"Comparative Anatomy of the Gastropod Telescopium telescopium in Punnakayal Mangrove Habitat"

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Abstract
Key anatomical features were carefully described and illustrated in this study, including the structure of the proboscis, radula morphology, esophageal glands, and the reproductive systems of both males and females. Comparisons were made with previously studied potamididae species, particularly *Telescopium telescopium*. Notable distinguishing features observed in *T. telescopium* include a narrow gill, variations in the osphradium, and radula, and presence of well developed seminal vesicles within the pallial region. These findings contribute to a better understanding of potamidid taxonomy and provide insights into the adaptations of *Telescopium telescopium* to its sedimentary life style in tropical marine ecosystem.

Key words: *Telescopium telescopium*, Potamididae, Osphradium, Pallial oviduct.

1 Introduction

Anatomy is a branch of natural science that deals with the structural organization of living organisms (Yusupovna, 2020). The anatomy of gastropods reflects the physical and functional diversity of their bodies (Fryda, 2004). Molluscs have soft parts that consists of a head, foot, visceral mass and mantle sensory elements (Ruppert *et al.,* 2004). This study has been carried to understand the anatomy of the potamididae gastropod *Telescopium telescopium*.

Several aspects of caenogastropod anatomy and histology work were discussed since early years by Fretter and Graham (1962, 1994), Hyman (1967), Houbrick and Fretter (1969). Recent anatomical studies include the following : Richard Houbrick (1991) described the anatomy of *Terebralia* and *Telescopium* from the Queenland, Australia. Sreenivasan (1995) studied the digestive system of *Cerithidea cingulata* from Parangipettai. Michel (2004) explained a new genus of gastropod *Cerithioidea; 'Thiaridae'* with two species from East Africa.

Omar Hernando *et al.* (2006) explained the histology of selected region of the alimentary system of *Strombus gigas*. Srong and Frest (2007) observed the anatomy and systematics of *Pleuroceridae*. Olivier *et al.* (2008) analyzed the digestive gland of the queen conch *Strombus gigas* from the coast of the Island of Guadeloupe.

Gomes *et al.* (2011) studied the anatomy of *Hemisinus lineolatus*. Von Bocxlaer and Strong (2016) studied the anatomy, functional morphology and systematics of the *Cipangopaladina japonica*. Moustafa and Hussien (2019) studied the morphology of digestive system of *Mieniplotia Scabra*. Elamier Hussein *et al.* (2022) investigated the anatomy of *Cleopatra bulimoides* from Egypt. The present study aims to describe the anatomy of digestive and reproductive systems of *T. telescopium.*

2 Material and Methods

For the present study *T. telescopium* were collected from the Punnakayal mangrove of Gulf of Mannar region during low tide by hand picking and brought to the laboratory for further observations. For the anatomical studies, the soft body of the animal inside the shell was recovered by cracking open the shell and the animals were relaxed by 75% aqueous solution of magnesium chloride. Live specimens were dissected to study the anatomical features and various systems. Figures were drawn using a binocular stereozoom microscope using camera lucida. For histological studies, the tissue samples were taken from buccal mass, radula, oesophagus, style sac, salivary gland, digestive gland, stomach, intestine, rectum, ovary, testis. These different soft tissues were fixed in aqueous Bouins and Zenker's solution. Sections of 6-8 µ thickness were made from different organs and stained in Delafield haemotoxylin with eosin as a counter stain. Freshly killed specimens were used for the study of digestive and reproductive systems.

3 Results

Digestive system

The digestive system consists of buccal mass, radula, oesophagus, stomach, style sac, intestine, rectum, salivary gland, and digestive gland.

1 Buccal mass

The buccal mass is 2 mm thick muscular and reddish globular structure. The connective tissue connects the anterior border of the buccal mass to the snout wall. The snout is around 4.5 mm in length, 7.5 mm at its widest, and 2.5 mm at its narrowest. The snout is elongated to form a long proboscis. Tentacles protrude from each side of the snout which narrows abruptly and the eye is positioned on it. The mouth is situated ventral to anterior border of the snout. The buccal mass dorsal surface is lined with epithelial cells that are arranged in columnar formations. These epithelial cells are connected to the epithelial lining of the snout. A thick layer of smooth muscles surrounds the entire buccal mass, allowing movement in all directions, including partial extraction of the radula through the mouth opening (Plate 1).

