DISCUSSION

The scorpion family Euscorpiidae has wide distribution in Indian subcontinent and it shows an interesting patchy distribution for three of its genera and 15 species so far known from India. The subgenus *Scorpiops* Peters occupies wide range from North West to North East Himalya, Nepal, Bhutan and the place in Satpura range in central India. The other subgenus *Euscorpiops* vachon seems to limited only to North eastern states of India. The third genus *Neoscorpiops* Vachon has a small, restricted patchy distribution between Tapi Vally in North and Krisha Valley on South in Maharashtra India.

No species amongst 15 known species of the family Euscorpiidae from India have been studied for details of Anatomical and Histological aspects of different systems. As a representative the recently described species *Neoscorpiops deccanensis* (Tikader and Bastawade 1977) was chosen for such studies. To restrict the vastness only three systems namely Nervous, Reproductive and Venom systems were selected. The following chapters in all 9 emphatically are dealt with, finally discussed, summarized in the present work.

*Neoscorpiops deccanensis* (Tikader and Bastawade) is a local species and comparatively easily collected from nearest locality of its distribution namely Singhagad fort and surrounding area. Collection is done timely visiting the area for two years of studies.

Various techniques used for studies were as follows:

1) Dissection and tracing of systems under binocular microscope.

2) Paraffin wax method of sectioning for histology of the systems under studies.

3) Haematoxyline -Eosin method for staining of histological slides.

4) Micrometry of the systems under studies for present research.

5) Microphotography of histological slides.

6) Scanning Electron Microscopy of some of the structures under study.
Useful magnification for histological study of ordinary light microscope is up to 1500 x. All slides prepare to illustrate the fine structures of systems under study. Instant killing is necessary for good results of histological preparations (Conn's H. J. 1969). Fixation of study material is done with Carnoy's fluid. It is very commonly used fixative for delicate material like nervous tissue, embryonic tissue and reproductive tissue. This fixative acts by two method autolysis and putrification (Conn's H. J. 1969). Autolysis is cell lysis by enzyme, cathepsin and proteinases liberated after the rupture of lysosomes. Putrification means the formation of gas, best preservation results are obtained by putting tissue into fixative as soon as possible fixative plays important role in presentation of cells hardening of soft tissue, irreversible semisolid consistency. Alteration of refractive indices to varying degrees which enable unstained material to be more easily stained. For staining preparations of the slides Haematoxylene-Eosin double staining method used. Haematoxylene is basic dye gives blue colour to acidic material i.e. nucleic acids (DNA) and Eosin is acidic dye it gives pink colour to cytoplasm which is basic in nature. Here eosin is used as counter stain. Thus by this method nucleus apparatus blue and cytoplasm appears pink (Godkar and Godkar 1969).

**Nervous system**

Anatomy of *Neoscorpiops deccanensis* studied in detail for female and male individual. The results together with the research earned out on the nervous system of other scorpion species permit to identify the series of structures those should be included in a basic plan of order Scorpions, homologous structures occupying highly similar position as well as possessing the specific features as other species studied by Millot and Vachon. (1949): Awati and Tembe (1952); Sasira Babu (1965); Hjelle 1990; Polis (1990) and Horn and Achaval (2002), Scorpions one of the early terrestrial arthropods have believed to preserved an ancient nervous system organization, but one that is functionally capable of integrating highly sophisticated senses, and producing coordinated movements in locomotion, burrowing, and attacking prey. Compared with other invertebrates, arachnids generally have highly cephalized nervous systems representing the fusion of many segmental ganglia (Polis, 1990).

