Journal of Natural History
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713192031

Origin, course and destination of the peripheral nerves of the beetle **Chilocorus nigritus** Fabr. (Coleoptera: Coccinellidae)

Y. N. Singh [a]
[a] Department of Zoology, University of Allahabad, India

Online Publication Date: 01 October 1974
To cite this Article: Singh, Y. N. (1974) 'Origin, course and destination of the peripheral nerves of the beetle **Chilocorus nigritus** Fabr. (Coleoptera: Coccinellidae)', Journal of Natural History, 8:5, 537 - 544
To link to this article: DOI: 10.1080/00222937400770451
URL: http://dx.doi.org/10.1080/00222937400770451

J. nat. Hist., 1974, **8** : 537–544

Origin, course and destination of the peripheral nerves of the beetle *Chilocorus nigritus* Fabr. (Coleoptera: Coccinellidae)

Y. N. SINGH
Department of Zoology, University of Allahabad, India

Introduction

The morphology of the nervous system of Coleoptera has been described by a good number of workers like Brandt (1878, in Bullock and Horridge, 1965) in *Lamellicornia*, Geipel (1915) in *Pyrophorus*, Dönges (1954) in *Cionus*, etc. Cody and Gray (1938) in *Passalus cornutus* and Pajni (1959) in *Callosobruchus* described the metamorphic changes in the nerve cord, but all these accounts are preliminary and do not deal with the peripheral nerves and innervation of musculature. Holste (1910 and 1923) in *Dytiscus*, Mao (1935) in *Xylotrupes* and Murray and Tiegs (1935) in *Calandra oryzae* described the system in detail but the accounts on the origin, course and destination of these nerves is not satisfactory. In the present study an effort has been made to trace the finer branches of the peripheral nerves and their correct identification by tracing them up to their terminal points.

Materials and methods

Beetles were collected from the vegetables fields during August to November and dissected under a powerful stereoscopic binocular microscope. A very dilute and fresh solution of methylene blue helped to stain and differentiate the finer branches of the nerves from the trachea. The diagrams were made with the help of a camera lucida.

Observations

The brain and the cerebral nerves

The brain is externally differentiated into proto-, deuto-, and tritocerebrum. The compound eyes are directly attached to the lateral lobes of the brain and the suboesophageal ganglion to the posteroventral part of the brain through extremely small crura cerebri. The brain gives rise to the antennary and labro-frontal nerves.

The antennary nerve (Ann) arises from the mid brain, extends antero-laterally and innervates the antenna.

The labro-frontal nerve (Lrfn) arises from the hind brain, proceeds anteriorly and divides into the labral (Lrn) and frontal ganglion connective nerve (Frgc). The former runs anteriorly to innervate the labral muscles and the latter bends medially to join with the anterolateral border of the frontal ganglion (Frg). Both are unbranched. (For the nerves arising from the brain which constitute stomatogastric system, see Singh, 1973.)

The suboesophageal ganglion (Subg) and its nerves

The ganglion is placed below the oesophagus and gives rise to 3 pairs of nerves—mandibular, maxillary and cervical.

The mandibular nerve (Mdn): Each Mdn nerve arises laterally from the middle part of the ganglion and proceeds anterolaterally below the oesophagus and brain. It is the thickest nerve among all the nerves arising from the ganglion. It divides into two branches, both of which innervate the mandibular muscles.

Each maxillary nerve (Mxn) arises from the anterolateral aspect of the ganglion, anteriorly to the origin of the mandibular nerve. It also runs anterolaterally, parallel to the mandibular nerve and innervates the maxillary muscles.

Each cervical nerve (Cn) arises from the posterolateral aspect of the ganglion, runs posterolaterally and innervates the muscles of the neck region.

Thoracic ganglia and their nerves

The prothoracic ganglion (Ptg) gives rise to 3 paired lateral nerves including a medially arising transverse nerve.

