3. ANATOMY

3.1 INTRODUCTION

The functional anatomy of an animal is directly correlated with its mode of life and habits. The anatomical studies of molluscs are of paramount importance because of their soft bodies. The anatomy of prosobranch molluscs needs to be largely understood. This study has been undertaken to understand the anatomy of soft bodied buccinid gastropod *Babylonia spirata*.

Vanstone (1894) studied the anatomy of Neogastropod *Melongena melongena*. Dakin (1912) studied the anatomy of *Buccinum* sp. Shaw (1915) studied the anatomy of *Conus tulipa* and *Conus textile*. Graham (1939, 1941, 1949) carried out work on the anatomy of some prosobranchs. Fretter (1941) studied the functional anatomy of the genital ducts of some stenoglossan prosobranchs. Wilsmann (1942) made a study on the anatomy of pharynx in *Buccinum undatum* and Olson and Crove (1963) on aquarium specimens of *Oliva sayana*. Smith (1967) studied the reproductive system of turridae while Brown (1969) on the structure and functions of the digestive system of the *Nassarius*.

Knowledge of the animal anatomy is essential in studying its inter-relationship with allied species and environment. The lacunae which exists in the studies of Indian spiral babylons make it imperative to undertake the present work on the anatomy of Babylonia spirata inhabiting the Gulf of Mannar Coastal waters of Tuticorin area. The present study aims to describe the digestive, nervous and reproductive systems of the species.

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3.2 MATERIAL AND METHODS

*B. spirata* were collected from the shallow water regions of the Gulf of Mannar coast of Tuticorin 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 proboscis, oesophagus, salivary gland, gland of leiblein, midgut gland, stomach, intestine, rectum, ovary, tesis, mantle, ctenidium and osphradium. These different soft tissues were fixed in aqueous Bouins and Zenker's solution. Sections of 6-8μ thickness were made from different organs and stained in delafield haemotoxylin with eosin as a counter stain.

Freshly killed specimens were used for a study of the digestive and reproductive systems, as the genital complex was more
readily visible. Measurements were made using ocular and stage micrometers. In order to study the nervous system, preserved animals were used since minute nerves stood out predominantly after fixation under direct illumination.

3.3 RESULTS

3.3.1 Digestive System

The system presents so many variations in prosobranchs mainly in correlation with feeding habits and hence it could be very difficult to suggest uniform terminology. The digestive system of *B. spirata* fig.7 is found to consist of a buccal mass, mouth, pleurembolic proboscis, radula, salivary glands, gland of leiblein, oesophagus, stomach, midgut gland, intestine, rectum and anus.

(i) Buccal Mass

The mouth is situated at the tip of the snout. The snout leads into the buccal cavity through a short tube. The characteristic feature of the buccal cavity is the buccal mass which is visible in the head. A small buccal mass is succeeded by a short narrow oesophagus. A pair of salivary gland is seen in the buccal mass which opens into the anterior
oesophagus, posterior to the buccal mass. Buccal mass is a complex mass of muscles which contains a pair of odontophore. These muscles control the movement of the radula and odontophore.

(ii) Proboscis

The most conspicuous feature of the digestive system is the massive proboscis. The forward extension of the snout forms a cylindrical tube, the proboscis with original mouth opens at its tip. In *B. spirata* the proboscis is pleurembolic type (fig.10) which is characteristic of the family Buccinidae. This type of proboscis is completely invaginable, on retraction it turns completely withdrawn in, plate 3A. The proboscis shows a definite ring of muscles and connective tissue. The lumen contains the oesophagus whose wall is made up of columnar ciliated cells. The dorsal food channel, radular teeth, (fig.7a) radular sac and odontophore are surrounded by the longitudinal muscle fibres. Usually the proboscis is pink in colour, encircled by proboscis sheath. The odontophore is composed of retractor muscles.

(iii) Salivary glands

A pair of salivary glands lie at the base of the proboscis that is at the anterior portion of the oesophagus. They are white irregular
bodies having a width of 0.4mm, composed of masses of minute tubules made up of cuboidal secretory cells. A pair of ducts originating from each gland, opens into the anterior oesophagus laterally. These glands are associated with much diffused tissue which makes it difficult to separate from oesophagus. Histologically the sections of salivary glands of *B. spirata* consist of two types of cells namely “mucoid cells” and secretory cells. The mucoid cells are relatively numerous and the oval nucleus is centrally located. The secretory cells are less than the mucoid cells and are triangular in shape with an oval nucleus located basally.