2 Radula and Radular sac

The taenioglossate radula is located in the oral cavity, just above the three sets of teeth (median, lateral, and marginal) that make up the odontophore. The radular sac communicates with the buccal cavity at its posterior end by a ventral opening. The radular sac is kept firmly pushed on the bottom of the buccal cavity by the radular membrane. The radial one in the centre is triangular, with a larger central cusp and three smaller lateral cusps on each side. The lateral tooth has six denticulations and is larger than the median. The dental formula of *T. telescopium* is 1:2:1:2:1 (Plate 1).

3 Oesophagus

The oesophagus is tubular in structure and extends from behind the radular sac to the stomach. It is a long, narrow tube that measures 77 mm in length and is divided into three sections: anterior, middle, and posterior. From the posterior border of the buccal mass, the anterior oesophagus extends backward along the mid ventral line of the snout and visceral stalk to pass through the nerve. When the mid oesophagus reaches the posterior left limit of the foot, it proceeds backward along the left border of the columellar muscle in a zig-zag pattern. The posterior oesophagus is the same size as the anterior one. The middle section is acoiled tube located dorsal to the posterior border of the columellar muscle. The outer epithelium of the alimentary canal is an extremely thin layer composed of flattened cells. The inner epithelium is composed of tall, columnar and ciliated cells (Plate 2, 3).

4 Stomach

The stomach is a large, elongated, curved tubular structure that measures approximately 19 × 6 mm. The digestive gland, followed by the spleen, partially surrounds the anterior end of the stomach. The food travels a longer distance, from the oesophagus to the anterior end of the stomach and from there to the intestine. The presence of typhlosoles, grooves and ridges in the stomach are to direct the gastric contents towards the gastric shield region. These ciliated ridges and grooves create vortex currents for transporation of food particles first towards the gastric shield, then towards the digestive gland for absorption and lastly towards the intestine for elimination of waste material in the form of faecal strings. Histologically, the stomach is lined by columnar epithelial cells (Plate 4).

5 Style sac

The sacs are shaped like long tubes and serve as the styles. The style sac aperture is located at its base, which is parallel to the stomach posteroventral boundary. The style sac is 25 mm long and 4 mm in diameter. A crystalline style measuring about 20 mm long runs along the style sac. It is transparent, flexible, rod-like and cylindrical in shape. Epithelial cells along the luminal border of the style sac are histologically distinguished by less dense cytoplasm and shorter cilia. A thick layer of tissue supports the basement membrane of the style sac, which is made up of loosely arranged circular and oblique muscle fibers as well as a few longitudinal fibers (Plate 5).

6 Intestine

The intestine starts from the rear end of the stomach. The intestinal tract exits the body on the right side of the proximal style sac after passing through the left convex edge of the visceral mass. The intestine is a long tube with a thin wall, a big typhlosole, and a feature resembling a ventral groove. A few circular muscle fibres are randomly placed to form the wall. Cells with long, slender cytoplasm and cilia make up the inner epithelium (Plate 6, 7).

7 Rectum

On the left side of the genital canal lies a broad tube known as the rectum. The terminal part of the rectum runs parallel to the ctenidium on its right side, separated by a mantle fold. The rectum ends with the anus, a round opening protected by sphincter muscles. The anus is a tube with a thin wall made up of circular and oblique muscle fibers. The inner epithelial cells of the rectum are tall, columnar, ciliated and have inconspicuous separating cell membranes and basement membranes (Plate 8).

8 Salivary glands

Salivary glands are organised into tubes that attach to the dorso lateral aspect of the anterior oesophagus. They are paired acinus glands extending forward from the nerve ring to a position anterior to the buccal mass. The accessory glands are compact tubular structure sheld together by connective tissue that runs parallel to the salivary glands. A single layer of wedge shaped cells line the salivary glands alon with connective tissue (Plate 9).

9 Digestive gland

Three to four whorls of the spire are occupied by the digestive gland, which is a huge, spirally coiled, compact mass. It is thick and broad at the anterior end, where it partially encloses the stomach, and gradually narrows towards the posterior region. It is composed of several big lobules that form the digestive gland. Each lobule is made up of excretory cells and calcic cells (Plate 10).

