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METAMORPHOSIS OF THE THORACIC NERVOUS CENTRE OF *PIERIS BRASSICAE* (LINN) (*LEPIDOPTERA, PIERIDAE*)

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Abstract: The histological changes occurring during the metamorphosis of the thoracic nervous centre of *Pieris brassicae* are described. The meso- and metathoracic ganglia fuse with the first and the second abdominal ganglia to form one centre. These and the prothoracic ganglion make up the adult thoracic nervous centre. The different histological changes taking place in the cortex and neuropile are relatively more complex in thorax as compared to the abdominal region. These are correlated with the functional responses.

Key words: *Pieris brassicae*, thoracic ganglia, prothoracic ganglia.

INTRODUCTION

Insects have different types of locomotion but walking and flying are the commonest. For these activities centrally generated programs produced by pattern generators are thought to control the basic pattern of acitvity in motor nerves supplying the muscles of the legs and wings, while input from peripheral sensory receptor systems provide a feedback system for precise control of locomotary movements. The nervous system plays the central role in these activities, which possesses electrical and chemical mechanisms for information reception, transmission and processing. The neurons, which are specialized for nervous function, produce axons and dendrites. These are especially adapted for neural transmission (Heitler and Burrowa, 1977; Pearson, 1982; Steaves and Pearson, 1982; Eaton, 1985). Synaptic junctions between the neurones lie in the ganglionic neuropile, especially in the various glomerular bodies where associations occur between axon branches or dendrites (Richards and Davies, 1977). Thus, extremely complicated networks are formed which are integrated to produce functional integrity in different activities. These enable the insects to receive, process and effectively use enormous amounts of information (Shankland and Frazier, 1985). The degree of complexity of a parhway depends upon the type of activity. As locomotion is a complicated activity in which different sets of sensory and effector organs are involved, the thoracic nervous centre, which is the locomotary centre, has complicated sets of nerve tracts. Fusion of the ganglia occur to increase the efficiency of the system. In *Pieris brassicae* during metamorphosis, the meso- and meta-thoracic ganglis beecome fused with the first and second abdominal ganglia to form the thoracic locomotary centre. There is such a complexity of network that in the present study attention has been paid only to the major nerve tracts and their neurons.

MATERIALS AND METHODS

The various larval, pupal and adult stages needed for this work were reared at 20-22°C from the first instar of *Pieris brassicae*. The various larvae were killed for

dissection and histological treatment in the middle of the instar. Material was fixed in Bouin's solution or Zenker's or Gilson's fixative for staining in Mallory's Triple Stain or Heidenhain's Iron Haemotoxilin. The material was embedded in paraffin wax and serial sections were cut at 5-8μ. To study the different nerve pathways and for additional information on cellular constituents, Wigglesworth's (1957, 1959) method of osmium tetroxide fixation followed by ethyl gallate treatment was used.

RESULTS AND DISCUSSION

In the present study metamorphic changes concerning meso- and metathoracic ganglia and those occuring in the first and second abdominal ganglis are described. Prothoracic ganglia which is also part of the thoracic motor centre has been described earlier in detail (Ali, 1993).

Peripheral nerves

Six pairs of nerves are given off from this part of the nervous system. Four of them are large but the other two are very delicate. The mesothoracic ganglion gives off one strong and one feeble pair; the other feeble nerve comes from the abdominal part of this centre.

Cortex

The cellular components of these ganglia are similar to those which have already been described (Ali, 1973; 1993). The structure of the first and second abdominal ganglia is essentially similar to the other more posterior abdominal ganglia in the larval stages but during metamorphosis they decrease in volume and finally lose their separate identity completely. Some of their cells undergo pyknosis and histolysis but most of their neurones apparently migrate to the thoracic nervous centre. This is indicated by the fact that the posterior region of the compound thoracic centre in the later pupal atages and adult contains cell groups and fibre tracts which correspond in position and arrangement to those previously present in the first and second abdominal ganglia of the larva.

Neuropile and axonal tracts

The pattern of the neuropile is generally the same in all the three thoracic ganglia of the 3th instar larva, while in the first and second larval abdominal ganglia it is like that the third abdominal ganglion (Ali, 1991). Considering this the fibre tracts of the adult meso- and meta-thoracic ganglia have only been described here in detail, but comparison has been made between the two stages of development among the different ganglia.