(iv) **Gland of Leiblien**

A single white coloured very thin gland of leiblein is present in *B. spirata*. The length is about 10 to 25 mm and the width is about 0.4 to 0.8 mm. It opens into the anterior oesophagus. At the beginning of the mid-oesophagus the valve with the width of 0.4 to 0.6mm is situated. Histology of the gland of leiblein reveals large branching and projecting septa which are lined by granular and mucous cells, with round or oval
nuclei, which appears in the basal portion of the cell. Mucoid cells sparsely occur among the granular cells plate 3C.

(v) Oesophagus

Oesophagus extends from the posterior end of the buccal cavity to the stomach. The oesophagus is divided into anterior, mid and posterior regions. The anterior oesophagus is followed by the mid-oesophagus and posterior oesophagus, which in turn opens into the stomach. The duct of the gland of leiblein opens into the anterior end of the mid-oesophagus. The oesophagus is green in colour with the length of 10 to 30 mm and the width of about 2 to 4 mm. Histologically the wall of the oesophagus contains ciliated columnar epithelium, underlined by basement membrane and secretory cells with large nuclei. Mucocytes are found scattered among the epithelial cells plate 3D.

(vi) Stomach

The stomach is brown in colour and irregular in shape. It is elongated in the antero-posterior direction. In the surface view the dorsal side of the stomach is visible. The stomach is embedded in the anterior region of the midgut gland and is divisible into an anterior and a posterior
The oesophagus opens on the ventral side. The intestine originates from the right lateral side of the stomach. The mid-gut gland opens into the junction of the anterior thick-walled and posterior thin-walled stomach through two openings. The rudimentary caecum is located in between the posterior stomach and the intestine. Internally the anterior part of the stomach is lined with fine ridges and furrows consisting of major and minor typhlosoles with ciliated deeper intestinal groove between them which aids the passage of the coarse food particles into the intestine. The stomach is lined by ciliated columnar epithelium. In all the epithelial cells, the elongated nuclei are centrally located. Mucous cells are scattered among the columnar epithelial cells. Phagocytes are seen at the bases of epithelial cells possessing oval or round nuclei. Below the epithelium, dense connective tissue is present where blood cells, fibroblasts and muscle fibres are embedded plate 4A and fig.7b.

(vii) **Midgut gland**

The midgut gland is present in the upper whorls of the animal. It is single-lobed, brownish yellow coloured gland and found covering the whole stomach except on the ventral side. It opens through
a pair of openings into the middle part of the stomach. Histologically the midgut gland is made up of glandular and calciferous cells plate 4B.

(viii) Intestine

The intestine is a short black yellow coloured structure and has a length of about 10-28 mm and the width of 4 mm. It is in the form of straight tube between the stomach and the anus. It shows a uniform diameter throughout, but may be regionated as a slender proximal small intestine and wider terminal rectum. After leaving the visceral mass, the intestine enters the mantle, where it runs in the roof of the mantle cavity to the anus situated near the free mantle edge. The intestine is lined with a cuboidal or columnar ciliated epithelium, generally interspersed with mucocytes or other gland cells. Epithelial cells are supported by connective tissue containing muscle fibres plate 4C.

(ix) Rectum and anus

The hind part of the intestine is distinguished by its size and differentiated as rectum. The rectum receives the accumulation of faecal pallets from the intestine prior to discharge. The faecal pallets are clearly visible through the wall of the rectum. The rectum measures about 20-30
mm in length and 2 to 4 mm in width. The rectum terminates in a conical tube which in turn opens outside through the anus. The anus opens into the right corner of the mantle cavity and terminates in a papilla like projection. The wall of the anus is distinctly folded into ridges and grooves. Histologically the rectal walls are made up of ciliated epithelial cells. The ciliated cells are responsible for the movement of the content of the rectum plate 4D.

3.4 Nervous System

The nervous system of prosobranch gastropod is streptoneurous type. The nervous system of B. spirata is a concentrated type with all the ganglia forming a ring around the anterior oesophagus. This ring is called circum-oesophageal ganglionic ring. This ring is constituted by a pair of buccal ganglia, a pair of cerebral ganglia, a pair of pleural ganglia, unpaired sub and supra-intestinal ganglia, a single pedal ganglion and a visceral ganglion. These ganglia are connected by commissures and connectives. Nerves from the buccal ganglia supplied oesophageal, pharyngeal walls, buccal glands and radular teeth. The cerebral ganglia supplies nerves to the tentacles, eyes, snout, and different parts of the head. The pleural ganglia supplies nerves to the
mantle wall and columnar muscles. The pedal ganglion is the longest one and innervates the entire muscular foot. The supra and sub-intestinal ganglia cross the floor of the anterior cavity and enter the wall on the right side and innervate the wall of the body cavity. The visceral ganglia are situated on the posterior to the mantle cavity and supply the gonads, and heart fig.11.

