Acarologia is proudly non-profit, with no page charges and free open access

Please help us maintain this system by encouraging your institutes to subscribe to the print version of the journal and by sending us your high quality research on the Acari.

Subscriptions: Year 2021 (Volume 61): 450 €
http://www1.montpellier.inra.fr/CBGP/acarologia/subscribe.php
Previous volumes (2010-2020): 250 € / year (4 issues)
Acarologia, CBGP, CS 30016, 34988 MONTFERRIER-sur-LEZ Cedex, France
ISSN 0044-586X (print), ISSN 2107-7207 (electronic)

The digitalization of Acarologia papers prior to 2000 was supported by Agropolis Fondation under the reference ID 1500-024 through the « Investissements d’avenir » programme (Labex Agro: ANR-10-LABX-0001-01)

Acarologia is under free license and distributed under the terms of the Creative Commons-BY-NC-ND which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are credited.
FINE STRUCTURE OF THE SYNGANGLION OF *ORNITHODOROS (PAVLOVSKYELLA) ERRATICUS* (IXODOIDEA : ARGASIDAE)

BY Samir M. EL SHOURA *

ABSTRACT: The fused synganglionic mass in the unfed *Ornithodoros (Pavlovskyella) erraticus* female is enclosed within a sinus of the circulatory system and consists of a neural lamella surrounding an outer cortex and an inner neuropile containing the oesophageal canal. The neural lamella consists of alternating layers of finely granular material containing collagenous-like fibers and may function to provide support to underlying tissues, resist positive hydrostatic pressure and allow permeability to nutrients and ionic exchange. Immediately below the neural lamella is a perineural layer of glial cells. The remainder of the cortex comprises two types of neurosecretory cell bodies, globuli cells and glial cells, and one type of non-neurosecretory cell. The glial cells are structurally related to the transfer of trophic material. The neuropile consists of nerve fibers (axons and dendrite) surrounded by glial cells.

INTRODUCTION

*Ornithodoros (P.) erraticus* is distributed in North Africa, Kenya, Arabia and Iran, and parasitizes certain vertebrates including humans (HOOGSTRAAL & *al.*, 1954). This tick is the reservoir and vector of *Borrelia crocidurae* spirochetes (DAVIS & HOOGSTRAAL, 1954) which appear to be a source of epidemic relapsing fever in North Africa (HOOGSTRAAL & *al.*, 1981).

The morphology of the tick synganglion was described classically by ROBINSON & DAVIDSON (1913) and by DOUGLAS (1943). IOFFE (1963) and TSVILENEVA (1964) studied the cellular organization and fiber tract relationships within the neuropile of the argasid and ixodid synganglion.

Neurosecretory cells and their axonal pathways were demonstrated in the synganglion of several tick species (GABE, 1955 ; IOFFE, 1964 ; DHANDA, 1967 ; BINNINGTON & TATCHELL, 1973 ; OBENCHAIN & OLIVER, 1975). EICHENBERGER (1970) and OBENCHAIN (1974b) studied the structure of perineurial glial cells and the neuronal perikarya forming the synganglion cortex. At the ultrastructure level, COONS *et al.* (1974) and BALASHOV (1983) have provided descriptions of the synganglia of argasid and ixodid ticks. BINNINGTON & LANE (1980) characterised types and permeabilities of junctions between glial cells of *Boophilus microplus*. Studies on the structure of the tick nervous and neuroendocrine systems have been reviewed by BINNINGTON & OBENCHAIN (1982).

* Department of Epidemiology and Public Health, Yale Arbovirus Research Unit, School of Medicine, Yale University, New Haven, Connecticut 06510, USA. Present adress: Sciences and Mathematics Centre, MAKKAH, P.O. 2064, Kingdom of Saudi Arabia.

Acarologia, t. XXVII, fasc. 4, 1986.
FIG. 1: Light photomicrograph of *O. erraticus* synganglion. Arrowhead points to a peripheral nerve. × 800.

FIG. 2: Parts of neural lamella (NL) and cortex (C) showing repeated layers of finely granular material (arrows) and collagen-like fibers (CF). Note numerous free ribosomes (r) in the glial cell cytoplasm (GC). Arrowheads point to junctions between glial cell processes. × 28 000.

