CHAPTER 1. GROSS MORPHOLOGY OF THE REDUVIID HEAD AND SALIVARY GLAND COMPLEX

1.1. ABSTRACT

Rhynocoris fuscipes is a generalist predator found to be preys belong to various insect orders. The reduviid used its stylet to feed the prey. The gross morphology of the feeding canal and the salivary apparatus of *R. fuscipes* were investigated for the first time. *Rhynocoris fuscipes* bears a pair each of compound eyes and oceli; bears curved rostrum (2.73 ± 0.01 mm length). The salivary apparatus has a pair of maxillary and mandibular stylets each. The maxillary stylets are shorter than the mandibular stylet and are used to deliver the venomous saliva (VS) and suck the predigested food. The mandibular stylet bears 28 barbs in 3 rows useful for holding and rasping the prey. The salivary gland consists of a pair of principal gland (PG) and accessory gland (AG) each. The PG is further bifurcated into anterior lobe (ALPG) and posterior lobe (PLPG) and is joined at hilus (HI) region. The ALPG (1.16 ± 0.04 mm) is smaller than the PLPG (1.52 ± 0.30 mm). The accessory gland (AG) was attached to the gut binding with the trachea and tracholes. AG was interlinked with the PG through the accessory duct (AD). From HI, a salivary duct (SD) extends towards the head and ends with the maxillary stylet through adductor muscles (AM). Histologically the anterior and the posterior portion of principal gland has a clear distinction. The AG is typically of the vesicular type. From these results, by its gross morphological features, it is evident that the predator *R. fuscipes* is equipped strictly for zoophagy.

1.2. INTRODUCTION

Reduviidae is the largest family of predaceous land Heteroptera (Maldonado, 1990). They are abundant, voracious predators that consume not only more prey but also a wide array of prey (Schaefer, 1988). The head and the rostrum are designed to prey by piercing and sucking the prey tissues. The reduviids contain their elongated head with a transverse groove behind the compound eyes, and the short, prominent apparently three segmented rostrum curved outwards from the head. The tip of the rostrum in response fits into the groove. The head has a pair of large compound eyes, with two oceli and a pair of four segmented antennae (Capinera, 2008). The oceli or simple eyes have been the subject of numerous anatomical, physiological and behavioral investigations (Goodman, 1981; Wehrhahn, 1984; Mizunami, 1995). *Rhynocoris marginellus* (Fab.) (Fabricius, 1803); *Rhynocoris manticola* (Oshanin) (Murugan *et al.,* 1870); *Rhynocoris marginatus* (Fab.) (Ambrose, 1980; Kumar, 2011);

Rhynocoris fuscipes (Fabricius) (Ambrose, 1980); *Rhynocoris kumarii* (Ambrose and Livingstone, 1986); *Rhynocoris cruralis* (Bergroth) (Bergroth, 1915); *Rhynocoris nysiiphagus* and *Rhyncoris lapidicola* (Samuel and Joseph, 1953) head morphology were briefly elaborated. External morphological features have also been studied in details by various investigators for the past five decades (Lavoipierre *et al.*, 1959; Edwards, 1961; Cobben, 1978; Haridass and Ananthakrishnan, 1981; Sivaraj, 1986; Morrison, 1989; Santha, 1986; Udayakumar, 1986; Vellingirinathan, 1986; Sahayaraj *et al.,* 2010). However gross morphology, internal anatomy of head or rostrum has not been studied in detail, except in the work of Cohen (1990, 2000); Boyd *et al.* (2002); Boyd (2003); Sahayaraj *et al.* (2010) and Kumar (2011).