10 Reproductive system

10.1 The male reproductive system

The testis is a single-celled organ that lies on top of the digestive gland and is yellowish brown (during the breeding season). The testis is made up of many follicles that are oblique to the longitudinal axis of the visceral mass. Each follicle is divided into acini, which contains an abundance of germ cells. There are many tiny ducts that connect the testis and vas deferens. The vas deferens is a single vein that connects to the pallial cavity. It is approximately 100 mm long and open into the mantle cavity. A 2 mm deep groove appears near the mouth of the vas deferens in the mantle cavity. This groove runs up to the edge of the mantle in the anterior region and ends with the rectum. The basal section of the seminal groove is whitish and firm. The genital fold forms a temporary tube for the sperm in the mantle cavity. These thick, folded and grooved glands are called prostate glands. The gland as a whole becomes thinner and narrower before it reaches the mantle edge. The male genital ridge is about 2 mm tall and convex in shape. This encompasses the area between the mantle cavity and the mantle border. The genital fold in an adult male specimen is 1 to 2 mm thick (Plate 11).

10.2 Female reproductive system

The ovary is pink in color and lies above the digestive gland. Follicles make up the ovary, and each one holds many eggs in varying stages of growth. The oviduct emerges from the penultimate whorl of the apical region and runs along the columella to the second body whorl. Two folds run perpendicular to the axis of the floor of the mantle, from the border of the mantle to the end of the pallial cavity. These folds extend from the genital grooves beginning in the mantle cavity to the hypobranchial gland exit at the mantle edge. The overall length of these folds is around 40 mm, but in dissections, they appear zigzag. Resorptive folds are a group of small placated structures located between the left genital fold and the albumen gland. There are five of them, with varying heights. Located at a short distance from the albumen gland and ending at the pallial cavity, these creases stretch for a total of 40 mm in the anterior-posterior direction.

The female genital groove starts from the mantle cavity and continues all the way to the mantle edge. As it approaches the mantle cavity, the groove appears deeper and wider, but it narrows as it approaches the mantle edge. These are approximately five in number folded and stuffed together to form a compact mass measuring 3 to 4 mm in width and 40 mm in length. These are placed next to each other, quite close together. The right genital fold forms the spermatheca, which crosses the left genital fold to form a long tubular tract. When the folds of the female genitalia meet throughout the whole length of the right genital groove, a fertilized egg is able to deposit itself in a protective sac. The only pouches with anterior openings are the spermatheca and fertilization pouches, while the middle resorptive pouch is closed in the anterior region (Plate 12).

Plate 1 : Cross section through buccal mass and radula of *T. telescopium* showing the histological organisation of epithelial cells and odontophore (4X)

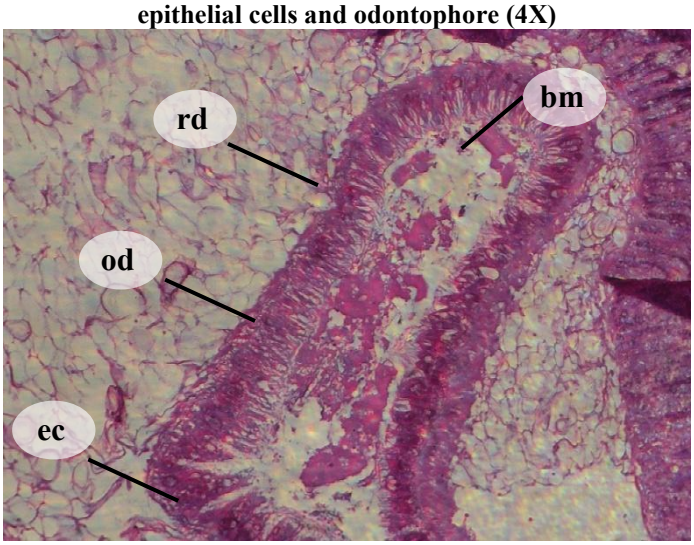
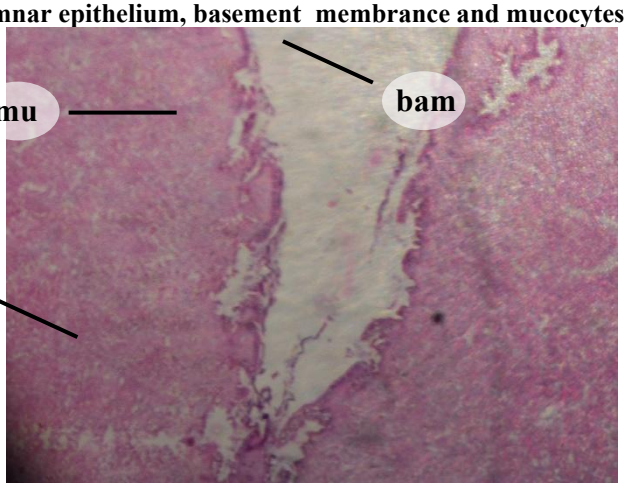


