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Nervous System of Poultry Lice, *Lipeurus lawrensis tropicalis* Peters (Phthiraptera: Ischnocera)

By

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With 3 Figures and 2 Plates

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Summary

The anatomy and histology of nervous system of *Lipeurus lawrensis tropicalis* (Phthiraptera: Ischnocera)is described in detail. The brain is U-shaped compact unit. It is tilted backwards to cover the tritocerebral commissure, circumoesophageal conncetives and a large portion of sub-oesophageal ganglion. The ventral nerve cord consists of sub-oesophageal ganglion and three thoracic ganglia. The abdominal ganglia are wanting and the abdomen is innervated by the nerves arising from the metathoracic ganglionic mass. Interganglionic connectives are absent between the thoracic ganglia, but the sub-oesophageal ganglion and the prothoracic ganglion are connected by interganglionic connectives. The origin and disposition of different nerves arising from metathoracic ganglion show that it is a compound ganglionic mass, in which abdominal ganglia are also fused. From this ganglionic mass three pairs of nerves are given in thoracic segments and three pairs to the abdominal segments. The frontal ganglion is situated anterior to the brain at a considerable distance. The histology of the brain and that of thoracic ganglion is also described.

Introduction

Snodgrass (1899) gave a preliminary account of brain and ganglia found in *Eurymetopus taurus* and *Menopon titan*. Later, the position and arrangement of ganglia were investigated in *Gliricola* sp. and *Gyropus* sp. by Strindberg (1916), in *Gyropus ovalis* Nitzsch by Blagoveshtchensky (1931) and in *Ibidoecus* sp. by Seguy (1951). A few workers, while describing the anatomy of head, have also described the brain, sub-oesophageal ganglion and their nerves in *Trimenopon jenningsi* Kellogg and Paine (Stowe 1943), *Bovicola caprae* Gurlt (Risler 1951), *Myrsidea cornicis* De Geer (Buckup 1959) and *Pseudomenopon pilosum* Scopoli and *Ornithobius cygni* Denny (Haub 1967 and 1971). Similarly, Cazal (1948) while describing the neuro-endocrine complex of *Menopon gallinae* has also given an account of the brain and frontal ganglion of this species. Mayer (1954) has described the brain. of *T. hispidum* Burmeister, *M. cornicis, Columbicola columbae* Linn. and *B. caprae* and has also pointed out that the nervous system of Mallophaga is highly specialized. Recently, Srivastava (1974) has described in detail the anatomy and histology of nervous system of *Laemobothrion percnopteri* Gervais (Amblycera).

Materials and Methods

Lice were collected from the poultry birds maintained in Banaras Hindu University Agricultural poultry farm and were dissected under Stereozoom binocular microscope in Insect Ringer's solution. After opening the terga few drops of aqueous Bouin's fluid were added to get the proper differentiation of internal organs. Paraffin sections were cut at 4...5 μm and stained in Haematoxylin-Eosin.

Observations

The nervous system of *L. lawrensis tropicalis* is described under three heads: 1. the brain and its nerves, 2. the ventral nerve cord and its nerves and 3. the stomodaeal nervous system.

The brain and its nerves (Fig. 1, 2 and 3)

The brain is lodged in the posterior region of head and is tilted backwards to cover the tritocerebral commissure, circumoesophageal connectives and a large portion of sub-oesophageal ganglion. It is a compact mass showing no clear differentiation between its three components, distinctly visible in sections. The protocerebrum forms the bulk of the brain and its anterior broadest part, due to backward tilting, lies in the posterior region of the head. The deutocerebrum is small, occupies the middle region of the brain and gradually tapers in to the hind brain. The tritocerebrum is the smallest of the three portions of the brain; the

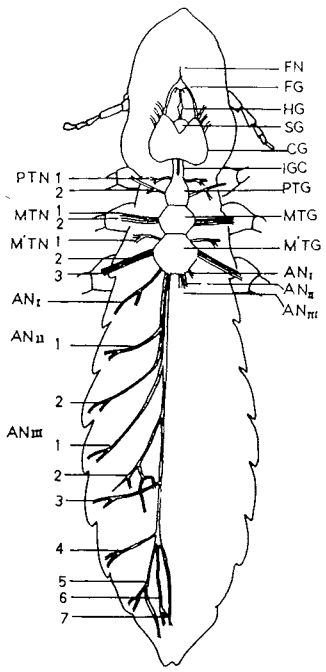

Fig. 1. Nervous system of *L. lawrensis tropicalis* (only the main nerves of one side shown)

right and left lobes lie separately and are connected with each other through tritocerebral commissure.

