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STUDIES ON THE MORPHOLOGY OF NERVOUS SYSTEM IN *Halys dentatus* F. (HETEROPTERA : PENTATOMIDAE)

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ABSTRACT

The nervous system of *Halys dentatus* F. exhibits a great degree of consolidation. It consists of a compact brain and two ventral ganglia situated in the thoracic region . The brain consists of the proto-, deuto - and tritocerebrum and gives out respectively, a pair of optic and ocellar nerves, a pair of antennal nerves and a pair of short thick fronto-labral nerves. The sub-oesophageal ganglion is inconspicuous and is connected to the brain by short circum-oesophageal connectives. The fusion between the two is so compact that the whole structure appears to be a single solid mass. . Three pairs of nerves mandibular, maxillary and labial arise from sub oesophageal ganglion and innervate the muscles in the respective areas. The first ventral ganglia (prothoracic ganglion) are situated in the prothorax. It gives out two pairs of nerves which innervate the prothorax. The second ganglia (thoracic ganglionic mass) lie in the mesothorax and are formed by the fusion of meso, metathoracic and all abdominal ganglia. It gives out two pairs of nerves to mesothoracic and two pairs in metathoracic regions. The ventral longitudinal nerve, which connects the sub-oesophageal, prothoracic and the thoracic ganglionic mass, are completely obliterated due to shifting of the ganglionic centres and their fusion. The abdomen is innervated by unpaired median abdominal nerve and three pairs of segmental abdominal nerves which innervate the muscles and all other visceral organs in the respective segment. The course and termination of nerves of different ganglionic centres have been traced to terminal ends.

KEY WORDS: Nervous system, *Halys dentatus* F.ganglionic centres,prothorax

The studies on the nervous system have been investigated by several Heteropterist. These studies revealed many variations in the degree of concentration of ganglion, number, origin and innervation of nerves from the brain, sub-oesophageal, prothoracic and thoracic ganglionic mass. The major contributions on terrestrial and semi-aquatic bugs are those of Rutschky and Stryjak (1955) *on Oncopeltus fasciatus (*Dallas); Johansson (1957) on Oncopeltus fasciatus; Akbar (1958) on *Leptocorisa varicornis:* Ewen (1960) on *Liocoris unctuosus*; Livingstone (1968) on *Tingis buddleiae*; Singh (1969) on *Chrysocoris stollii* and Mathur (1977) on *Scutelleria nobilis* Fabr. Contributions on aquatic bugs are of Guthrie (1961) on Gerris and Parsons (1960,) on *Gelestocoris oculatus* and *Lethocerus*, respectively, and Kaushik (1970) on *Belostoma indicum*. The review reveals that detailed studies on nervous system, origin and innervation of nerves to target organs in *H. dentatus* has not been done, therefore the present investigation has been undertaken.

MATERIALS AND METHODS

The adults of *H. dentatus* F. were collected from the neem tree plant throughout the year, except during the winter season. The adults were narcotised with chloroform vapours and dissected in physiological saline (Ringer's) solution. Further, 8-10 drops of 0.5% Methylene blue solution was added to the dissected tissues. The exposed material was kept in the staining solution for 2-3 hrs. and later on washed repeatedly with distilled water. Subsequently, the finer branches of nerves innervating different parts of head thorax and abdomen were traced.

OBSERVATION AND DISCUSSION

The brain is a conspicuous, bilobed mass situated in the posterior part of the head. It consists of the prominent protocerebrum (Fig. 1, 2,) (PC), a small deutocerebrum (DC) and tritocerebrum (TC). The disposition of the three regions of the brain towards the prothorax shows a deviation from the generalised plan. Due to shifting of the ganglia and their subsequent fusion it is difficult to delimit the various regions particularly the tritocerebrum and sub-oesophageal ganglion. The protocerebrum (PC) is the largest part of the brain, and is constituted by the protocerebral lobes. These lobes cover the entire brain, due of which the sub-oesophageal ganglion and circum-oesophageal connectives are invisible dorsally. The protocerebral lobes give out a pair