The dorsal portion of the cephalothoracic mass is more noticeably equivalent to the "Brain" of other arthropods, but comparisons of its histological structure with
those of the protocerebrum, deuterocerebrum and tritocerebrum of other arthropods are not precise. Moreover, since arachnids lack antennae, a deuterocerebrum is not defined in the adult. As a result, many different names have been given to divisions of the cephalothoracic mass as dorsal "Brain" including protocerebrum and tritocerebrum and ventral sub-oesophageal ganglion (Bullock & Horridge, 1965): dorsal supra-oesophageal ganglion and ventral sub-oesophageal ganglion (Sasira Rabu 1965): dorsal cerebral ganglion and ventral sub-oesophageal ganglion (Henry 1949): dorsal cephalic or dorso-pharyngeal ganglion and ventral thoracic or ventrom-pharyngeal ganglion (Birula 1917). A microscopic examination of microtome sections of brain show four parts i.e. the dorsal one being the fore-brain followed by the midbrain, hind brain and accessory brain (Awati and Tembe. 1952). The most logical division based upon histological information, seem to be as follows: the supra-oesophageal ganglion is equivalent to the protocerebrum, the circum oesophageal connective are derived from the tritocerebrum and the sub-oesophageal ganglion, representing the fusion of several ganglia, contains neural centers controlling segments of the cephalothoracic region (Polis, 1990).

The scorpions have morphologically primitive nervous system in which the ancestral organization has been preserved (Polls 1990; Root. 1990). The basic layout consists of an anterior cephalothoracic mass divided into a dorsal supraesophageal ganglion and ventral subesophageal ganglion connected by circum esophageal connective, as well as a long double ventral nerve cord that originates in this cephalothoracic mass and extends posteriorly. The ventral nerve cord composed of seven free ganglia joined longitudinally by connective and laterally by commissure (Millot and Vachon, 1949, Hjelle 1990, Horn and Achaval, 2002). The central nervous system of both the scorpions consists of basic layout. The cephalothoracic mass is very compact, thick and well oriented.

The central nervous system of scorpion is ensheathed by fibrous outer layer of connective tissue and cellular inner perineurium. The connective tissue sheath of scorpion is composed of collagen fibrils embedded in a mucopolysaccharide matrix. The perineurium acts as a blood brain barrier with numerous tight junctions between cells in a perineurium selectively restricting the passage of molecules into the central nervous system (Polis, 1990).

The protocerebrum of Neoscorpiops deccanensis situated on antero-dorsal surface of the sub esophageal ganglion (Fig. 4.2). This location of protocerebrum in...
Neoscorpiops deccanensis appears similar to the other scorpions such as to Cenruroides sp. (Buthidae) (McClendon, 1904); Uroctonus mordax (Euscorpiidae) (Henry, 1949); Tytius serrulatus (Buthidae) (Lucas, et.al. 1965). Bonarinsis bonarimis (C. L. KOCH. 1842) (Horn. A. C. M. and Achaval, M. 2002). The protocerebrum of female Neoscorpiops deccanensis is pear shaped and and in male bean shaped (Fig. 4.2 and 4.3).