(i) The dorsal nerve (1Dn): It arises from the anterolateral margin of the ganglion and extends below the dorsal longitudinal muscles and the dorsal muscles running below the tergum. After running for a long distance, it gives its first branch (1DnI) which runs anteriorly and gives a sub-branch (1DnIa). It runs anteriorly and innervates the base of the head and the oblique muscles of the head. The main branch (1DnI) runs laterally for a long distance and innervates the anteroventral region of the segment. The second branch arises after a little distance to the origin of 1DnI and runs laterally and innervates the dorsal longitudinal muscles, giving a few fine fibres to the transverse muscles. The fine 1Dn nerve ultimately innervates the neck region.

(ii) The ventral nerve (1Vn): It arises from the posterolateral and ventral margin of the ganglion and runs below the dorsal longitudinal muscles. Its first branch (1VnI) bifurcates soon after its origin and both the branches run posterolaterally and deep ventrally. The outer branch (1VnIa) enters in the prothoracic leg to innervate the intrinsic muscles and the inner branch (1VnIb) ends in the extrinsic leg muscles. The 1Vn nerve runs lateroventrally and posteriorly for a long distance and gives off a small branch (1VnII) which innervates the ventral integument. The 1Vn nerve extends further and innervates the posteroventral region of the segment.

(iii) The transverse nerve (1Tn): It arises from the anterodorsal and median part of the ganglion and runs anterolaterally for a short distance above the dorsal nerve. It divides into two main branches. The anterior branch (1TnII) runs laterally and ends in the lateral body wall, and the muscles of the dorsolateral region. The posterior branch (1TnI) extends posteroventrally, and innervates the ventral muscles.

The mesothoracic ganglion (Msg) gives off a set of nerves similar to that of the prothoracic segment and the nerves resemble the respective prothoracic nerves, except for a few minor differences which are as follows:

(*a*) The dorsal nerve (2Dn) gives off a small branch (2DnI) just after its origin from the ganglion and runs ventromedially to innervate the ventral muscles. It is absent in 1Dn nerve.

(*b*) The ventral nerve (2Vn) does not have a branch comparable to the 1VnII branch.

(*c*) The transverse nerve runs anterolaterally to the dorsal nerve and does not give any branch.

The thoracoabdominal ganglionic mass (Tag) is situated in the metathoracic segment and is made by the fusion of metathoracic and first abdominal ganglia (representing the first and second abdominal ganglia of embryo), however, their identity is clearly established in stained preparations and sections of the mass. It gives off the following paired nerves:

(i) The first thoracoabdominal nerve (3Dn) arises from the anterolateral margin of the ganglion and runs laterally over the dorsal longitudinal muscles. It is a thick nerve and its first branch (3DnI) arises away from its origin, bends anteriorly and innervates the dorsal muscles. The 3Dn nerve runs laterally, bifurcates and the resulting branches innervate the muscles of the metathoracic wing.

(ii) The second thoracoabdominal nerve (1Abn) arises from the ganglion slightly posterior to the 3Dn and extends lateroanteriorly. It bifurcates into an anterior dorsal and a posterior branch. The former (1AbnI) runs posterolaterally above the dorsal longitudinal muscles and after running for a long distance innervates the external dorsal oblique muscles of the first abdominal segment. The posterior branch (1AbnII) runs posterolaterally below the dorsal muscles and bifurcates into two small branches in the second abdominal segment. The resulting branches (1AbnIIa and 1AbnIIb) innervate the external dorsal oblique muscles from dorsal and ventral sides respectively.

(iii) The third thoracoabdominal nerve (2Abn) is a short but stout nerve arising from the midventral and lateral margin of the mass. After running for a short distance it bifurcates into two branches, both running posteroventrally and laterally to innervate the intrinsic and extrinsic muscles of the metathoracic leg.

(iv) The fourth thoracoabdominal nerve (3Abn) arises from the posterolateral margin of the ganglion and runs posterolaterally, reaching the intersegmental area where it bends dorsolaterally and gives off two fine branches to the intersegmental region. The main nerve (3Abn) crosses the 1AbnII branch and external dorsal oblique muscles and gives off a few fine nerves to the integument.