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of bulbous, elongated optic lobe (OPL) from which emerges, stout optic nerves innervating the compound eyes. The ocellar nerves emerges mid-dorsally from the antero-lateral angles of the proto- cerebral lobes and innervates the ocelli. The deutocerebrum (DC) is situated on the ventral surface of the brain. It is constituted by paired deutocerebral lobes (DCL) which are situated on both side of the pharynx. Each lobe is drawn out into an antennal nerve (AN) which runs antero-laterally and innervates the intrinsic antennal muscles and sensilla of the antennal segments. A thin antennal nerve, tegumentary nerve (TAN) also arises separately from the deutocerebrum and runs parallel with the antennary nerve and innervates the extrinsic muscles of the antenna. The number of antennal nerves varies in Heteroptera, However, Johansson (1957) & Kaushik (1970) described double antennal nerve in Heteroptera similar to that found in the present investigation. The tritocerebrum (TC) is the smallest part of the brain. Externally, it is not much prominent, but its position can be ascertained by the point of origin of the fronto-labral nerves. The tritocerebral lobes are also connected with each other by external nerve tract, the tritocerebral commissure (TLC) which runs ventral to the pharynx and connects the two lobes. A pair of thick fronto-labral nerve (FLN) arises from the tritocerebral lobes and runs anteriorly on the ventro-lateral surface of the pharynx. It soon divides into outer labral nerve (LN) and inner frontal nerve (FM). The labral nerve is long, slender and runs anteriorly to innervate labral and pharyngeal dilator muscles. The frontal nerves (FN) of both the sides join together medially and form the frontal ganglion (FG). The number of tritocerebral nerves are also reported to vary in bugs. Parson (1960) reported four nerves, while Kaushik (1970) and Livingstone (1968) reported two nerves.

The frontal ganglion (Fig. 2, FG) is situated dorsal to the pharynx, in between the two protocerebral lobes. It gives anteriorly an unpaired median, long and slender procurrent nerve (PN) (frontal nerve of many anthors). It runs forward in between the cibarial muscles and innervates the cibarial and labral muscles. Posteriorly, the frontal ganglion gives an unpaired, median recurrent nerve (RN) which continues posteriorly along the dorsal surface of the pharynx below the brain and it finally terminates into a hypocerebral ganglion. It is situated in close association with the endocrine glands, but no organic connection exists between the two as well as with the corpus allatum. Similar observations were made by Livingstone (1968) in *Tingis*. However, Parson (1960), reported a "nerve plexus" between the corpus cardiacum and the hypo-cerebral ganglion in bugs. The sub-oesophageal ganglion (SOG) is separated from the brain by a constriction. Three pairs of nerves i.e. maxillary, mandibular and labial arise from the anterolateral part of the ganglion and run in the anterior direction to innervate the different trophi. The mandibular nerve (MDN) runs in the anterior direction to innervate the mandibular protector and retractor muscles. The maxillary nerve (MXN) arises close to the point of origin of mandibular and runs anteriorly to supply the maxillary protractor and retractor muscles. The labial nerve (LBN) is thick and stout and runs parallel with the labro- frontal nerve to innervate the labium. The mandibular and maxillary nerves are reported to vary in number in Heteroptera. Livingstone (1968) reported paired mandibular and maxillary nerve while Parsons (1960) describes three main branches of the maxillary and two pairs of mandibular nerves in *Gelastrocoris* arising from suboesophageal ganglion. One pair to mandibular nerve have been reported by Parson (1968) and Kaushik (1970) in aquatic bugs. However, Mathur (1977) reported a salivary and cervical nerve originating from this ganglion, and also a thin delicate nerve branching from the base of mandibular nerve in *S. nobilis.* These nerves are, however, not observed in *H. dentatus.*

The prothoracic ganglion (Fig. 1, 3) (PG) is situated in the anterior region of the prothorax. Two pairs of nerves arise laterally from this ganglion. The first nerve (FPN) runs laterally to innervate the antero-ventral portion of thorax and anterior prothoracic musles. The second nerve (Fig. 3) (SPN) runs parallel to the first and soon birfurcates into an anterior (SPN_2) and posterior (SPN_1) branch. The former (SPN_2) is stouter than the later and innvervates the prothoracic leg. The posterior ramus (SPN_2) runs backwards to innervate the tergo-sternal and posterior muscles of the prothorax. The prothoracic nerves vary from one to six in number in bugs. Livingstone (1968) reported one pair, Ewen (1960) observed two pairs, Akbar (1958) Johansson

(1957) Singh (1969), Mathur (1977) and Kaushik (1970,) observed three pairs and Parsons (1960,) reported six pairs of nerves in *Gelastocoris* and *Lethocerus*. The thoracic ganglionic mass (TG) is located in the mesothorax. It is formed by the fusion of meso-, matathoracic and all the abdominal ganglia. There is no distint external demarcation between these ganglionic centres and their position can be ascertained by point of origin of individual nerves. The thoracic ganglionic mass gives off two pairs of mesothoracic, two pairs of metathoracic, three pairs of segmental abdominal nerves and a single median abdominal nerve to the abdominal segments.