The median and lateral eye nerves, rostral nerves, cheliceral nerves, pedipalpal nerves, ambulatory nerves, pectinal nerves, lateral nerves of first six ganglia and posterior nerves of the seventh ganglion show same specifications and innervations as in other species studied (McClendon, 1904; Henry, 1949; Sasira Babu. 1965; Lucas, et. al. 1965, Horn and Achaval, 2002). The major nerves, tracts, and neural centers of the cephalothoracic mass have been described by Sasira Babu (1965). The protocerebrum of the scorpion under study shows major nerves and neural centers as described by Sasira Babu (1065). The protocerebrum contains (Fig. 4.2) four bilateral optic nerve centers. Out of these four, paired median optic nerve centers, present at the base of median optic nerves, while other two centers present at the base of lateral optic nerves. A single neutrophil region is present at the base of each optic nerve center. Both median and lateral optic nerve centers send tracts to the central body through optic commissure. The central body receives inputs from other sensory and motor centers and therefore probably functions as sensory-motor integration center (Sasira Babu 1065). The protocerebrum also consist of globuli cell regions. The globuli cell region arc probable higher order association and integration centers (Sasira Babu 1965). It was observed that the protocerebrum of Neoscorpiops deccanensis surrounded by large cell body of neurons containing secretory granules (NSC) (PT 4.4 & 4.5). These cells are probably a neurosecretory cells (Habibulla M, 1961, and Sasira Babu 1965).The area of brain that (Awati and Tembe 1944) termed the midbrain was called the tritocerebrum by Bullock & Horridge (1965). The largest internal centers of the tritocerebrum are the cheliceral ganglia, located in-the circum-esophageal region at the bases of the paired cheliceral nerves, which control the movements of the mouth parts. It was observed that peripheral portion of tritocerebrum and anterior portion of sub-oesophageal ganglion of young specimens consist of large cell masses with secretory granules (Nsc) (PT. 4.8). Such neurosecretory cells have also been marked and described by Habibulla M. (1961) in Heterometrus swammerdami and Sasira Babu (1965) in Heterometrus fulvipes.
Dorsally, the sub-oesophageal ganglion of *Neoscorpiops deccanensis* oval in shape in female and male resembles with *Cenuroide sp* (Buthidae) (McClendon, 1904) and *Tytius serrulatus* (Buthidae) (Lucas, et al. 1965). The suboesophageal ganglion is a compound ganglion that supplies a pair of pedipalpal nerves, accessory pedipalpal nerves, four pairs of ambulatory nerves pedal nerves, a pair of accessory ambulatory nerves. Henry (1949) also mentioned one small accessory pedal nerve to first, third and fourth and two accessory pedal nerves to second leg and four pairs of vagus nerves, out of four pairs. The first pair goes to the pectines, the second pair to the genital operculi, the third and fourth pairs to the first two pairs of book lungs. Sasira Babu (1965) described an unpaired, dorsal ephemeral nerve, which innervates the endosternite and surrounding muscles; anterior and posterior genital nerves; large pectinal nerves; and third and fourth mesosomatic segmental nerves, which comprise dorsal branches to the dorsum of the respective segments and ventral branches to the book lungs and ventral muscles. The first pair of ambulatory nerves present slightly frontward and enters in interior of first pair of legs. The second, third and fourth pairs of ambulatory nerves oriented in caudal direction and enter in interior of the respective legs (Fig. 4.1, 4.2 and 4.3). It was also observed that the small pair of accessory ambulatory nerves arise from the dorsal and ventral region at the point of origin of main 1-4 ambulatory nerves and run parallel to them. The four pairs of mesosomal nerves (vagus nerves), the first pair goes to the pectines, the second pair to the genital operculi, and the third and fourth pairs to the first two pairs of book lungs.

Histologically, the sub-oesophageal ganglion of *Neoscorpiops deccanensis* consist of major nerve centers includes major pedipalpal nerve centers, ambulatory nerve centers, and vagus nerve centers and ventral nerve cord nerve centers. Sasira Babu (1965) and Polis G. A. (1990) describe pedipalpal ganglia, leg ganglia and group of cells at the base of vagus nerves. They describe separate large nerves and cell groups for pedipalpal and leg centers. Root (1980) confirms motoneurons are located in the leg ganglia. Sasira Babu (1965) describes groups of giant cells located in the cheliceral, pedipalp, and leg ganglia. Bowerman and Burrows (1980) in *Paruroctonus mesoensis* stained motoneurons ambulatory leg nerve centers of the sub-oesophageal ganglion, innervated eight different leg muscles. These are located in the ventral cortex of the sub-oesophageal ganglion. The central ganglion lies along the midline, near the ventral surface. It receives connections from sensory tracts arising in the pedipalps and legs and connects with many of the major incoming and outgoing tracts in the sub-oesophageal ganglion (Polis G. A., 1990).
The ventral nerve cord is a group of nerve fibers arising from the posterior region of sub-oesophageal ganglion and extends in mesosoma, metasoma and also gives innervations to the telson. There are three mesosomal ganglia, four metasomal ganglia.

Each ganglion is a fusion of two symmetrical hemiganglia, internally connected by T. S. connectives. (PT. 4.11) Two pairs of nerves arise from each of the first six ganglia. In each hemiganglion, there is an antero-dorsal nerve and postero-ventral nerve respectively. The dorsal nerves from each ganglion supply branches to the muscles, receptors and dorsal body wall structures, while the ventral nerves supply to the corresponding ventral side. In *Neoscorpiops deccanensis* the first, second and third mesosomal ganglions are located in the anterior margin of the fourth mesosomal segment, slight posterior to the fifth mesosomal segment and posterior half of sixth mesosomal segment respectively. Fourth metasomal, fifth metasomal and sixth metasomal ganglia of both the species are located in first, second and third metasomal segments respectively.

