middle distended region of vas deferens is a slightly enlarged vesicular structure lying on the lateral side of the sperm sac. It is thin walled and stores spermatozoa.

The distal region of vas deferens is comparatively narrow and opens terminally into the sperm sac on the ventro-lateral side.

**The Sperm Sac**

The sperm sac is a median antero-posteriorly elongated bilobed organ of translucent white colour measuring 0.343 mm. in length and 0.193 mm. across at the constricted region. It is located in the middle of the ninth abdominal segment beneath the alimentary canal and is formed by the union of the two vasa deferentia (Pl. XXXII, fig. 1). The two lobes of the sperm sac are anterior and posterior in position. The anterior lobe of the sperm sac receives on its ventro-lateral sides the openings of the narrow distal region of the vasa deferentia. The ventral wall of the sperm sac rests on a chitinous structure present on the anterior side of the gonopore.

**The Ejaculatory Duct**

The anterior lobe of the sperm sac communicates ventrally with the gonopore through an ejaculatory duct of microscopic size. The minute ejaculatory duct is lodged in the cavity of a broad chitinous structure.
(B) HISTOLOGY

The Testis

The wall of the testis (Pl. XXXII, fig. 2) is composed of a peritoneal layer on the inner side and an adipose tissue layer on the outer side. The adipose tissue consists of large fat cells with prominent granular nuclei and highly vacuolated cytoplasm. Tracheae and tracheoles form a network in the adipose tissue.

The peritoneal layer is a thin and distinct layer of stretched cells, each containing a prominent nucleus occupying most of the space in the interior. There are two shapes of cells in the peritoneum, spherical and elliptical. A spherical cell measures 3 micra in diameter and possesses a large globular nucleus bearing an eccentrically placed nucleolus. The elliptical cells are flattened in shape, each measuring 5 micra in length and 2 micra across and possessing an elongated granular nucleus.

A very large number of lobules is contained within the wall of the testis. The lobules are connected by fine ductules to a common duct running throughout the length of the testis on the lateral side within the peritoneal limits. The wall of the common lateral duct consists of an outer muscular layer and an inner epithelial layer. The muscular layer is thin and comprises circular muscle fibres only. The epithelial layer is thick and composed of columnar cells which are arranged in a single layer in the wall on outer side of the duct. The epithelium on the inner side of the wall is, however, two or three cells thick. The cytoplasm in an epithelial cell of the outer wall of the lateral duct is vacuolated near the basal end and granular towards the apical side. The nucleus is spherical in shape measuring 8 micra in diameter and containing four or five deeply-staining granules inside the nuclear membrane. The epithelial cells of the inner wall of the lateral duct are packed with highly granular cytoplasm which is lacking in vacuoles. The nuclei are elliptical in shape, each measuring 9 micra long and
possessing a central nucleolus in addition to numerous deeply-staining granules. A few spherical nuclei are also seen in the multilayered epithelium. The epithelial cells rest on a basement membrane. The lumen is narrow in the anterior region of the duct and spacious in the posterior region where it contains sperm masses also.

The lobules:

A lobule is almost a spherical and solid mass of germ cells bounded externally by a very thin limiting membrane. There is no germinial epithelium. All the germ cells of a lobule are alike and represent a particular stage of spermatogenesis. Different lobules contain germ cells in different stages of spermatogenesis. The lobules containing spermatocytes and sperm masses are situated near the lateral duct and those containing germ cells in earlier stages of spermatogenesis are located away from the duct. The lobules open separately into the lateral duct through very minute ductules which possess the same histological structure as the lobules.

The Vas Deferens

The wall of the vas deferens consists of the following layers from within outwards:— (i) Epithelium, (ii) Basement membrane, (iii) Musculature, (iv) Peritoneal layer, and (v) Adipose tissue.

The epithelium is composed of a row of large cuboidal cells arranged round a central lumen, usually containing sperms. Each epithelial cell rests on a basement membrane and possesses a slightly granular cytoplasm and a large nucleus of oval shape, the latter provided with many deeply-staining granules. The musculature consists of circular muscle fibres only, on the outer side of the basement membrane. External to the musculature is situated a peritoneal layer which is composed of greatly stretched cells with granular, elongated nuclei. The adipose tissue is present on the outermost side in the wall of the vas
deferens forming a regular layer round the duct.

Histologically, the wall of the proximal tubular region of vas deferens is surrounded by a thick coat of adipose tissue. The epithelium consists of large cuboidal to columnar cells replete with secretion and separated by distinct cell-membranes (Pl. XXXII, fig. 3).

The wall of the distended middle region is thin and consists of small cuboidal cells in the epithelial layer. The nuclei are highly granular in appearance and elliptical in shape. The lumen is spacious and filled with a secretion in which sperms are present in a definite arrangement (Pl. XXXII, fig. 4). The spermatozoa near the periphery form a single layer of sperm groups, each adhering to the apical side of the epithelium. However, in the centre, the sperms lie scattered in granular secretory material.

The distal region (Pl. XXXII, fig. 5) shows a structure which is histologically similar to that of the middle distended portion of vas deferens except that (a) its lumen is small, (b) epithelium is thin, (c) musculature is thick, and (d) adipose layer is irregular.

The Sperm Sac

The orientation of the tissue in the wall of sperm sac (Pl. XXXII, fig. 5) is as follows:

(i) Epithelium, (ii) Basement membrane, (iii) Musculature,
(iv) Peritoneum, and (v) Adipose tissue.

The epithelial layer of the sperm sac is very thin and consists of small flat cells with granular rounded nuclei. The basal ends of the epithelial cells are supported on a basement membrane. The musculature is well developed and composed of striated circular muscle fibres which are specially thick on the ventral side. A distinct peritoneal layer is present next to the musculature on the outer side. The adipose tissue is also
present in the form of a thin discontinuous layer round the wall of the sperm sac. In the centre, the sperm sac possesses a spacious cavity which is not lined by chitinous intima. It is replete with secretion and contains spermatosoa arranged in two zones, a peripheral zone of sperm masses and a central zone of scattered spermatosoa.

The Ejaculatory Duct

The conical ejaculatory duct (Pl. XXXII, fig. 6) shows the same histological structure as the sperm sac except that its lumen is lined by a thin chitinous intima and is devoid of spermatosoa. Moreover, the epithelium of the ejaculatory duct is prominent and consists of columnar cells, grouped in patches at places. The cytoplasm of the epithelial cells is dense and granular. The nuclei are large and spherical, each measuring 5 micra in diameter and containing several deeply-staining granules. The musculature is also quite thick and consists of an inner longitudinal muscle layer and an outer circular muscle layer. Adipose tissue is also present in the vicinity of the duct. The ejaculatory duct connects the sperm sac to the male gonopore.