Two pairs of mesothoracic nerves (Fg. 1, 3 FMSN; SMSN) arise from the antero-lateral margin of the thoracic ganglionic mass and after running for a short distance divides into two branches ($FMSN_1$; $FMSN_2$). The anterior branch ($FMSN_1$) runs laterally through the longitudinal and dorso-ventral muscles of the mesothorax and innervates first pair of wing. The posterior branch ($FMSN_2$) runs backwards and innervates the posterior dorso-ventral muscles. The second mesothoracic nerve (SMSN) runs for a short distance and bifurcates into two branches. ($SMSN_1$; $SMSN_2$). The first branch ($SMSN_1$) is thin and innervates the mesothoracic longitudinal muscles, while the second branch ($SMSN_2$) is stout and innervates the mesothoracic leg. The number of mesothoracic nerves varies from two to six pairs in terrestrial bugs. Livingstone (1968) observed only two pairs whereas, Akbar (1958) and Kaushik (1970) observed three pairs. Still a higher number i.e. four and six pairs of nerves were observed by Johansson (1957); Mathur (1977) and Parsons (1960,) respectively. The two pairs of long, stout, metathoracic nerves originate from the mediolateral margin of the thoracic ganglionic mass. The first nerve (FMTN) is thin and delicate. It runs laterally to innervates the second pair of wing and wing muscles and also sends fine branches to the anterior dorso-ventral muscles. The second nerve (SMTN) is however, very thick and stout. It runs short postero-laterally and bifurcates into a thin anterior ($SMTN_1$), and thick posterior branch ($SMTN_2$). The former ramus ($SMTN_2$) innervates the ventral metathoracic and extrinsic leg muscles, while the later ramus ($SMTN_2$), after innervating the metathoracic posterior dorso-ventral muscles, enters the hind leg. Variable number of metathoracic nerves have been reported in terrestrial bugs. Livingstone (1968), Ewen (1962) and Johansson (1957) observed two pairs; Akbar (1958) and Kaushik (1970) observed three pairs and Mathur (1977) observed five pairs of metathoracic nerves.

The abdomen in *H. dentatus* is innervated by an unpaired, median, longitudinal nerve (Fig. 1, MABN) and three pairs of segmental abdominal nerves (ABN_{1-3}). The segmental abdominal nerves arise from the postero-lateral region of the thoracic ganglionic mass and run posteriorly to innervate the sternal muscles in the second, third and fourth segments. The remaining segments are innervated by the median abdominal nerve (MABN) which arises from the posterior tip of the ganglionic mass *and continues up to the eighth segment. It is placed in a deep median notch and gives* first and second lateral abdominal nerves (LAN_1; LAN_2) in the second and third abdominal segments, respectively. The former nerve (LAN_1) innervates the sternal muscles of the fifth segment while the latter (LAN_2), after originating from the main nerve innervates the sternal muscles of the sixth segment. The median longitudinal nerve, (MABN) thereafter, continues posteriorly, and in fifth segment it bifurcates into two branches. Each branch runs short in the sixth segment and bifurcates into a dorsal (GN a) and ventral (GN b) ramus. The ventral ramus innervates the intersegmental and steral muscles of the sixth, seventh & eighth abdominal segments. In the seventh segment it further divides into two branches and innervates the sternal muscles of the respective sides. The dorsal branch (GN a) continues up to seventh segment and bifurcates into two ramus. Its inner ramus (GN a_1) supplies the spermatheca while the outer branch (GN a_2) passes ventral to the spermatheca and continue up to the hindgut in the genital segment. The abdominal nerves also varies in the terrestrial bugs.

Johansson (1957) reported seven pairs, Akbar (1958), Livingstone (1968) and Mathur (1977) reported four pairs. The number of nerves in aquatic bugs also vary from two to five pairs, Kaushik (1970) reported four pairs in *Belostoma*, whereas, Parsons (1960,) observed five pairs in *Gelastocoris* and *Lithocerus.* However, in the present

investigations, the abdomen is innervated by three paired and an unpaired nerve.

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ABBREVIATION

ABN- Abdominal nerves I, II & III, AN- Antennal nerve, CE- Compound Eyes, DC- Deuto cerebrum, DCL- Deutocerebral lobe, FG- Frontal ganglion, FN- Frontal nerve, FLN- Fronto labral nerve, FPN- First prothoracic nerve, FMSN- First mesothoracic nerve, FMTN- First metathoracic nerve, GN (a) Dorsal genital nerve, GN (a_1) & GN (a_2) Branches of dorsal genital nerve, GN (b) ventral genital nerve, LAN_{1-3}. Lateral abdominal nerve 1-3, LBN- Labial nerve, MDN- Mandibulary nerve, MXN- Maxillary nerve, MABN- Median abdominal nerve, OPL- Optic lobe, PC- Proto cerebrum, PG- Prothoracic ganglion, PCL- Proto cerebral lobe, PN- Procurrent nerve, RN- Recurrent nerve, SOG- Sub-oesophageal ganglion, SPN- Second Prothoracic nerve, SMSN- Second mesothoracic nerve, TC- Trito cerebrum, TCL- Trito cerebral lobe, TG- Thoracic ganglionic mass. TAN- Thin antennary nerve, TLC- Trito cerebral commissure.