The last or seventh ganglion located in most anterior margin of fourth metasomal segment and it is slightly larger than other ganglia (1.35 mm size) (PT. 4.1, Fig. 4.1), the ganglion from which a five pairs of nerves arise. Yellamma et al. (1983), found that this last metasomal ganglion consists of a larger number of cells compared to other ganglia and hypothesized a role in the stinging reflex.

Histologically, the first six ganglia of both the species are similarly organized, bilateral symmetrical group of nerve cells are observed. It indicates the double organisation of the ganglia and ventral nerve cord. The first six ganglia are structurally similar but seventh ganglion is more complex. The longitudinal section of seventh ganglion (PT. 4.10) also consists of bilaterally symmetrical groups of nerve cells, nerve tracts and in addition it also contains the large nerve fibers originate from posterior portion of ganglion and extend in fifth metasomal segment. The cell bodies of these fibers are located in the distal border of the 7th ganglion (PT. 4.10) The cell body of these cells contain large centrally placed nucleus. This system of giant fibers integrates quick movement and stinging behavior of scorpion (Sasira Babu, 1961).

Sasira Babu (1965) described major nerve tracts with schematic diagram of first and seventh ganglia. He described the centro-lateral tracts, central tracts, dorso-lateral tracts, ventro-lateral tracts, latero-segmental tracts, mid-central tracts, mid-
dorsal tracts, mid-ventral tracts as well as dorsal and ventral commissures. The seventh ganglion along nerve tracts also shows major cell masses located in the cortex of the ganglion. He also indicated the fifth segmental nerves and telsonic nerves in the photograph (PT. 4.12).

The ventral and dorsal pairs of nerves arise from the posterior region of the 7th ganglion, ventral pair supply branches to the muscles of fifth metasoma called fifth metasomal nerve, and other dorsal pair called telsonic nerves supply branches to telson (PT. 4.3, Fig. 4.7) Directly to the venom gland and corresponding muscles of fifth metasoma the paired dorsal telsonic nerves form ring around the digestive tract and again run parallel posteriorly (PT. 4.3), to enter in to venom glands and corresponding muscles. At the base of vesicle, around a dorso-ventral muscular strand, the telsonic nerves form thick ramification by dividing into fine branches. These fine branches concentrate in the muscles present at the posterior end of venom glands; appear more or less as a band or a collar. It supplies their branches to dorsal, lateral and ventral muscles to form a ring like structure around the base of telsonic muscles, continue and penetrate both the venom glands, where it supplies fine branches to venom glands and musculature present around it. In *Bothriurus bonarinsis* (C. L. KOCH, 1842) Horn, A. C M. and Achaval, M. (2002) described that, at the division to fourth and fifth metasomal segments, these telsonic nerves adhere to each other for a short distance, forming a ring around the alimentary channel, from this point onward, turn ventrally and transverse the abdomen in the direction of the central nervous system, until opening at the anus. In the one third posterior of the fifth metasomal segment, the pair of nerves once again separate, forming a second ring around a dorso-ventral muscular strand located at the insertion point of the telson. The observations in *Neoscorpiops deccanensis* show similarities with this observation (PT. 4.3) The double ventral nerve cord of *Neoscorpiops deccanensis* surrounded by perineurium (PT. 4.10). It encloses group nerve fibers, forming many large longitudinal nerve tracts. Sasira Babu (1961) and Babu and Venkatachari (1966) reported numerous "giant fibers" in the ventral nerve cord of *H. fulvipes* and *H. swammerdami*, the fibers range from approximately 18 to 30 μm in diameter. Giant fibers seem to mediate quick behaviours, such as escape, by virtue of their large diameters and their consequently fast conduction velocities. The giant fibers typically have much greater diameter axons than other nerve fibers. In these scorpions, giant fibers were observed in all the major longitudinal tracts of ventral nerve cord. The fibers range from approximately 12 to 15 μm in diameter. Ventral nerve called...
innervates the fifth metasomal segment and the telson. The cell bodies of these fibers are located in the distal border of the 7th ganglion (PT. 4.11).