2. EXTERNAL GENITAL ORGANS

Male external genitalia of copera consist of a pair of small supra-anal appendages, a pair of long infra-anal appendages, a pair of small coxites on the ninth abdominal sternum and a secondary copulatory apparatus on the ventral side of the second and a part of the third abdominal segments. The male genital aperture is situated in the mid-ventral line on the ninth abdominal segment.

The supra-anal Appendages

There is a characteristically small pair of stumpy
conical appendages, the supra-anal appendages coming out dorso-laterally from the terminal end of the tenth abdominal segment (Pl. XXIII, fig. 1). The apex of the appendage is obtuse and directed ventrad as a hook-like structure (Pl. XXIII, fig. 2). Each supra-anal appendage is 0.252 mm. long, the size being less than one-fourth of the length of infra-anal appendage. It is whitish in teneral forms and pale-yellow coloured in the sexually mature forms. The surface of the appendage is rich in hair and tubercles.

The Infra-anal Appendages

There is a pair of 1.468 mm. long, cylindrical infra-anal appendages situated beneath the supra-anal appendages on the ventro-lateral sides of the anus (Pl. XXIII, fig. 1). Each infra-anal appendage is broad at the base, bluntly rounded at the apex and possesses a wide depression on mesal side. Tubercles and hair are abundantly present all over the surface of the appendage except on the basal region and the mesal depression. The infra-anal appendages are coloured pale-yellow with black lateral margins and are characteristically longer in size than the supra-anal appendages.

The Male Gonopore

The male genital opening is situated between a pair of small coxites on the ventral surface of the ninth abdominal segment and is slightly displaced posteriorly from the middle position (Pl. XXIII, fig. 3). The gonopore is a circular orifice measuring 0.128 mm. in diameter and outlined by a sclerotized ring. The wall of the gonopore is invaginated to form a broad tubular chitinous structure which supports the ejaculatory duct and a portion of sperm sac. During sperm translocation from the ninth to the second abdominal segment the wall around the gonopore is exerted out as a small tube carrying the gonopore at its apex.
The Coxites:

The coxites are a pair of small, weakly sclerotized, elliptical structures measuring 0.468 mm. in length and located on either side of the gonopore in the posterior half of the ninth abdominal segment. These have been described as 'genital valves' by Walker (1953) and consist of a broad basal portion and a tapering apical portion. The basal portion is fused with the sternum and the apical portion remains projecting from it as a tapering stylus-like structure. The coxites are whitish-pale in colour and bear numerous minute tubercles and long posteriorly directed hair on the ventral surface.

The Anterior genital plate:

The portion of the ninth sternum lying anterior to the gonopore is strongly sclerotized to form an anterior genital plate. It is a large pale-white plate measuring 0.466 mm. long and 0.659 mm. wide which shows identical black markings on the lateral sides and a mark in the median line. The surface of the anterior genital plate is covered with numerous minute tubercles and sparsely distributed hair.

The Post-genital plate:

It is a whitish chitinous plate which is broader than long measuring 0.18 mm. in length and 0.547 mm. in width and situated posterior to the genital pore. The post-genital plate seems to have developed as a result of secondary chitinization and sclerotization of the intersegmental membranous area behind the gonopore. It is united anteriorly with the anterior genital plate, laterally with the pleural membranes and posteriorly with the tenth sternite. Hair are characteristically absent on the surface of the post-genital plate, which however, possesses numerous tubercles only.

THE SECONDARY COPULATORY APPARATUS

The secondary copulatory apparatus in male copera
consists of several sclerites and structures associated with the act of copulation lodged compactly in the genital fossa (Pl. XXXII, fig. 7). These include anterior lamina, hamuli anteriores, lamina batilliformis, genital sac, framework and hamuli posteriores. In addition to these, there is a median penis serving as intromittent organ and a vesicula spermatica which stores seminal fluid.

The Genital Fossa

The ventral surface of the second abdominal segment is invaginated to form a deep cavity, the genital fossa in which all the organs of the secondary copulatory apparatus are lodged. The genital fossa is bounded anteriorly by the anterior lamina, posteriorly by the anterior portion of third sternite, laterally by the hamules and dorsally by the chitinous framework.

The Anterior Lamina

The anterior lamina (Pl. XXXII, fig. 8) is a 0.612 mm. long more or less rectangular chitinous plate forming the anterior border of the genital fossa. A strongly sclerotized transverse apophysis on the superior side marks the limit of the anterior margin of the lamina. The posterior margin of the lamina is emarginated in the middle to form an inverted 'V'-shaped cleft and two lateral limbs. The mesal margin of each limb is provided with 10-12 hair projecting into the cavity. The notch is covered dorsally by a membrane forming internally a 0.662 mm. long sac-like structure, the median laminar sac. Anteriorly, the sac narrows and divides to form two closely apposed processes which project into the first abdominal segment. The anterior lamina is coloured pale white and bears a few small hair on the ventral surface.

The Hamuli Anteriores

The anterior hamules are a pair of well developed chitinous black coloured structures (Pl. XXXII, fig. 3) placed
laterally in the genital fossa and united on the sides with the ventro-lateral borders of the second tergite through pleural membranes. Each hamule consists of a large outer and a small inner plate. The outer plate is 0.41 mm. long and 0.38 mm. broad, more or less quadrat in shape and united basally with the limb portion of the anterior lamina. The antero-mesal corner of the outer plate is produced into a forwardly directed spine-like process. The inner plate of the hamule lies on the dorsal surface of the outer plate and the two are connected mesally. The inner plate comprises a mesal membranous part and a lateral strongly sclerotized part. The sclerotized part is divisible into two regions, a basal posterior region and an anteriorly directed apical region, the latter being curved like a hook.

The Lamina Batilliformis

The lamina batilliformis is present above the cleft of the anterior lamina nearly in the middle of the genital fossa (Pl. XXXII, fig. 8). It measures 0.569 mm. in length and consists of a scoop-like plate which is notched in the middle on the posterior side forming a pair of postero-lateral limbs (Pl. XXXII, fig. 4). Each limb is strongly sclerotized and terminally reflexed towards the dorsal side to form a cornu which is incurved apically. A few hair are present in a row on the ventral surface of the limbs and projecting towards the notch of the lamina batilliformis. The plate of the lamina batilliformis is scooped deeply with its concavity facing dorsally. It supports the median laminar sac on its margin.

