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## **Supplemental Information**

### **A Systematic Nomenclature**

#### **for the *Drosophila* Ventral Nerve Cord**

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## Definitions

Agreed definitions of the anatomical structures. Highlighting any changes from the classical definition with the group's reasoning for making the change. Synonyms for each structure are provided and unless stated otherwise these are exact synonyms.

### The Ventral Nerve Cord (VNC)

The non-cephalic division of the central nervous system consolidated into a single ganglion located in the ventral thorax. The ganglion contains all of the thoracic and abdominal neuromeres (Figure 1). For this reason, it was called the thoracicoabdominal ganglion by Power (1948) but is most often referred to as the ventral nerve cord (VNC) although the VNC would include the suboesophageal ganglion (Niven et al., 2008). The VNC ganglion has three paired enlargements at its anterior end, thoracic neuromeres, which correspond to the prothoracic, mesothoracic and metathoracic segments, with a single posterior, dorsally located mass, the abdominal neuromeres that contains all the fused abdominal neuromeres.

### Changes:

Although the name thoracicoabdominal ganglion (TAG) (Power, 1948) was initially agreed by the group, many who worked in both larvae and adult felt that ventral nerve cord (VNC) was more appropriate and indeed was often used in the adult and was agreed upon with all alternatives recorded as synonyms.

### Synonyms:

- Ventral Nervous System (VNS),
- thoracico-abdominal ganglion (Power, 1948),
- thoracico-abdominal ganglia (Lundquist and Nässel, 1990),
- adult ventral nerve cord (Niven et al., 2008),
- VNC [BROAD] (Niven et al., 2008),
- TAC (Merritt and Murphey, 1992),
- TAG (Ito et al., 2014),
- ThGng (Miller and Demerec, 1950),
- thoracic + abdominal ganglion,
- T1 + T2 + T3 + A1 + A2 + A3 + A4 + A5 + A7 + A8,
- thoracico-abdominal center (Power, 1948; Merritt and Murphey, 1992),
- thoracic nerve center (Miller and Demerec, 1950),
- abdominal ganglion RELATED (Power, 1948).

### Dense Neuropil/Synapse Rich Neuropil

Dense neuropil, as referred to in this document, indicates more tightly packed synaptic regions. It can be identified by a notably brighter signal than that from the general surrounding neuropil when imaging the VNC using confocal microscopy of probes targeting synapse associated proteins such as Bruchpilot or N-cadherin. See Figure 1 and video S1.

### Major neuropil features of the VNC

The defined region of each neuropil is shown in Figure 2 and video S2.

### *Thoracic Neuromeres*

The three thoracic neuromeres are segmentally homologous and share common structural features. The detailed organization of serially homologous tracts and neuropil regions within the leg neuropils, as well as the angle of entry of the relevant leg nerve into the VNC,

indicate that the thoracic neuromeres have undergone rotation during development. This is such that the prothoracic neuromeres are rotated anteriorly, the mesothoracic and metathoracic and neuromeres rotated posteriorly.

**The Prothoracic Neuromere** (ProNm; also called T1) is the anteriormost of the 4 major neuropils that makes up the VNC and derives almost completely from the somata and projections of central neurons derived from the prothoracic array of neuroblasts, as well as the axonal projections of sensory afferents from the prothoracic legs and prothorax. The paired neuropil is formed as two more or less spherical masses. Its anterior boundary defines the anterior extent of the VNC. Although the posterior boundary is less obvious, it can be defined by the extent of the primary neurite projections of the central neurons produced by the prothoracic NBs (0, 3, 6, 11, 21, 20/22 and 23). These neuroglial positive tracts project anteriorly into the neuromere and their entry points represent the posterior limit of the prothoracic neuropil.

Changes:

The abbreviation was changed to resolve the clash for the original abbreviation PN with those for both the prosternal nerve and the adult antennal lobe projection neuron. The internal boundaries were clarified in relation to lineage tracts (Shepherd et al., 2016).

Synonyms:

- ProNm (Proposed by group),
- Pro (Merritt and Murphey, 1992),
- PN (Power, 1948).

**The Mesothoracic Neuromere** (MesoNm; also called T2) The 2nd (anterior-posterior) of the 4 major neuropils of the VNC that derives almost completely from the somata and projections of central neurons derived from the mesothoracic array of neuroblasts as well as the axonal projections of sensory afferents from the mesothoracic legs and mesothorax. The mesothoracic neuromere is closely associated with two distinct subdivisions of the thoracic neuropils: the accessory mesothoracic neuromere and the tectulum. It is delimited anteriorly by the entry points of the neuroglial-positive tracts from the anterior mesothoracic lineages 2, 7, 8, 10, 15 and 16. The posterior margin is defined by the entry points of the neuroglial-positive tracts from the posterior mesothoracic lineages 0, 3, 6, 12, 11, 19, 21 and 23, all of which project anteriorly into the neuromere.

Changes:

The abbreviation was changed for consistency. The internal boundaries were clarified in relation to lineage tracts (Shepherd et al., 2016).

Synonyms:

- MesoNm (Proposed by group),
- Meso (Merritt and Murphey),
- MN (Power, 1948).

**The Metathoracic Neuromere** (MetaNm; also called T3) The 3rd (anterior-posterior) of the 4 major neuropils that make up the VNC. It derives almost completely from the somata and projections of central neurons derived from the metathoracic array of neuroblasts as well as the axonal projections of sensory afferents from the metathoracic legs and metathorax. Because the MetaNp is drawn anteriorly by morphogenetic changes the anterior metathoracic neuroblast primary neurites are not a reliable marker for the anterior margin of the MetaNp.