Plate 2 : Cross section through oesophagus of *T. telescopium* showing the histological organisation of ciliated columnar epithelium, basement membrance and mucocytes (4X)



rd - radula
od - odontophore
mu - mucocytes
cce - ciliated columnar epithelium
bm - buccal mass
ec - epithelial cells
bam - basement membrane

Plate .3 : Cross section through oesophagus and Salivary gland of *T. telescopium* showing the histological organisation of ciliated cells (4x)

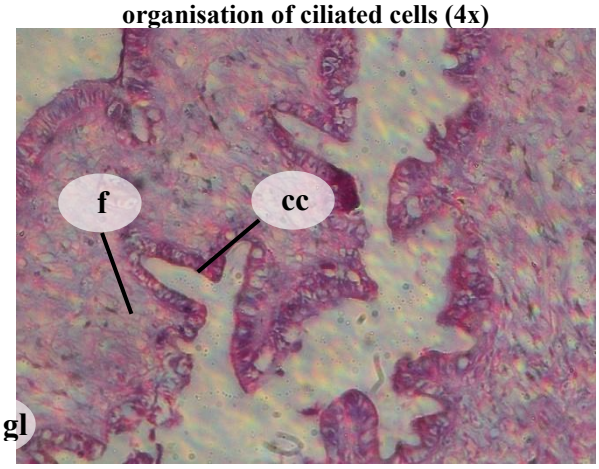
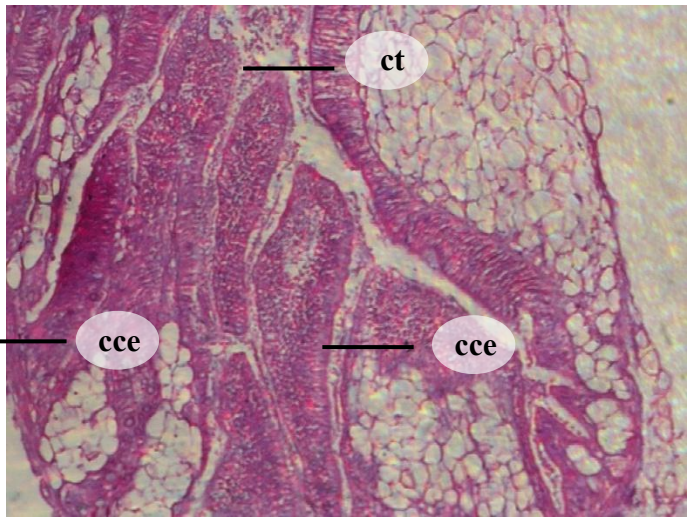


Plate 4 : Cross section through the stomach of *T. telescopium* showing the histological organisation of ciliated columnar epithelium and connective tissue (4x)



f - fold
ac gl - accessory gland
ct - connective tissue
cc - ciliated cells
s gl - salivary gland
cce - ciliated columnar epithelium

Plate 5 : Transverse section passing through the style sac (a part enlarged)