The reduviid predator salivary gland has been previously described by many investigators (Baptist, 1941; Barth, 1954; Southwood, 1955, Louis and Kumar, 1973; Haridass and Ananathakrishnan, 1981; Morrsion, 1989, Maran, 1999; Sahayaraj *et al.,* 2010). The morphology of salivary glands is diverse in different sub-families which could be utilized as reliable taxonomical tools (says Louis and Kumar, 1973). In general, the principal gland is unilobed or bilobed or multilobed, and the accessory gland is unilobed and vesicular, exhibiting distinct functional and histological differences. Further, it was reported that the principal gland is divided into anterior lobe and posterior lobe, suggesting the differential functions of the lobes involving division of labor (Haridass and Ananathakrishnan, 1981). The anterior lobe secretes zootoxic enzymes which are used to paralyze the prey, and the posterior lobe secretes the digestive enzymes. The accessory gland is typically vesicular (says Baptist, 1941; Southwood, 1955; Edwards, 1961). However, the detailed morphology, anatomy and histology of *R. fuscipes* are not available in the literature. The animal mouthpart and salivary gland morphology and its characteristic features give an idea of the toxicological, biological and biochemical characters. Thus, the focus of this study was to examine the structural morphology of *R. fuscipes* mouthparts including maxillary and mandibular stylets using light and scanning electron microscope (SEM). Furthermore the morphology and histology of salivary gland complex has also been studied using light-microscope.

1.3. MATERIALS AND METHODS

1.3.1. Insect collection and maintenance

Life stages of *R. fuscipes* were collected from cotton, bhendi agro-ecosystem of Tirunelveli district, Tamil Nadu, India. The collected animals were reared with factitious host *Corcyra cephalonica* (Stainton) fourth and fifth instar larvae under laboratory conditions at 30 ± 0.21 ºC temperature, 71.68 ± 0.41% RH and a photoperiod of 13L:11D h. Laboratory emerged adult male predators were used for the studies.

1.3.2. Head and stylet preparation

Fifteen to twenty alive adult male predators were kept in ice for 5 min and the animal were transferred into the dissection plate contain insect ringers solution (IRS) [1.09% NaCl, 0.16% KCl, 0.08% $CaCl_2$**.** $2H_2O$, 0.08% $MgCl_2.6H_2O$ (Li *et al.,* 2009)]. The excised head and the stylet samples were placed separately in the fixation solution (2.5% glutaraldehyde) for 24-48 h. Then the samples were rinsed with phosphate buffered saline (PBS) (0.2M Na_2HPo_4, 0.2M NaH_2Po_4, 0.8% NaCl) four times for 5 min and dehydrated in a gradient series of ethanol (75%, 80%, 85%, 90% and 99.9%-3 min in each gradient). Now the head, rostrum and stylets were air dried and coated by carbon particles using the carbon coater. The carbon coated samples were placed in the sample holding disc and it was loaded into the scanning electron microscope (SEM) (JSM – 6390) (Heng-Moss *et al.,* 2003). The images of the head and stylet were photographed and displayed in plate 1.1b, c, d and 1.2e.

For line diagram, the head of the animals were excised and placed in 70% ethanol for 24 h. After the incubation, the head was transferred to clean glass slide, and mounted using DPX moutant (Qualigens, India). The stylet of animals were dissected out longitudinally from the rostrum using the fine forceps, the head of the animal was held and using other fine forceps the rostral tip was gently and carefully removed without damaging the inner stylets using a dissection microscope. Removed stylets were prewashed with 70% ethanol and mounted on a clean glass slide using the DPX mountant (Qualigens, India). The specimens were then examined and photographed with a phase contrast microscope (Olympus CS 41, Japan) (Ambrose and Livingstone, 1986a; Fernández *et al.,* 2005).