The anterior MetNm boundary is best defined by the neuroglial tracts associated with the posterior T2 hemilineages 0, 3, 6, 11, 12, and 21, which also define the posterior margin of the MesoNp. The posterior margin of the neuromere is defined by the neuroglial tracts from the posterior hemilineages 0, 3, 6, 20/22 and 21, all of which project anteriorly into the neuromere.

Changes:

The abbreviation was changed for consistency. The internal boundaries were clarified in relation to lineage tracts (Shepherd et al., 2016).

Synonyms:

- MetaNm (Proposed by group),
- Meta (Merritt and Murphey, 1992),
- MtN (Power, 1948).

#### *Abdominal Neuromeres (ANm)*

The 4th major neuropil situated at the posterior end of the VNC, composed of the fused neuromeres A1 through A8. The lineage composition of the abdominal neuromeres has not been undertaken but the anterior limit of the ANm is defined by reference to the neuroglial bundles delineating the posterior limit of the MetaNm. The neuropil regions posterior to the neuroglial tracts of hemilineages 0, 5, 6, 19 and 23 define the ANm.

Synonyms:

- ANm (Proposed by group),
- AbGng (Miller and Demerec, 1950),
- AG (Merritt and Murphey, 1992),
- ac (Power, 1948),
- A1+A2+A3+A4+A5+A6+A7+A8,
- abdominal ganglia (Merritt and Murphey, 1992),
- abdominal ganglion (Yu et al., 2010),
- abdominal center (Power, 1948),
- abdominal nerve center (Miller and Demerec, 1950).

#### *Other major Neuropils*

The fusion of the thoracic neuromeres created two additional major neuropil regions, the accessory mesothoracic neuropil (AMNp) and the tectulum, that do not conform to the evolutionarily ancestral segmental origins.

**The accessory mesothoracic neuropil (AMNp)** The accessory mesothoracic neuropil (AMNp) is a distinct subdivision of the mesothoracic neuromere. It is formed of dense neuropil (as seen by brighter signal in bruchpilot or N-cadherin labeling) largely from the sensory afferents from the wing and notum entering the VNC via the Anterior Dorsal Median Nerve (ADMN) (Power, 1948). This dense synaptic neuropil corresponds to a structure called the ovoid by Merritt and Murphey (1992). The AMNp was originally called the Accessory Mesothoracic Neuromere by Merritt and Murphey (1992) but we substitute *neuropil* to indicate that it is a region made up of incoming sensory afferents rather than intrinsic neurons of a common developmental origin. The AMNp sits at the interface between the pro- and mesothoracic neuromeres from which it is morphologically distinct with the tectulum (Tct) forming the dorsal boundary. The AMNp is bounded anteriorly by the primary neurites from

the posterior T1 hemilineages 0, 5, 6, 11, 19 and 23 and posteriorly by the primary neurites from the anterior T2 hemilineages 1, 2, 7, 8, 9, 15, and 16.

Changes:

After careful consideration it was concluded and agreed by all that the accessory region was indicated by the dense neuropil (see description) and that any area posterior to the prothoracic neuromere lineage boundary but not dense neuropil should be considered part of the mesothoracic neuromere. This also meant that the accessory region should more correctly be labelled neuropil rather than a neuromere. The internal boundaries were clarified in relation to lineage tracts (Shepherd et al., 2016).

Synonyms:

- AMNp (Proposed by group),
- accessory mesothoracic neuromere (Power, 1948),
- Acc Meso (Merritt and Murphey, 1992),
- AMN (Power, 1948),
- ovoid (Merritt and Murphey, 1992).

### *Tectulum*

The tectulum is a distinct subdivision of the thoracic regions of the VNC. The region forms a saddle-like structure located dorsally, primarily over the accessory mesothoracic neuropil (AMNp) and the mesothoracic neuromere (MesoNm) but extending over the posteriormost region of the prothoracic neuromere (ProNm) and the anteriormost region of the metathoracic neuromere (MetaNm). Its internal boundaries within the VNC can be defined as the dorsal region of the neuropil posterior to the ventral ellipse in ProNm, but dorsal to the bundles from hemilineages 12B, 6B, 23, 17, 18B. Extending posteriorly through MesoNm to the entry point of hemilineage 3 in MetaNm. The tectulum can be stratified into three regions (Namiki et al., 2018), which the working group renamed as upper, intermediate and lower tectulum.

The **upper tectulum** is the dorsalmost stratum of the tectulum sitting dorsal to the tracts DMT, MTD and ITD-HT. The upper tectulum can be further segregated on the basis of the synapse rich neuropil regions into three neuromere specific neuropils. A prothoracic neck neuropil (NTct), a mesothoracic wing neuropil (WTct) and a metathoracic haltere neuropil (HTct).

The **intermediate tectulum**, lies immediately ventral to the upper tectulum and dorsal to the lower tectulum and extends from the ProNm mVAC to the posterior margin of the MesoNm at the ITD-CFF commissure.

The **lower tectulum** is a region of the pro and mesothoracic neuromeres ventral to the intermediate tectulum extending posteriorly from the proNm mVAC and the posterior margin of the mesoNm at the ITD-CFF commissure. It is contained ventrally by the tract VTV and laterally by DLV tract.

Changes:

Abbreviation changed from Power's 'T' (Power, 1948) to avoid potential confusion. The internal boundaries were clarified in relation to lineage tracts (Shepherd et al., 2016). Agreed naming and definitions of the upper, intermediate and lower tectulum.

Synonyms:

- Tct (Proposed by group),
- T (Power, 1948),
- Flight neuropil RELATED (Leise, 1991; Power, 1948).

### *Leg Neuropil*

Whilst the tectulum occupies the dorsal regions of the thoracic neuromeres, the remaining ventral portion is considered leg neuropils. Unlike the tectulum, the leg neuropils exhibit overt segmental boundaries and although each thoracic neuromere is slightly different the leg neuropils conform to the same organizational principles. The leg neuropils receive sensory inputs from the legs and contains the dendritic processes of the motor neurons that target leg muscles. The leg neuropils are best described in transverse section and can be readily partitioned into distinct regions along the dorsoventral axis.