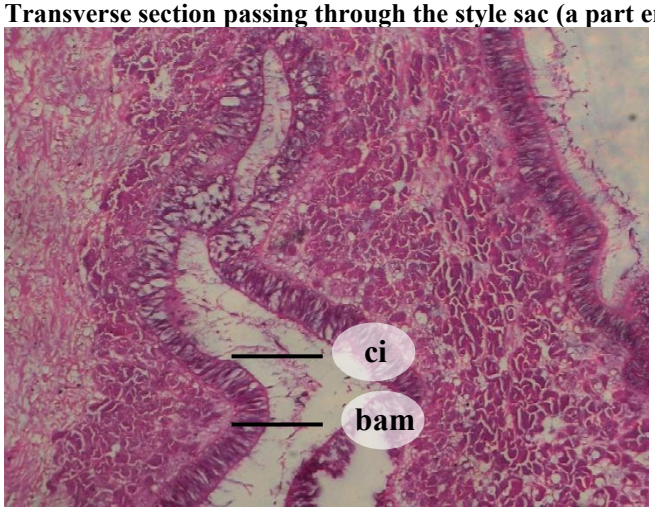
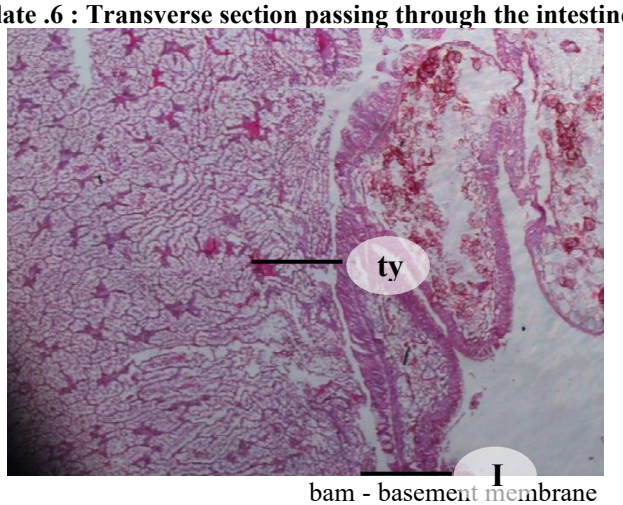


Plate .6 : Transverse section passing through the intestine



ci - cilia
ty - typhlosole
bam - basement membrane
I – Intestine

Plate 7 : Cross section through typical typhlosole zone of *T. telescopium* showing the histological organisation of inner epithelium cells (4x)

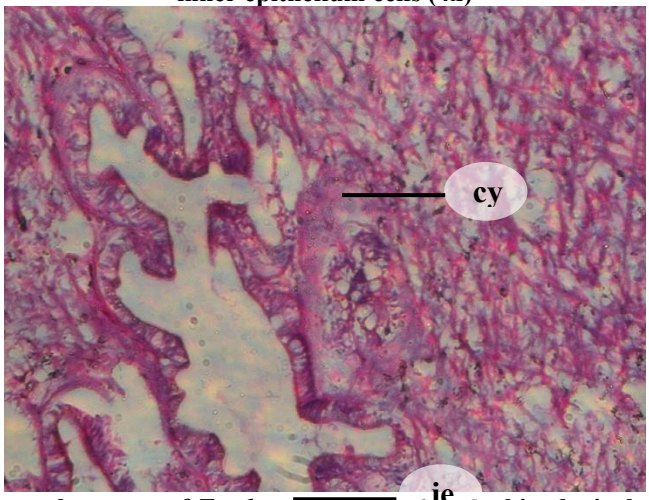
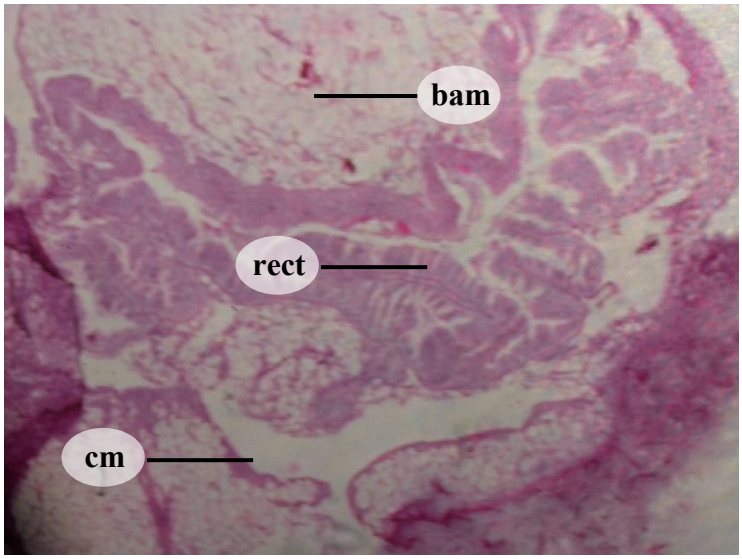