1.3.3. Morphometry of head and stylet

The mounted head and stylet samples were analyzed for their morphometry by using a light microscope (Amba Optik – AE 11, India) equipped with ocular and stage micrometer (Erma Inc, Japan). The size of the various parts of head (anteoocular, postoccular, compound eyes, oceli and rostrum), mouthparts (base, mid and terminal) and stylets (maxillary and mandibular) were recorded. Ten male animals were used in each analysis. The line diagram of the head and the stylet were drawn using the Camera Lucida fitted to the light microscope and the diagram was drawn at 5X. Moreover, phase contrast photographs were taken using a phase contrast microscope (Olympus CS 41, Japan) equipped with a digital camera (Olympus E 240, Japan)

1.3.4. Gross morphology and histology of salivary gland

Ten alive adult predators were initially anaesthetized by placing them in ice as described by Sahayaraj *et al.* (2010) and transferred into the dissection tray coated with wax containing ice cold IRS. Using fine forceps, the animals were held, the wings, legs were cut off using scissors. A circular lateral incison around the first segment of abdomen was made with a sterile surgical blade. The main salivary duct was detached from the sclerotised mouthparts closer to the salivarium. The salivary gland complex was transferred to a clean watch glass containing ice cold IRS. The dissected glands were fixed for one hour in 0.1M sodium phosphate buffer (pH 7.2) containing 40% (v/v) paraformaldehyde at room temperature. The glands were settled onto micro slides and imaged using phase contrast microscope. The length and width of the principal gland and accessory gland were measured using the micrometer and the micro drawing (line diagram) was performed using the Camera Lucida (Kumar, 2011).

For histological studies, the salivary gland complex such as PG (ALPG and PLPG) and AG were separated in the IRS, which was drained off and washed with distilled water. The dissected glands were fixed in alcoholic Bovines fluid (Haridass and Ananthakrishnan, 1981; Moraes *et al.,* 1995). After the 24 h of the fixation, the glands were dehydrated in series of increasing alcohol dilutions (30, 50, 70, 90 and 100%), for 15–30 min of each concentration, embedded in the paraffin wax and cut in 5µm thin sliced segments using a rotary microtome (Microtome India, No, 1010-SMT-005, India). The sections were stained with Eosin followed by haematoxylin (sections were fixed on a clean glass slide which was preheated at 60 °C). After the staining, the slides were washed with distilled water. Stained

sections were dehydrated with absolute alcohol for 2 min, washed with xylene for removing the bounded in the glass slide. Now the sections were mounted on the glass slide using DPX mountant. The slides were viewed through the phase contrast microscope and image was captured using the digital camera fitted to the microscope.

1.4. RESULTS

1.4.1 Head

The entire head of *R. fuscipes* (Plate 1.1a) is a bright colored, finely pubescent, moderately elongated and shorter that the pronatum, anteriorly unarmed, a median transverse impression in between eyes dividing the head into almost four portions. Anteoccular portion (1.03 ± 0.02 mm) is significantly longer than the post ocular portion (0.62 ± 0.01 mm) ($t = 90.529$; $p < 0.05$) and ocular portion (0.42 ± 0.01 mm) ($t = 46.342$; $p < 0.05$). The reduviid possesses a pair of oceli (0.10 ± 0.00 mm) located at the anterior region (Plate 1.1b) of the head projecting backwards of the compound eyes. The rostrum (Plate 1.1c) is cylindrical and it was anteriorly bisected by a deep labial groove. The rostrum consists of base (B) (0.63 ± 0.01 mm), mid (M) (1.13 ± 0.01 mm) and terminal (T) (0.33 ± 0.00 mm) (Plate 1.1a, b). The base is shorter than the mid segment. The surface of the segment is covered with a few numbers of trichomes (Plate 1.1d). The rostrum contains different types of trichomes such as long spikes (LS) (117.33 ± 13.82 µm), short spikes (SP) (50.00 ± 5.00 µm), small spikes (SS) (12.66 ± 1.45 µm) and solei (S) (2.43 ± 0.14 µm) (Plate 1.1c).