### *Ventral Association Centre (VAC)*

The ventralmost layer of leg neuropil, the Ventral Association Center (VAC) (Merritt and Murphey, 1992) is readily distinguishable as a unique region by the high expression levels of the synaptic proteins Bruchpilot and N-cadherin indicating high synaptic density in VAC. The VAC is innervated by sensory afferents from sensory neurons associated with tactile bristles on the leg which form a somatotopic projection (Murphey et al., 1989) within the VAC.

### *Medial Ventral Association Centre (mVAC)*

Adjacent to the VAC of each leg neuropil is a paired globular structure, the medial Ventral Association Center (mVAC), a bilaterally symmetrical region that can be identified both by its fine textured appearance and the high expression levels of bruchpilot and N-cadherin (Merritt and Murphey, 1992). In *Drosophila* the mVAC is innervated by a subset of Femoral Chordotonal Organ (FeCO) sensory neurons which form a “club” shaped projection that terminates in the mVAC (Phillis et al., 1996). The *Drosophila* mVAC is homologous to the mVAC described in locusts and other insects which also receive primary sensory afferents for leg chordotonal organs and is known as “auditory neuropil” (Oshinsky and Hoy, 2002; Pflüger et al., 1988; Römer et al., 1988).

### *Intermediate Neuropil (Int Np)*

The leg neuropil, between the VAC and the tectulum, is called “intermediate neuropil” (IntNp) because it occupies most of the central third of the dorsoventral area in transverse section (IntNp, Figure 2 and video S2). The leg neuropil contains the dendritic branches of the leg motorneurons as well as premotor interneurons (Shepherd et al., 2019) and sensory afferent terminals from leg campaniform sensilla, hair plates and the “hook” and “claw” projection types from the FeCO (Mamiya et al., 2018). Like the tectulum, the leg neuropils exhibit clear functional segregation: Motor neurons are located dorsally and the sensory modalities are partitioned into layers, with proprioception in intermediate neuropil, and a somatotopic representation of tactile information in the ventralmost zone (Murphey et al., 1989; Tsubouchi et al., 2017).

## The Commissures

Defined region of the commissures are shown in Figure S1.

### *Commissures derived from the larval aV commissure*

The larval aV commissure is present in all three thoracic neuromeres. In the adult thoracic neuromeres it segregates into two distinct commissures which we called the **anterior Anterior Ventral Commissure** (aAV) and the **posterior Anterior Ventral Commissure** (pAV).

The **anterior Anterior Ventral Commissure** (aAV) is present in all three thoracic neuromeres and is formed by the primary neurite bundles of hemilineage 1A. It sits at the anterior of the neuromere at the ventralmost margins, outside the neuropil and cell cortex and anterior to the hemilineage 2A axons. The MesoTh aAV commissure was called the Accessory Prothoracic Commissure by Power (1948). The MetaTh aAV commissure was called the Accessory Commissure of the Metathoracic Neuromere by Power (1948).

Synonyms:

- Accessory Prothoracic Commissure (Power, 1948),
- APC (Power, 1948).
- Accessory Commissure of the Metathoracic Neuromere (Power, 1948),
- ACM (Power, 1948).

The **posterior anterior Ventral Commissure** (pAV) is present in all three thoracic neuromeres and is formed by the primary neurite bundles of hemilineages 13B and 14A. It sits at the anterior of the neuromere but crosses the midline posterior to the hemilineage 2A primary neurites (Shepherd et al., 2016). In the ProNm and MesoNm the axons form a single commissure but in MetaNm the axons of pAV are pulled apart to form two distinct commissures (pAVa and pAVp). The MesoNm pAV was called the Ventral Accessory Commissure of the Mesothoracic Neuromere by Power.

Synonyms:

- Ventral Accessory Commissure of the Mesothoracic Neuromere (Power, 1948),
- VAC (Power, 1948).

### *Commissures derived from the larval AI commissure*

The larval anterior Intermediate Commissure (AI) is present in all three thoracic neuromeres and crosses the midline as two neurite bundles separated by the primary neurites of hemilineage 2A. The axon bundle anterior to 2A contains the fibers from hemilineages 10B and 18B, except in the ProNm where hemilineage 18B is not found. The neurite bundle posterior to 2A contains the neurites from hemilineages 7B and 8B Truman et al. (2004).

In the adult ProNm, the **Anterior Intermediate Commissure** (AI) segregates into three commissures. 1) The **ventral Anterior Intermediate Commissure** (vAI) formed by the 10B neurons which crosses anterior to the hemilineage 2A fibers. 2) the **Anterior Intermediate anterior Commissure** (AIa) formed by the 8B neurons and 3) the **Anterior Intermediate posterior Commissure** (AIp) formed by the 7B neurons. Both dorsal AI commissures cross the midline posterior to the 2A neurites with dAIa anterior to dAIp (Shepherd et al., 2016).

In the adult MesoNm aI commissure segregates into three separate commissures. 1) The **ventral Anterior Intermediate Commissure** (vAI) formed by the 10B neurons which

crosses the midline anterior to the 2A neurites. 2) A single **Anterior Intermediate Commissure (AI)** that contains fibers from both hemilineages 7B and 8B which crosses the midline posterior to the 2A neurites. The AI commissures in the MesoNm is one of the most prominent commissures of the VNC and was called the **Commissure of the Mesothoracic Neuromere** by Power (1948). 3) The **dorsal Anterior Intermediate Commissure (dAI)** containing the fibers of hemilineage 18B and crosses the midline anterior to hemilineage 2A.