(v) The fifth thoracoabdominal nerve (4Abn) arises from the posterior portion of the mass, descends posterolaterally and crosses the intersegmental area. Its first branch is a small one which arises after a very long distance and innervates the ovariole in the female. The 4Abn moves laterally and gives off the second branch which runs laterally and bifurcates into an anterodorsal (4AbnIIb) and a posteroventral branch (4AbnIIa). The former runs above the dorsal longitudinal muscles and the latter runs below these muscles and both innervate these muscles. The main nerve remains very fine and ends in the ventral integument.

Abdominal ganglia and their nerves

The abdomen has a free and a fused terminal ganglia. The first abdominal ganglion (1Abg) is an elongated ganglion connected with the thoracoabdominal ganglionic mass by distinct, paired, very short and stout connectives. It gives rise to one pair of lateral nerves (5Abn) which runs posterolaterally for a very long distance. Its first branch (5AbnI) is a very small nerve running

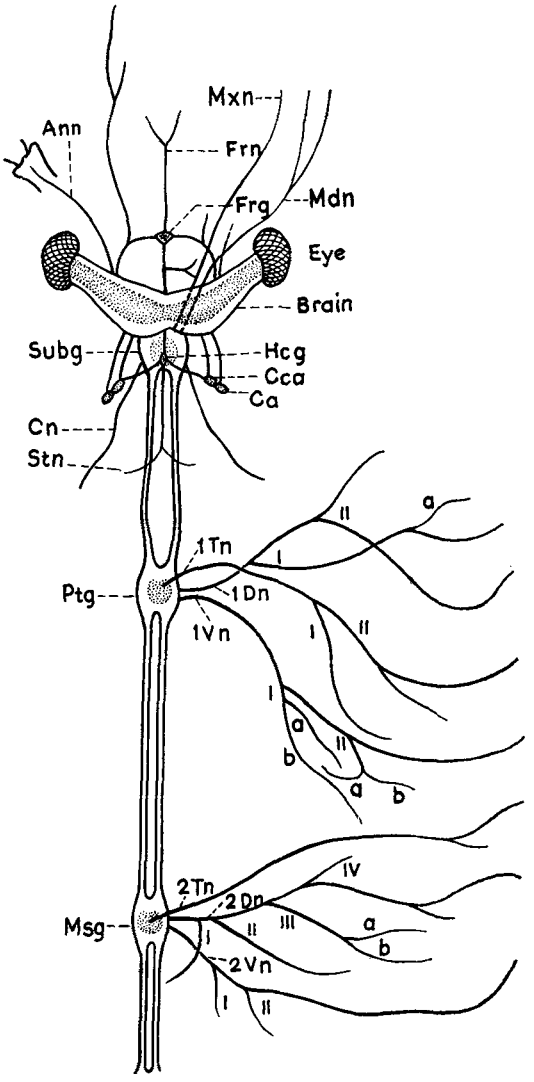

FIG. 1. Cephalic, prothoracic and mesothoracic nerves of *Chilocorus nigritus*.

posteromedially and ventrally and innervates the ventral integument. The second branch (5AbnII) arises shortly, runs posteromedially and innervates the dorsal longitudinal muscles. The 5Abn nerve bends laterally and bifurcates into two branches—one of these (5AbnIII) bends anterolaterally and dorsally, runs for a long distance and innervates the anterolateral and dorsal regions of the segment; the other branch (5AbnIV) runs posterolaterally and ventrally, gives some fine branches to the ventral margin of the dorsal longitudinal muscles and ends in the ventral integument.

Terminal ganglion (Tg) and the nerves

The terminal ganglion is made by the fusion of the fourth to ninth abdominal ganglia of larva (Singh, 1967). It is an elongated, flattened ganglionic mass