1.4.2. Mandibular stylet

The stylet is located inside the rostrum; composed of a pair of mandibular stylet (Plate 1.2a) and a pair of maxillary stylet (Plate 1.3a). The average length of mandibular and maxillary stylet is 6.54 ± 0.00 mm and 5.26 ± 0.04 mm respectively. The mandibular stylet (MAS) is situated on each of the lateral side of the maxillary stylets (MS). MAS consists of three distinct parts namely base (B), mid (M) and terminal (T). The base is attached to the head by means of adductor muscles (AM) (Plate 1.2f, 1.3f). The base is continually up to salivary gland complex by a distinct duct called salivary canal (SC) (Plate 1.2e). There are three rows of numerous teeth like barbs (Ba) (Plate 1.2b, 2c) on the inner edges of the mandibular stylets. The barbs are in the form of concave shape (Plate 1.2d, 1.2e) facing outwards the head. In the mandibular stylet each row of the barbs is located adjacently with a distance of 5.25 ± 0.25 µm, whereas the space between the barbs is 4.90 ± 0.10 µm to 8.00 ± 0.50 µm (Plate 1.2f). SEM photograph showed that there are three types of barbs: long (6.57

µm), medium (5.26 µm) and small (4.47 µm) (Plate 1.2f). These barbs are helpful to the predator for holding and rasping the tissue of prey.

1.4.3. Maxillary stylet

The maxillary stylets (MS) are located in between the mandibular stylets. Structurally, they are similar to MAS as base (B), mid (M) and terminal (T) segments (Plate 1.3b, 1.3c). However anatomically, MS are smooth without any serrations and the tip of the stylet is highly pointed (To). The inner margin of the stylet contains a small finger like projection that seems to be a brush (Br) (Plate 1.3d, 1.3e). Along with the brush like structures, maxillary stylet possesses a hook (H) at the tip with furrow (F) for holding the prey (Plate 1.3b, 1.3c) and at the tip a terminal opening (TO) which helps in sucking the contents of predigested prey (PDF) (Plate 1.3c). During prey capturing both the MS interlock to form a canal like (FC) structure, which acts as a salivary canal for the delivery of the VS and also as a food canal for sucking the predigested prey contents. Generally, these maxillary stylets are inserted after the mechanical disruption of the prey tissue by the MAS.

The movements of stylets are supported by the adductor muscles (AM) (Plate 1.3a and 1.3f) located at the head. These adductor muscles support both the MAS and MS for their movement during the prey capture and ingesting the prey contents. Through the adductor muscles, the salivary and food canal pass in and out from the stylets.

1.4.4. Salivary gland-Morphology and Anatomy

The salivary gland complex (SGC) contains a pair of principal (PG) and accessory glands (AG) (Plate 1.4a and 1.4b). The PG is bilobed, comprising anterior and posterior lobes. The PG is started from the mesothorax and extended up to the abdomen (2.70 ± 0.11 mm long). It is divisible into anterior lobe (ALPG) and posterior lobe (PLPG). The anterior lobe (ALPG) (1.16 ± 0.04 mm) is smaller than the posterior lobe (PLPG) (1.52 ± 0.30 mm) (Plate 1.4a, 1.4b). They are situated in the thorax on either side of the gut. The ALPG is vesicular and is always filled with watery fluid. A very lobulated PLPG extends into the abdominal cavity located on either side of the gut. PLPG is highly nodulosus at posterior side rather than at the anterior side. These nodulosus is highly distinct as constrictions, attached to the foregut region and both the AG and PG are joined by the AD. The AG (1.15 ± 0.04 mm) is a vesicular unilobed having its base, mid and terminal region and the secretions are milky white in colour. The ALPG and PLPG join at hilus (HI) (Plate 1.4a, 1.b) which is well-