**Female reproductive system**

Female reproductive system, embryology, and parturition of scorpions reviewed by Werner F. (1935). According to Birula 1917a, Millot and Vachon 1949, Mathew 1956 and Francke 1979 a family Buthidae have five transverse ovariuterus tubes, whereas all other families have a four transverse ovariuterus tubes, interconnected by four transverse tubules. It forms six loops, three on each side. These constitute ovariuterus of scorpion. *Neoscorpiops deccanensis* the loops of reproductive system are present in 3rd mesosoma to 5th mesosoma. Matthiesen (1970) however, showed that *Tityus cambridgege* and *T. stigmurus* as Buthids do not have five transverse tubes; only the anterior and posterior transverse ovarian tubes are present, forming a two-celled ovariuterus. In *Neoscorpiops deccanensis* both male & Female specimens under study, from the anterior angle of each lateral longitudinal ovariuterus tube, the oviducts proceed anteriorly, forming the dilated receptacle seminalis. The receptacle seminalis open into genital chamber, which opens to the exterior through the genital aperture, which is externally covered by the genital operculum.

The ultrastructure study of ovariuterus and oocytes maturation has been studied in *Euscorpius carpathicus (L.)* (Euscorpiidae) (Soranzo) (L) et. al. 2000) present studies of ovariuterus by two layers of cells surrounding irregular lumen. The outer layer consists of follicles provide nutrients at initial stage of development and then hepatopancrease provide nourishment. After gastrulation embryo detaches from ovariuterus and special ovarian puff like apparatus for nourishment is developed by ovariuterus for providing nourishment of the developing embryo. (PT. 5.15 to 5.20) This structure found in *Neoscorpiops deccanensis* for first time. Such type of feeding apparatus are not reported before by any other studies so far reported.

Further development of embryos has been studied by many authors (Laurie, 1890, 1896a b; Pavlowsky, 1924b, 1925; Mathew, 1948 and 1956, 1957). According to embryonic development, the scorpions have two types of developments apoikogenic and katoikogenic. The developmental type of these five families belongs is referred to as apoikogenic (Laurie 1896a, b) ova of apoikogenic scorpion have variable amount of yolk (Pavlowsky, 1924b, 1925).

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In *Neoscorpiops deccanensis* ovum is spherical and alecithal. Numerous ovarian diverticula develop from the ovariuterus and invaded into hepatopancreatic mass present surrounding the ovarian tubules.

Development starts with first cleavage in *Neoscorpiops deccanensis*, first cleavage is **vertical equal holoblasite** (PT. 5.12 B) results to form two celled embryo. Second cleavage is also vertical equal holoblasite but at right angles to first, which results into four celled embryo (PT. 5.12). The successive cleavages result into formation of morula. Embryo gets feeding from surrounding follicular cells. In due course of development of blastula reach to the lumen of oviduct simultaneous the regression of the diverticula on outer surface take place. It gets specific position in ovariuterus. At this stage the uterine wall fuses with embryonic cells to form trophocyte cells (PT. 5.7 C). The trophocytes become feeding apparatus and now the cleavages are meroblastic cleavage. The upper layer of blastomeric divide and the basal layer is modify in to trophocytes. The development of embryos is in disc shape therefore it is called as discoidal cleavage. It is modified meroblastic cleavage. As a result of successive cleavages gastrula is formed. During successive cleavages the cleft occurs in developing epiblastomerces and trophocytes (hypoblasts). The gastrula is developed after the morphogenetic movements in the blastula by delamination process. After formation of gastrula oviduct develops special feeding apparatus. Ovarian follicles get swollen to form puff like structures at both the ends of the site of embryo development. The anterior follicular puffs release nutrient granules by their microvilli in the amniotic sac of embryos (PT. 5.20). The ovarian follicular puffs present at posterior end of embryonic development lacking the microvilli (PT. 5.16). The posterior puff has compact mass of follicular cells which forms tight enclosure for developing embryo. Embryo now starts getting nutrients from microvilli and it detaches from the wall of ovariuterus. All diverticula regress towards the lumen of oviduct embryo get detached form the wall of ovariuterus. Extra embryonic membranes appeared surrounding developing embryo and embryo remains floating freely in the amniotic fluid present surrounding it. At this stage embryo gets the nourishment released into the amniotic sac by microvilli of ovarian puffs (PT. 5.15). The SEM (Scanning electron microscopy) of microvilli shows the exact mechanism of feeding of developing embryo by follicular puffs (PT. 5.19, 5.20).