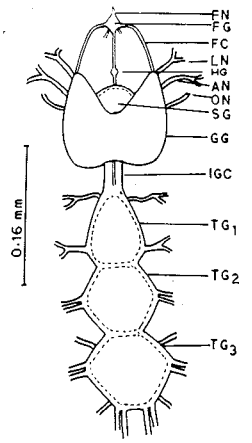

Fig. 2. Nervous system of *L. lawrensis tropicalis*

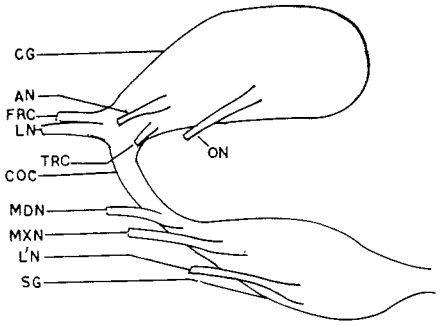

Fig. 3. Side view of brain and suboesophageal ganglion

Three pairs of principal nerves optic, antennary and labrofrontalis, arise from the lateral margins of brain to innervate eyes, antennae, labrum and frontal ganglion. The short optic nerves arise from the protocerebrum (Fig. 1 and 3) and innervate the eyes. Optic lobes are absent in *L. lawrensis tropicalis*. The antennal nerves originate from the deutocerebrum and go to the antennae. From each tritocerebral lobe a labro-frontalis nerve originates and divides into labral and frontal nerves. The labral goes to the labrum while the frontal connects the brain with the frontal ganglion forming a frontal connective. From the posterior end of each tritocerebral lobe a thick short nerve or crura cerebri originates and goes to the sub-oesophageal ganglion; the right and left nerves form the circum-oesophageal connective. The tritocerebral commissure connecting the two tritocerebral lobes is thin and long.

The ventral nerve cord and its nerves (Fig. 1, 2 and 3)

The ventral nerve cord includes the sub-oesophageal ganglion situated in the head and three thoracic ganglia located in pro-, meso- and metathorax. All the three thoracic ganglia lie appressed to one another and the usual interganglionic connectives between them are altogether absent. No nerve ganglion is found in the abdomen of *L. lawrensis tropicalis* and it is innervated by the nerves arising from ganglion situated in the metathorax.

The sub-oesophageal ganglion is oval in shape and lies close to and just beneath the brain in the head region (Fig. 1, 2 and 3). Three pairs of principal nerves-mandibular, maxillary and labial, arise from this ganglion. The mandibular nerve arises from its antero-lateral extremity (Fig. 3) where the circum-oesophageal connectives join the sub-oesophageal ganglion and run anteriorly to innervate the mandibles. The maxillary nerves arise from the middle region of the ganglion and innervate the maxillae. The labial nerves arise from the posterior region of ganglion and supply the labium.

The prothoracic ganglion is more or less triangular with tapering anterior and broad posterior portions. Anteriorly it is connected with the sub-oesophageal ganglion by a pair of thick interganglionic connectives. In all two pairs of nerves are given off by this ganglion. The first pair originates from its anterolateral margins to innervate the prothoracic muscles, while the other pair arises from the mid-lateral margins to innervate the first pair of legs.

The mesothoracic ganglion is comparatively large, more or less hexagonal in shape, and is directly attached to pro- and metathoracic ganglion. Two pairs of nerves, originating from lateral margins of the ganglion go to the second pair of legs.

The metathoracic ganglion represents actually a compound ganglionic mass, being formed by the fusion of metathoracic ganglion and the abdominal ganglia. It is, more or less, similar to the mesothoracic ganglion but is comparatively larger in size.

In all six pairs of principal nerves arise from the compound metathoracic ganglionic mass. The first pair of nerves originates from the dorso-lateral margins of its anterior region and innervates the metathoracic muscles. The next two pairs of nerves arise from its mid-lateral margins and directly go to the metathoracic legs without giving any sub-branch. Since these three pairs of nerves, originating from the compound ganglionic mass innervate the organs present in the metathorax; these are regarded as metathoracic nerves. On the other hand, the next three pairs of nerves innervate different parts of the abdomen; these are regarded as abdominal nerves.