In the MetaNm the AI commissure segregates into 2 commissures. 1) The **ventral Anterior Intermediate Commissure (vAI)** formed by the 10B neurons which crosses anterior to the 2A axons. 2) A single **Anterior Intermediate Commissure (AI)** that contains the fibers from hemilineages 7B, 8B and 18B to create the largest and most notable commissure of the VNC which was called the **Haltere Commissure** by Power (1948).

Synonyms:

- Commissure of the Mesothoracic Neuromere (Power, 1948),
- CMN (Power, 1948).
- Haltere Commissure (Power, 1948),
- cHIN (Merritt and Murphey, 1992; Pflüger et al., 1988; Tyrer and Gregory, 1982),
- ITD-HC (Boerner and Duch, 2010),
- HC (Power, 1948).

#### *Commissures derived from the larval pI commissure*

The larval posterior Intermediate Commissure (pI) is formed by neurites from hemilineages 5B, 6B, 12B, 19B and 23B. In all three thoracic neuromeres pI segregates into multiple commissures. In all three thoracic neuromeres the fibers of hemilineage 5B form the most anterior commissure the **anterior PI Commissure (aPI)**. In the ProNm the fibers from hemilineages 6B, 12B and 23B remain closely bundled and cross the midline, slightly posterior and ventral to aPI, as a single commissure called the **posterior PI Commissure (pPI)**. The neurites from 19B form a separate, more dorsally located commissure called the **dorsal PI Commissure (dPI)** that crosses the midline close to, but anterior to the Posterior Dorsal Commissure (pD).

In the MesoNm and MetaNm the PI commissure segregates into four distinct commissural pathways. In addition to aPI formed by the 5B neurons and dPI by the 19B neuron, the pPI segregate into distinct commissures the **pPI anterior (pPIa)** commissure formed by hemilineage 6B neurites which is located just anterior to the **pPI posterior (pPIp)** commissure formed by 12B and 23B neurites.

None of these commissures has been previously identified.

#### *Commissures derived from the larval pD commissure*

The larval posterior Dorsal commissure (pD) is the dorsalmost commissure and is found in all three thoracic neuromeres. It contains the axons from hemilineage 6A. In the adult the commissure is the dorsalmost and located in the upper tectulum. Power (1948) only described this commissure in the mesothorax and called it the Posterior Dorsal Mesothoracic Decussation (PDD). We called all three commissures the **Posterior Dorsal Commissures (PD)**.

Synonyms:

- MesoPDC (Proposed by group),

- Posterior Dorsal Mesothoracic Decussation (Power, 1948),
- PDD (Power, 1948).

#### *Commissures formed by descending neurons*

##### *Commissure of Fine Fibers of the Intermediate Tract of the Dorsal Cervical Fasciculus (CFF)*

In the MesoNm there is a robust commissure formed by the inner tracts of the intermediate tract of the dorsal cervical fasciculus (ITD-CFF), as they cross the midline, anterior to the haltere commissure in the upper tectulum above the MesoNm to terminate on the contralateral side.

Synonyms:

- CFF (Power, 1948).
- ITD-CFF BROAD (Boerner and Duch, 2010).

#### *Other Commissures*

In addition to the commissures that can be related to the projections of specific hemilineages there are two commissures described by Power (1948) that cannot be related to specific hemilineages.

##### *Commissure of Prothoracic Neuromeres (CPN)*

A transverse bundle of fibers that cross the midline in the ProNm. The fibers characteristically bow posteriorly and are dorsal to the dorsal lateral tracts of the ventral cervical fasciculus (DLV). The commissure crosses the midline just dorsal to the axons of the apI commissure. The arms of the bow are directed lateroanteriorly and extend almost to the lateral borders of the neuromeres.

Synonyms:

- CPN (Power, 1948),
- Prothoracic commissure (Bacon and Strausfeld, 1986).

##### *Dorsal Accessory Commissure of the Mesothoracic Neuromeres (DAM)*

A transverse thin bundle of fibers that crosses the dorsoposterior region of the MesoNm. It is ventral to the roots of the dorsal metathoracic (haltere) nerves, dorsal to the ventral ellipse, and ventroanterior to the haltere chiasma.

Synonyms:

DAM (Power, 1948).

## Longitudinal Tracts

Defined region of the longitudinal tracts are shown in Figure 2 and Video S3

### *Dorsal Lateral Tract (DLT)*

As its name implies the DLT is located in dorsal lateral neuropil, it is formed by fibers from the lateral bundles in the cervical (neck) connective and projects posteriorly and superficially at the dorsal lateral edge of the neuropil to terminate in the metathoracic neuromere. The tract contains the axons of descending neurons that innervate neck, wing, haltere and leg neuropils (Namiki et al, 2018). Histologically DLT has coarser fibers than the other tracts derived from the ventral bundles of the cervical connective described below.

### *Intermediate Tract of Dorsal Cervical Fasciculus (ITD)*

The ITD is a dorsal tract, derived from the dorsal fibers in the connective and sits just medial to the DLT. According to Power (1948), the ITD projects posteriorly and separates into three adjacent tracts. The medialmost of these subdivisions, called ITD-CFF turns medially in the mesothoracic neuromere to cross its contralateral homolog to form the chiasma of fine fibers of the intermediate tracts of the dorsal cervical fasciculus (ITD-CFF). This longitudinal projection is what we now refer to as ITD. It contains the axons of many descending interneurons that terminate widely in neck, wing, haltere and leg neuropils (Namiki et al 2018). The other two subdivisions of ITD are now recognized as distinct tracts and called the Haltere Chiasma (ITD-HC) and the Haltere Tract (ITD-HT) respectively.