developed, compartmentalized, provided with valvular openings for their regulation of secretions sent out from the different lobe of principal gland and accessory glands. The outer chamber of hilus receives the incoming accessory duct (AD) and sends out the main salivary duct (SD); the respective openings of these ducts are being guarded by valve-like flaps. The openings of the outer chamber into the salivary and accessory ducts as well as into the inner one are provided with separate valves. The SD arises from the hilus moves to the head and finally it gets ended with the MS by the help of the AM. Both the PG and AG and their ducts receive a tracheal supply (1.4a, 1.4c, 1.4d). AG and both ALPG and PLPG are derived from a tracheal trunk of the cephalic and thoracic spiracular trachea respectively. A distinct nerve plexus (NP) is found on the principal gland of *R. fuscipes.* The nerve (N) which supplies this plexus was also seen, and is derived from the hypcerebral ganglion of the stomatogastric bervous system (Plate 1.4d, e).

1.4.5. Salivary gland-Histology

The principal gland of *R. fuscipes* is bilobed in nature having ALPG and PLPG. Both these lobes are interconnected by hilus. The PLPG (Plate 1.5A a) is surrounded by the thin layered membrane propia (MP) (Plate 1.5A b) followed by the epithelial cells (EC) (Plate 1.5A c) and beneath the inner membrane (IM). The EC possesses dense cytoplasm region having the secretory granules (Plate 1.5A b, c). These granules are located below the IM and form dense patches (DPSG). There are several number of collecting vacuoles (CV) (Plate 1.5A d) located in and around the EC, these CV help to accumulate the secretions and they become a larger one. The CV finally end with the lumen (L) which is lined by the columnar epithelial cells (CEC). The lumen is the place of the secretions which are stored and used when needed. The outer surface of the principal gland is occupied by the surface cells (Plate 1.5A f, g) which are in the dense form and the cytoplasm is highly viscous and dense in nature. And similar observations were seen in the ALPG (Plate 1.5B a), but the nature of the secretions are highly denser than the PLPG having a larger lumen for the storage of the secretions of the secretory materials. The ALPG possesses different types of cells such as uninucleated (UN), binucleated (BI) and polynucletaed (PN) (Plate 1.5B b), but in the PLPG only UN and BI cells were observed. And between each cell intercellular spacing (ICS) (Plate 1.5B f) was seen. Irregular shaped secretion granules (SG) are distributed both in anterior and posterior principal gland, which are concentrated in the ALPG (Plate 1.5B h) and more separately distributed in the PLPG (Plate 1.5Ae).

The AG (Plate 1.5C e) is of vesicular type having a minimum of secretory granules which is surrounded by the MP and EC which is almost UN in nature and produce watery saliva. The inner margins of the cells in AG exhibit distinguished striated or separate filaments with prominent nucleus. The hilus (Plate 1.5B g, h) is surrounded by the MP followed by the EC that shows the presence of UN and BN cells on the outer surface cells and devoid of rich CV where observed.

1.5. DISCUSSION

1.5.1. Head

The gross morphological features of the head and the mouthparts of *R. fuscipes* are similar to those that have been reported for other harpactorinae reduviids (Haridass and Anathakrishnan, 1981; Sivaraj, 1986; Morrison, 1989; Santha, 1986; Udayakumar, 1986; Vellingirinathan, 1986; Agnes, 1990; Ambrose, 1999; Sahayaraj *et al.,* 2010; Kumar, 2011). The head is elongated having a median transverse impression in between eyes dividing the head into almost two areas such as anteoccular and postoccular areas. Head gross morphology is similar in *R. kumarii* as described by Ambrose and Livingstone (1986b). The three segmented rostrum bears a short base, moderate median segement and a long terminal segment. It bears hair-like sensillae used in the orientation of the stylet fascile to the prey surface which is a typical pattern of *R. marginatus* (Kumar, 2011). This is aptly suited for the pin and jab type of feeding behavior, where, the rostrum and stylets are used to attack the soft bodied preys types without the necessity to actively chase, to grab, to hold or to pounce on them as done by the "chase and pounce" type of reduviids (Sahayaraj *et al.,* 2010). The oceli help the predator for the dorsal light response used during the flight (Gooddman, 1981; Wehrhah, 1984; Mizunami, 1995). The hair-like sensilla are mostly used to detect the worth or suitability or palatability or acceptability of the prey, and it is to assign a sensory function too. The trichomes present in the surface of the rostrum of *R. fuscipes* are used by this predator for the location of the prey and similarly types of the trichomes have been previously reported in *R. marginatus* (Kumar, 2011).