FIG. 3: Perineurium (Pn) showing glial cell processes (GC) enclosing single forms of micro-organism-like structures (large arrowheads) and trachea (Tr). Small arrowheads point to junctions as in Fig. 2. × 13 000.

FIG. 4: Perineurium (Pn) and neuropile (Np) showing glial cell processes (arrows) ensheathing axons (ax). Large arrowheads point to neurotubules. Small arrowheads point to axon neurosecretory granules. × 10 500.
Herein the fine structure of the synganglion of the unfed *O. erraticus* female is described and compared to that of other tick species, insects and mites as a basis for investigating structural changes in ticks infected by viruses and rickettsiae.

**MATERIALS AND METHODS**

*O. erraticus* females were from a colony maintained at 28°C and 75-80 % R.H. at the Yale Arbovirus Research Unit laboratory. Dissected synganglia of unfed ticks were fixed in a mixture of 2 % formaldehyde, 2.5 % glutaraldehyde, 1 % osmium tetroxide, 0.05 M phosphate buffer, pH 7.2, 0.15 M sodium chloride and 0.2 mM calcium chloride in 0.015 M phosphate buffer, pH 7.2, at room temperature. Postfixation was carried out on 1 % osmium tetroxide in 0.15 M phosphate buffer, pH 7.2, containing 0.15 M sodium chloride and 0.2 mM calcium chloride for 1 hr at room temperature. Following a brief wash in phosphate buffer, pH 7.2, and two 15-min changes of 30 % ethanol, synganglia were immersed in 1 % uranyl acetate in distilled water for 1 hr at room temperature. Synganglia were then dehydrated through an ascending series of ethanol to propylene oxide and embedded in epon 812. Semithin sections were stained with 1 % toluidine blue in 1 % borax. Ultrathin sections were stained with uranyl acetate and lead citrate and examined under a Philips EM 201.

**OBSERVATIONS**

The synganglion of *O. erraticus* consists of a mass of fused ganglia with peripheral neurons extending to various organs. This mass is pierced by the oesophagus and thus divided into supraoesophageal and suboesophageal portions which are fused laterally.

The nervous tissue is surrounded by an external connective tissue sheath, or neural lamella, which separates the ganglionic tissue from the haemolymph. The enclosed ganglionic mass consists of an outer cortex surrounding an inner neuropile (Fig. 1). The nervous mass is enclosed within a sinus of the circulatory system which gives rise to a dorsal aortic vessel and anterior and lateral vessels which enclose the major nerve trunks (BINNINGTON & TATCHELL, 1973).

Ultrastructurally, the acellular neural lamella (2-6 μm thick) consists of alternating layers of finely granular material. Spaces between these layers are occupied by randomly oriented collagen-like fibers (Fig. 2).

**THE CORTEX**

This outer zone comprises the perineurium and neuronal cell bodies. The perineurial cells lie below the neural lamella and form, narrow tortuous cytoplasmic processes enclosing intercellular spaces and tracheae (Figs. 2, 3, 4, 11). Below the perineurial glial cells, ensheathing neuronal cell bodies, form invaginations with the neuronal cell membranes (Fig. 11). Perineurial and other glial cells are connected by numerous intercellular junctions (Figs. 2, 3, 7, 10). The glial cell cytoplasm contains numerous free ribosomes and a few, scattered mitochondria (Fig. 2). Rickettsia-like micro-organisms appear as single forms in the narrow cell processes (Figs. 3, 4), and in groups occupying large cytoplasmic areas (Fig. 5).