### *Intermediate Tract of Dorsal Cervical Fasciculus – Haltere Chiasma (ITD-HC)*

ITD-HC is formed by the axons of the cHIN interneurons as they project anteriorly from the metathoracic neuromere. The axons originate from interneurons produced by metathoracic hemilineage 8B, the primary projections of which also form the major component of the Haltere Commissure. The tract itself extends anteriorly from the HC just lateral to the ITD and medial to the HC. This tract was termed cHIN by Merritt and Murphey (1992).

### *Haltere Tract ITD-(HT)*

The haltere tract is the most lateral component of Power's (1948) ITD and is composed of many large-diameter fibers that can be traced as a bundle into the cervical connective. The HT is formed by the sensory afferent axons (Ghysen, 1980; Strausfeld and Seyan, 1985) from the dorsal metathoracic nerve (Haltere Nerve) entering the metathoracic neuromere and extending anteriorly through the cervical connective (Merritt and Murphey, 1992; Power, 1948). The tract has small arborizations with some of the Fibers bending anterolaterally to become part of the haltere commissure (HC) in the metathoracic neuromere, while others turn ventrally and straggle into the dorsolateral part of the mesothoracic neuromere where they are quickly lost (Power, 1948).

### *Dorsal Medial Tract (DMT)*

The **Dorsal Medial Tract** was previously called the Median Tracts of the Dorsal Cervical Connective (MTD) by Power, (1948) and Merritt and Murphey (1992); we propose DMT as an alternative to be more consistent with the rest of the tract nomenclature. The DMT is derived from the dorsal bundles in the cervical connective and extends posteriorly and bows laterally slightly, in the mesothoracic region, bending again medially, towards each other, at the narrowing between the meso- and metathoracic neuromeres. The tract turns laterally and posteriorly at the level of the haltere commissure and enters the metathoracic neuromere, where it forms collateral fibers that merge with the oblique tract of the metathoracic leg nerve (Power, 1948). The DMT contains the projections of a large number of descending neurons

that innervate both the dorsal and ventral tectulum and the leg neuropils (Namiki et al., 2018).

#### *Dorsal Lateral Tract of Ventral Cervical Fasciculus (DLV)*

The DLV derives from the ventral bundles of the cervical connective. It contains coarser fibers than the other tracts derived from the ventral bundles of the cervical connective (DLV, VLT and VTV). The tract broadens as it extends posteriorly, in a medial position and just ventral to the tectulum to terminate in the mesothoracic neuromere merging with the Oblique Tract.

#### *Ventral Median Tract of Ventral Cervical Fasciculus (VTV)*

VTV is the ventralmost tract in the VNC. It runs adjacent to the midline and derives from the ventral bundles of the cervical connective. The tract extends posteriorly on either side of the midline just under the ventral most part of the lower tectulum until they bend dorsally and terminates in the ventral-anterior region of the abdominal ganglion. A few fibers extend laterally in into the leg neuropil of each neuromere before the tract terminates in the abdominal ganglion (Power, 1948).

#### *Median Dorsal Abdominal Tract (MDT)*

**MDT** is the dorsalmost tract in the VNC, sits close to midline (Merritt and Murphey, 1992) and runs dorsally along the length of the tectulum (Boerner and Duch, 2010) past the haltere chiasma to terminate into the abdominal neuromeres (Power, 1948). It is the medialmost of the three small dorsal tracts which connects the thoracic and abdominal neuromeres.

#### *Lateral Dorsal Abdominal Tract (LDT)*

The lateral pair of three small dorsal tracts which connects the thoracic and abdominal neuromeres dorsal to the metathoracic neuromeres (Power, 1948).

Synonyms:

- LDT (Proposed by group).

#### *Ventral Cervical Fasciculus (VCF)*

Ventral fascicle of the dorsal tectulum. It enters the thoracico-abdominal mass along with the dorsal bundles and takes a more ventral course. There are two of these fascicles. Each fascicle passes posteriorly between the prothoracic and at an intermediate position in these neuromeres, dividing into the dorsal lateral (DLV) and ventral median (VTV) tracts (Power, 1948).

Synonyms:

- VCF (Power, 1948).

#### *Dorsal Cervical Fasciculus (DCF)*

Dorsal fascicle of the dorsal tectulum. It occupies the uppermost region within the anterior part of the dorsal tectulum. The fibers slope gently ventrally, so that by the time they have passed over the anterior tips of the mesothoracic neuromeres, they have descended to a relatively lower position, below the mesothoracic decussations. There are two of these fascicles. Near the anterior end of the VNC each of the dorsal fasciculus separates forming three poorly defined longitudinal tracts: the dorsal lateral (DLT), intermediate (ITD) and dorsal median tract (DMT) (Power, 1948).

Synonyms:

- DCF (Power, 1948).

### *Ventral Ellipse (VE)*

Flattened annulus of fibers which lies in a frontal plane that crosses the midline at the posterior edge of the prothoracic mVAC and extends axons posteriorly to the isthmus between the meso- and metathoracic neuromeres. It lies immediately below the dorsal decussations of the mesothoracic and metathoracic neuromeres. A right and left arm of fibers extends lateroposteriorly from the posterior end of the ellipse into the respective metathoracic neuromeres, and within them, joins the bundle which runs out into the third leg nerve. At the anterior end, the ventral ellipse incorporates the dorsolateral tracts of the ventral fasciculi (DLV) (Power, 1948).

Synonyms:

- VE (Power, 1948).

### *The peripheral nerves*

Most nerves have been historically well defined by Power (1948) in which case the definitions are maintained, however, with some of the abdominal nerves we decided to utilise later terms (Shepherd and Smith, 1996) naming each nerve according to its neuromere of origin to give them a more consistent naming scheme than the original. Defined regions for each peripheral nerve are shown in Figure S3

### *Cervical Connective (CvC)*

Major axon tract connecting the posteriormost subesophageal ganglion to the VNC in the adult central nervous system (Power, 1948).