The Genital Sac

It is a large membranous chamber projecting into the cavity of second abdominal segment and opening ventrally (Pl. XXXII, fig. 7). The sac protects the proximal part of the penis which is lodged in its cavity. The sac is supported anteriorly by the lamina batilliformis, posteriorly by the median
plate of frame and laterally by the bars of the framework.

The Framework

The framework is skeletal structure of the secondary copulatory apparatus composed of a pair of anterior vertical bars, a pair of lateral longitudinal bars and a posterior median plate (Pl. XXXIII, fig. 5).

The Anterior Vertical Bars:

These are a slender pair of 0.54 mm. long bars directed antero-vertically upward towards the median line and giving support to the genital sac and anterior sclerite of the penis.

The Lateral Longitudinal Bars:

The lateral longitudinal bars are a pair of 0.367 mm. long bars present laterally in genital fossa and giving support to the genital sac and other structures of the frame. Its anterior ends are attached to the ventral apices of the vertical bars at the level of hamuli anteriores to which it gives strength also.

The Posterior Median Plate:

It is a 0.49 mm. wide rectangular plate (Pl. XXXIII, fig. 6) which is situated dorsad to the neck of vesicula spermatica in the posterior part of the genital fossa. Both the anterior and posterior margins of the plate are notched doubly to form small median processes. The antero-lateral margins of the plate are extended as anterior limbs and the postero-lateral margins are produced backwards as posterior limbs. Each anterior limb gives out a subapical mesad process before articulating with the lateral longitudinal bar of the frame. The stumpy posterior limbs of the median plate unite with the lateral extremities of the anterior apodeme of vesicula spermatica. The ventral surface of the median plate of the frame is beset with numerous hair which are longer near the base of anterior limbs.
The Hamuli Posteriores

The posterior hamules are a pair of simple, strongly sclerotized structures borne on the ventral side of the apices of the anterior limbs belonging to posterior median plate (Pl. XCVIII, fig. 6). Each hamule is a small, 0.223 mm. long, hollow, flattened, club-like structure bearing hair all over the surface.

The Penis

The penis in Copera is a prominent median unsegmented rod-like 'Z'-shaped organ located ventrally in the second abdominal segment (Pl. XCVI, fig. 7). The penis lacks an orifice and is not connected with the vesicula spermatica. At rest, the penis lies flat in the genital fossa along the median line with its distal end lodged between neck of the vesicula spermatica and the median plate of the frame. The penis is protruded from the genital fossa only during copulation. It is morphologically divided into a small basal plate and a long shaft (Pl. XCVIII, fig. 7).

The Basal Plate:

The strongly sclerotized antero-proximal part of the penis which is incorporated in the roof of genital sac is termed the basal plate. The basal plate comprises an anterior sclerite and a posterior sclerite which enclose between their bases a small foramen that connects the haemocoel with a narrow lumen in the shaft.

The Anterior sclerite:– The anterior sclerite is a 0.316 mm. wide horizontal structure which is supported at the ends by the anterior vertical bars of the frame.

The Posterior sclerite:– The posterior sclerite of the basal plate is a 0.432 mm. long spoon-shaped structure which possesses a narrow base, a large rounded apex and a concavity on the dorsal side.
The Shaft:-

The remaining part of the penis is the shaft which is proximally united with the basal plate. Internally there is a long narrow duct opening only at the base of the shaft. The shaft is morphologically divisible into three regions, a proximal region, a middle region and a distal region.

(i) The Proximal region: The proximal region is longest of the three regions of shaft which is curved ventrally near its origin. Later on, it extends posteriorwards along the median line in the genital fossa. The proximal region of the shaft is sclerotized heavily on the ventral and lateral surfaces but is membranous dorsally. The sclerotized area is produced distally into a small dorsal process on each side.

(ii) The Middle region: The middle region of the shaft is shorter and wider than the proximal region. Its dorsal and lateral walls are membranous and only the ventral wall is sclerotized. A median groove runs externally along the membranous dorsal surface of the proximal and middle regions. The groove is narrow and shallow in the proximal region but broad and deep in the middle region of the shaft.

(iii) The Distal region: The distal region of the shaft measures 0.216 mm in length and consists of a glans and a prepuce. The glans is a median membranous fold situated at the posterior extremity of the shaft. The fold becomes a knob-like structure when distended. The prepuce is a comparatively large membranous part which usually lies bent over the ventral surface of the middle region. It becomes wide anteriorly where the apical margin is deeply emarginated forming a pair of wing-like lobes projected latero-dorsad.
The Vesicula Spermalis

The vesicula spermalis (Pl. XXXIII, fig. 6) is a 0.814 mm. long, flask-shaped median receptacle borne by the third sternite and lying in the posterior part of the genital fossa. The vesicle consists of an anterior neck and a bulging body. The neck is strongly sclerotized along the ventro-lateral surface forming a pair of limbs. The apices of the limbs are directed mesad and enclose a membranous area on the ventral side in which a slit-like orifice of the vesicle is located at the front margin. The ventral bulging surface of the vesicula spermalis is hard and chitinized especially on the sides where strong sclerotization results into a pair of ventro-lateral sclerites. A few hair are also present on the antero-lateral side of the ventral surface of vesicle. The dorsal wall of the vesicula spermalis is membranous and strengthened by an anterior and a posterior apodeme.

The Anterior Apodeme:— The anterior apodeme is a thin, curved, sclerotized transverse structure situated at the posterior extremity of the second abdominal sternite. It gives mechanical support to the dorsal wall of the vesicula spermalis.

The Posterior Apodeme:— The posterior apodeme is a stout bar placed transversely at the anterior end of the third sternite with which it is fused also. It is slightly expanded at the two ends which are dorsally directed.

The lumen of the vesicula spermalis bears no internal connection either with haemocoel, or penis or genital fossa.
The female reproductive system of **Copera marginipes** (Ram.) consists of two parts:

1. Internal genital organs
2. External genital organs

### 1. INTERNAL GENITAL ORGANS

**(A) GROSS MORPHOLOGY**

The internal genital organs consist of a pair of ovaries, a pair of oviducts, a common median oviduct and an '8th Complex'. There is a pair of accessory glands also which open into the terminal part of the system.

**The Ovaries**

The ovaries are a pair of 22.5 mm. long, pale-white organs (in fresh condition) extending from the anterior region of the first abdominal segment. The two ovaries are placed mid-dorsal to the gut upto the sixth segment and thereafter, become subdorsal to it extending upto middle of the seventh segment of abdomen. The ovaries of the two sides are united by a large median dorsal ligament which is anteriorly attached to the dorsal body-wall of the metathorax and posteriorly to the tergum near the end of the ninth abdominal segment.