Three types of neurons are distinguished in the cortical zone. As in COONS & *et al.* (1974), BINNINGTON & OBJENCHAIN (1982) and BALASHOV (1983), the neurons may be classified according to the cell size, relation of nuclear size and position to the surrounding cytoplasm, and neurosecretory activity. Type I and II are neurosecretory neurons, while type III are non-neurosecretory. Type I neurons, 5-8 μm in diameter, are grouped in 3-5-cell masses (Fig. 6), commonly distributed in all ganglionic centers, and are characterised by large nuclei and relatively little cytoplasm. These neurons are either "dark" polygonal cells with irregular nuclei (Figs. 6, 7), or "light" polygonal or oval cells with regular nuclei (Figs. 7, 8, 9). The perikarya contains free ribosomes, rough endoplasmic reticulum, Golgi bodies, mitochondria, lysosome-like bodies and electron-dense neu-
FIG. 5: Glial cell cytoplasm packed with micro-organism-like structures (MO). × 7000.

FIG. 6: Type I "dark" neurosecretory cells (1) grouped in 4-cell-mass. Note the glial cell processes (GC) between the "light" type I cell (1) and type II cell. × 10 500.

FIG. 7: Higher magnification of type I "dark" and "light" neurosecretory cells (1) showing that their cytoplasm contains Golgi bodies (G) and lysosome-like structures (LB). Arrowhead points to a junction between glial cell processes (GC) and type I "light" neuron (1). × 10 500.

FIG. 8: Two "light" cells of type I (1) (compare with Fig. 6), and type II cell (2) are ensheathed by glial cell processes (GC). × 10 500.
rosecretory granules, 40-75 µm in diameter (Figs. 6, 7, 8, 9). The latter are accumulated in one or two zones within the cytoplasm.

Type II are round to oval neurosecretory cells, 7-15 µm in diameter (Figs. 6, 8, 9, 10), and are distributed among the other neurons. They have a much greater cytoplasmic volume than type I neurons and their nuclei lie to one side of the cell. They contain organelles similar to those of type I neurons except that the electron-dense neurosecretory granules in type II are larger (50-200 µm in diameter) and may be clumped (Fig. 10) or scattered (Figs. 8, 9) in the cytoplasm.

Type III, non-neurosecretory neurons, 6-7 µm in diameter, are grouped in the first pedal ganglia, and characterised by large nuclei with electron-dense chromatin clumps (Fig. 11). The cytoplasm contains a few mitochondria, rough endoplasmic reticulum, and free ribosomes (Fig. 11). They are similar to the globuli cells described in B. microplus (BINNINGTON, 1981).

THE NEUROPILE

This inner zone is formed of nerve fibers surrounded by glial cells which may extend from the cortex or originate in the neuropile (Figs. 4, 11). Some of these fibers are neurosecretory cell axons containing neurosecretory granules, mitochondria and longitudinally oriented neurotubules (Figs. 4, 12), and may belong to types I or II neurons. Neurosecretory vesicles, 25-35 µm in diameter, occur in some axons (Fig. 12), which may be neuron terminals. There are other, non-neurosecretory nerve fibers which are probably axons of type III neurons.

DISCUSSION


The fine structure of the neural lamella containing collagenous-like fibers is similar to that described for other argasid and ixodid ticks (COONS & al., 1974), insects (ASHHURTS, 1968; TREHERNE & PICHON, 1972). It differs from that of mites which are devoid of collagen-like fibers in the neural lamella (COONS & AXTELL, 1971). In this respect the neural lamella of O. erraticus probably functions in the same way as those of other tick species and of insects. It provides support to underlying tissues, resists positive hydrostatic pressure, and probably provides relative permeability to nutrients and ions as has been suggested for other ticks (COONS & al., 1974), and insects (TREHERNE, 1974).

The spaces between the cortical cell processes within the O. erraticus synganglion are a common feature of argasids and ixodids (EICHENBERGER, 1970; COONS & al., 1974; BINNINGTON & LANE, 1980; BALASHOV, 1983). In ixodids, however, extracellular spaces contain flocculent material that could serve as a reservoir for cations and which might have a role in the regulation of ion concentration (BINNINGTON & LANE, 1980). Furthermore, glial cell invaginations into the neural cell bodies are a feature which is probably related to the transfer of trophic material as suggested for insects (SMITH, 1968) and ticks (COONS & al., 1974). The presence of extracellular spaces in ixodids, while not found in argasids, could be due to the remarkable difference in the feeding habits between the two families. In unfed ixodids (COONS & al., 1974; BINNINGTON & LANE, 1980)
FIG. 9: Types I and II neurons showing clumped (1) and scattered (2) neurosecretory granules (NG). Note the glial cell invagination into type II (arrowhead). × 13 500.