Synonyms:

- CvC (Power, 1948),
- cephalo-thoracic cord (Bodenstein, 1950),
- cephalo-thoracic nerve strand,
- CC (Merritt and Murphey, 1992),
- CV (Ito et al., 2014),
- CvCon (Miller and Demerec, 1950).

### *Cervical Nerve (CvN)*

A bilaterally paired nerve that connects laterally to the cervical connective, immediately posterior to where it enters the thorax. Each cervical nerve extends laterally, branching and innervating horizontal muscles of the anterior thorax (Power, 1948).

Synonyms:

- CvN (Power, 1948),
- nerve to crop (Miller and Demerec, 1950),
- CvNv (Miller and Demerec, 1950).

Dorsal nerves directly innervating the neuropil of the prothoracic neuromere

The dorsal prothoracic nerve, prosternal nerve, prothoracic chordotonal nerve, prothoracic accessory nerve and the ventral prothoracic nerve emerge closely adjacent to each other in

the anteriolateral corner of the prothoracic neuromere. Their proximity is such that in some preparations they appear to share a common exit point.

#### *Dorsal Prothoracic Nerve (DProN)*

A nerve that projects latero-anteriorly from the antero-lateral corner of the ventral nervous cord (VNC) (prothoracic neuromere). It splits into 4 or more branches before innervating various muscles (Power, 1948).

Synonyms:

- DProN (Proposed by group),
- ADN (Power, 1948),
- anterior dorsal nerve (Power, 1948),
- DPN (Merritt and Murphey, 1992),
- First dorsal nerve (Miller and Demerec, 1950),
- DNv1 (Miller and Demerec, 1950).

#### *Prosternal Nerve (PrN)*

A slender nerve that projects anteriorly from the ventral nerve cord (VNC), medial to the base of the dorsal prothoracic nerve to the prosternal sense organ (Power, 1948).

Synonyms:

- PrN (Power, 1948),
- PN (Merritt and Murphey, 1992).

#### *Prothoracic Chordotonal Nerve (ProCN)*

Very short and thick nerve that arises in the prothoracic neuromere, immediately below the anterior dorsal and prosternal nerves, and connects to each prothoracic chordotonal sense organ (Power, 1948).

Synonyms:

- ProCN (Proposed by group),
- CN (Power, 1948).

#### *Prothoracic Accessory Nerve (ProAN)*

A mixed motor-sensory nerve that connects to the prothoracic neuromere, slightly posterior and ventral to the anterior prothoracic chordotonal organ and slightly dorsal to the root of the ventral prothoracic nerves. It extends laterally and dorsally almost to the lateral body wall before branching to innervate muscles (Power, 1948).

Synonyms:

- ProAN (Proposed by group),
- accessory prothoracic nerve,
- PAN (Power, 1948),
- First accessory nerve (Miller and Demerec, 1950),
- AcNv1 (Miller and Demerec, 1950).

#### *Ventral Prothoracic Nerve (VProN)*

A mixed motor-sensory nerve that carries axons from two clusters of microchaetae on the prothoracic coxa and to motor neuron fibers from lateral anterior muscles. It connects to the

prothoracic neuromere just dorsal to the root of the prothoracic leg nerve and branches about halfway along its length into a motor branch that stays within the body and a sensory branch that projects to the leg (Power, 1948).

Synonyms:

- VProN (Proposed by group),
- VPN (Power, 1948),
- prosternal sense organ (Miller and Demerec, 1950),
- PSO (Miller and Demerec, 1950).

#### *Prothoracic Leg Nerve (ProLN)*

A nerve that carries a mix of motor and sensory axons from the prothoracic leg to the adult prothoracic neuromere. Each nerve extends laterally and slightly anteriorly from the ventral anterior region of the prothoracic neuromere (Power, 1948).

Synonyms:

- ProLN (Proposed by group),
- PLN (Power, 1948),
- T1LN (Merritt and Murphey, 1992),
- First ventral nerve (Miller and Demerec, 1950),
- VNv1 (Miller and Demerec, 1950).

#### *Anterior Dorsal Mesothoracic Nerve (ADMN)*

A mixed sensory-motor nerve that is the thicker of the two dorsal nerves of the mesothorax. The nerve enters the mesothoracic neuromere slightly anterior and dorsal to the smaller PDMN. The ADMN projects anteriorly and dorsally (Power, 1948).

Synonyms:

- ADMN (Power, 1948),
- second dorsal nerve BROAD (Miller and Demerec, 1950),
- DNv2 BROAD (Miller and Demerec, 1950),
- wing nerve BROAD (Merritt and Murphey, 1992).

#### *Wing Nerve*

A nerve that carries sensory fibers from the sense organs of the wing, eventually joining the anterior dorsal mesothoracic nerve (ADMN) (Merritt and Murphey, 1992).

#### *Posterior Dorsal Mesothoracic Nerve (PDMN)*

A nerve that arises from the ventral nerve cord (VNC), just posterior to the root of the anterior dorsal mesothoracic nerve. It projects posterolaterally before branching, with one branch innervating the tergal depressor of the trochanter (jump muscle), while the other branch forms further, terminal branches that innervate targets including the dorsal medial muscle (dorsal longitudinal muscle) (Power, 1948).

Synonyms:

- PDMN (Merritt and Murphey, 1992),
- PDM (Power, 1948)
- second dorsal nerve BROAD (Miller and Demerec, 1950),
- DNv2 BROAD (Miller and Demerec, 1950).

### *Mesothoracic Accessory Nerve (MesoAN)*

A nerve that arises from the lateroposterior side of the mesothoracic neuromere at a point anterior to the root of the haltere nerve. It extends posteriorly and slightly dorsally and laterally, around the anterior wings of the mesofurca, before branching. One branch innervates the furcoentopleural muscles (muscles 59 and 60) and the other innervates laterally placed muscles, anterior to the halteres (Power, 1948).