Plate 8 : Cross section through rectum of *T. telescopium* showing the histological organisation of basement membrane and cell membrane (4x)



cy - cytoplasm
bam - basement membrane
cm - cell membrane
ie - inner epithelium
rect - rectum

Plate 9 : Cross section through salivary gland of *T. telescopium* showing the histological organisation of wedge shaped cells and connective tissue

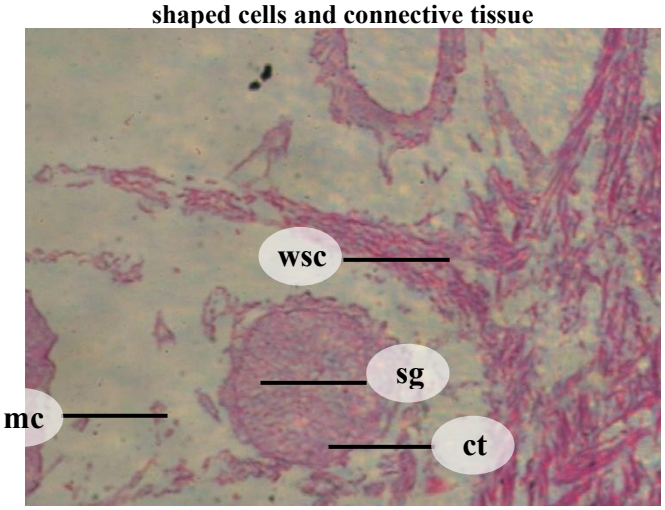
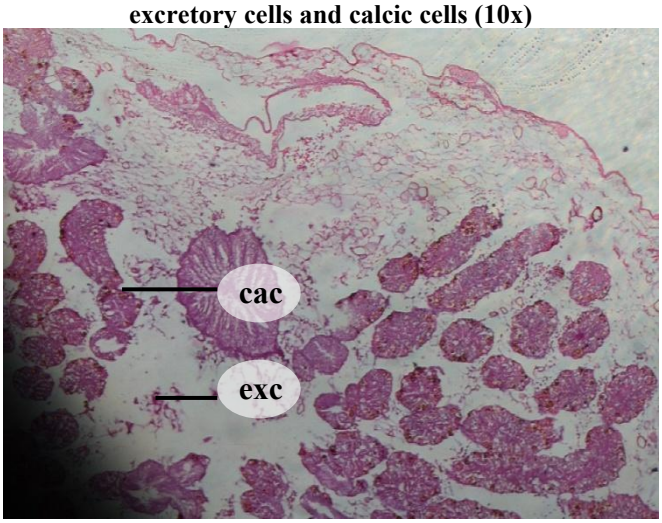


Plate 10 : Cross section through digestive gland of *T. telescopium* showing the histological organization of excretory cells and calcic cells (10x)



wsc - wedge shaped cells
ct - connective tissue
ex c - excretory cells
mc - mucoid cells
cac - calcic cells
sg - salivary gland

Plate 11 : Cross section of matured male gonad of *T. telescopium* showing the histological organization of spermatocytes (10x)