3.5 Reproductive system

*B. spirata*, a dioecious animal and the males are larger than females. The male snail has a well-developed penis lying at the base of the right tentacle. The reproductive system is constituted by the gonad, gonoducts, organ of copulation and reproductive glands.

(i) Male reproductive system

The male reproductive system consists of the testis, vesicular seminalis, vasdeferens, prostate gland and penis fig.8.

Testis

The testis is seen on the ventral surface of the visceral mass, where its tubules formed a compact mass and do not ramify through digestive gland. The testis is made up of numerous follicles, and small
ductules, which join to form a genital duct called vas deferens. The vas deferens is thrown into numerous convulsions, which serve as vesicular seminals. In fully matured condition the colour of the testis is yellow. During the breeding season the testis occupies a greater part of the visceral mass. The histology of the testis reveals numerous lobules, each comprising an oval or elongate sperms in its different stage of development plate 5A.

**Vesicular seminalis**

Vesicular seminalis is formed by the union of several ductlets from the globules of the testis, which during the breeding season serve to store sperms. For this purpose it is thrown into numerous convolutions. When the sperm is placed into the vesicular seminalis it appears dull yellow coloured.

**Vas deferens**

From the testis, situated on the columnellar side of the visceral mass is the coiled vas deferens, which pass anteriorly in a superficial position. It proceeds further beneath the pericardium and close to the intestine towards the right posterior margin of the mantle cavity where it joins with the prostate gland. At this point the
vasdeferens embedded in the body wall and continued anteriorly until it joined the penis.

**Prostate gland**

Prostate gland commences at the posterior end of the pallial cavity where it receives the vasdeferens. Its size depends on the productive stage of the animal, being well developed in mature animal at its breeding peak. The vasdeferens which opened at the posterior end of the prostate run through it as a slit like lumen. The prostate gland provides a liquid medium for the spermatozoa, so that it could be transferred from male to female. The width of the prostate gland is uniform throughout the length until the region where it joins the posterior part of vasdeferens. The prostate gland is surrounded by a thick layer of circular muscles enclosing glandular cells alternate with ciliated columnar epithelial cells plate 5B.

**Penis**

The penis is located on the right side of the head just behind the base of the right cephalic tentacle. The penis is a dorsoventrally flattened structure and is pale yellow in colour. The tip of the penis is
pointed, recurved and has a genital pore through which the sperm is released during copulation. It measures about 6-10 mm in length and 2 to 4 mm in width. The vas deferens which entered the penis at its base run through the penis towards its tip on the outer edge. The penis is provided with several lateral wrinkles. Histologically a portion of the penis shows muscle fibres, circular connective tissues and blood spaces covered externally by cuboidal epithelium. A layer of circular muscle is found beneath the epithelium. Throughout the thickness of the penis muscle fibres penetrate the connective tissue plate 5C.

(ii) Female reproductive system

The female reproductive system consisted of ovary, oviduct, pallial oviduct, albumen gland, capsule gland and bursa copulatrix fig.9.

Ovary

The ovary is found in the upper part of the visceral coil, intermingling with midgut gland. It is bright orange in colour. In a fully matured female, the ovary occupies one third of the visceral coil and attains one fourth of the body weight. In the immature females gonad tissue is white in colour, thin and smooth in appearance. The histology
of ovary reveals several follicles. Each follicle contains a spherical ovum, with different stage of development plate 6A & B.

**Oviduct**

From the ovary a thin walled oviduct originated, which is formed by the union of several ovarian follicles fig.9. The oviduct was a thin walled tube and pale red in colour. It is seen on the right side of the viscera as a straight tube and opens into the albumin gland at the point just below the kidney. The oviduct has a length of about 20-28 mm in length.

**Pallial oviduct**

The oviduct runs forward in the pallial region as pallial oviduct, and joins with a creamy white coloured albumin gland.

**Albumen gland**

The first and posterior most part of the pallial oviduct is albumen gland into which the pallial oviduct opens. It is oval in shape and measured about 20 –30 mm in diameter. It is creamy white in colour and in a matured animal bulges prominently into the mantle.
capsular gland. The albumen gland opens into posterior ventral wall of the capsular gland plate 6C.