The following are the paired tracts and other features of the adult mesothoracic ganglion:

Tract at 1: From dorsolateral groups of motor neurones. Runs around neuropile ventrally.

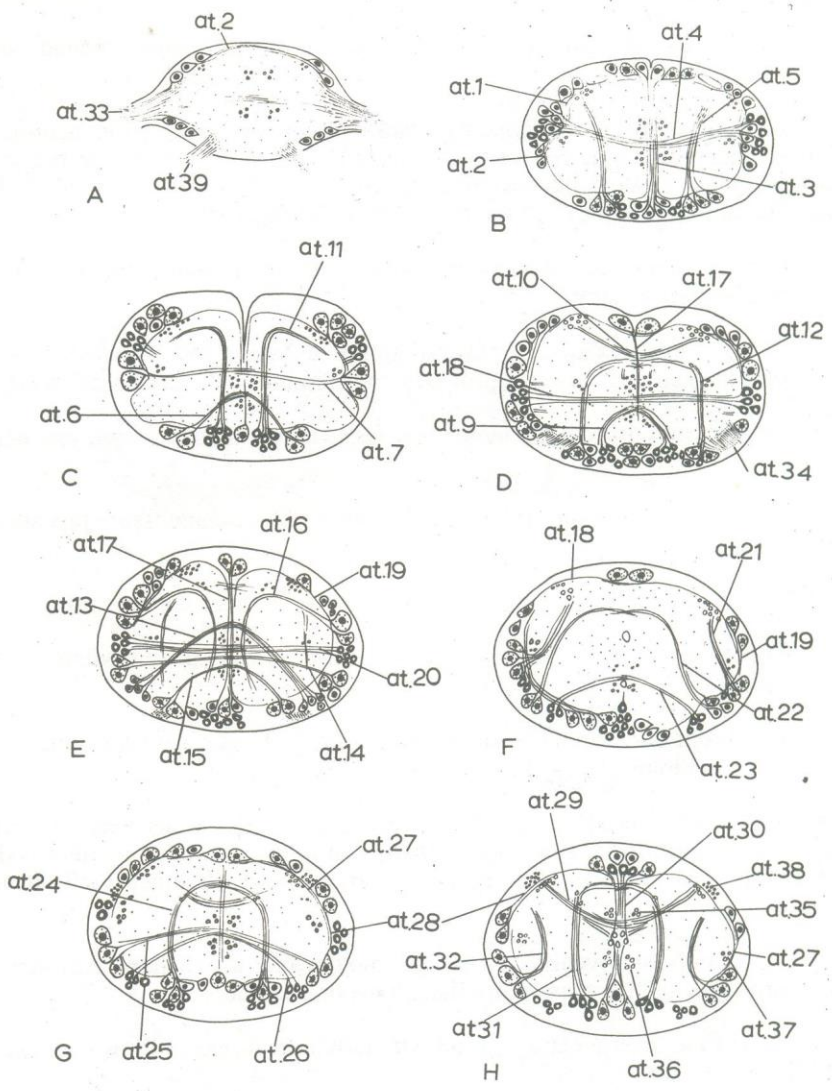

Fig. 1. Diagrammatic serial drawings of transverse sections of adult mesothoracic ganglion showing the major fibre tracts with neurones. Cells with dark nuclei and dotted cytoplasm represent the large motor neurones; cells with dark nuclei and white cytoplasm represent medium-sized motor neurones; cells with dark cytoplasm represent association neurones; small clusters of circles represent axons cut transversely; heavily shaded areas represent glomerular bodies.
at1, at2.... adult mesothoracic fibre tracts.

Tract at 2: From lateral and dorsolateral motor neurones. Runs around neuropile dorsally.

Tract at 3: From ventrally and dorsally placed motor and association neurones. The fibres from the ventral side run vertically upwards and from dorsal side run vertically downwards, some curving out and running along periphery of neuropile. It forms a median vertical partition dividing the ganglion into a right and left half.