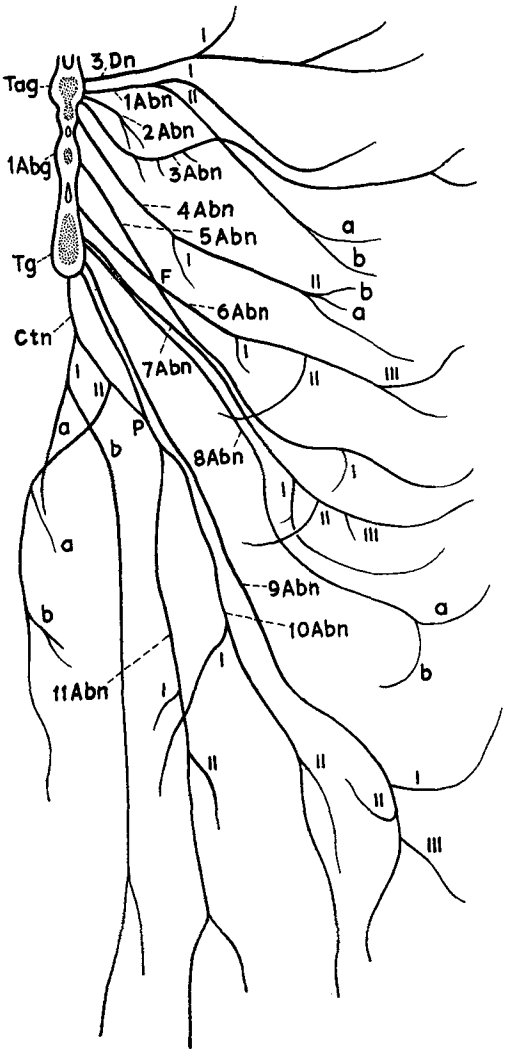

FIG. 2. Metathoracic and abdominal nerves of *chilocorus nigritus*.

situated in the second abdominal segment and connected with the first abdominal ganglion by distinctly paired very stout connectives. The nerve pattern of this ganglion shows certain differences in male and female beetles, hence it will be described separately in both the sexes. Fig. 2 is common for both the sexes except the Ctn nerve which is not paired in the female and lacks its CtnI and CtnII branches.

In the female the ganglion gives rise to 5 paired and a median nerves. These nerves will be described here from the anterior.

(i) The first terminal nerve (6Abn) arises from the anterolateral margin of the ganglion and proceeds more or less parallel to the 5Abn with which it fuses (Point F in fig. 2) and again separates off. It is a long nerve, reaching the fourth abdominal segment where it gives a fine branch (6AbnI) and a long branch (6AbnII) which run posteroventrally and posteromedially respectively and

innervate the ventral regions of the segment. The main nerve 6Abn proceeds laterally and finally gives fine branches to the anterodorsal and lateral regions of the segment.

(ii) The second terminal nerve (7Abn) arises from the midlateral margin of the ganglion and passes posterolaterally for a long distance in the anterior part of the third abdominal segment; it runs parallel to 6Abn and reaches in the middle region of the fourth abdominal segment where its first branch (7AbnI) arises. The 7AbnI runs posterolaterally and gives a sub-branch which is a small nerve innervating the ovariole. The 7AbnI now bends ventrolaterally and gives many fine branches to fat bodies and tracheae and finally ends in the ventral wall. The 7Abn nerve gives its second branch (7AbnII), at a short distance after the origin of the I, which runs posteromedially, crosses the 7AbnI dorsally and spreads over the laterodorsal part of the ovary.

(iii) The third terminal nerve (8Abn) arises behind but close to the origin of the 7Abn and runs with it, giving the impression of a single thick nerve, although the two remain separate throughout. Its first branch (8Abna) arises in the fifth abdominal segment and runs laterally to innervate the anterodorsal and lateral regions of the segment. The main 8Abn nerve runs posteriorly below the reproductive organs and gives a few slender branches to tracheae, fat bodies, body wall and ovary.

(iv) The fourth terminal nerve (9Abn) arises from the posterolateral margin of the ganglion and runs posteriorly till it reaches the anterior margin of the sixth abdominal segment. The first branch (9AbnI) of it innervates the body wall and a few transverse muscles. The 9Abn proceeds posteriorly for a short distance and gives off its second branch (9AbnII) which runs anteroventrally to the ovary, which it innervates. The third branch (9AbnIII) arises after a short distance to the origin of 9AbnII and runs posterolaterally and dorsally to innervate the rectum from its ventral side. The 9Abn nerve remains fine and innervates the ventral region of the seventh abdominal segment.