As in all other heteropterans, the stylet bundle of *R. fuscipes* has two maxillary stylets inside and two mandibular stylet outside. Both MAS and MS of *R. fuscipes* are typical of the Reduviidae as reported in *Catamirus brevipennis* (Sahayaraj *et al.,* 2010) and *R. marginatus* (Kumar, 2011). Many other heteropterans produce a salivary flange that is used as a fulcrum, among other functions, for stylet movement (Cohen, 1998b, 2000). Because reduviids do not

produce a salivary flange, the apical serrations on the MS (Plate 1.2d) are considered adaptive in holding onto tissues below the outer layer of the prey and in producing a fulcrum for the movement of the MAS (Cobben, 1978; Cohen, 2000; Wheeler, 2001; Boyd, 2003). The MS is longer than the MAS. This mandibular stylet surrounds the maxillary stylet (Lavoipierre *et al.*, 1959; Cobben, 1978). Boyd (2003) and Boyd *et al.* (2002) reported that the maxillary stylets of *Deraeocoris nigritulus* (Uhler) are more serrated than the phytophagous insects (e.g., Tingidae), but in *R. fuscipes,* the mandibular stylet is used to tear and wear the tissues of the prey by using the barbs (Ba) or serrations present on the outer edge of the stylet (Cohen, 1990, 2000; Kumar, 2011). Similarly, in the predaceous pentatomids the barbs on the mandibular stylets are found pointing towards the head of *R. fuscipes* (Cohen, 1996). The barbs point away from the head indicating that the cutting action occurs when the stylet is thrust forward, unlike predatory pentatomids, which have barbs on the MS pointing towards the head (Cohen, 1996). The barbs on the mandibular stylets of reduviids and other predacious heteropterans are more numerous than the barbs on the mandibular stylets of phytophagous Heteroptera (e.g., Lygaeidae, *Sensu lato*) (Cohen, 1990). *Rhynocoris fuscipes* has three rows of barbs on the surface of the mandibular stylet. The SEM photograph showed that the barbs (Plate 1.2f) are varied in the size and concave in shape ranging from large to small facing towards the head and so during the action the barbs move to and fro which helps to tear the prey tissues and help to form a pore to deliver the VS into the prey. The inner maxillary stylet is sharply pointed and has numerous brush (Br) like projections (Cobben, 1979) over the inner side of the stylet. The deeper serrations in the MAS of *R. fuscipes* are similar to those of *Deracoerous nebulosus* (Boyd *et al.,* 2002), *Deracoerous alivaceaous* (F.) (Cobben, 1978), *Deracoerous nigritulus* (Boyd, 2003), probably are used to disrupt prey by ripping and tearing tissues (Cohen, 2000). The mandibular stylets are considered adaptive in holding the prey tissues below the outer layer of prey and produce a fulcrum for maxillary stylet movement (Cobben, 1978; Cohen, 2000; Wheeler, 2001; Kumar, 2011). For both mandibular and maxillary stylet holds support by the adductor muscles (AM) (Plate 1.2e and 1.3f), because inside the rostrum (labium) there is no muscles are present and so far movement adductor muscles were used. And at each base of the stylet, the adductor muscles are present. Generally, these stylets serve multiple purposes, including prey anchoring, delivery of VS. Mechanical disruption of solid structures by laceration or rasping with stylet dentition, delivery of digestive secretions, uptake of partially digested food (Cobben, 1978; Cohen, 2000; Wheeler, 2001; Sahayaraj *et al.,* 2010; Kumar, 2011).