Tract at 4: From lateral and dorsolateral group of motor and association neurones. Forms a median commissure.

Tract at 5: From ventral and ventrolateral group of motor and association neurones. Runs upward then curves outwards probably contributing to the peripheral nerve.

Tract at 6: From ventral group of motor neurones. Forms a commissure just below the centre.

Tract at 7: From internal group of motor neurones. Forms a commissure just above tract at 6.

Tract at 8: From lateral group of association neurones. Forms a commissurre.

Tract at 9: From ventral group of association neurones. Runs dorsomedially forming a weak commissure.

Tract at 10: From dorsolateral boundary of neuropile. Forms a weak commissure near dorsal end of ganglion.

Tract at 11: From ventral group of association neurones. Runs vertically upwards curving outward near dorsal side, and is finally lost in the ventral glomerular body. The corresponding tracts of opposite sides run parallel to each other until they curve outwards.

Tract at 12: From lateroventral group of motor and association neurones. Runs upwards turning medially crossing midline on the dorsal side.

Tract at 13: From lateroventral group of motor neurones. Runs dorsomedially forming a commissure.

Tract at 14: From laterally placed motor neurones. Forms a commissure.

Tract at 15: From ventrally placed motor neurones. Runs dorsomedially forming a commissure just below tract at 14.

Tract at 16: From dorsolateral and lateral motor neurones. Runs dorsomedially. Curves downwards and run down, where it is lost in ventral glomerular body.

