

## GENERAL INSECT MORPHOLOGY

### Lab 14 - A study of the nervous system of the tobacco hornworm larva

Use a dorsally dissected tobacco hornworm larva to study the nervous system. Remove the alimentary tract carefully, being careful not to disturb the sub-oesophageal commissures or other parts of the nervous system of the head which are closely associated with the alimentary tract.

**DRAWINGS:** 1) Sketch the entire nervous system in an outline of the body, giving only enough labels and details to show the general plan. 2) Sketch a ventral abdominal ganglion in detail, and a thoracic ganglion in detail. 3) Make one or two sketches of the brain and head nerves.

The nervous system of the tobacco hornworm larva consists of a long, white cord, knotted at segmental intervals, which extends for the most part along the meso-ventral portion of the body. This simple nervous system is made up of 3 parts: **ganglia, commissures, and nerves**. The enlarged oval knots found in each segment of the body are the **ganglia**. Only one ganglion exists in each body segment outside of the head and the 7th and 8th abdominal segments. The cords running between the ganglia, which in some cases double or partially so, are the **commissures**. The **nerves** are the branches of various sizes extending from each ganglion and in some cases from the commissures. These fine threads permeate all parts of the body.

#### ABDOMINAL GANGLIA

The abdominal ganglia are the simplest in type. The distinct similarity between the first 6 abdominal ganglia makes it possible for one description to fit for all.

**First 6 abdominal ganglia.** The first 6 abdominal ganglia are located in the middle or cephalic part of each abdominal segment and consist of the following parts:

**Lateral nerves.** The lateral nerves are the 2 branches, which arise from the cephalic part of the lateral margins of the ganglia, which innervate the latero-dorsal portion of the body.

**Ventral nerves.** Directly caudad and slightly ventrad of the lateral nerves, the ventral nerves arise and extend caudo-laterad to innervate the ventral area of the body segments. Near the point of entrance of the ventral nerves, a pair of small nerve-like tracheae enter the ganglia. These 2 tracheae, one on each side, are derived from the transverse tracheae located in each abdominal segment ventrad of the nerve cord.

**Ventral sympathetic system.** Extending between the ganglia there is a single, large, white cord, the **commissure**. Just before the commissure enters the cephalic end of a ganglion, it divides into cords or it is furrowed on the dorsal surface. The ventral sympathetic nerves arise from the cephalic end of this fork. With some of the ganglia, this forking or splitting of the commissure is not very great but can in each case be detected.

**Median and Transverse nerves.** The median nerve arises from the commissure at the cephalic end of this inverted V-shaped spit and extends caudad for a short distance. At its caudal end near the ganglion, it forks and gives rise to 2 transverse nerves that extend in opposite lateral directions and more or less parallel with the lateral nerves. In the short distance in which the transverse and lateral nerves are parallel the transverse nerve gives rise to a web of nerve fibers which connect with the lateral nerves and the ganglion. Beyond this web or plexus, the transverse nerves diverge from the lateral nerves in a cephalo-lateral direction.

#### GANGLION OF THE 7TH AND 8TH ABDOMINAL SEGMENT

Within the 7th abdominal segment is a double ganglion, or rather 2 ganglia, but no visible commissure connects the two because of the close approximation of the ganglia.

**Seventh abdominal ganglion.** The 7th abdominal ganglion is comparable to the ganglia of the first 6 abdominal segments. It gives rise to nerves arranged in the same manner and does not need further description.

**Eighth abdominal ganglion.** The elimination of the commissure between the 7th and 8th ganglia has not only brought the ganglia together but has lengthened as well as changed the place of origin of the nerves from the ganglion.

**Lateral nerves.** The comparatively large lateral nerves arise not from the lateral margin of the ganglion but from its dorso-caudal end extend with a slight divergence far into the 8th segment before branching.

**Ventral nerves.** Ventrad and slightly laterad of the lateral nerves, there arises a small pair of ventral nerves which also extend into the 8th abdominal segment before branching. Adjacent to these ventral nerves the accompanying tracheae, which resemble nerves closely enter the ganglion. The ventral trachea of the 8th abdominal segment, however, still exists in its normal position within the 8th segment. This elongates to a great extent the pair of tracheae that arise from it to supply the 8th abdominal ganglion.

**Ventral sympathetic system.** The fusing of the 7th and 8th abdominal ganglia causes the sympathetic system apparently to arise from the caudal end and dorsal side of the 7th abdominal ganglion.