The first pair of abdominal nerves arises from the posterolateral margins of the metathoracic ganglionic mass. These are the shortest nerves in the abdomen and are confined to the combined first and second abdominal (first apparent) segment. Each one sub-divides into two, to innervate the pleural and sternal muscles of its side.

The second pair of abdominal nerves also originates from the posterior margin of the metathoracic ganglionic mass and runs to the third abdominal segment, where each one divides into two, anterior and posterior branches. The anterior branch innervates the third abdominal segment while the posterior goes to the fourth abdominal segment. Each, anterior and posterior, nerve further divides into two; the branches of the first innervate the spiracle and tergal muscles while those of second innervate the sternal and pleural muscles of the corresponding segment.

The third pair of abdominal nerves also originates from the posterior margin of the ganglionic mass, close to the second abdominal nerve. These are the thickest nerves and extend to the posterior end of the abdomen. Seven branches arise from each nerve at different levels. The first, third, fourth and fifth branches innervate the muscles and spiracles located in fifth to eighth abdominal segments. The second branch, on the other hand, goes to the reproductive organs, both in male and female. The sixth branch supplies the rectum while the seventh innervates the heart.

The stomodaeal nervous system (Fig. 1 and 2)

The stomodaeal nervous system or stomatogastric nervous system includes the frontal ganglion and its nerves. The frontal ganglion is situated anterior to the brain at a considerable distance. It is small, pear-shaped and connected with the two tritocerebral lobes by a pair of frontal connectives. Anteriorly the frontal ganglion gives a frontal nerve which runs to the clypeus. The posterior end of the frontal ganglion is connected with the hypocerebral ganglion by a thin recurrent nerve. The hypocerebral ganglion is also anterior to the brain in position and lies on the dorsal wall of the pharynx at the anterior end of the aorta. However, the ingluvial ganglion could not be detected.

Histology

The brain is covered externally by a non-cellular neurilemma of almost uniform thickness (Pl. 1, Fig. 1, 2, 3 and 4). Histologically, the brain has two regions, the outer cortical and the inner neuropilar (Pl. 1, Fig. 1, 2, 3 and 4). The cortical region of the brain consists of various globuli cells and neurons etc., while the dense neuropilar region consists of masses of axons, collaterals and dendrites. Internally the brain is distinctly divisible into proto-, deuto- and tritocerebrum. The protocerebrum is the largest part of cerebral mass and includes lateral protocerebral lobes, the middle pars intercerebralis and the accessory lobes. The two protocerebral lobes are connected with each other by pons cerebralis or protocerebral bridge (Pl. 1, Fig. 2). The globuli cells of protocerebrum are small, arranged compactly in median, dorso-lateral and ventro-lateral groups and each cell has chromatin rich nucleus (Pl. 1, Fig. 1 and 2). All the three groups of globuli cells are best seen in the anterior most part of the protocerebrum (Pl. 1, Fig. 1); the middle group is not present in its posterior part. The neurites of the globuli cells form fibrous bodies of the brain. The fibrous and glomerular masses of the