**Capsular gland**

Capsular gland is white in colour and occupies greater portion of the oviduct and joins with albumen gland. It is measured about 20-25mm in length and 4-10mm in width. Capsular gland is found at its tip of the vestibule and vagina. Throughout the length of the capsular gland a channel called ventral channel runs on the ventral aspect of the capsular gland, which is a closed duct. Posteriorly ventral channel enters the receptaculum seminalis and anteriorly to the bursa copulatrix. Histologically the capsular gland is composed of groups of gland cells lying at the various heights. Cells are packed together with a layer of connective tissue between each group. Beneath the ciliated epithelium, a layer of circular muscles occurs plate 6D.

**Bursa Copulatrix**

The bursa copulatrix is in the proximal part of the pallial oviduct situated ventral to the capsular gland. It is a pouch like structure
which receives the sperm along with prostatic secretion during copulation.

3.6 DISCUSSION

In general, the anatomy and organisation of *Babylonia spirata* resembles other neogastropods.

The digestive system in this snail begins with pleurembolic type of proboscis as observed in *Cancellarica* (Graham, 1966), in *Columbarium* sp., *Colozea* sp (Ponder, 1973), *Thais* sp. (Tagore, 1989) and *Chicoreus* sp., (Stella, 1995). The radula is rachigloisate type and the radular formula is 1+R+1. The type of teeth in each row is similar to that of other Neogastropods, *Chicoreus virgineus* (Raghunathan, 1996), *Urosalpinx* sp (Radwin and Wells, 1968), *Thais* sp and *Muricanthus* sp. (Kool, 1993).

The general organisation of salivary glands are similar to those present in other families of Neogastropods such as volutidae (Ponder, 1970). In *B. spirata* two whitish loosely compact salivary glands are situated anterior to the nerve ring and lateral and dorsal to the origin of the oesophagus. The gland of leiblein extends towards the - 53 -
posterior oesophagus. This observation coincides with the findings of Vanstone (1894) in Buccinaceae and Volutaceae, as reported for *Thais* sp and *Muricanthus* sp (Kool, 1993). Fretter (1962) pointed out that the evolution among rachiglossa proceeded towards the suspension of the gland of leiblein and as such the *B. spirata* occupies the higher position in the evolutionary trend among rachiglossa. Woodward (1901) stated the activity of the midgut gland in association with the reduction of gland of leiblein. In *B. spirata* the increased volume of midgut gland with the reduction to leiblein gland infact complied with this fact.

Usually the neogastropods are carnivorous in their feeding habit, and the stomach is modified to suit this as in *Nucella* sp (Graham, 1949), *Natica* sp and *Buccinum* sp Brock et al., (1989). Jenner (1956) studied the structure of stomach of *Olivella veneauxii* and *Oliva sayana*. The ‘U’ shaped stomach had been observed in olividae (Marcus and Marcus, 1959) in Turridae (Smith, 1967), in *Chicoreus virgeneus* (Stella, 1995) and on *Rapana rapiformis* (Rajakumar, 1995). Baskara Sanjeevi (2001) noticed a trilobed stomach in *Lambis lambis*. The anal gland was present in the super family Muricacea. Pelseneer (1935) noted the anal
gland in some naticids. Fretter (1941), who observed the absence of anal
gland in *Natica catena*. The absence of anal gland in *B. spirata* could be
corroborated with the findings of Fretter, (1941).

The concentration type of nervous system with various
ganglion forming a ring around anterior oesophagus is found in
*B. spirata*. The circum-oesophageal nerve ring is formed by the fusion of
6 types of ganglia, such as pair of buccal ganglia, cerebral ganglia,
pleural ganglia, supra and sub intestinal ganglia, a pedal ganglion and a
visceral ganglion. A similar observation has been made by Li Guohua et
al., (1990) in *Rapana venosa*.

The cellular organizations of the various body parts of
*B. spirata* histologically proved the same type of functional significance
as encountered in other buccinids.

The male and female reproductive system of *B. spirata*
follows the same general neogastropod patterns. In most neogastropods
the prostate gland is a closed type (Thivakaran, 1988). Open prostate
gland occurs in primitive neogastropods like *Alcithoe arabacia* which
was reported by Ponder (1970). Marcus and Marcus (1959) reported the presence of a closed type of prostate gland in all the families of the order neogastropoda. In B. spirata also the prostate gland is closed type (Houston, 1976). The males possessed a small strongly recurved penis characteristics of buccinid and muricid type. The penis of B. spirata is sickle shaped and resembled the muricids and buccinids. The penis is a muscular non-invaginable process, having a ciliated groove and having communication with vasdeferens which helps the passage of the sperm. In all neogastropods the upper part of the vasdeferens was modified to form a sperm storing seminal vesicle (Fretter, 1941; Smith, 1967). Dakin (1912) observed the coiled structure of anterior vasdeferens in Buccinum sp and also in Nassarius incrassaters and Hoston (1976) in Columbella fascata. The male genital duct of B. spirata had a well developed seminal vesicle, which is formed from the coiled vasdeferens, modified to store the sperm as reported by Fretter (1962) in other neogastropods.