**Median and Transverse nerves.** The median nerve arises from the mid-dorsal area of the double ganglion. It is very short. On tearing apart the 2 ganglia, the median nerve remains attached to the caudal end of the 7th abdominal segment. It immediately gives rise to its pair of transverse nerves which extend caudo-laterad into the 8th abdominal segment more or less parallel to and laterad of the pair of lateral nerves. However, no plexus exists between the transverse and lateral nerves of this ganglion, as was noted in other segments.

### **THORACIC GANGLIA**

The thoracic ganglia are 3 in number, the mesothoracic and metathoracic ganglia are similar in form.

**Mesothoracic and Metathoracic ganglia.** The mesothoracic and metathoracic ganglia are slightly larger than the abdominal ganglia and are not as far apart. Extending from the caudal ends of all the thoracic ganglia, there is a large commissure which, in the case of the prothoracic and mesothoracic, proceeds but a short distance and then forks and forms the diamond shaped area in which the ventral sympathetic nerves are located. In both cases, the diamond shaped area between the metathoracic and mesothoracic, and between the mesothoracic and prothoracic ganglia occupies about two-thirds of the distance between the ganglia.

**Lateral nerves.** The lateral nerves proceed from the ganglia at their latero-cephalic part and are adjacent to the lateral edges of the commissures. The lateral nerves extend in a latero-cephalic direction.

**Connective nerves.** The connective nerves arise from the lateral edges of the commissure and extend in a caudal direction. In the case of the diamond-shaped area between the mesothoracic and metathoracic ganglia, the connective nerves arise midway between the anterior and posterior angles of the diamond. While with the diamond-shaped area between the prothoracic and metathoracic ganglia, the commissure gives rise to its connective nerves very much nearer the mesothoracic ganglion than to the anterior end of the opening. The connective nerves proceed a short distance caudad, then turn laterad and somewhat cephalad, and soon fuse with the lateral nerves laterad of their connection with the commissure. Before fusing with the lateral nerves, the connective nerves give rise to a branch that extends cephalad and somewhat parallel with the lateral nerves. This branch soon forks, one branch extends lateral across the lateral nerve, the other branch cephalo-laterad and parallel with the lateral nerves.

**Ventral sympathetic system.** With the mesothoracic and metathoracic ganglia, the ventral sympathetic system consists of a median nerve and transverse nerves.

**Median and Transverse nerves.** The median nerves arise from the commissure in the cephalic angle of the diamond-shaped areas and in both cases is longer than the metathoracic nerve. In both cases the transverse nerves, after arising from the caudal end of the median nerve, proceed in such a direction as to cross the commissure at the point near where the connective nerves arise. After crossing the commissure, they tend to take, as usual, a course parallel to the lateral nerves. The web or plexus of nerves in these 2 ganglia is very distinct; this is especially true in the metathoracic ganglion. The plexus occurs principally in the triangular area between the commissures, the lateral nerves, the transverse, and the connective nerves.

**Prothoracic ganglion.** The prothoracic ganglion is very similar in form and in arrangement of its nerves to the abdominal ganglia. As heretofore mentioned, the commissure, which projects caudad from the prothoracic ganglion, is simple and large. The ganglion cephalad of the prothoracic ganglion is the suboesophageal ganglion and is located only a very short distance from the prothoracic ganglion. The commissure extending between these 2 ganglia fail to unite before entering the caudal end of the suboesophageal ganglion; consequently, the 2 ganglia are connected by 2 distinct parallel strands.

**Lateral nerves.** The lateral nerves are the 2 branches which arise from the cephalic part of the lateral margins of the ganglion. These nerves soon divide into many small branches and innervate the lateral areas of the prothorax.

**Ventral nerves.** The ventral nerves project from the caudo-lateral margin and are accompanied by the usually pair of tracheae. In this ganglion, however, the ventral nerve of each side is not single but is composed of 2 small branches.

**Ventral sympathetic system.** With the prothoracic ganglion, the customary median and transverse nerves are wanting but the following new arrangement exists:

**Subconnective nerve.** Dorsad and cephalad of the prothoracic ganglion, the large subconnective nerves exist, which cross the commissure. Within the region adjacent to the ganglion, a plexus or web of nerves extends between the subconnective nerve, the ganglion, and proximal ends of the lateral nerves.