An ovary is composed of a common lateral duct and numerous ovarioles. The common lateral duct is a large, thin-walled tube running longitudinally on the ventro-lateral side of the ovary throughout its length. The ovarioles are arranged longitudinally on the dorso-mesal side of the common lateral duct. The arrangement of the ovarioles on the common lateral duct differentiates between the dorsal and ventral surfaces of the ovary. Each ovariole is a long, thread-like structure which
tapers into the terminal filament at the distal end. The terminal filaments of the ovarioles are directed anteriorwards and lie embedded in the tissue of the median dorsal ligament. However, the terminal filaments of the anterior ovarioles combine together to form a thick cord, termed the apical filament of the ovary. The apical filaments of the two ovaries converge anteriorly to become attached to the dorsal wall of the metathorax at a common point. The ovaries are richly supplied with tracheae and tracheoles which form a dense reticulum on the surface. Fat-bodies in the form of adipose tissue are also found adhering to the ovarian surface at places. These separate off easily from the gonad. The ovaries are held in position by the terminal filaments, the median dorsal ligament and the network of the tracheae and fat-bodies.

The Oviduct

The common lateral ducts running throughout the length of the ovaries, continue posteriorly on the lateral sides of the alimentary canal as paired oviducts. Each oviduct is a thin-walled tube measuring 2.375 mm. in length; its diameter decreasing gradually posteriorwards. The oviduct extends from the middle of the seventh abdominal segment unto the anterior region of the eighth abdominal segment (Pl. XXXIV, fig. 1). In the beginning the oviduct is subdorsal to the gut, then turns ventralwards and inwards and finally comes to lie below the alimentary canal. The surface of the oviduct is covered with large amounts of adipose tissue and tracheal network.

The Common Median Oviduct (Oviductus Communis)

The two oviducts join each other in the anterior part of the eighth abdominal segment to form a short but distinct duct, the common median oviduct (Pl. XXXIV, fig. 1). It lies in the second quarter of the segment underneath the alimentary canal and eighth abdominal ganglion. The common median oviduct opens posteriorly into the '8th Complex' through an aperture termed the female gonopore.
The '8th Complex'

The '8th Complex' is a composite translucent structure present in the posterior half of the eighth abdominal segment below the hind-gut (Pl. XXXIV, fig. 1). It is formed of vagina, bursa copulatrix and spermatheca.

The Vagina

The main part of the '8th Complex' is comprised of the vagina which lies on its ventral side. The vagina is divisible into an anterior tubular portion and a posterior genital atrium (Pl. XXXIV, fig. 2).

(a) The Anterior Tubular Portion:–

It is the major portion of the vagina present on the ventro-median side of the '8th Complex'. The portion receives anteriorly the openings of two ducts, the common median oviduct from the ventral side and the ductus bursae from the dorsal side. Posteriorly, the anterior tubular portion leads into the genital atrium. The anterior tubular portion is a strongly muscular organ in which the muscles are arranged in an orderly fashion as follows:–

(i) The Anterior vaginal muscles:– These are a pair of long bundles of muscles which are inserted at one end on the anterior wall of the vagina near the gonopore. The other end is attached to the sternum of the seventh abdominal segment.

(ii) The Sterno-vaginal muscles:– These are a pair of thick, stumpy muscles, one on either side of the vagina (Pl. XXXIV, fig. 1). At one end, the sterno-vaginal muscles are attached to the lateral wall of the anterior tubular portion and at the other end to the eighth abdominal sternite.

(iii) The Longitudinal muscles:– The longitudinal muscles are bow-shaped in appearance and run along each lateral side of the
tubular portion (Pl. XXXV, fig. 1). These are attached at both the ends on the vagina itself.

(iv) The Radial muscles: - A few muscle fibres run from the dorso-lateral, lateral and ventral sides of the vagina especially in the posterior region, and become attached to the sternum. These are termed radial muscles.

Internally, the wall of the anterior tubular portion of the vagina is strongly chitinized and thickened at places forming the characteristic cuticular structures, the collar and lateral plates.

(b) The Genital Atrium: -

The anterior tubular portion of the vagina communicates with the vulva through a small chamber-like tube, the genital atrium. It is a thin-walled structure which lies wrinkled when empty. The genital atrium serves to hold the ovum temporarily in its lumen before extrusion through the vulvar orifice.

The Bursa Copulatrix

The bursa copulatrix is a small roundish organ situated above the anterior end of the vagina (Pl. XXXIV, fig. 2). It communicates with the vagina through a small narrow duct, the ductus bursae which is directed postero-ventral. The bursa copulatrix receives the intromittent organ of the male during copulation and stores spermatozoa after deposition.

The Spermatheca

The spermatheca is a median, elongated diverticulum like posteriorly directed structure overhanging the dorsal side of the vagina (Pl. XXXIV, fig. 2). It is a translucent organ which lies surrounded by a coat of adipose tissue. The adipose tissue is thick in the basal region of spermatheca and thins out gradually towards the apex, thereby providing a conical shape
to the organ. In a KOH-treated preparation, the adipose tissue is dissolved and then the spermatheca appears club-shaped. The spermatheca opens into the middle of the bursa copulatrix from the dorsal side.

The Accessory Glands

A pair of dirty-white coloured accessory glands are located ventral to the rectum behind the '8th Complex' in the ninth segment of abdomen (Pl. XXXIV, fig. 1). Each gland comprises a proximal ductule and a distal bulb-like saccular portion. The ductule is very small, nearly half the size of the sac. It is a slender thread-like duct which opens dorso-posteriorly into the region of the genital atrium lying close to the vulva. The sac of the gland is an elongated, cylindrical organ curved near apex.

(B) HISTOLOGY

The Ovary

Each ovary is composed of a very large number of panoramic ovarioles which are closely arranged on the dorso-mesal side of the common lateral duct. An ovariole (Pl. XXXIV, fig. 3) is an elongated thread-like organ, broad proximally and tapering to a point at the free end. It contains a chain of developing ova arranged one over the other in a single row, the oldest being situated at the base near the union of the ovariole with the common lateral duct. Each ovariole is surrounded by a very thin cellular membrane forming the epithelium. The cellular nature of the epithelium is clearly evident in between the spaces of adjacent developing ova. In the germarium region the epithelial sheath is very thin consisting of greatly stretched cells, but posteriorly in the region of the vitellarium the cellular nature is prominently exhibited by the epithelial wall which also forms a follicular epithelium round the developing oocytes. The chorion of the ovum is secreted by the follicular epithelium. The
epithelium of the wall of the ovariole is continuous with that of the common lateral duct. The following regions of the ovariole are clearly differentiated in this damselfly:

(i) The Terminal filament: It is a small, delicate apical prolongation of the wall of the ovariole holding the latter in its position by becoming embedded in the tissue of the median dorsal ligament. Such threads of many anterior ovarioles form collectively a large apical filament of the ovary.