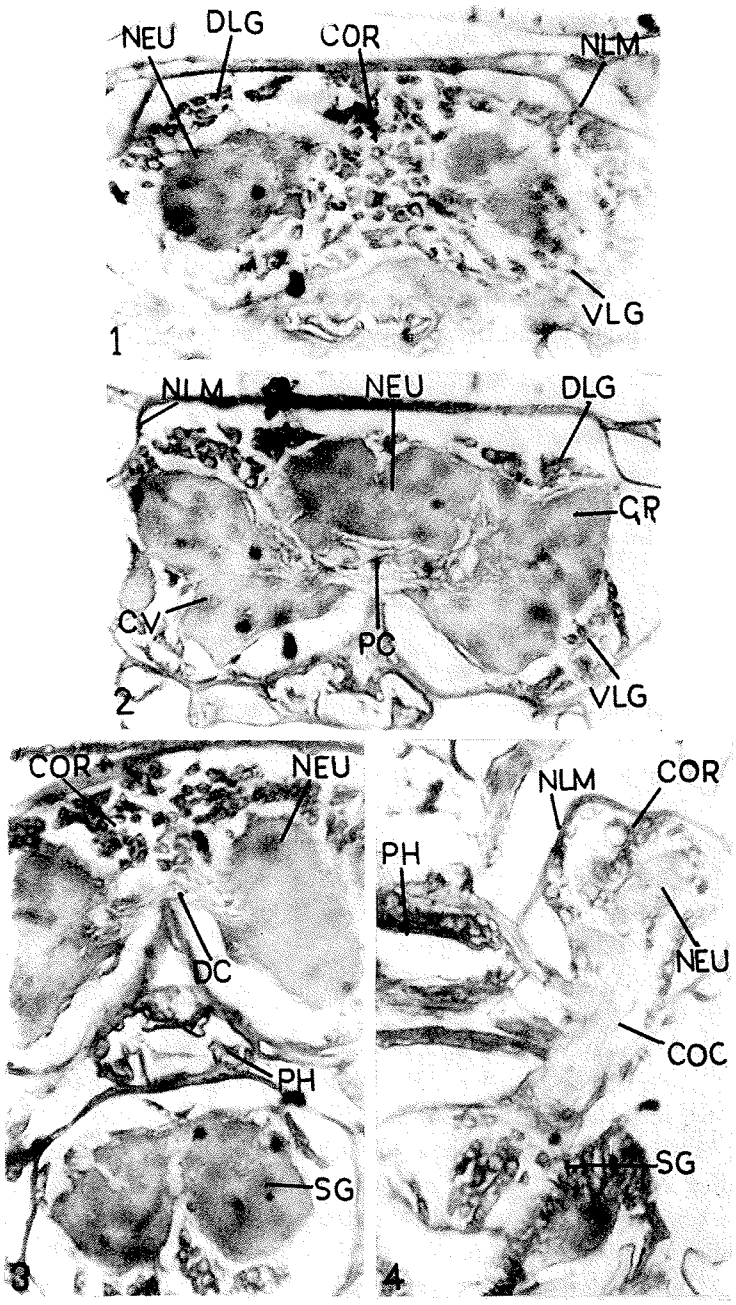

Plate 1

Fig. 1. T.S. of the brain passing through anterior portion of protocerebrum. Haematoxylin-Eosin, ×630

Fig. 2. T.S. of the brain passing through posterior portion of protocerebrum. Haematoxylin-Eosin. ×630

Fig. 3. T.S. of brain passing through deutocerebral region. Haematoxylin-Eosin. ×630

Fig. 4. T.S. of brain passing through tritocerebral lobe and suboesophageal ganglion and showing circumoesophageal connective. Haematoxylin-Eosin. ×630

protocerebrum form the median-dorsal pons cerebralis, the corpus centrale, the dorso-lateral corpora pedunculata and the ventro-lateral corpora ventralia (Pl. 1, Fig. 2).

The two neuropilar masses of the deutocerebrum are connected to each other by a fibrous deutocerebral commissure (Pl. 1, Fig. 3). The neuropile masses contain dense fibrous areas. The globuli cells are confined to the median dorsal and the two lateral groups.

