Short Communication

Stomatogastric nervous system in the larva of *Oryctes rhinoceros* (Coleoptera: Scarabaeidae)

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Abstract

The larvae of *Oryctes rhinoceros* possess a well-developed stomatogastric nervous system. It consists of a median frontal ganglion placed in front of the brain on the dorsal side of the oesophagus and is connected to the brain by a pair of frontal connectives. It also gives out a single recurrent nerve to the hypocerebral ganglion. The hypocerebral ganglion, in turn, is connected to the ingluvial ganglion located at the posterior part of the oesophagus. The stomatogastric nervous system innervates the mouth parts, oesophagus and the anterior part of the pharyngeal musculature and plays an important role in the regulation of feeding.

Keywords: *Oryctes rhinoceros,* stomatogastric nervous system, frontal ganglion, ingluvial ganglion, hypocerebral ganglion.

Introduction

The sensory system in insects has been evolved to numerous specialisations to permit them to detect the features of external environment and to monitor constantly the internal state of an organism. Food selection and gustation are of primary importance to sustain growth and development in voracious immature stages of insects.[1] In most insects, among the external organs associated with feeding, the maxilla is the primary organ of sensory system with virtual tasting capability. This property of maxilla is due to the presence of variously modified integumentary sensory processes with rich nerve supply known as sensilla. In *Oryctes rhinoceros* two types of sensilla are predominantly present in the maxilla viz, trichoid and basiconic sensilla.[2] The trichoid sensilla are further recognised into pointed and blunt types. The basiconic sensilla are associated with gustatory reception. Among the trichoid sensilla, the blunt types may be chemosensory while the pointed ones may have a chemo-mechanosensory function. All the chemoreceptors appear to respond to phagostimulants, and deterrents and the system appears to be both complex and plastic. [3,4] Several studies have reported changes in the number of chemosensory sensilla on mouth parts and antennae of grasshoppers with variation in the complexity of chemosensory environment. In insects the mouth parts including sensory structures, foregut and the anterior part of the midgut are associated with a network of neurons and ganglia and this part of the nervous system is referred to as stomatogastric nervous system (SGNS). It controls feeding as well as the movement of food through the foregut and midgut. SGNS is also a centre of neuroendocrine activity due to the presence of neurosecretory cells in one of its components, the frontal ganglion. The present report describes the stomatogastric nerve system in the larvae of *Oryctes rhinoceros*.

Materials and Methods

Actively feeding larvae were ether anaesthetized and pinned dorsal side up on a wax layered petri dish flooded with insect saline. The cuticle and head capsule of the larvae were cut open at mid dorsal line to expose the stomatogastric nervous system (SGNS). The fat body and muscles adhering to the SGNS were removed carefully using a pair of forceps and the parts of SGNS were observed under stereoscopic dissection microscope.

Observations

Stomatogastric nervous system in the final instar larvae of *Oryctes rhinoceros* is well developed and found associated with brain lying on the dorsal side of oesophagus (Figure 1). The stomatogastric nervous system innervates the anterior parts of the alimentary canal. The integral part of the system is the median frontal ganglion. The frontal ganglion is visible as an intact pear-shaped structure with apex pointing posteriorly, just in front of the brain lying above the oesophagus. The frontal ganglion gives out a single frontal nerve, which passes to clypeus and also innervates the mouthparts. The frontal ganglion is connected to the tritocerebrum by a pair of frontal connectives which arises from the antero-lateral portions of the frontal ganglion and runs through the sides of oesophagus to join the brain. On its way, it receives labral nerves. The labral nerves pass into the pharyngeal musculature and to the labrum. The frontal ganglion gives out a single median recurrent nerve which passes backward along the mid dorsal line of the oesophagus and just behind the brain it passes through the hypocerebral ganglion to get connected to the single median ingluvial ganglion. The recurrent nerve also innervates pharynx. The hypocerebral ganglion is connected to brain via two connectives. The ingluvial ganglion innervates the posterior as well as the anterior midgut.