FIG. 10: Higher magnification of type II neuron (2) showing that the cytoplasm contains Golgi bodies (G), mitochondria (M) lysosome-like structures (LB) and clumped neurosecretory granules (NG). Arrowheads point to a junction between glial cell processes and type II neuron. × 28 000.

FIG. 11: Type III neurons (3) showing that most neuropile elements (Np) are surrounded by glial cell processes (GC). Note nuclei with electron-dense chromatin clumps. Arrowhead points to a glial cell invagination into a type III neuron. × 2 600.

FIG. 12: The neuropile (Np) showing axons (ax) containing neurosecretory vesicles (Nv) and electron-dense granules (arrowheads) in their "axoplasm". × 7 000.
and insects (WIGGLESWORTH, 1960), glial cell cytoplasm contains glycogen which markedly increases in ixodids during feeding and before oviposition. These authors suggested that the perineurium of ixodids and insects probably provides an energy store for the central nervous system. However, glycogen has not been detected in this study, thus it is difficult to confirm that perineurium of O. erraticus function as that of ixodids and insects and awaits further investigation on the feeding and fully engorged females.

Intracellular junctions of the type observed in the cortical zone of the O. erraticus synganglion have also been described for the ixodid B. microplus (BIDDEN TIM & LANE, 1980). These authors suggested that the junctions are involved in cell to cell adhesion and in the transfer of low molecular weight nutrients between the nerve tissue cells.

The presence of three type of neurons in the nervous tissues of O. erraticus conforms with observations on other tick species (IOFFE, 1963; TSVILENEVA, 1964; EICHENERGER, 1970; COONS et al., 1974; BINNINGTON & OBENCHAIN, 1982; BALASHOV, 1983). In addition the fine structure of O. erraticus neurons agrees with that described for other tick species (COONS et al., 1974; BINNINGTON, 1981), except for the type I cells described here. According to the basic classification of neurons, type I cells in the synganglion of O. erraticus are similar to the motor or ”association-motor neurons” of other tick species in size and relation of the nuclear size and position to cytoplasm, but different in their neurosecretory activity. Type I neurons found in this study are neurosecretory, while those in other tick species are not (COONS et al., 1974; BINNINGTON, 1981; BALASHOV, 1983).

The type II and III neurons are structurally identical to their neurosecretory counterparts, and ”olfactory globuli cells”, described in other argasid and ixodid ticks, respectively (COONS et al., 1974; BALASHOV, 1983). The neuropile arrangement and structure in O. erraticus conforms with that described in other ticks (COONS et al., 1974; BINNINGTON & LANE, 1980; BALASHOV, 1983), mites (COONS & AXTELL, 1971) and insects (SMITH, 1968).

Acknowledgements

My deep appreciation to Dr. Keith C. BINNINGTON, CSIRO, Division of Entomology, Canberra, Australia, and Dr. B. R. LAURENCE, Department of Entomology, London School of Hygiene and Tropical Medicine, for critically reading this manuscript. My gratitude is also due Professor Robert SHOPE, Yale Arboviruses Research Unit, USA, for the use of his EM laboratory facilities.

Literature Cited


ROBINSON (L. E.) & DAVIDSON (J.), 1913. — The anatomy of *Argas persicus* (Oken). — Parasitology, 6 : 382-430.


**LIST OF ABBREVIATIONS**

1, 2, 3 types of neurosecretory cells
ax axons
C cortex
CF collagen-like fibers
G Golgi bodies
GC glial cells
Is intercisternal spaces
LB lysosome-like bodies
M mitochondria
MO micro-organism-like structures
NG neurosecretory granules
NL neural lamella
Np neuropile
Nu nucleus
Nv neurosecretory vesicles
Pr perineurium
r free ribosomes
RER rough endoplasmic reticulum
Tr trachea
W wall of the blood sinus

Paru en Décembre 1986.