Synonyms:

- MesoAN (Proposed by group),
- MAC (Power, 1948),
- accessory mesothoracic nerve (Power, 1948)
- second accessory nerve (Miller and Demerec, 1950),
- AcNv2 (Miller and Demerec, 1950).

### *Mesothoracic Leg Nerve (MesoLN)*

A mixed motor-sensory nerve that arises ventrally from the mesothoracic neuromere. It splits at its base, with a small number of axons innervating a ventral muscle that is posterior-lateral to the tergal depressor of the trochanter (jump muscle) and the rest projecting into the mesothoracic leg (Power, 1948).

Synonyms:

- MesoLN (Proposed by group),
- T2LN (Merritt and Murphey, 1992),
- second ventral nerve (Miller and Demerec, 1950),
- VNv2 (Miller and Demerec, 1950),
- ventral mesothoracic nerve.

### *Dorsal Metathoracic Nerve (DMetaN)*

A thick nerve that primarily carries sensory axons from the haltere to the metathoracic neuromere. It extends anteriorly and somewhat medially to terminate in the center of the metathoracic neuromere. Its fibers extend anteriorly, contributing to the tectulum (Power, 1948).

Synonyms:

- DMetaN (Proposed by group),
- haltere nerve (Power, 1948),
- HN (Power, 1948),
- third dorsal nerve (Miller and Demerec, 1950),
- DNv3 (Miller and Demerec, 1950).

### *Metathoracic Leg Nerve (MetaLN)*

A large sensory motor nerve that originates in the ventral metathoracic neuromere and innervates the metathoracic leg (Power, 1948).

Synonyms:

- MetaLN (Proposed by group),
- MLN (Power, 1948),
- T3LN (Merritt and Murphey, 1992),
- third ventral nerve (Miller and Demerec, 1950),
- VNv3 (Miller and Demerec, 1950),

- ventral metathoracic nerve.

### The Abdominal Nerves

Emerging from the abdominal neuromeres are four paired nerves that extend posteriorly and laterally into the abdomen.

#### *First Abdominal Nerve (AbN1)*

The first abdominal nerve apparently emerges from the metathoracic neuromere but contains axons that originate/terminate in the first abdominal neuromere. The nerve exits laterally just dorsal to the exit of the metathoracic leg nerve (Shepherd and Smith, 1996).

Synonyms:

- AbN1 (Shepherd and Smith, 1996),
- accessory metathoracic nerve,
- MA (Power, 1948),
- metathoracic accessory nerve (Power, 1948),
- nerve of the 1st abdominal segment (Miller and Demerec, 1950),
- Ab1Nv (Miller and Demerec, 1950).

#### *Second Abdominal Nerve (AbN2)*

A nerve that apparently emerges in the dorsalmost region of the metathoracic neuromere but contains axons that originate/terminate in the second abdominal neuromere. The nerve projects postero-laterally to the most posterior-lateral corner of the thorax, where it innervates transverse tubular muscles. This nerve also contains the afferent fibers from a multisclophorous organ located on the ventral surface of the second abdominal segment (Shepherd and Smith, 1996).

Synonyms:

- AbN2 (Shepherd and Smith, 1996),
- extra metathoracic nerve (Power, 1948),
- EMN (Power, 1948),
- nerve of the second abdominal segment (Miller and Demerec, 1950),
- Ab2Nv (Miller and Demerec, 1950).

#### *Third Abdominal Nerve (AbN3)*

Lateralmost of the two bilaterally paired nerves connected to the abdominal neuropil. It is thin, containing only fine fibers (Shepherd and Smith, 1996).

Synonyms:

- AbN3 (Shepherd and Smith, 1996),
- First lateral abdominal nerve (Power, 1948),
- FLA (Power, 1948),
- nerve of the third abdominal segment (Miller and Demerec, 1950),
- Ab3Nv (Miller and Demerec, 1950).

#### *Fourth Abdominal Nerve (AbN4)*

Medialmost of the two bilaterally paired nerves connected to the abdominal neuropil. (Shepherd and Smith, 1996).

Synonyms:

- AbN4 (Shepherd and Smith, 1996),
- second lateral abdominal nerve (Power, 1948),
- SLA (Power, 1948),
- nerve of the fourth abdominal segment (Miller and Demerec, 1950),
- Ab4Nv (Miller and Demerec, 1950).

#### *Abdominal Nerve Trunk (AbNT)*

A fused terminal nerve that projects posteriorly along the midline from the posterior of the abdominal neuropil (Shepherd and Smith, 1996).

#### Synonyms:

- AbNT (Shepherd and Smith, 1996),
- abdominal median nerve trunk,
- median nerve trunk (Middleton et al., 2006),
- AbNvTr (Middleton et al., 2006),
- MAN (Power, 1948),
- median abdominal nerve (Power, 1948),
- terminal abdominal nerves (Miller and Demerec, 1950),
- AbTNv (Miller and Demerec, 1950).