As described by Fretter (1941) for Nucella lapillus, the female reproductive system of B. spirata resembles other buccinid gastropods. In the female reproductive system of Colus stimpsoni
(Buccinidae) absence of ingesting gland and seminal receptacle are reported by West (1978). In *B. spirata* also ingesting gland is absent, but a single lobed receptacle and bursa copulatrix are present. The capsule gland forms the major part of the pallial oviduct and is smaller than the albumen gland, whereas the capsular gland is smaller than albumen gland in *Alcithoe* sp. (Ponder, 1970).
PLATE 2

A. CTENIDIUM: Cross section through the gill of *Babylonia spirata* showing the histological organization of gill leaflets (10 x).

B. OSPHRADIUM: Cross section through the osphradium of *Babylonia spirata* showing the histological organization of Central zone and ciliated band (4 x)

C. MANTLE: Cross section through the mantle edge of *Babylonia spirata* showing the histological organization of connective tissue, blood space and epidermis (4 x)

D. FOOT: Cross section through the foot of *Babylonia spirata* showing the histological organization of epidermal gland cells, muscle fibres and connective tissue (4 x).

bs – blood space
ct – connective tissue
ec – epidermal cells
gll – gill leaflets
A. PROBOSCIS – Cross section through proboscis of *Babylonia spirata* showing the histological organisation of columnar ciliated cells and odontophore (4 x)

B. SALIVARY GLAND – Cross section through the salivary gland of *Babylonia spirata* showing the histological organisation of mucoid cells and secretory cells (4 x)

C. LEIBLEIN GLAND – Cross section through leiblein gland of *Babylonia spirata* showing the histological organisation of glandular cells (10 x)

D. OESOPHAGUS – Cross section through the oesophagus of *Babylonia spirata* showing the histological organisation of ciliated columnar epithelium, basement membrane and mucocytes (4 x).

bm – basement membrane  
mc – mucoid cells

cm – circular muscle  
n – nucleus

cce – ciliated columnar epithelium  
od – odontophore

gc – globlet cells  
rt – radular teeth

lu – lumen  
sc – secretory cells
PLATE 4

A. STOMACH – Cross section through the stomach of *Babylonia spirata* showing the histological organisation of ciliated columnar epithelium and connective tissue (4 x).

B. MIDGUT GLAND – Cross section through the midgut gland of *Babylonia spirata* showing the histological organisation of glandular cells (10 x)

C. INTESTINE – Cross section through the intestine of *Babylonia spirata* showing the histological organisation of ciliated columnar epithelium and gland cells (4 x)

D. RECTUM – Cross section through the rectum of *Babylonia spirata* showing the histological organisation of flagella and ciliated columnar epithelial cells (4 x)

cc – ciliated cells

ccce – ciliated columnar epithelium

ce – ciliated epithelium

ct – connective tissue

lu - lumen

mf – muscle fibre

sc – secretary cells
PLATE 5

A. Cross section of matured male gonad of *Babylonia spirata* showing the histological organization of spermatocytes (10 x)

B. PROSTATE GLAND: Cross section through the prostate gland of *Babylonia spirata* showing the histological organization of ciliated columnar epithelium and globet cells (10 x)

C. PENIS: Cross section through the penis of *Babylonia spirata* showing the histological organisation of connective tissue (4 x)

bs – blood space

cce – ciliated columnar epithelium

cue – cuboidal epithelium

d – duct

f – follicular cells

mf – muscle fibre

spc – spermatocytes
PLATE 6

A. Cross section of matured female gonad of *Babylonia spirata* showing the histological organization of the follicles (4 x)

B. Showing the enlarged view of plate 6 A (10 x)

C. ALBUMEN GLAND: Cross section through the albumen gland of *Babylonia spirata* showing the histological organization of ciliated cells (10 x)

D. CAPSULAR GLAND: Cross section through the capsular gland of *Babylonia spirata* showing the histological organisation of subepithelial gland cells (10 x)

cce – ciliated columnar epithelium

ce – ciliated epithelium

d – ducts

o – oocytes

ov – ovary

se – secretary cells