(ii) The Germarium: It is a small region of undifferentiated germ cells situated next to the terminal filament near the apical end of an ovariole. The cells of the germarium divide actively to produce a large number of germ cells which descend down into the vitellarium as oocytes.

(iii) The Vitellarium: The remaining portion of the ovariole forms the large vitellarium in which ova in different stages of development are present.

The Median Dorsal Ligament:

The median dorsal ligament is composed of a non-cellular matrix of connective tissue in which fat-bodies, a few muscle fibres and terminal filaments of the ovarioles are present.

The Common Lateral Duct:

The wall of the common lateral duct is composed of two layers, an epithelial layer on the inner side and a muscle layer on the outer side. The epithelial layer surrounds the lumen of the duct and consists of small columnar cells arranged in a single row. The cell-boundaries are indistinct. Each cell possesses a large, non-granular and vesicular nucleus near its apical end. A single large nucleolus is prominently present in the nucleus. The epithelial layer on the inner side consists of relatively larger cells and is apparently more developed than
that of the outer side. The muscle layer is thin and consists of longitudinal muscle fibres. There is a large lumen in the centre of the duct. The outer wall of the common lateral duct is nearly smooth while the inner wall shows a large number of irregular foldings due to the fact that this side gives rise to ovarioles.

The Oviduct

The wall of the oviduct shows the same layers as the wall of the common lateral duct with minor differences:

(i) The epithelium is 7 micra thick and consists of a tier of cuboidal cells round the lumen. Each cell possesses a 4 micra large nucleus of spherical shape. (ii) The epithelium forms a regular, smooth and uniform layer all round on the inner side. (iii) The muscular coat is comparatively thick. (iv) The lumen is spacious.

The Common Median Oviduct

Histologically, the oviductus communis (Pl. XXXIV, fig.4) is similar to the oviduct, and shows a well developed musculature and fat-bodies on the outer side and a thin chitinous intima internally.

The epithelium consists of a layer of 9 micra long cuboidal cells arranged in a single row. Each cell possesses a granular cytoplasm and spherical nucleus. The nucleus measures 5 micra in diameter and lies near the apical end of the cell. The epithelial cells rest externally upon a basement membrane. The musculature comprises an inner layer of circular muscles and an outer layer of longitudinal muscles. The lumen of the common median oviduct is narrow and allows only one ovum at a time to pass. It communicates posteriorly with the vagina. A pair of anterior vaginal muscles of the vagina run along the dorsal surface of this duct. In the present specimen only one of them is seen. Perhaps, the other was separated off during sectioning.
The Anterior Tubular Portion of Vagina

Beginning from inside, the orientation of layers in the wall of tubular vagina (Pl. XXXIV, fig. 5 and Pl. XXXV, fig. 1) is as follows:—

(i) Chitinous intima, (ii) Epithelium, (iii) Basement membrane, and (iv) Musculature.

The central lumen of the anterior tubular portion is wide anteriorly and laterally compressed posteriorly. It receives the opening of ductus bursae on the antero-dorsal side and the opening of oviductus communis (gonopore) on the antero-ventral side. The sperms reach from the former and ova from the latter for fertilization to take place in the anterior region. Ventrally, the lumen sends out a pair of lateral evaginations. The lumen of the anterior tubular portion of vagina is lined by a thick chitinous layer which is modified at places to form the collar and lateral plates. The collar is present in a dorso-ventral plane in the anterior part of the vagina and comprises a central portion and a pair of lateral arms. The antero-ventral end of the central portion is produced forward as a short spiny process, the anterior process of the collar. A wing-like transverse process arises on each lateral side of the central portion to give rise to the lateral arm which is directed posterior-ventrally. The lateral arms project into the cavity of the vagina. The lateral plates are present in the lateral wall of the vagina. These are connected together dorsally and ventrally by chitinous membranes.

The chitinous layer is surrounded externally by a tier of cuboidal cells forming the epithelium. Each epithelial cell measures 10 micra in length and possesses a prominent nucleus in the middle region. It is highly granular in appearance and roundish in shape measuring 6 micra in diameter. The basal ends of the epithelial cells are supported on a smooth and structureless basement membrane.
The musculature in the vagina is strongly developed and consists of striated muscle fibres which are grouped in definite muscle bundles. These have been described earlier with the morphology of the organ. The anterior process of the collar provides attachment to the anterior vaginal muscles. The lateral plates provide surface for insertion of the sterno-vaginal and the radial muscles. The bow-shaped longitudinal muscles are anteriorly attached on the lateral arms of the collar and posteriorly near the dorsal membrane connecting the two lateral plates. Large amount of adipose tissue is also present scattered among the muscle fibres.

The Genital Atrium

The histological structure of the genital atrium of vagina is almost similar to that of the anterior tubular portion with the difference that its wall is very thin and non-muscular. The epithelium consists of brick-shaped cells, each measuring 5 micra in length and possessing a 3 micra large ovoid nucleus. The cytoplasm and the nucleus both are granular and stain deeply. The epithelium is lined internally by chitinous intima which appears colourless and unsclerotized. Anteriorly, the genital atrium receives the opening of the tubular portion of the vagina and on the posterior side, it opens out through the vulva.

The Bursa Copulatrix

The epithelium of the bursa copulatrix (Pl. XXXIV, figs. 5 & 6) consists of a layer of 8 micra large cuboidal cells arranged in a row. Each epithelial cell has clear cytoplasm and a large, oval to roundish nucleus measuring 5 micra in diameter. A few nuclei possess a nucleolus and 2-3 deeply-staining granules. External to the epithelial layer is present a thick layer of musculature which consists of striated circular muscle fibres. The muscular layer is separated from the epithelial layer by smooth and structureless basement membrane. The outermost layer comprises the adipose tissue which forms a thick and complete
layer outside the musculature. The lumen in the centre is wide and lined by a layer of chitin, the chitinous intima which is thrown into irregular folds. The cavity of the bursa copulatrix is filled with spermatosoa.

The histological structure of the ductus bursae is same as that of the bursa copulatrix except that its lumen is narrow and the wall possesses many small cuticular spines ventrally.