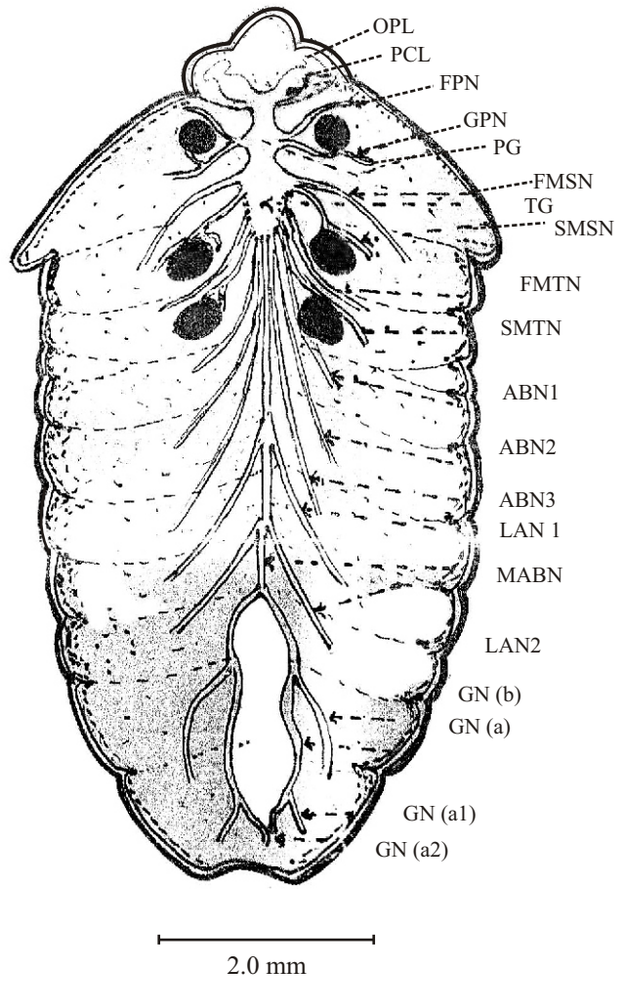

Fig. 1: Nervous system of *Halys dentatus* in situ

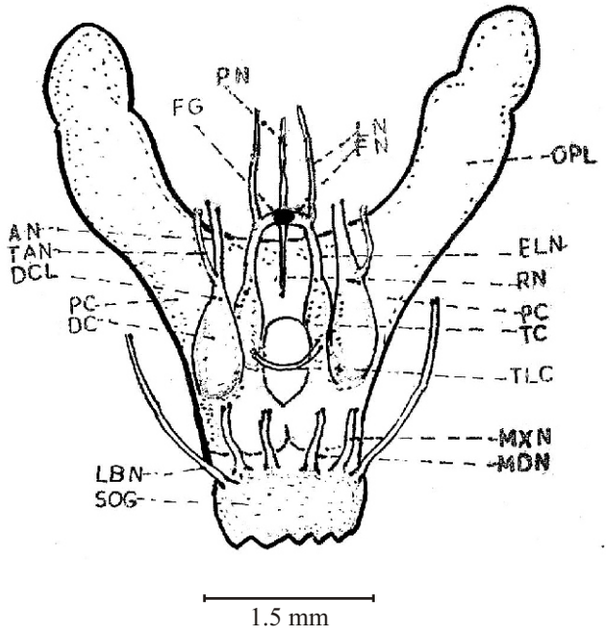

Fig. 2: Ventral view of the brain of *H. dentatus*

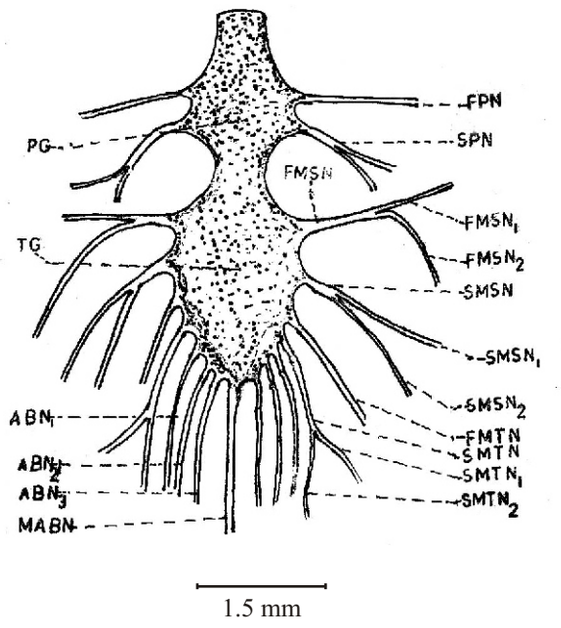

Fig. 3: Dorsal view of the prothorax and thoracic ganglionic mass and the nerves (digramatic)

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