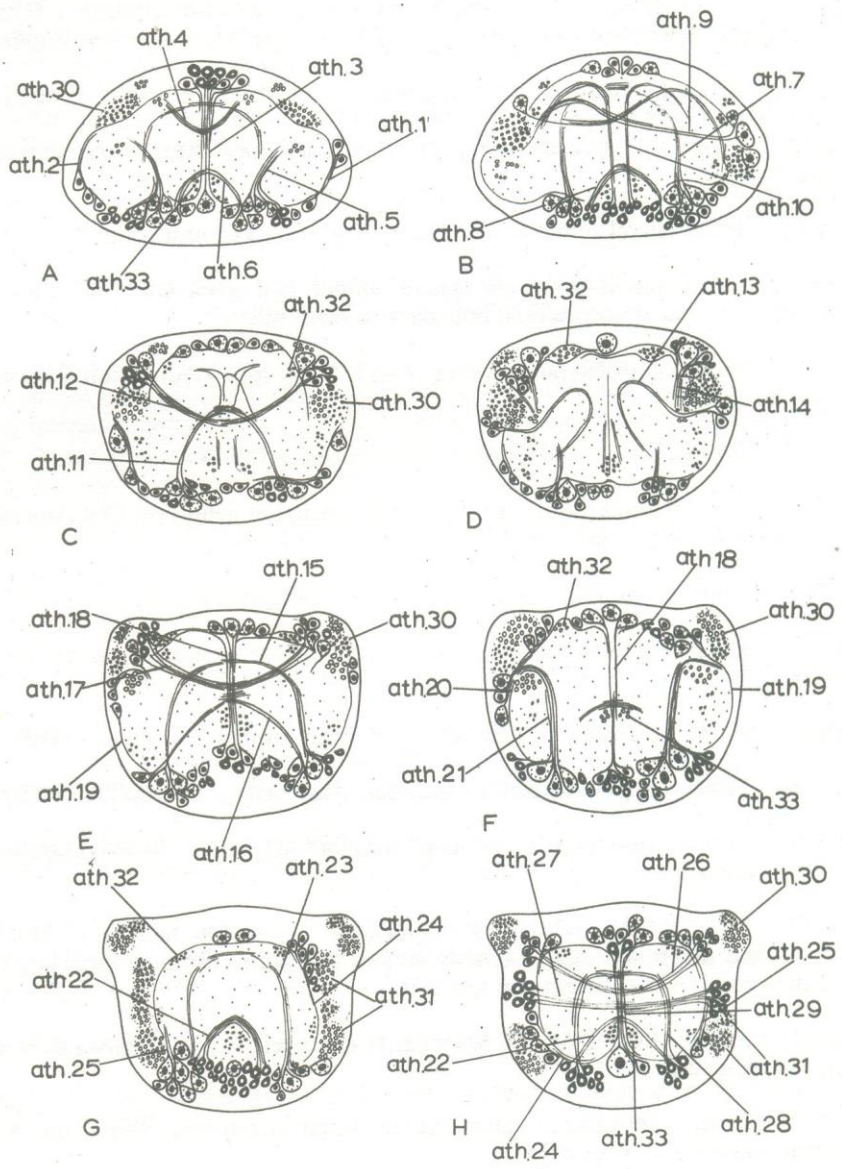

Fig. 2. Diagrammatic serial drawings of adult metathoracic ganglion cut transversely. (expalnations as Fig. 1).
ath1, ath2.... adult metathoracic fibre tracts.

Tract at 17: From dorsal and ventral motor and association neurones. Fibres run vertically up and down then curve outwards running along boundary of neuropiles.

Tract at 18: From dorsolateral motor neurones. Runs around boundary of neuropile.

Tract at 19: From dorsolateral and lateral motor neurones. Runs along boundary of neuropile ventrally.

Tract at 20: From lateral group of association neurones. Forms a commissure.

Tract at 21: From lateral and ventrolateral motor and association neurones. Goes upwards and is lost near dorsolateral boundary of neuropile.

Tract at 22: From ventrolateral motor neurones. Runs dorsomedially crossing midline on dorsal side.

Tract at 23: From ventrolateral association neurones. Forms a commissure.

Tract at 24: From ventral group of motor and association neurones. Goes dorsalwards curving medially crossing midline.

Tract at 25: From lateral motor neurones. Forms a commissure.

Tract at 26: From ventrolateral association neurones. Forms a commissure just below tract at 25.

Tract at 27: From dorsolateral motor neurones. Runs around neuropile ventrally.

Tract at 28: From ventrolateral motor neurones. Runs around neuropile dorsally.

Tract at 29: From a dorsolateral group of longitudinal axons. Runs ventromedially and crosses midline.

Tract at 30: From dorsal and ventral motor and association neurones. Fibres run ventrally up and down and then outwards around neuropile. Forms a median partition dividing the ganglion into a right and left half.

Tract at 31: From ventral group of association neurones. Runs dorsalwards and then medially, crossing midline.

Tract at 32: From ventrolateral and lateral motor neurones. Runs up towards dorsolateral boundary of neuropile.

Tract at 33: From neuropile and some motor neurones. Forms the first peripheral nerve of this ganglion. It leaves laterally.

Tract at 34: From neuropile. Forms the second peripheral nerve, leaving the ganglion ventrolaterally.

Tract at 35: From intraganglionic connectives at the anterior end of ganglion. A thick bundle of axons, some of them are lost in the neuropile while the others pass through the whole length of ganglion and join the connectives at the posterior end.

Tract at 36: The interganglionic connectives at the anterior end of ganglion. Runs longitudinally at the posterior end of gnglion.

Tract at 37: From connectives at the anterior end of ganglion. Runs through the ganglion longitudinally and joins the connectives at the posterior end of the ganglion.

Tract at 38: From connectives at the anterior end of ganglion. It traverses the whole ganglionic length and continues into the meta-thoracic ganglion.

The last four tracts are longitudinal while the remainder are transverse ones. Comparable tracts can be found among those of the adult prothoracic ganglion but there is no corresponding tract to at.35 (Ali, 1993) in the mesothoracic ganglion. It 4, 5, 15, and 29 are the only larval tracts not represented in the adult while at 10, 13, 14, 15, 20, 21, 24, 25, and 29 are adult tracts not represented in the larva (Ali, 1993).

Paired tracts and other features of adult metathoracic ganglion are as following:

Tract ath.1: From dorsal and lateral motor neurones. Runs around neuropile ventrally.

Tract ath.2: From lateral motor neurones. Runs around neuropile dorsally.

Tract ath.3: From dorsal and ventral motor and association neurones. Fibres run vertically up and down then curve outwards to run around neuropile. It forms a median vertical partition dividing the ganglion into a right and left half.

Tract ath.4: From group of axons cut transversely on dorsal boundary of neuropile in the sections. Runs medioventrally crossing the midline.