The Spermatheca

The structure of the spermatheca (Pl. xxxv, fig. 2) is histologically similar to that of the bursa copulatrix. The epithelial wall is formed by a single layer of large cuboidal cells, each measuring 8 micra in length. The cytoplasm is granular and highly vacuolated. The nucleus of the cell is spherical and measures 4 micra in diameter. The epithelium which appears to be glandular, rests upon a thin basement membrane. The basement membrane is surrounded on the outer side by a thick layer of striated circular muscles. The outermost coat in the wall is formed by an incomplete layer of adipose tissue.

The lumen of the spermatheca is nearly circular in outline and contains spermatosoa. It is surrounded by a thin chitinous layer.

The Accessory Gland

The saccular portion:-

The wall of the saccular portion of accessory gland is composed of following layers, in order from within outwards:-

(i) Chitinous intima, (ii) Epithelium, (iii) Basement membrane, and (iv) Musculature.

The lumen is spacious and irregular in outline. It is surrounded by a thin colourless chitinous layer, lying in contact with the inner margin of the epithelium. The epithelium is composed of a single tier of columnar cells, each measuring
9 micra in length. The cytoplasm of the epithelial cells is granular, vacuolated and full of secretory material. The secretion is accumulated mostly in the apical part of the cell, hence the apical part stains deeply. The nucleus is oval to rounded in shape, granular in appearance and 4 micra in diameter. The epithelial layer is surrounded by a thin, non-cellular basement membrane. The muscular coat is thin and consists of a layer of circular muscle fibres outside the basement membrane. A few longitudinal muscle fibres are also present in the musculature. Adipose tissue is found scattered on the surface of the wall.

The Ductule:-

The lumen of the ductule (Pl. XXXV, fig. 3) is narrow and slightly compressed laterally. It is surrounded by a layer of chitinous intima. The epithelial layer is composed of a tier of small cells measuring 6 micra. The cytoplasm is homogeneous and non-granular. The nuclei are large and ovoid, each measuring 4 micra in diameter. The epithelium of the duct seems to be non-secretory in nature. The muscular coat on the outer side of the epithelium is very thick and consists of circular muscle fibres only. Adipose tissue is often found attached to the wall.

2. EXTERNAL GENITAL ORGANS

The female external genital organs comprise a pair of supra-anal appendages, and a stout and well-developed ovipositor. The vulva lies ventrally between the eighth and ninth abdominal segments and is guarded by the base of the ovipositor.

The Supra-anal Appendages

These are a pair of 0.39 mm. long brownish-white appendages arising from the terminal end of the tenth abdominal segment above the anus and projecting postero-ventrally. Each appendage is a hollow and conical organ which bears numerous minute tubercles and hair on the surface.
The Genital Aperture

The female genital aperture or vulva is a simple, nearly circular orifice, located ventro-medially between the eighth and ninth abdominal segments. It is guarded ventrally and dorsally by the anterior ends of the first valvulae and the second valvulae respectively.

THE OVIPOSITOR

The ovipositor in Copera marginipes (Ramb.) is situated on the ventral side of the ninth abdominal segment. It consists of five pairs of sclerotized structures as follows:-

(i) First valvifers
(ii) Second valvifers
(iii) First valvulae
(iv) Second valvulae, and
(v) Gonangula

(i) The First Valvifers

The first valvifers (Pl. XXXV, fig. 4) are present in the membranous venter near the apex of the eighth abdominal segment. These are horizontally placed plates of nearly triangular shape. The two valvifers are connected together mesally by a narrow membrane. The anterior margin of each valvifer is produced into an anteriorly tapering apophysis which projects inside the eighth abdominal segment. The lateral margin of the valvifer is slightly upturned.

(ii) The Second Valvifers

The second valvifers (Pl. XXXV, figs. 5 & 6) are termed as lateral valves. These are a pair of large structures hanging from the ventral region of the ninth abdominal segment. The bases of the second valvifers are inserted into the venter of the segment. There is present a weakly sclerotized bar, the laterotergite between the base of the lateral valve and the
ventro-lateral edge of the ninth abdominal tergite. It is pointed at the ends and lies lengthwise. Each lateral valve consists of a large basal portion and a terminal style.

The Basal portion:-

The basal portion of the second valvifer is a broad, brown coloured structure measuring 1.826 mm. in length and extending beneath the tenth abdominal segment. Its basal dorsal region is very strongly sclerotized and developed into two apophyses, the anterior apophysis and the posterior apophysis. The anterior apophysis extends lengthwise throughout the base and projects internally as a horizontal hood-like process. The posterior apophysis is situated at right angle to the distal end of the anterior apophysis near the posterior margin of the ninth abdominal segment. It is an upwardly directed bar which is broad proximally and tapering distally.

The basal portions of the two valvifers are joined together on the ventral side by an intervalvular membrane which comprises the ventral wall of the ninth segment. The intervalvular membrane bears a shallow longitudinal groove on the external side on the either side of which, lies the flap-like lateral valve. The anterior and posterior margins of the membrane are strengthened by the presence of an anterior intervalvular sclerite and a posterior intervalvular sclerite respectively. The anterior intervalvular sclerite is a small, elongated and laterally compressed median structure present nearly in the centre of the ninth abdominal venter. The posterior intervalvular sclerite is a bow-shaped structure placed transversely at the posterior end of the ninth sternum. It provides posterior attachment to the intervalvular membrane, and anterior attachment to the sternum of the tenth abdominal segment.

The external surface of the basal portion of second valvifer is beset with numerous posteriorly directed hair. Its ventral border is denticulated in the middle region while that
of the posterior region is smooth and heavily sclerotized. The basal portions extend posteriorly beyond the posterior inter-valvular sclerite as conical structures. The inner surface of the conical portion is membranous and folded prominently near the distal end forming a short hollow, dorsal structure, the gonoplac (third valvule, according to Scudder, 1971). The inner surface of the gonoplac bears a shallow longitudinal depression. Its apical margin is semicircular in outline and furnished with many posteriorly directed hair.

The Terminal style:-

The style is the hollow apical prolongation of the basal portion which lies ventro-lateral to the gonoplac. It measures 0.425 mm. in length and comprises a hard, stout, heavily sclerotized, unsegmented palp-like structure of brownish-black colour. The apex of the style is obliquely truncated and bears a tuft of short cilia-like hair on the ventro-mesal surface. Hair are also sparsely distributed on the remaining portion of the style.

(iii) The First Valvulae

The first valvulae (Pl. XXXV, fig. 4) are heavily sclerotized and lancet-like structures, each measuring 1.400 mm. in length and consisting of a ramus and a shaft.