## GANGLIA OF THE HEAD

In the alimentary tract as it extends to the mouth by means of the pharynx, there is to be noted a distinct flexure in the head. The 2 head ganglia are located slightly distad of this flexure. The corresponding flexure in the nervous system is located between the suboesophageal and prothoracic ganglia. The 2 ganglia form a complete ring about the pharynx.

**Suboesophageal ganglion.** The suboesophageal ganglion is located caudad of the pharynx and in a plane ventrad of the supraoesophageal. It gives rise to the following nerves:

**Crura Cerebri.** The crura cerebri arise from the cephalo-ventral portion of the lateral margin of the suboesophageal ganglion very close to the pharynx. This pair of large cords arising from the lateral margins help to complete the circle about the pharynx by connecting themselves to the latero-caudal portions of the supraoesophageal ganglion.

**Mandibular nerves.** Adjacent to the crura cerebri and extending in a caudo-mesal direction, there arises a pair of nerves which are of approximately the same size as the crura cerebri. These nerves extend ventrad and divide into 2 nerves of unequal size: the larger proceeds cephalad and ventrad and innervates the mandible.

**Labial nerves.** The labial nerves arise from the mesal side of the mandibular-labial nerve. They extend ventro-caudad and innervate the labium.

**Maxillary nerves.** Caudad and adjacent to the mandibular nerves, the maxillary nerves arise. They are smaller and soon branch and innervate the maxillae.

**Unidentified nerves.** Caudad and slightly dorsad of the maxillary nerves, these arise on each side and extend laterad into the muscles of the head toward the salivary ducts but it has not been determined what they innervate.

**Ventral nerves.** From the mid-lateral area of the ganglion, the ventral nerves project accompanied by their usual tracheae. In this ganglion a light stain brings out very successfully the branches of the tracheae as they radiate over the surface of the ganglion. The ventral nerves in this case project dorso-caudad into the caudal part of the head.

**Supraoesophageal ganglion.** The supraoesophageal ganglion is the largest ganglion of the nervous system and is located on the cephalic surface of the pharynx. The transverse diameter of the ganglion is constricted along the meson into 2 lobes. The following nerves arise from this ganglion:

**Crura Cerebri.** The 2 large crura cerebri that proceed from the suboesophageal ganglion in a dorso-cephalic direction, connect with the supraoesophageal ganglion on the latero-dorsal margins. The 2 trunks are comparable to the commissures that extend between the ganglia in other regions of the body. The tracheae, a short distance from the ganglion, fork, one branch extending ventrad and the other more or less dorsad. These particular tracheae arise from branches that lead into the head from the spiracle located in the prothorax.

**Suboesophageal commissures.** The suboesophageal commissures are the branches that arise from the ventral side of the crura cerebri near the supraoesophageal ganglion. These 2 branches encircle the pharynx. On the caudal part of this semicircle 2 small branches occur which extend dorsad and innervate the large muscle fibers of the pharynx. These semicircular nerves have received the name of commissures, but a comparison with other ganglia shows that they are not the true commissures. The crura cerebri should be called the commissures. It is probable that the so-called suboesophageal commissures are nothing more than connective nerves that have united to form a semicircle about the pharynx.

**Optic nerves.** The small optic nerves arise the most cephalad of any of the nerves from the supraoesophageal ganglion and without branching extend to the groups of ocelli on each side of the head where they break up into small branches and supply each ocellus.

**Antennal nerves.** The antennal nerves are of about the same size as the optic nerves and arise from the ganglion caudad of and adjacent to the optic nerves, and extend cephalad and ventrad. Not far from the ganglion, they fork and form 2 branches, one of which innervates the area at the base of the antenna and the other the antenna itself.

**Clypeo-labral nerves.** The pair of clypeo-labral nerves are the most caudal pair of nerves arising from this region of the supraoesophageal ganglion. Each clypeo-labral nerve gives rise to several cephalo-mesal extending nerves and 1 caudo-lateral branch. The latter branch, arises from the clypeo-labral nerve in a plane slightly ventrad of the frontal ganglion and terminates in an enlarged ganglion-like structure on the labral aspect of the pharynx. This ganglion-like structure gives rise to several nerves (small). The 1st cephalo-mesal branch from the clypeo-labral nerve is very short and arises in a plane slightly dorsad of the frontal ganglion. The succeeding or 2nd cephalo-mesal nerve from the clypeo-labral nerve connects with the Y-shaped branch given off from the frontal ganglion. In different specimens, variations often occur in respect to the exact origin of these nerves. For

example, this 2nd cephalo-mesal nerve arises at times ventrad of the caudo-lateral branch, while in the majority of cases it arises from the clypeo-labral nerve dorsad of the caudo-lateral branch. Further ventrad on the clypeo-labral nerves 2 or 3 other cephalo-mesal nerves project and innervate the cephalic area of the pharynx.