Figure S1- Related to Figure 2

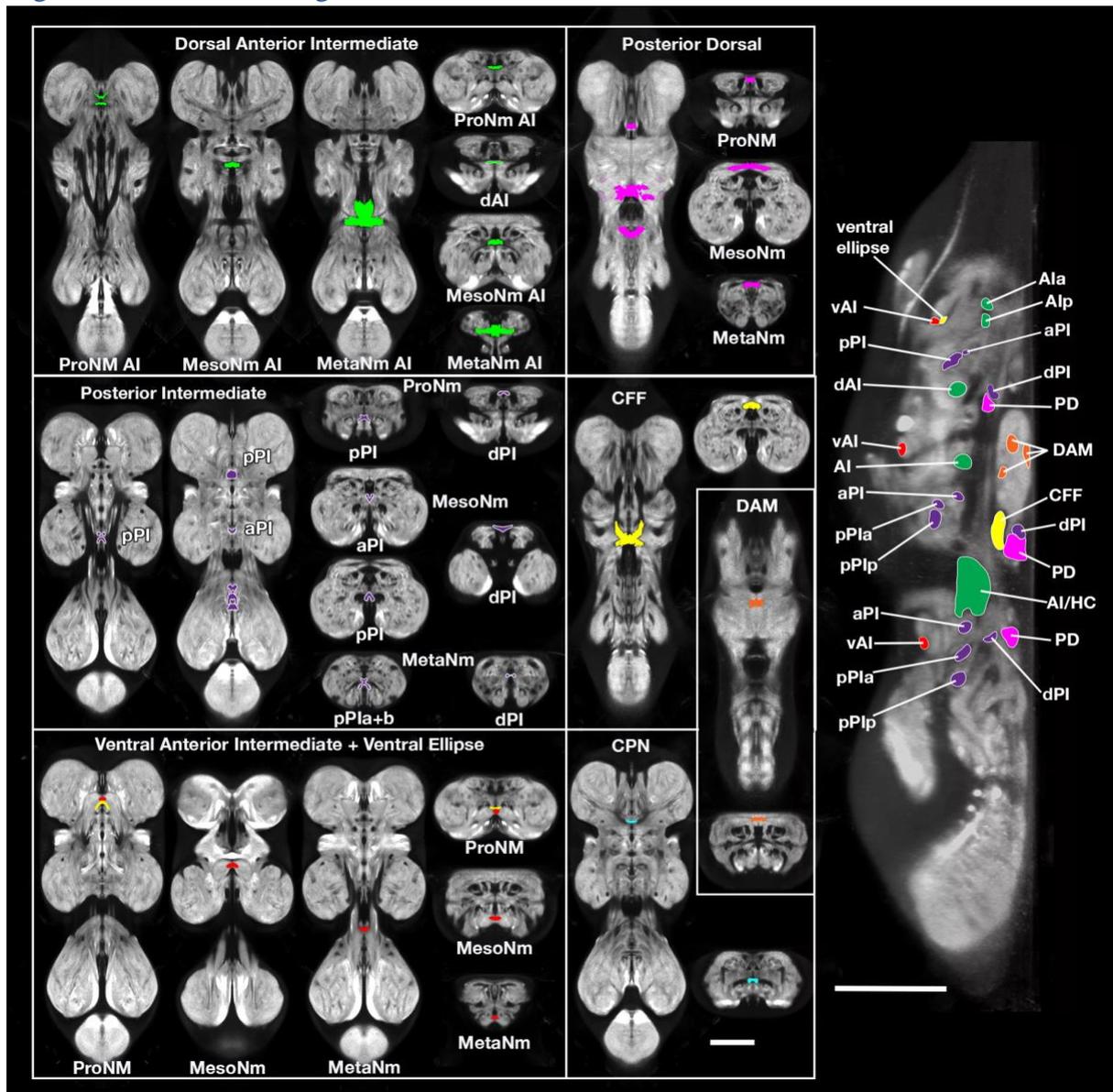


Figure S1- Related to Figure 2) The major identified commissures of the VNC – the positions of the major commissures of the VNC shown in horizontal, transverse and lateral sections. The horizontal and transverse sections are taken at planes that transect each commissure to reveal the commissural position against the neuropil structure. A list of the abbreviations is given in Table 1. Scale 50 $\mu$ m

Figure S2 – Related to Figure 1

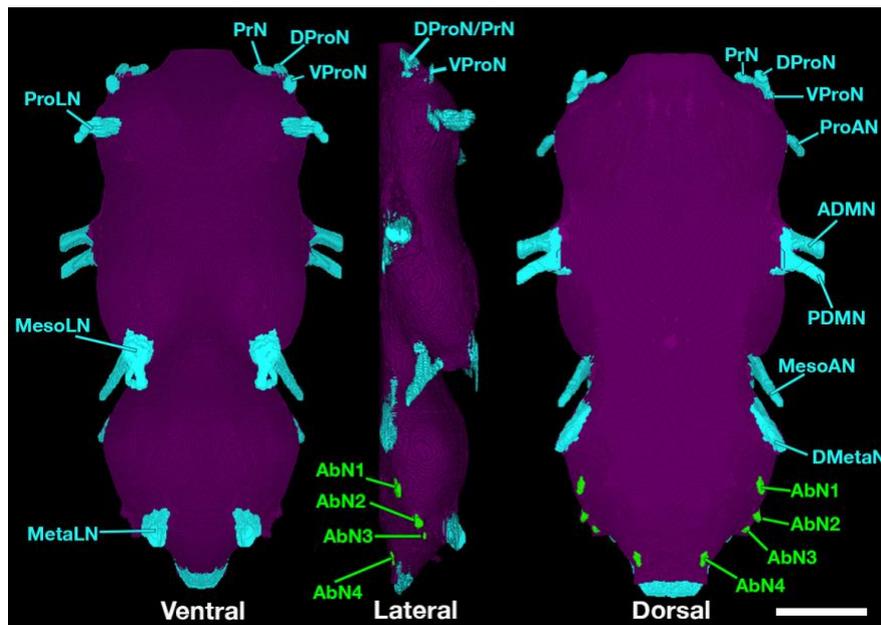


Figure S2 – Related to Figure 1) Peripheral nerves – Rendered volume of the VNC showing the location of the peripheral nerve roots of the VNC from ventral, lateral and dorsal view. A list of the abbreviations is given in Table 1. Scale 50 $\mu$ m