(v) The fifth terminal nerve (10Abn) is the thickest terminal nerve running parallel to the 9Abn nerve up to the fifth segment where it fuses with the median terminal nerve (Ctn) at the point P. This fused nerve runs for a very short distance and again separates off. It is not possible to say whether these two branches contain fibres of both the nerves or only one. For convenience the lateral branch of this would be referred to as the outer nerve (10Abn) and the median nerve as the inner nerve (11Abn). The 10Abn gives off its first branch (10AbnI) which runs posterodorsally over the rectum, which it innervates. 10Abn passes back over the reproductive organs and gives off the second branch which innervates the posterior portion of reproductive organ and the main nerve reaches the posterior part of the sixth segment.

The 11Abn nerve gives off its first branch over the middle region of the reproductive organ and the second a short distance after. The latter innervates the muscles governing genitalia and the main nerve innervates the base of external genitalia.

The median terminal nerve (Ctn) originates from the mid-posterior portion of the ganglion, runs straight posteriorly and fuses with the 10Abn; its further path is described above (11Abn). In the male, Ctn differs from that of the female in two ways—(i) it is paired, (ii) it has two branches before the point

of fusion with 10Abn. The course of these two branches is as follows: The Ctn nerve runs posteriorly and gives off its first branch CtnI which runs posteromedially and obliquely over the anterior region of the rectum. Its own sub-branch (CtnIa) extends posteriorly over the rectum. The second sub-branch (CtnIb) runs over rectum till it reaches the penultimate abdominal segment where it bifurcates and the resulting branches innervate posteriormost part of reproductive organ and the base of the genitalia. The CtnII nerve gives off two sub-branches both of which, along with the main branch, innervate the reproductive organs and integument. The Ctn nerve after giving its second branch runs posteriorly, outer to the reproductive organs and fuses with 10Abn nerve; its further path is described above.

Discussion

In *Tenebrio* (Bretschneider, 1914) the head nerves are simple and have separate origin from the brain, but in *Calandra* larva (Murray & Tiegs, 1935) the nerves emerge as a single trunk from the tip of the brain. *Chilocorus* resembles *Tenebrio* in this respect. Among the suboesophageal nerves, the mandibular nerves are the thickest. This is obviously related to the mandibles and their muscles being highly developed.

Murray & Tiegs (1935) found only one pair of lateral nerves in *Calandra* in each thoracic segment but in *Chilocorus* 3 pairs of nerves arise from each thoracic ganglion excluding the metathorax which bears the fused ganglionic mass. The transverse nerve does not have a connection either with the dorsal or with the ventral nerve of any thoracic segment.

Unlike *Passalus* (Cody & Gray, 1938), *Calandra* (Murray & Tiegs, 1935) and *Callosobruchus* (Pajni, 1959) in *Chilocorus* the mesothoracic ganglion does not take part in the formation of thoracoabdominal ganglionic mass. A marked difference is seen in *Chilocorus* from *Passalus* regarding the number of abdominal ganglia in adult. In the former, two abdominal ganglia (one simple and a fused terminal) are present besides the thoracoabdominal mass which is present in the metathoracic region. In the latter, only one fused ganglionic mass is present in the thoracic region, made by the fusion of mesothoracic to terminal abdominal ganglia of the larva. On the other hand *Oryctes* (Michels, 1880 in Cody & Gray, 1938) resembles *Chilocorus*.

Number of ganglia vary in different species from a simple long chain with three thoracic and six to eight abdominal ganglia, to a completely fused single mass situated anteriorly. Brandt (1878 in Cody & Gray, 1938) reported such variation in the male and female of the beetle *Dictyopterus sanguineus* where the male has eight and the female only seven abdominal ganglia. Beier (1927) classified the coleopteran larvae into six broad types according to the number of ganglia present but the scheme does not fit with the adults.