The rami of the first valvulae comprise small horizontal plates which are joined together at the anterior margin to form a median triangular structure. Each ramus bears two processes, the lateral process and the dorsal process. The lateral process is a prominent wing-like extension on the lateral side. The dorsal process is a longitudinal ridge-like structure present on the dorsal surface of the plate.

The shaft of the valvule is an elongated, curved, slender process directed posteriorwards. Externally, the shaft in its distal one-third area of the blade bears transverse ridges and
a few teeth. The apex of the shaft is pointed.

(iv) **The second Valvulae**

The second valvulae (Pl. XXXV, figs. 5 & 6) are a pair of 1.342 mm. long and heavily sclerotized lancet-like structures, each comprising a ramus and a shaft. The ramus is the antero-proximal region of the valvule which lies attached mesally to the anterior end of the second valvifer. It is an elongated vertical plate having a triangular outline in the lateral view. The plate is slightly convex on the lateral side and concave on the mesal side forming a spoon-shaped structure. The convex surface of the plate bears a bunch of cilia-like hair.

The shaft of the second valvule is the posterior prolongation of the ramus. It is curved more strongly than the shaft of the first valvule. The distal half of the shaft bears several transverse pleats alternating with small tubercular teeth on the external surface. The apical end of the shaft is pointed.

The shafts of the second valvulae are placed above the shafts of first valvulae which are interlocked with the corresponding ones by a sliding interlocking mechanism, termed 'Olistheter' by Smith (1969). The first and the second pair of valvulae comprise together the aculeus or the teresbra. Only the rami of the first valvulae are externally visible. The shafts of the aculeus lie ventro-medially in the groove of the intervalvular membrane and are apically ensheathed by the gonoplae of the lateral valves. The ventral margins of the two lateral valves lie closely opposed to each other so as to enclose and protect the shafts completely. The rami of the second valvulae are placed above and slightly posterior to the rami of the first valvulae. These together basally enclose the vulva.

The shafts of the second valvulae are placed above the shafts of the first valvulae in such a manner that a long tubular passage, the ovipositor canal is formed. During the oviposition, the lateral valves are held apart and the teresbra is projected
ventrally. The eggs are then passed down, one by one, through the tubular passage. The dentated edges of the shafts along with their pointed spines make holes in the plant tissues where the eggs are deposited.

(v) The Gonangula

The gonangula (Pl. XXXI, fig. 4) are small but strongly chitinized bar-like structures present one on each side of the median line, at the junction of the eighth and ninth abdominal sternae. These are placed obliquely in an antero-posterior direction. The lower end of the gonangulum is supported on the dorsal surface of the lateral process belonging to the ramus of first valvule. The upper end of the gonangulum lies attached to the antero-ventral border of its side of the ninth abdominal tergite.
The musculature in the genital and non-genital segments of abdomen has been studied in both the sexes of *Pseudagrion rubriceps* Selys, *Pseudagrion decorum* (Rambur), *Ceriagrion coromandelianum* (Fabr.), *Ischnura senegalensis* (Rambur), *Ischnura rufostigma* Selys, *Aegriopnis pygmaea* (Rambur), *Enallagma malaynum* Selys, *Enallagma parvum* Selys and *Copera marginipes* (Ramb.). Except for the genital segments (2nd in the male and 9th in the female), the abdominal musculature in the male damselflies is similar to that of the female damselflies. The musculature of the fourth abdominal segment is described below as the typical musculature of a non-genital abdominal segment in Zygoptera.

**THE MUSCULATURE OF A NON-GENITAL ABDOMINAL SEGMENT**

There are four pairs of muscles in an abdominal segment (Pl. XXXVI, fig. 3) as follows:
(1) Superior Longitudinal Tergal Muscle
(2) Inferior Longitudinal Tergal Muscle
(3) Longitudinal Sternal Muscle
(4) Apodemal Muscle

The Superior Longitudinal Tergal Muscle is a broad, fan-shaped intersegmental muscle present in the posterior part of the tergum on the dorso-lateral side. It originates on the tergum and extends straight posteriorwards to get inserted on the antecostal ridge of the segment lying behind the one which possesses it.

The Inferior Longitudinal Tergal Muscle is largest of all the muscles. It also lies in the posterior part of the tergum but on the ventro-lateral side. It is broad near its origin on the tergum and runs almost straight towards the posterior side, becoming gradually narrower in its course towards the opposite end. Its ventral margin lies parallel and close to the dorso-pleural line. The inferior longitudinal tergal muscle is inserted near the pleuro-tergal suture on the ventral portion of the antecostal ridge of the succeeding segment and hence, is an intersegmental muscle.

The Longitudinal Sternal Muscle is a flat and narrow intersegmental muscle. It arises from the posterior part of the sternal plate on a point close to the pleuro-sternal suture. The muscle runs posteriorwards and becomes inserted on the anterior margin of the sternal plate of the next segment behind. It has been observed to be slightly curved in relaxed condition.

The Apodemal Muscle is situated in the anterior part of the segment. It arises from the ventral border of the tergum near the pleuro-tergal suture and extends ventrad, slightly mesad and caudad. The muscle is inserted on the ventro-lateral border of the posterior sternal apodeme. The apodemal muscle is smallest in size and intrasegmental in nature, being confined within the same segment.
THE MUSCULATURE OF THE SECOND ABDOMINAL SEGMENT
IN MALE ZYGOPTERA

The musculature of the second abdominal segment in male
damsel flies has been studied in Pseudagrion rubriceps Selys,
Pseudagrion decorum (Rambur), Ceriagrion cornmandelianum (Fabr.),
Lechnura senegalensis (Rambur), Lechnura rufostigma Selys,
Agriocnemis pygmaea (Rambur), Enallagma maleynum Selys, Enallagma
parvum Selys and Copera marginipes (Ramb.). The general plan
of musculature exhibits remarkable consistency in all the
species investigated and comprises the following paired muscles
(Pl. XXXVII, fig. 1):-

(1) Superior Longitudinal Tergal Muscle
(2) Inferior Longitudinal Tergal Muscle
(3) Tergo-pleural Muscle of Vesicula Spermalis
(4) Longitudinal Muscle of Framework
(5) Posterior Muscle of Framework
(6) Anterior Muscle of Framework
(7) Muscle of the Anterior Lamina
(8) Anterior Apophysial Muscle

In addition to these, one more paired muscle, the
Dorso-ventral Apodemat Muscle of the Vesicula Spermalis is also
associated with the copulatory mechanism though it belongs to
the third abdominal segment.