Tract ath.5: From ventral and ventrolateral motor and association neurones. Runs upwards and then outwards towards dorsolateral boundary of neuropile, probably contributes to the peripheral nerve.

Tract ath.6: From ventral group of motor neurones. Forms weak commissure.

Tract ath.7: From ventrolateral motor and association neurones. Runs dorsalwards, then curves medially crossing midline on dorsal side.

Tract ath.8: From ventral group of association neurones. Froms a commissure.

Tract ath.9: From dorsolateral and lateral motor neurones. Runs medially and the corresponding opposite tracts cross each other at mid-dorsal line, making a chiasma. After crossing their fibres continue along peiphery of neuropile.

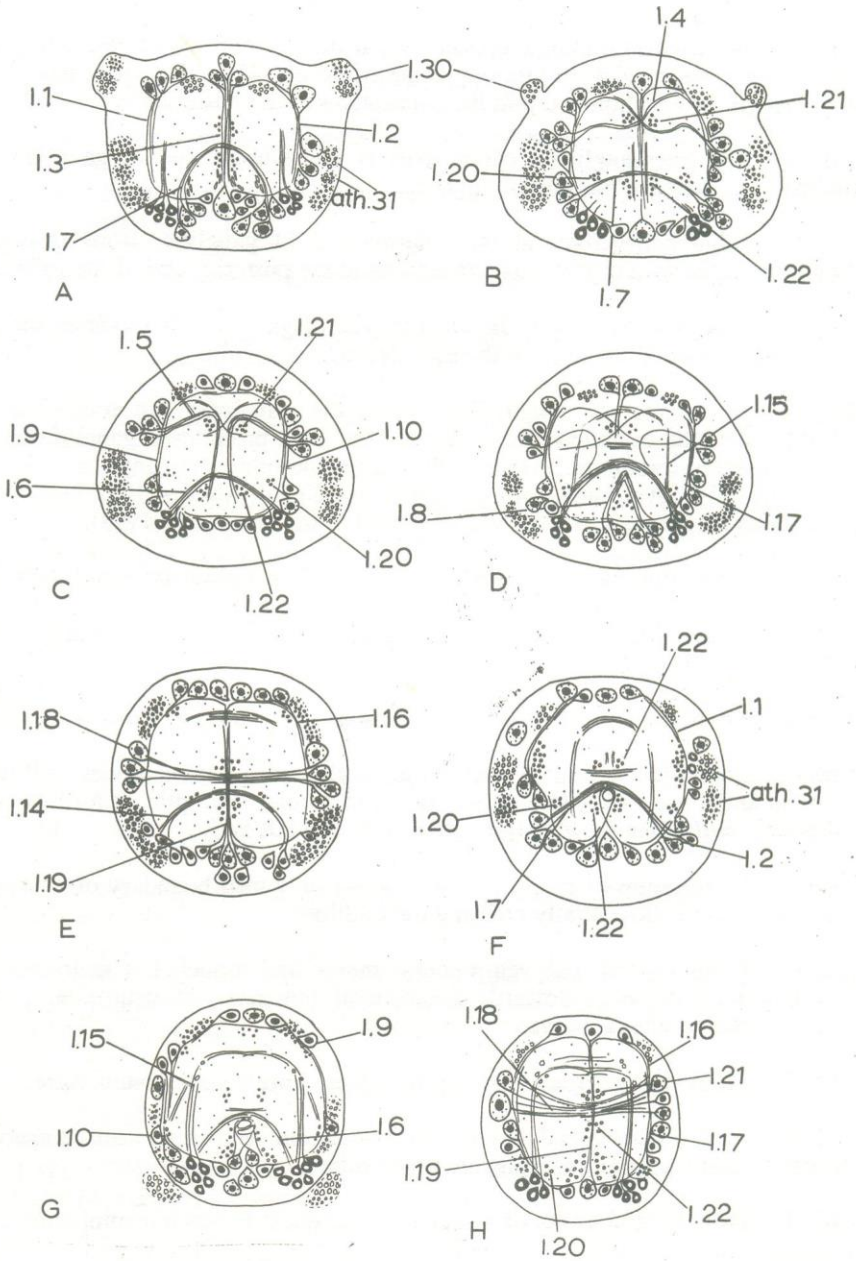

Fig. 3. Diagrammatic serial drawings of adult first and second abdominal ganglia cut transversely and showing the same features and with the same explanations as Fig. 1. A-E, first abdominal ganglion (explanations as Fig. 1)
1.1, 1.2 Adult abdominal fibre tract.