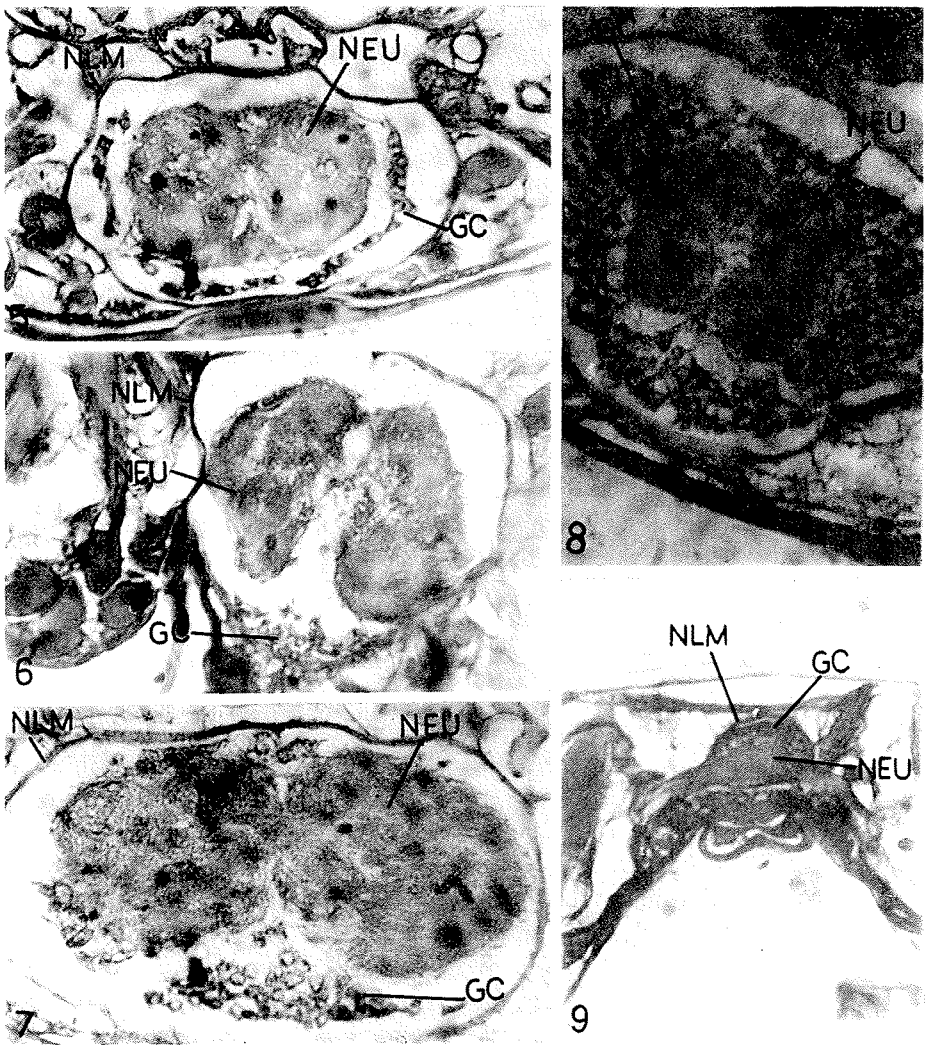

Plate 2

Fig. 5. T.S. of suboesophageal ganglion. Haematoxylin-Eosin. ×630
Fig. 6. T.S. of prothoracic ganglion. Haematoxylin-Eosin. ×630
Fig. 7. T.S. of mesothoracic ganglion. Haematoxylin-Eosin. ×630
Fig. 8. T.S. of metathoracic ganglion. Haematoxylin-Eosin. ×630
Fig. 9. T.S. passing through the frontal ganglion. Haematoxylin-Eosin. ×630

Each tritocerebral lobe shows the presence of a tritocerebral mass (Pl. 1, Fig. 4), and globuli cells located in its lateral region. The fibrous connections, crura cerebri (circum-oesophageal connective) between tritocerebrum and sub-oesophageal ganglion are quite distinct (Pl. 1, Fig. 4).

Histologically, the sub-oesophageal ganglion and the thoracic ganglia conform to the same fundamental plan. Connective tissue sheath, cellular elements and the neuropilar mass are clearly visible (Pl. 2, Fig. 5, 6, 7, 8 and 9). The connective tissue sheath is composed of two distinct layers, an outer non-cellular neural lamella (perilemma) and an inner cellular perineurium. The cellular elements lie inner to the connective tissue sheath; the ganglion cells are situated peripherally, each cell having a distinct nucleus. A number of globuli cells are also scattered in the region of cellular element. The central part of ganglion is occupied with a dense mass of nerve fibrils which constitute the neuropile.

In the sub-oesophageal ganglion (Pl. 2, Fig. 5), the ganglion cells are concentrated on the lateral and ventro-lateral margins of a centrally located neuropile mass.

On the other hand, the neuropile shows a clear division into a pair of masses in the thoracic ganglia. The disposition of ganglion cells is more or less similar in the pro- and mesothoracic ganglia; these being confined to ventral side of the neuropile (Pl. 2, Fig. 6 and 7). In the metathoracic ganglion, on the other hand, ganglion cells surround the neuroplie completely (Pl. 2, Fig. 8 and 9). However, these cells show greater condensations laterally.

In the frontal ganglion a single mass of compact neuropile, occurs centrally; the ganglion cells are localised dorsally (Pl. 2, Fig. 10).