Summary

The brain and suboesophageal ganglion are placed very close to each other and give off two and three pairs of nerves respectively. The thorax has prothoracic, mesothoracic and a thoracoabdominal ganglionic mass. Each of the former two ganglia gives three pairs of nerves and the last gives five pairs of nerves. The ganglionic mass is the result of the fusion of metathoracic and first abdominal ganglia of the larva. The abdomen has a free

and a fused terminal ganglia situated in the first and second abdominal segments respectively. The former gives one pair of lateral nerves, whereas the latter gives five paired and a median unpaired nerves in the female and six paired nerves in the male. The terminal ganglion is made by the fusion of the fourth to the ninth abdominal ganglia of the larva. The pathways and destination of different nerves is studied in detail.

Key to figures

Ann	Antennary nerve
Ca	Corpus allatum
Cca	Corpus cardiacum
Cn	Cervical nerve
Frg	Frontal ganglion
Frn	Frontal nerve
Hcg	Hypocerebral ganglion
Mdn	Mandibular nerve
Msg	Mesothoracic ganglion
Mxn	Maxillary nerve
Ptg	Prothoracic ganglion
Stn	Stomatogastric nerve
Subg	Suboesophageal ganglion
Tag	Thoracoabdominal ganglionic mass
Tg	Terminal ganglion.

Acknowledgments

I would like to express my indebtedness to Professor U. S. Srivastava for his valuable guidance. The U.G.C. provided a Junior Research Fellowship during the tenure of which the work was done.

References

BEIER, M. 1927. Vergleichende Untersuchungen über das Centralnervensystem der Coleopteranlarven. *Z. Wiss. Zool.* **130** : 174–250.

BRANDT, E. 1878. Uber das Nervensystem der Laufkäfer (Carabidae). *Hor. Soc. Ent. Ross.* Bd. **14.**

BRETSCHNEIDER, F. 1914. Uber die Gehirne des Goldkäfers und des Lederlaufkäfers. *Zool. Anz.* **43** : 490–497.

BULLOCK, T. H. & HORRIDGE, G. A. 1965. *Structure and function in the nervous systems of Invertebrates Vol. I & II.* San Francisco: W. H. Freeman.

CODY, F. P. & GRAY, I. E. 1938. The changes in the nervous system during the life history of the beetle *Passalus cornutus*. *J. Morph.* **62** : 503–522.

DÖNGES, J. 1954. Der Kopf von *Ciorus acrophulariae* L. (Curculionidae). *Zool. Jb.* (*Anat.*) **74** : 1–76.

GEIPEL, E. 1915. Beitrage zur Anatomie der Leuchtorgane tropischer Käfer. *Z. Wiss Zool.* **122** : 239–290.

HOLSTE, G. 1910. Das Nervensystem von *Dytiscus marginalis*. Ein Beitrag zur Morphologie des InsectenKörpers. *Z. Wiss. Zool.* **96** : 419–276.

—— 1923. Das Gehirn von *Dytiscus marginalis* L. *Z. Wiss. Zool.* **120** : 251–280.

MAO, Y. T. 1935. Morphology and anatomy of the Scarabaeid beetle (*Xylotrupes dichotomus*) *Peking Nat. Hist. Bull.*, **9** : 299–323.

MICHELS, N. 1880. Beschreibung des Nervensystems von *Oryctes nasicornis* in Larven, Puppen und Käferzustande. *Zeitschr. f. wiss. Zool. Bd.* **34** : 641–702.

MURRAY, F. V. & TIEGS, O. W. 1935. The metamorphosis of *Calandra oryzae*. *Quart. Jour. Micr. Sci.* **77** : 405–495.

PAJNI, H. R. 1959. Anatomy of *Callosobruchus analis* Fabr. (Bruchidae: coleoptera) I. Metamorphic changes in the central nervous system. *Res. Bull.* (*N.S.*) *Punjab Univ.* **10** (I) : 21–24.

SINGH, Y. N. 1967. *Studies on the nervous system of certain endopterygote insects and post-embryonic changes in it.* Ph.D. thesis, Bihar University, Muzaffarpur, India.

—— 1973. The stomatogastric nervous system of the larvae and adults of three endopterygote insects. *J. Nat. Hist.* **7** (1) : 77–84.