1.5.2. Salivary gland

The anatomical pattern of the salivary system of *R. fuscipes,* confirms to the general heteropteran plan in general (Baptist, 1941; Barth, 1954; Southwood, 1955) and reduviid in particular (Louis and Kumar, 1973; Haridass and Ananthakrishnan, 1981 and Morrison, 1989; Maran, 1999; Azevedo *et al.,* 2007; Sahayaraj *et al.,* 2010; Kumar, 2011). The under lying form of the salivary gland of *R. fuscipes* is obviously consisting of a principal part and an accessory part. The principal part is bilobed, and where it is further sub-divided to anterior and posterior glands with reference to the issuing salivary duct. The PG is found to be simply bilobed in the family Reduviidae (Baptist, 1941; Haridass and Anathakrishnanan, 1981; Maran, 1999; Sahayaraj *et al.,* 2010). However, Louis and Kumar (1973) suggested the trilobed condition of the salivary system as primitive type and an advanced character and unilobed was recorded in Triatominae of Reduviidae (Anhe and Oliveria, 2008). The principal salivary glands of *R. fuscipes* are elongated vesicles with tubular extensions as observed among the members of Reduviinae, Salyavatinae and a member of Harpactorinae (Haridass and Ananthakrishnan, 1981). Similar morphology was also reported in a sister species *R. marginatus* (Kumar, 2011). The differential functions of anterior and posterior lobes suggest division of labour. But Baptist (1941) believed that there is no such division in the functions of salivary glands of Heteroptera. In Pentatomomorphid families, the secretions of anterior lobes are primarily concerned with stylet – sheath formation, whereas those of posterior lobes involved in the production of digestive enzymes (Hori, 1969; Miles, 1972). Edwards (1961) found that in *Platymeris rhadhamanthus* (Gearstacker), zootoxic enzymes present both in the anterior and posterior lobes. The secretion in the anterior lobe is lesser in quantity, viscous and transparent, whereas the posterior lobe secretes larger quantity of highly viscous and milky white secretions as reported by Haridass and Ananthakrishnan (1981). In the forth coming chapter we analyzed, recorded and discussed in detail about various types of enzymes secreted by PG and AG.

Muscle layer associated with the lobes were not found in the principal salivary glands. This indicated that the saliva of *R. fuscipes* could be injected into the prey by extrinsic muscles. The presence of muscle fibers seems to be related with the predatory habit (Baptist, 1941), where a muscle sheath might be important to mobilize greater amounts of saliva. The nerve plexus, trachea and fine muscle fibres support and discharge the required quantity of saliva for paralysising or killing the prey. The tracheal supply of the salivary gland comes from the first visceral trachea which is generally the largest of the tracheae supplying the gut

as observed by Baptist (1941). The accessory salivary glands of *R. fuscipes* are typical of vesicular type as observed in other heteropterans (Baptist, 1941; Southwood, 1955) including reduviids (Edwards, 1961; Haridass and Ananthakrishnan, 1981; Vellingirinathan, 1986; Agnes, 1990; Kumar, 2011). However, it is an elongated vesicle with triradiate tubular branches in ectrichodiines, elongated vesicle in peiratines and saccular vesicle in triatomines (Haridass and Ananthakrishnan, 1981; Santha, 1986). Accessory glands are filled with watery fluid which helps the predator to flush out the predigested food from the body of the prey, very similar to the lacerate-flush mode of feeding of Pentatomomorpha in which the watery saliva is useful in flushing out the food from its source (Miles, 1972; Miles and Slowiak, 1976).