Discussion

The brain of *L. lawrensis tropicalis* does not show any external demarcation into various regions and, therefore, has a typical ischnoceran pattern. In this respect it resembles the brain of all the described ischnoceran species, *B. caprae* (Risler 1951 and Mayer 1954) and *O. cygni* and a few Amblycera like, *M. cornicis* (Mayer 1954 and Buckup 1959) and *L. percnopteri* (Srivastava 1974). However, it differs from that of other amblyceran species, *T. jenningsi* (Stowe 1943), *M. gallinae* (Cazal 1948) and *P. pilosum* (Haub 1967) in which a faint external demarcation into proto-, deuto- and tritocerebrum is present.

The sub-oesophageal ganglion shows similarity in appearance with that of *B. caprae* (Risler 1951 and Mayer 1954) and *O. cygni* (Haub 1971) in so far that its anterior part is not covered by the brain in all these species.

In *L. lawrensis tropicalis* the interganglionic connectives are not present between the three thoracic ganglia. Similar condition is reported by Snodgrass (1899) in *E. taurus* and by Seguy (1951) in *Ibidoecus* sp. However, a pair of connectives between the pro- and meso- and also between meso- and metathoracic ganglia is reported in *C. columbae* (Seguy 1951), *Gliricola* sp. (Strindberg, 1916a) and *L. percnopteri* (Srivastava 1974). The connectives in *C. co-*

lumbae are short while those of *Gliricola* sp. are long. However, in *L. percnopteri* the anterior pair of connective is long and the posterior is short.

In *L. lawrensis tropicalis* the position of frontal gauglion is similar to *B. caprae* (Risler 1951 and Mayer 1954), *O. cygni* (Haub 1971) and *L. percnopteri* (Srivastava 1974); in all these forms it is situated at a distance from tritocerebrum and joined to the latter by a pair of long thin frontal connectives. But in several other species, like *T. jenningsi* (Stowe 1943), *M. gallinae* (Cazal 1948), *M. cornicis* (Mayer 1954 and Buckup 1959) and *P. pilosum* (Haub 1967), the frontal ganglion lies close to tritocerebrum and the frontal connectives are short and thick.

The origin and distribution of nerves of the brain and sub-oesophageal ganglion in *L. lawrensis tropicalis* are more or less similar to those of the other ischnoceran species described so far. The present observation on *L. lawrensis tropicalis* that two pairs of nerves arise from prothoracic ganglion finds support from that of Seguy (1951) on *Ibidoecus* sp. and Srivastava (1974) on *L. percnopteri*, as they have also reported two pairs of nerves from prothoracic ganglion. However, the distribution of these two pairs of nerves is different in *L. percnopetri* in which both of them go to the fore legs while in *L. lawrensis tropicalis* and *Ibidoecus* sp. (Seguy 1951) only one goes to the leg and the other supplies the prothoracic muscles. Two pairs of nerves also arise from the mesothoracic ganglion of *L. lawrensis tropicalis*, whereas three pairs are reported in *Ibidoecus* sp. (Seguy 1951). According to him the anterior pair of nerves supplies the mesothoracic muscles in *Ibidoecus* but such a pair of nerves was not found in *L. lawrensis tropicalis*, as also in *L. percnopteri* (Srivastava 1974).

The distribution of abdominal nerves in *L. lawrensis tropicalis* differs from that of *L. percnopteri* (Srivastava 1974), the only other Mallophaga in which the nerves have been described. In *L. lawrensis tropicalis* the second abdominal nerve innervates only the third and fourth abdominal segments whereas in *L. percnopteri* it supplies branches to the abdominal segments 2 to 7. The division of third abdominal nerve of *L. lawrensis tropicalis* into seven branches resembles to that reported in *L. percnopteri* (Srivastava 1974). The details of distribution, however, differ in these two species in so far that in *L. lawrensis tropicalis* branch numbers 1, 3, 4 and 5 supply the spirales and muscles of abdominal segments 5 to 8. Branch no. 2 innervates the reproductive organs, no. 6 the rectum and no. 7 the heart. In *L. percnopteri*, on the other hand, branch nos. 1 to 6 of second abdominal nerve supply abdominal segments 2 to 7; branch nos. 1 and 2 of third abdominal nerve supply abdominal segments 8 and 9, while 3, 4 and 5 to reproductive organs and 6 and 7 to rectum and heart. The distribution of branches supplying rectum and heart is similar in *L. lawrensis tropicalis* and *L. percnopteri*.