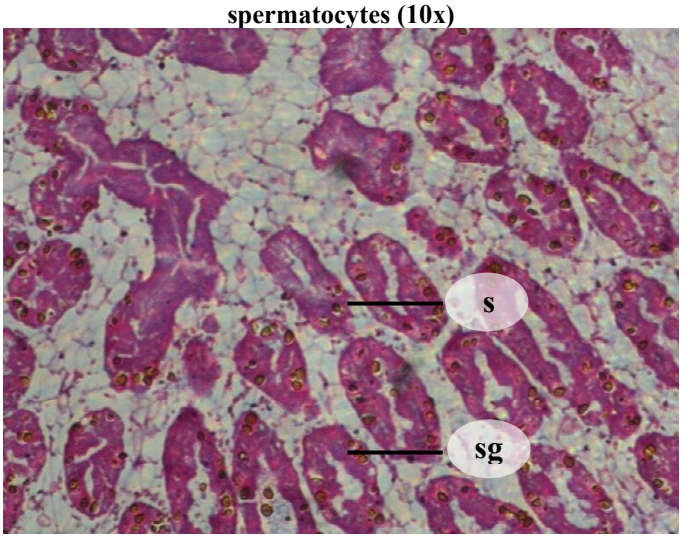
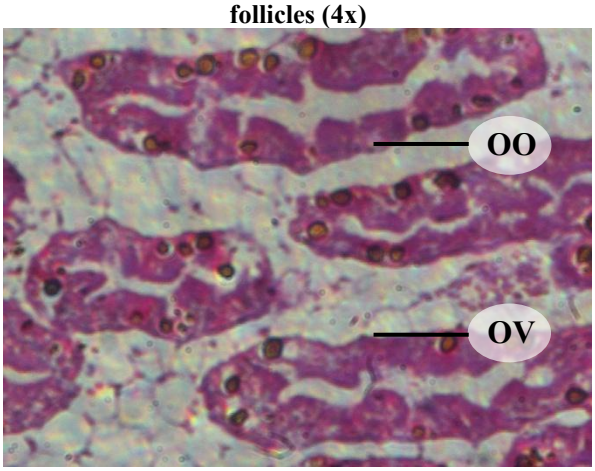


Plate 12 : Cross section of matures female gonad of *T. telescopium* showing the histological organization of the follicles (4x)



s - spermatids sg - spermapogonia
oo - oocyte ov – ovary

4 Discussion

The anatomy of *T. telescopium* resembles with the anatomy of other caenogastropods. The morphology of the foregut of the *T. telescopium* is in conformity with published data (Sheshaiya, 1930; Richard Hourbrick, 1991; Sreenivasan, 1995; Metcalfe, 2007; Veronica, 2013). The digestive system begins with the extensible snout, with strong musculature which helps in swallowing. The buccal mass found with muscles aids in the protrusion and retraction of the snout. The anatomy of the buccal mass and foregut region of *T. telescopium* conforms most aspects with the anatomy of *Terebralia plaustris* (Hourbrick, 1991), *Cerithidea cingulata* (Sreenivasan, 1995), *Pila virens* (Gayathri *et al.,* 2016).

The radula is taenioglossate type. In this work, we observed that *T. telescopium* radial structures resembled those of *Cerithidea rhizoporarum* (Suwanjarat, 1994); *Cerithidea anticipata* (Reid, 2014); and *Cerithidea obtusa* (Hafizul Haque and Amalesh Choudhury, 2014). The difference of cusp is found in the inner and outer flanking denticles of the lateral teeth encompassed by these potamididae. (Suwanjarat, 1994). A characteristic anatomical features of most potamididae mollusc is the pair of salivary glands which are dignified into anterior and posterior lobes. The morphology of salivary glands are identical to those present in other families of caenogastropods such as *Cerithidea, Tonnidae, Littorinidae*. The salivary gland appears to serve only the function of mucous secretions for binding the food materials but not digestion. This method is ideal for a slow, incessant eater like the snail because it guarantees an enzyme supply that is always high enough to completely digest the meal. The style sac is fully formed, secreting proteinaceous crystalline style that dissolves to release digesting enzymes. The present findings are similar to those recorded in *Batillaria zonalis* and *Cerithidea californica* (Driscoll, 1972); *Rissoa membranacea* and *Rissoa stomia* (Falniowski, 1988); *Srombus gigas* (Omar Herando, 2006). The oesophagus and the salivary gland pass through the central nerve ring (Richard willan, 2013). The present investigation were similar to the facts reported in murex (Masour Bek, 1934); *Pirenella conica* (Demain *et al.,* 1963); *Chicoreus ramosus* (Stella *et al.,* 1992). Oesophagus is normally divided into anterior, middle and posterior regions (Voltzow, 1994). The structure of the oesophagus is stricking when compared to non-style bearing prosobranchs. Snails that have an oesophagus use it only for feeding (Graham, 1939). The oesophagus in

T. telescopium shows moderate amylolytic, proteolytic activity. It might be presumed that the enzymic activities traced in the oesophagus is a sum total of the activities present in the saliva and in the fluid secreted by the digestive gland flushed back to the oesophagus from the stomach, which is most common in gastropod molluscs. The present findings were similar to facts explained in *Patella vulgata* (Bush, 1988); *Lymnaea stagnalis* (Boer and Kits, 1990); Muricid and Nassariid (Andrews and Thorogood, 2005).