The follicular cells in the puff area are swollen and become secretary in nature to get loaded with nutrients. Follicular cells acquire large size about 10 μm and the
size of food granule is about 5 μm. At the tip of lobe of follicular puff the cells elongate in size and become deciduous i.e. they sacrifice themselves while releasing the nutrient granules. They have rupturing microvilli (10 μm) to provide the nutrient granules as nourishment to the embryo (PT. 5.20). These types of cells are named as deciduous cells (Bayle 1962).

Embryo develops freely in the Embryo sac the size of puffs almost remain constant throughout the gestation period (1 mm). The size of embryo increases form 1 mm to 7 mm in due course of development.

The other apoikogenic families have large ova rich in yolk such as, the ova of Centruroides vittatus, (Francke 1982); Euscorpius italicus, (Werner 1935); Lychas tricarinatus (has alecitha! ova) (Mathew 1960). Ova of apoikogenic scorpions are alecithal, isolecithal, or telolecithal (Yoshikura 1975). An epiblast (ectoderm rudiment) and ahypoblast (endoderm rudiment). The hypoblast produces the mesoblast (mesoderm rudiment), and, the two apparently separate through delamination (Laurie 1890).

Gestation period in Neoscorpiops deccanensis can be divided in to two phases because of hibernating behavior of Neoscorpiops deccanensis. First the period of gestation in which fertilization occurs before the hibernation period i.e. pre hibernation period and the period in which the fertilization occurs after the hibernation period i.e. post hibernation. After the months February post hibernating period (5 months) and pre hibernating period gestation (7 months) occurs.

**Male reproductive system**

The male reproductive system of scorpion, in general, has been described by many authors such as Buthus australis L and Scorpio maurus L (Pavlowsky 1915, 1921); Male reproductive system, embryology and parturition of scorpions reviewed by Werner F. (1935); Buthus tamulus Fabr. (Awati and Tembe, 1952), Buthus quinquestriatus (Abd-el-Wahab, 1957). The account of the reproductive organs of the scorpions available in the literature is neither precise nor complete. There are many points that still need explanation. Here, the efforts have been made to provide additional description of reproductive systems Neoscorpiops deccanensis. The male reproductive organs of Neoscorpiops deccanensis (Fig. 6.1) are paired testis. Each
testies formed by two longitudinal tubes united by four transverse tubes, thus forming three loops in each testis, extending from 3rd to 6th mesosomal segment. Millot and Vachon (1949) have described the male reproductive system as having two longitudinal tubules but always shown four tubes in their illustration. In *Scorpio maurus* (Pavlowsky 1921), each testis is made up of only a single longitudinal tubule provided with four blind diverticula projecting medially, although the first one or two diverticula may partially unite with one another. The histological structures of the testies of scorpion studied by Awati and Tembe (1952), Abd-el-Wahab (1957) and Giramkar (2008). The germinal epithelium based on basement membrane. The cells of germinal epithelium are flat and each with large distinct nucleus. Germinal epithelium is divided by septa into different lobules. There is a lumen in the center of testis. The lobules consist of various stages of spermatogenesis i.e. spermatogonia, spermatids and spermatozoa and mature sperms found in bundles. The spermatocyte in late prophase first stage is having chromosomes in coiled threads and the nucleus has nuclear membrane. In the spermatocyte in metaphase-I has all chromosome aggregated at equatorial line of the cell. Chromosomes become thick and short in length. They are more compact and highly stained with haematoxyline nuclear stain. The spermatocyte in Anaphase first all chromosome get pulling towards both the ends of cell and they are clearly seen in this stage. In the spermatocyte in Anaphase second the chromosome of metaphase second clearly segregated and four group of chromosome separated to from telophase second. In the spermatocyte in Telophase second stage, four separate groups of chromosomes clearly visible in the dividing cell. Each group has six chromosomes indicating 24 chromosomes are present in *Neoscorpiops deccanensis*.