Hilus is distinct in *A. pedestris* (Morrison, 1989). The hilus provides a regulatory system for sending out secretions from different lobes of the salivary system. In *Lestomerus affinis* and *Haematorrhophus nigroviolaceous,* the valves in the hilus make it possible not only to send the secretions independently from the accessory glands, but also to send separately the secretions issued from the anterior and posterior lobes of the principal gland (Haridass and Ananthakrishnan, 1981). Such an independent flow for the anterior and posterior lobes of the principal gland is also observed in *R. fuscipes*. The salivary lobes open out individually by a small pore, guarded by thick circular muscles into a compartmentalized hilus as observed by Morrison (1989). A complex nervous supply was observed previously by Baptist (1941) and Miles and Slowiak (1976). A double nerve supplies separately to the anterior and posterior lobes facilitates independent discharge of saliva (Miles, 1972). Perhaps the nerve plexus is responsible for an acceleration of cellular activity, which seems to result in the production of a somewhat thinner secretion than that ordinarily found stored up in the lumen of the gland.

Different types of cells such as, mono, di, and poly nucleated cells were observed in ALPG and PLPG. Both the ALPG and PLPG possess bi-nucleated cells. But Morrison (1989) observed uni-nucleate cells in anterior lobe and bi-nucleate cells with highly viscous cytoplasm in posterior lobes of *A. pedestris.* Such variations are found among members of different subfamilies of Reduviidae (*Triatoma rubrofasiata*) (Haridass and Anathakrishnan, 1981). The cytoplasm is traversed by various sizes of collecting vacuoles (CV) containing secretion. These increase in size towards the inner parts of the cells. Regular rounded secretion granules are distributed to near or around the collecting vacuoles. Another characteristic feature is that the central lumen of the gland is lined by a special flattened

secretary epithelium, with irregular intercellular space around the central lumen. The cytoplasm possesses typical secretion granules, dense around the collecting vacuole. The cytoplasm of the anterior- and posterior-lobe cells differs slightly in texture. The cytoplasm is densely packed with large secretion granules and the collecting vacuoles are moderate in size and full of dense secretion. This characteristic feature of collecting vacuoles is to serve the purpose of storing up quite an appreciable quantity of secretion. The accessory glands attached to the lateral sides of the first midgut appear triangular with a tubular appendix opening into the common salivary duct. Accessory glands are thought to function as water recapturing organs, a function that has been underemphasized in an account of feeding by predaceous heteropterans, *R, fuscipes* (Miles, 1972). Accessory salivary glands are filled with watery fluid (Baptist, 1941), which recirculate water from the gut to ensure a copious flow of watery saliva and helps the predator to flush out the predigested food from the body of the prey. It is forwarded by a single layered epithelium as observed in other predatory bugs like *Brontocoris tabidus* (Pentatomidae) (Azevedo *et al.,* 2007). The accessory glands differ histologically from the lobes of the principal gland and secrete watery saliva, which has less protein fractions than the other lobes. Similar results were highlighted in Pentatomid and Coreid bugs (Miles and Slowiak, 1976), and in assassin bugs (Haridass and Anathakrishnan, 1981; Morrison, 1989). A well developed nerve plexus is always present on the surface of the principal gland. The histochemical analysis by Agnes (1990) suggests excretory function to the salivary system in addition to the salivary secretory function (Schuh and Slater, 1995). A poorly developed nervous plexus is always present on the surface of the accessory gland (Haridass and Ananthakrishnan, 1981).

1.6. CONCLUSION

The gross morphological features of *R. fuscipes* are strictly for the zoophagy by its presence of the stylets used for the rasping and holding of the prey tissues. The stylet movements are supported by the head adductor muscles. The salivary gland complex is made up of a pair of principal and accessory gland, where the principal gland is further bifurcated into anterior lobe and posterior lobe interconnected by the hilus. The histological features of the salivary gland showed the presence of the secretory cells and the also the secretory granules from the two lobes of the principal gland. Less or no secretion was observed in the accessory gland. Centralized lumen helps for the secretion and for it the release. The nerve plexus stimulated to secrete the secretions and are present on the surface of the salivary gland complex.