T. telescopium has a dilated rectum that enters into the mantle chamber via the anus, and a stomach and intestine that are anatomically indistinguishable from one another. Multiple gastropods stomach anatomy and histology were reported (Fretter and Graham, 1994; Luchtel *et al.,* 1997). The stomach is a sac-like organ inside the digestive system, including ducts that exit through the stomach wall. The waste products from the digestive gland are transported to the intestine via a groove between two conspicuous ridges called typhlosoles. The digestive gland is situated below the stomach and extends all the way to the very tips of the whorls. Results from studies on *Littorina littorea* (Pipe, 1986), *Terebralia palustris* (Sara fratini *et al.,* 2001), the Potamidid snails are consistent with the current observation (Richard Willan, 2013).

Several environmental stresses have been linked to changes in the structure of the digestive gland in numerous invertebrate phyla (Lomte *et al.,* 1989; Sontakke *et al.,* 1992). As with other potamidids, the histological examination of numerous body components of *T. telescopium* confirmed their functional relevance. Multiple lobules containing four different cell types (calcic, excretory, secretory, and vesicular) were found in the digestive gland of *T. telescopium* by Das and Manna (1991). The form and function of the digestive gland of gastropods may differ even among members of the same groups, as shown by histological research (Kress *et al.,* 1994).

Extensive discussion and analysis of the sexual anatomy of gastropods were detailed by Fretter and Graham, 1962; Hyman, 1967; Voltzow, 1994; Morton, 1967; Strong, 2003; Hodgson, 2010. Reproductive system of *T. telescopium* is simple with unpaired gonads, closed gonoduct and open pallial duct.

The male reproductive system of *T. telescopium* lack penis. It is composed of follicular testis, collactive primordial tissue, spermatocytes and spermatozoa. Fretter (1984) who studied the reproductive system of *Cerithidea* did not report any copulatory organ. Development of spermatophore was to ensure the transfer of sperm into the female duct in the absence of a proper copulatory organ which was reported in *Littorina* (Lenderking, 1954); *Goniobasis* (Dazo, 1965); *Cerithium* (Hourbrick, 1973), *Neritids* (Govindan, 1974); The safe release of sperm into the female is ensured by the male transfer of spermatophore into the female inhalant steams during mating (Swaminathan, 1978).

The snails were superficially based on the groove and ovipositor characterization of Houbrick (1991); Richard Willan (2013). Female were found to have a well developed and extended ovipositor on the right side of the foot. Sex determination was observed on the extent of deep and highly ciliated grooves present in both sexes, which run down on the right side of foot appearing from the exhalant siphon. Most females were discovered to be on the spawning stage due to the presence of densely packed follicles and all have developing oocytes. Normally, the oocytes are relatively same in size and were undergoing the same stages of maturity. Male had sperm cells with varied sizes and developmental phases as exemplified according to Jerry Lan Leonida and Nathaniel Anasco, 2013. The gonoduct of the female reproductive system is discussed at length as a means by which sperm may be captured, stored, and released for fertilization. During spawning, the spermatophore is deposited into a sperm collecting gutter, from which the eupyrene sperm travel via a sperm collecting pouch and into the seminal receptacles. When an ova becomes fertilized, it travels via the albumen gland, where albumen is produced around the zygote, and then the capsular gland, where a jelly-like capsule is created around the egg. Similar observation have been made in *Rinoclavis psuedovertgus* and *Clavo cerithium* (Hourbrick, 1978); *Cerithium moniliferum* (Cannon, 1978); *Cerithidea cingulata* (Sreenivasan, 1995); *Terebralia* (Hourbrick, 1991); Potamid snails (Richard Willan, 2013). Its anatomical similarities to other caenogastropods are also well known.

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