**Structure of mature sperm**

A mature sperm (PT. 6.10) consists of head, middle piece and tail. The head of sperm is elongated. It is broader at the proximal end and narrower towards middle piece. The middle piece of sperm is much longer than head. There is no clear demarcation between head, middle piece and tail. The tail is the last portion of the sperm. It gets stained lightly than other parts. The mature sperm measure about 38 \( \mu \text{m} \) in length.

The antero-lateral loop of each testis of both the scorpions under study gives rise to a vas deferens, into which the vesicula seminalis opens. In *Neoscorpiops deccanensis* additional accessory glands are noted. There is considerable confusion in
the literature about the terminology to be applied to the accessory glands and no
definite knowledge about their functions. Several authors have described two pairs of
accessory glands: the cylindrical glands and the oval glands (described as seminal
receptacles in Millet and Vachon (1949). Birula (1917) described the oval gland
(ovate vesicle) is posterior to the cylindrical gland, whereas Millot and Vachon (1949)
and Abd-el-Wahab (1957) showed the reverse situation in their illustrations. In this
study in *Neoscorpiops deccanensis* three pairs of glands are present. The
hypothesized function of the accessory glands is the secretion of the various
components of the hemispermatophore or the material to glue the two halves together
(Franckc 1979a and Polls, 1990). The cytoplasmic granules or epithelial cells are
stained by haematoxylin.

Various authors referred to paired ejaculatory sacs, structures formed tubular
organs for transmitting sperms. It is now considered that the ejaculatory sacs
(elongate, hollow tubules behind the seminal vesicles), the seminal vesicles, and the
accessory glands constitute the paired paraxial organs (terminology after Pavlowsky
1917). Histologically, the wall of ejaculatory sac of *Neoscorpiops deccanensis* is
covered by thin smooth muscle layers enclosing a connective tissue capsule (PT. 6.6).
The inner of columnar epithelium continue throughout the inner border of ejaculatory
cac. The basal plate consists of tall columnar epithelial layer. The trunk region
consists of thick layer of epithelium, enclosing a lumen with nutritive fluid. The
lumen of capsular region consists of sperm packets along with nutritive fluid. The
chitinous supporting stalk extends dorsally from the base of posterior border of
capsular region to the distal portion of lamella. The lining of epithelium is thin in
basal plate, while thick in trunk portion. In the lumen of capsular region sperm
packets were observed along with nutritive fluid. The chitinous supporting stalk
extends from proximal portion of capsular region to lamella. Pavlowsky (1921)
mentioned the chitinous nature of the posterior process of the supporting shaft in
*Scorpio maurus*. In *Neoscorpiops deccanensis* of chitinous rod light like structure is
present. It may act as trigger at the time of expulsion of hemispermatophore during
courtship. Each of the paraxial organ secretes half spermatophore to stores sperms
with seminal fluid from vas deference and seminal vesicle respectively. During
courtship the two halves or the hemispermatophores are extruded and fused together
to form the spermatophore, which is glued to a substratum. Each paraxial organ
produces half the spermatophore, called the hemispermatophores (Polis, 1990). The
right paraxial organ produces the right hemispermatophore. The left
hemispermatophores spermatophore produced by left paraxial organ (Bastawade, 1994). Both the paraxial organs are mirror image of each other.

The sperms enter into the capsule of the hemispermatophore by the seminal vesicle; the accessory glands produce components of the hemispermatophore or the material to glue the two halves together, or both and the ejaculatory sac serves to push the two halves out of the gonopore, forming a complete bilaterally symmetrical spermatophore. Mature male ejects a complete spermatophore at a time during nuptial dance (Francke 1979a).