Discussion

The present study reveals that the final instar larva of *Oryctes rhinoceros* has a well-developed stomatogastric nervous system. It includes a median frontal ganglion on the dorsal surface of the oesophagus and in close proximity with the brain.[5] This is in accordance with the earlier observations of Orlov (1924) in *Oryctes nasicornis* and for other insect orders.[6] It is observed in the present study that in the larvae of *Oryctes rhinoceros,* the frontal ganglion is seen as a pear-shaped intact structure with apex pointing posterior. From the antero-lateral sides of frontal ganglion, a pair of frontal connectives arises and they run through sides of oesophagus to the brain. Ayali (2004) has described that in *Schistocera gregaria* and *Manduca sexta*, frontal connectives emerging from the frontal ganglion remain connected to the tritocerebrum of the brain.[7] The frontal connectives of *Oryctes*

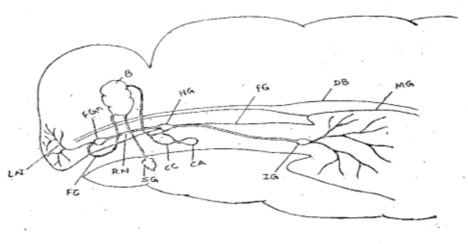

Figure 1 *Stomatogastric nervous system in larvae of Oryctes rhinoceros*

B	:	Brain
SG	:	Suboesophageal Ganglion
CA	:	Corpus allatum
CC	:	Corpus Cardiacum
DB	:	Dorsal Blood Vessel
FC	:	Frontal
FGN	:	Frontal ganglion
FG	:	Frontal Ganglion
HG	:	Hypocerebral Ganglion
IG	:	Ingluvial Ganglion
MG	:	Midgut
RN	:	Recurrent Nerve
LN	:	Labral Nerves

larvae are found to have innervations in the pharyngeal musculature. The frontal ganglion gives out a frontal nerve which innervates the clypeus and mandibles. In *Manduca sexta*, an anteriorly directed frontal nerve innervates buccal musculature.[7] The frontal ganglion posteriorly gives out a recurrent nerve which passes underneath the brain and enters into hypocerebral ganglion. The recurrent nerve on its way receives innervations from the anterior part of the oesophagus as in *Calliphora* and *Drosophila* [8] and larval *Manduca sexta*.[9] The recurrent nerve ends in the single ingluvial or stomachic ganglion. It innervates the posterior part of the foregut and anterior part of the midgut. These findings are in accordance with the earlier reports by Orlov (1924) in *Oryctes nasicornis* and *Oryctes rhinoceros* and others.[10] Variable degree of modification from this basic Pterygota plan may be seen in other insect groups described so far by these authors.

Thomsen (1951) has described varying degree of fusion in between hypocerebral ganglion, corpora cardiaca and corpora allata to form Weisman’s ring in Cyclorrampha (Diptera) [11]. In Ephemeroptera, Odonata, Blattoidea, Megaloptera and Isoptera, the frontal ganglion is connected with brain at pars intercerebralis or medialis region by a median connective. In Dictyoptera the hypocerebral ganglion gives out a median recurrent nerve which runs back to the crop and terminates in a single ventricular ganglion, whereas hypocerebral ganglion of Orthoptera sends out paired lateral nerves which end in ingluvial ganglion. [7,12] Apterygota represents an under developed stomato-gastric nervous system .[13]

It is reported that the frontal ganglion innervates foregut muscles and is necessary for producing motor patterns of foregut in *Manduca sexta* and adult locust.[7,9,12] Miles and booker (1994) have found that in the adult *Manduca sexta*, the frontal ganglion is essential for the action of the cibarial pump during feeding.[9] Cessation of feeding is observed in frontal ganglionectomised larvae of *Oryctes rhinoceros*[5], probably by exerting effects on movement of mandibles and foregut peristalsis. From these studies it can be deduced that, in insects, frontal ganglion is instrumental in passing food through foregut and crop emptying.[7] The regulatory action of gut muscles can be attributed to the sensory component of the stomatogastric nervous system. Sensory information mediated via the gut wall has shown to be instrumental in controlling feeding.[14] The volumetric feedback from the gut influences regulation of meal size in crickets and locusts.[15,16] Clark and Langley (1963) have reported that in *Locusta migratoria* the frontal ganglion forms a link in the conduction of nervous impulses originating from the stretch receptors of pharynx passing via posterior pharyngeal nerve and frontal connectives to the brain.[17] The present observations also agree well with these earlier reports.

Conclusion

The frontal ganglion of *Oryctes rhinoceros* has a critical role in feeding and moulting as reported in other insect orders.[7] Most of the previous studies and the present study on *Oryctes rhinoceros* indicate that the frontal ganglion plays an important role in growth, feeding and metamorphosis. Information on feeding and metamorphosis can be of great value in designing alternative insect pest management strategies.[7]

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Conflict of interest

There are no conflicts of interest.

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