The Superior Longitudinal Tergal Muscle is more or less
a straight intersegmental muscle located on the dorso-lateral
wall in the posterior part of the second abdominal segment. It
is attached anteriorly to the second abdominal tergum and
posteriorly to the antecostal ridge of the third abdominal
segment.

The Inferior Longitudinal Tergal Muscle is an inter-
segmental muscle lying in the posterior portion of the segment
on the ventro-lateral wall of the tergum. It has its origin on
the lateral wall and extends caudal and ventrad. The inferior
longitudinal tergal muscle is inserted on the antecostal ridge of the third abdominal segment near the pleuro-tergal suture.

The Tergo-pleural Muscle of Vesicula Spermalis runs very close to the inferior longitudinal tergal muscle and the two muscles are not distinct from each other. On separation, however, the tergo-pleural muscle of vesicula spermalis is found to originate from the lateral tergite at a point which is ventral to that of the inferior longitudinal tergal muscle. The tergo-pleural muscle of the vesicula spermalis convergingly proceeds ventro-caudally along the ventro-mesal margin of the inferior longitudinal tergal muscle. Its point of insertion is near the roof of the vesicula spermalis on the lateral surface of the pleural membrane connecting the anterior and posterior apodemes of the vesicle (Pl. XXXVI, fig. 4). This point is adjacent to the insertion point of the inferior longitudinal tergal muscle. The tergo-pleural muscle of the vesicula spermalis has been regarded as an intersegmental muscle.

The Longitudinal Muscle of Framework is an intrasegmental muscle situated on the dorsal surface of the lateral part of the posterior median plate of the frame. It arises on the postero-lateral part of the frame near the anterior apodeme of the vesicula spermalis and extends slantly in an antero-ventral direction. The front end of the muscle is inserted on the ventral portion of the anterior vertical bar of the frame. The longitudinal muscle of framework is largest of all the genital muscles present in the second abdominal segment.

The Posterior Muscle of Framework is an intrasegmental band of thin muscle fibres which originates on the ventro-lateral wall of the posterior part of the tergum. It is directed mesad and slightly postero-ventrad. The posterior muscle of the framework is attached on the middle part of the lateral border of the posterior median plate of frame.
The Anterior Muscle of framework has a broad origin on the lateral wall of the tergum near the middle of the segment. It runs ventrad, mesad and caudad to converge to a point on the lateral longitudinal bar of the anterior part of the frame where it is inserted. The anterior muscle of the framework is an intrasegmental muscle.

The Muscle of the Anterior Lamina is thick and intrasegmental in position. It originates on the lateral wall of the tergum in the anterior part of the segment. The muscle extends ventrad and mesad, becoming broad near the end which is fixed on the mesal part of the lateral half of anterior lamina. A small portion of the muscle is also attached to the middle of the front margin of the anterior hamule.

The Anterior Apophysial Muscle is a thin and narrow intrasegmental muscle present in the anterior part of the second abdominal segment near the front end. Its origin is upon the ventral portion of the tergal wall near the pleuro-tergal suture and the insertion is on the ventro-lateral surface of the apophysis of the anterior lamina. The anterior apophysial muscle extends anteriorward, mesad and slightly ventrad. In size, it is smallest of all the muscles in the second segment.

The Dorso-ventral Apodemal Muscle of the Vesicula spermalis is situated near the anterior end of the third abdominal segment. It is a ventro-dorsally directed muscle (Pl. XXXVI, fig. 4) which originates on the ventral portion of the tergite near the pleuro-tergal suture. The muscle proceeds cephalad, dorsad and slightly mesad. The dorso-ventral apodemal muscle is inserted on the ventral surface of the posterior apodeme of the vesicula spermalis.
THE MUSCULATURE OF THE NINTH ABDOMINAL SEGMENT IN
FEMALE ZYGOPTERA

In all the nine species of female damselflies investigated, the musculature of the ninth abdominal segment reveals a consistency of structure. The musculature of the female genitalia consists of paired muscles (Pl. XXXVII, fig. 2) as follows:

(1) Longitudinal Muscle of the First Valvifer
(2) Dorso-ventral Muscle of the First Valvifer
(3) Anterior Apophysial Muscle of the Lateral Valve
(4) Posterior Apophysial Muscle of the Lateral Valve
(5) Anterior Intervalvular Muscle
(6) Muscle of the Second Valvule
(7) Longitudinal Tergal Muscle
(8) Transverse Sternal Muscle (unpaired)

The Longitudinal Muscle of the First Valvifer is thin and longest of all the muscles. It has its origin on the ventro-lateral part of the antecostal ridge of the eighth abdominal tergum and then extends caudad, mesad and ventrad. The posterior part of the muscle lies ventro-laterally beneath the '8th Complex' in the eighth segment. The muscle is inserted on the ventral surface of the anterior margin of the first valvifer near the median plane.

The Dorso-ventral Muscle of the First Valvifer is a stouter muscle which originates on the ventro-lateral wall of the eighth abdominal tergum near the posterior margin. It proceeds cephalad, ventrad and mesad to get inserted on the apophysis of the first valvifer.

The Anterior Apophysial Muscle of the Lateral Valve is a broad, fan-shaped muscle situated in the anterior part of the ninth abdominal segment. Starting from the broad base in the dorso-lateral wall of the tergite, the muscle is directed
ventrad and mesad. The other end of the muscle is attached to the anterior apophysis of the lateral valve (second valvifer).

The Posterior Apophysial Muscle of the Lateral Valve is the largest of all the muscles and occupies a space which is more than two-thirds of the ninth abdominal tergum. It originates on the antecostal ridge of the ninth tergum and proceeds obliquely in the postero-mesal direction. The muscle is inserted on the posterior apophysis of the lateral valve.

The Anterior Intervalvular Muscle arises upon the base of the posterior apophysis of the lateral valve and the lateral part of the posterior intervalvular sclerite. It extends anteriorward, mesad and ventrad to become inserted on the anterior intervalvular sclerite.

The Muscle of the Second Valvule is a short and stout muscle which arises upon the anterior apophysis of the lateral valve and is inserted on the ramus of the second valvule. The muscle runs cephalad, mesad and ventrad from the point of its origin up to the point of its insertion.

The Longitudinal Tergal Muscle is located in the posterior part of the dorso-lateral tergal wall of the ninth abdominal segment. It is a narrow muscle which proceeds posteriorward to become attached to the dorso-lateral area of the antecostal ridge of the tenth abdominal segment.

The Transverse Sternal Muscle is short, slender and the only unpaired muscle, present behind the anterior intervalvular sclerite and above the pair of the anterior intervalvular muscles. It is stretched transversely between the bases of the lateral valves of the two sides where it is attached also.