The histology of brain of *L. lawrensis tropicalis* closely resembles to that of *L. percnopteri* (Srivastava 1974). On the other hand, the sub-oesophageal ganglion and the three thoracic ganglia differ in details of their neuropile and condensation of ganglion cells. The histology of frontal ganglion does not show any difference from that described for *L. percnopteri*.

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Abbreviations

AN — Antennary nerve, ANI — First abdominal nerve, ANII — Second abdominal nerve, $ANII_{1\&2}$ — First and second branches of second abdominal nerve, ANIII — Third abdominal nerve, $ANIII_{1\text{ to }7}$ — First to seven branches of third abdominal nerve, CG — Cerebral ganglion, COC — Circumoesophageal connective, COR — Cortical region, CP — Corpora pedunculata, CV — Corpora ventralia, DC — Deutocerebral commissure, DLG — Dorsolateral groups of globuli cells, FC — Frontal connective, FG — Frontal ganglion, FN — Frontal nerve, GC — Ganglion cells, HG — Hypocerebral ganglion, IGC — Interganglionic connective, LN — Labral nerve, L'N — Labial nerve, MDN — Mandibular nerve, MTG — Mesothoracic ganglion, M'TG — Metathoracic ganglion, $MTN_{1\&2}$ — First & second nerves of mesothoracic ganglion, $M'TN_{1,2\&3}$ — First, second and third nerves of Metathoracic ganglion, MXN — Maxillary nerve, NEU — Neuropilar region, NLM — Neurilemma, ON — Optic nerve, PC — Pons cerebralis, PH — Pharynx, PTG — Prothoracic ganglion, $PTN_{1\&2}$ — First and second nerves of Pro-thoracic ganglion, SG — Suboesophageal ganglion, TG_1 — Protharacic ganglion, TG_2 — Mesotharacic ganglion, TG_3 — Metathoracic ganglion, TRC — Tritocerebral commissure, VLG — Ventrolateral group of globuli cells.

References

Blagoveshtchensky, D. I.: Zur Anatomie von *Gyropus ovalis*. N. Mag. Parasit., Leningrad **2** (1931) 181—228.

Buckup, L.: Der Kopf von *Myrsidea cornicis* (De Geer) (Mallophaga: Amblycera). Zool. Jahrb. Anat. **77** (1959) 241—288.

Cazal, P.: Les glandes endocrines retro-cerebralis des insects (etude Morphologique). Bull. biol. Fr. Belg. **32** (1948) 1—227.

Haub, F.: Der Kopf von *Pseudomenopon pilosum* (Scopoli) (Mallophaga-Amblycera). Zool. Jahrb. Anat. **84** (1967) 493—558.

Haub, F.: Der Kopf von *Ornithobius cygni* (Denny) (Mallophaga: Ischnocera). Zool. Jahrb. Anat. **88** (1971) 450—504.

Mayer, C.: Vergleichende Untersuchungen am Skelett-Muskelsystem des Thorax der Mallophagen unter Berücksichtigung des Nerven systems, Zool. Jahrb. Anat. **74** (1954) 77—131.

Risler, H.: Der Kopf von *Bovicola caprae* (Gurlt) (Mallophaga). Zool. Jahrb. Anat. **71** (1951) 325—374.

Seguy, E.: Ordre des Mallophages. In: Grasse, P. P: Traite de Zoologie. Paris: Masson et Cie 1951, 1341—1364.

Snodgrass, R. E.: The anatomy of Mallophaga. Occ. Pap. Calif. Acad. Sci. **6** (1899) 145—224.

Srivastava, R. K.: Studies on the anatomy and histology of various organ systems of *Laemobothrion percnopteri* (Gervais); Mallophaga: Amblycera. Ph. D. thesis, Banaras Hindu University, India 1974.

Stowe, E.: Der Kopf von *Trimenopon jenningsi* Kellogg und Paine (Mallophaga). Zool. Jahrb. Anat. **68** (1943) 177—226.

Strindberg, H.: Zur Entwicklungsgeschichte und Anatomie der Mallophagen. Z. wiss. Zool. **115** (1916) 382—459.

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