The report on the glued post insemination spermatophore of Indian species Mesobuthus tamulus tamulus (Fabr.) (Buthidae) are available by Bastawade (1992) (PT.) and Heterometrus scaber (Pocock) by Mathew (1957). Indian scorpion fauna comprises of five families namely Buthidae, Chaerilidae, Euscorpiidae, Liochilidae and Scorpionidae. Buthidae possesses a lamelliform spermatophore, consists of Basal plate (Bp), Trunk (Tr), Capsular region (Cap), Flagella (Fl) and remaining families possess the lamelliform spermatophore (Bastawade 1994) (Fig. 6.2) with Basal plate (Bp), Trunk (Tr), Capsular region (Cap) and Lamella (Lam). The spermatophore in post-insemination state in Mesobuthus tamulus tamulus (Fabr.) (Buthidae) is pinkish-brown, much darker on capsular region, which is chitinous and pale, transparent on the stem and almost whitish on the flagellum. It is lamelliform and measures about 15 to 18 mm in total length (Bastawade 1992). The phylogenetic relationship of some Chaetoids has been discussed by Francke and Soleglad (1981) on the basis of hemispermatophores along with other characters. Francke (1979a) suggested that the lamelliform spermatophore is homologous to the spermatophores of pseudoscorpions. Maury (1980) indicated, it is not always a simple matter to obtain pre insemination spermatophores for study, but it is probable that these will have the greatest significance for taxonomic purposes.


Venom gland

The venom glands of scorpions were extensively studied by Pavlowsky (1913, 1924a, 1925); Wemer F. (1935); Joseph E. Mazurkiewicz & Eldridge M. Bertke ... 82 ...
Pavlowsky (1913, 1924b) was among the first author to survey important anatomical systems of scorpions across many scorpion genera and families, with an unusually representative selection of scorpion genera. He specifically paid attention to the phylogenetic importance of anatomical features.

The cuticle of venom glands of Neoscorpiops deccanensis made up of three layers. Joseph E. Mazurkiewicz & Eldridge M. Bertke (1972) named these as outermost layer epicuticle, a waxy layer. The middle homogeneous layer is exocuticle and innermost thick layer is endocuticle. In Bothriurus vittatus (Bothriuridae) the transverse section of poison gland shows the chitin of poison vesicle corresponding to the dorsal concavity, sometimes thicker than remaining surface of the ampulla. The hypoderm forms a special organ in the form of many longitudinal folds of the cuboidal epithelium (Pavlowsky, 1924c). The cuboidal epithelial cells are present in between the cuticle and secretory epithelium of venom gland of Neoscorpiops deccanensis. These cuboidal epithelial cells consist of irregularly shaped centrally placed nucleus. The cytoplasm of these cell is dark granular.

The venom glands of Neoscorpiops deccanensis surrounded by striated muscle fibers. Joseph E. Mazurkiewicz & Eldridge M. Bertke (1972) reported that the muscle, fibers are attached to the cuticle by means of tendon cells. The connective tissue, circular muscle fibers and compressor muscles surround gland from all sides and also extended in median fissure to separate both the glands. It keeps the glands away from each other. Thick musculature surrounds the venom glands.

Pavlowsky (1913) discovered two types of glands: one with simple, smooth epithelium (Type I), and another, with folded epithelium (Type II). Type I glands were found by Pavlowsky (1913, 1924b) in families Chactidae, Euscorpiidae, Luridae (Calchas), and Liochelidae. Type II glands were found in Bothriuridae, Buthidae, Caraboctonidae, luridae (lurus), Liochelidae and Scorpionidae. Type I gland was considered to be the primitive (or embryonic type) condition due to the fact that Type II folded gland is derived from Type I during embryogenesis in both Scorpio maurus (Scorpionidae) and Androctonus crassicauda (Buthidae); this developmental feature was later confirmed by Probst (1972). The venom glands of Neoscorpiops deccanensis are type I glands.

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In *Bothriurus viitatus* (Bothriuridae) the epithelial cells are much longer with rounded nuclei containing fairly granular network of chromatin (Pavlowsky 1924c). The venom apparatus of scorpion *Centruroides sculpturatus* (Ewing) consist of paired glands, lined by secretary epithelium with columnar cells. The secretary products are either membrane bound or unbound vesicles released in the lumen of the gland (Joseph E. Mazurkiewicz & Eldridge M. Bertke, 1972). The venom gland of scorpion *Urodactus novaehollandiae* Peters (Scorpionidae) is complex and contains two types of secretary epithelial cells: goblet and columnar cells. The secretary compound contains proteins, PAS-positive and acidic muco substances (Halse S. A., Prideaux P.L., Cockson A. & Zwicky K.T., 1980). The venom glands of *Neoscorpiops deccanensis* encloses a lumen, surrounded by single lining of secretory epithelium. The goblet cells and columnar epithelial cells are present in linear manner.