Tract ath.10: From venral group of association neurones. Runs dorsalwards and then curves outwards, finally lost in lateral glomerular body.

Tract ath.11: From ventrolateral motor neurones. Runs dorsomedially and crosses midline.

Tract ath.12: From dorsolateral motor and association neurones. Runs dorsomedially and crosses midline.

Tract ath.13: From lateral motor neurones. Runs dorsomedially, curving outwards near midline, then runs outwards and is finally lost in ventral glomerular body.

Tract ath.14: From dorsolateral motor and association neurones. Runs downwards and is then lost in neuropile.

Tract ath.15: From ventrolateral motor and association neurones. Runs downwards and crosses midline on dorsal side.

Tract ath.16: From ventrolateral motor neurones. Runs dorsoventrally and crosses midline.

Tract ath.17: From dorsolateral motor and association neurones. Runs ventrolaterally and crosses midline near tract arh.16.

Tract ath.18: From dorsal and ventral motor and association neurones. Fibres run vertically up and down and then outwards along periphery of neuropile forming a median vertical partition.

Tract ath.19: From dorsolateral and lateral motor neurones. Runs around neuropile ventrally.

Tract ath.20: From lateral motor neurones. Runs around neuropile dorsally.

Tract ath.21: From ventrolateral motor and association neurones. Runs upwards and then turns outwards. It seems to contribute to motor axons of peripheral nerve.

Tract ath.22: From ventral association neurones. Forms a commissure.

Tract ath.23: From ventrolateral motor and association neurones. Runs dorsalward and then turns medially to cross midline.

Tract ath.24: From dorsolateral motor neurones. Runs around neuropile ventrally.

Tract ath.25: From ventrolateral motor neurones. Runs around boundary of neuropile dorsally.

Tract ath.26: From dorsolateral motor neurones. Runs ventromedially forming a

Glomerular bodies

In the larval stages two pairs of glumerular bodies are found in each thoracic ganglion. The first pair appears in the middle of the ganglion on the ventral side. It ends towards the posterior end of each ganglion. The second pair is lateral, also in the middle of the ganglia and ending towards the posterior end. The fibres of tracts It. 9, 11 and 15 break up in both lateral and ventral bodies (Ali, 1991; 1993).

In the adult only traces of the larval ventral glomerular body can be seen, but the lateral pair is quite prominent. Apart from these there is also a dorsal glomerular body in the adult ganglia. It is near the posterior end of each ganglion and appears after 72 hours of pupal life when the ventral glomerular body loses its prominences, till in the 120 hours pupa they assume the adult condition.

First and second abdominal ganglia

In general appearance the first and second abdominal ganglia of the larva are exactly the same as any other simple abdominal ganglia, though they are in some ways more akin to the sixth abdominal ganglion which fuses with the seveth and eighth abdominal ganglia during metamorphosis. In the same way the first and second abdominal ganglia fuse with the mtathoracic ganglion and thus lose their external identity forming a part of the thoracic nervous centre of the adult.

In the stages when these ganglis are intact, all the normal abdominal fivre tracts can be seen but later they comprise only an undifferentiated mass of vacuolated perineurial cells surrounding the connectives. Peripheral nerves are still seen to run through the perineurial tissue and leave the ganglis. Even in the late pupal stages and the adult some of the abdominal tracts can be seen. For example, the first abdominal ganglion has the following tracts in the adult: 1. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 17, 18, 19, 20, 21, and 22. The second abdominal ganglion has the following tracts in the late pupal stages and the adult: 1. 1, 2, 6, 7, 9, 10, 15, 16, 17, 18, 19, 20, 21, and 22 (Ali, 1991). The remaining 5th instar larval tracts of these ganglia, as described by Ali (1993), evidently disappear at metamorphosis and no specifically adult tracts arise in theie place.

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