#### **SYMPATHETIC SYSTEMS OF THE HEAD**

Two sympathetic systems exist in connection with the supraoesophageal ganglion. The vagus system is an unpaired system while the paired sympathetic system located laterad and dorsad of the pharynx is paired.

**Vagus or unpaired sympathetic system.** The vagus system originates from the ventro-lateral part of the supraoesophageal ganglion near the clypeo-labral nerve and consists of the following parts:

**Arched nerves.** The pair of arched nerves which arise from the ventro-lateral area of the supraoesophageal ganglion and project ventrad on each side of the head adjacent to and somewhat cephalad of the clypeo-labral pair mesad and unite on the meson ventrad of the supraoesophageal ganglion and from a small ganglion.

**Frontal ganglion.** The enlarged, fused, mesal part of the arched nerves is the frontal ganglion. It rests on the pharynx and is located caudad beneath the mouth opening of the aorta. Nerves ventrad and dorsad extending arise from the ganglion.

**Frontal nerve.** The nerve extending ventrad from the frontal ganglion is the frontal nerve. It is very short and soon divides into 2 branches which proceed latero-ventrad for a short distance and then turn directly ventrad. At the point where they turn ventrad the 2nd cephalo-mesal branch arising from the clypeo-labral nerve fuses with them.

**Recurrent nerve.** The nerve extending dorsad on the meson from the frontal ganglion is the recurrent nerve. It extends in its dorso-caudal course between the aorta and the pharynx and oesophagus. As it continues its course between these organs, it follows the flexure of the pharynx so that it extends caudad as well as dorsad. In its course along the cephalic and dorsal surface of the pharynx and oesophagus, it gives rise to paired and unpaired laterad extending branches which innervate the cephalic and dorsal parts of the pharynx and oesophagus respectively and probably also the aorta. As the recurrent nerve approaches the caudal end of the oesophagus, it divides into 2 branches, which pass around the side of the oesophagus.

**Vagus ganglion.** At the point of the forking of the recurrent nerve near the ventriculus, a minute ganglion exists, the vagus ganglion.

**Stomogastric nerves.** The branches that proceed from the vagus ganglion on each side are the stomogastric nerves. These nerves curve laterad around the oesophagus and innervate its caudal portion.

**Paired Sympathetic system.** On each side of the pharynx dorsad of the supraoesophageal ganglion, a sympathetic system exists, composed of 2 distinct nerves and 2 ganglia.

**Lateral nerve.** Just dorsad and slightly mesad of the large trachea that enters the supraoesophageal ganglion is the point of origin of the very small lateral nerve. This nerve continues dorsad and slightly caudad until it ends in an enlarged, irregular ovate-shaped ganglion on the lateral aspect of the pharynx cephalad of the suboesophageal ganglion. Running parallel with this nerve is a minute trachea which resembles a nerve very closely and is easily mistaken for one. Often the lateral nerve, before entering the anterior, lateral ganglion, gives rise to a small branch which connects directly with the ganglion or with the fronto-lateral nerve.

**Anterior lateral ganglion.** The ganglion on which the lateral nerve ends, is the anterior lateral ganglion. This ganglion gives rise on its caudal and cephalic ends to 2 or 3 nerves of various sizes which extend caudad between the muscles of the pharynx. On its dorsal margin, it gives rise to a lateral commissure which connects with the posterior lateral ganglion.

**Fronto-lateral nerve.** The fronto-lateral nerve arises from the cephalic end of the anterior ganglion adjacent to or cephalad of the point where the lateral nerve enters. The fronto-lateral nerve continues ventrad to the caudo-lateral aspect of the supraoesophageal ganglion and connects with the ganglion by means of a short stub and then continues ventrad into the head for a considerable distance.

**Lateral commissure.** The lateral commissure is a short nerve that arises from the middle of the dorsal surface of the anterior lateral ganglion and unites with a larger ganglion dorsad and caudad of the anterior lateral ganglion. This commissure gives rise to a nerve which extends ventrad.

**Posterior lateral ganglion.** The posterior lateral ganglion is larger than the anterior lateral ganglion and is located dorsad and somewhat caudad of it. It likewise gives rise to several nerves at its caudal and cephalic ends.