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STUDIES ON THE SECRETORY-EXCRETORY SYSTEM OF NEMATODES: A REVIEW

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ABSTRACT

A considerable variability occurs in the structure of the excretory system of nematodes. In animal-parasitic nematodes the morphology of the excretory organs is different among the larval and adult stages of the same species. Two types of excretory system were found in case of nematodes, namely glandular and tubular. These types have several modifications. Structure of the excretory glands, lateral canals and excretory sinus along with modification of different parts in various nematode species was studied by different workers. These workers have critically assessed the morphology, histology and histochemistry of different parts of excretory system and their probable role in excretion among different nematode species. The present paper reviews the research work carried on the excretory system of nematodes.

Keywords: Excretory organs, nematodes, histology, morphology, organ-system.

INTRODUCTION

Nematodes are fascinating multicellular organisms for the study of morphology, biology and host-parasite relationship. These are among the most ubiquitous organisms on earth. Nematodes are a diverse group of multicellular organisms inhabiting a broad range of environments. These have successfully adapted to nearly every ecosystem of the earth.

Morphologically, the Nematoda is an exceedingly variable group and there hardly exists any statement that could be made regarding their anatomy and morphology, which would apply to all forms. Different types of anatomical features are present in different species of parasitic nematodes which are the result of adaptation influenced by their particular type of habitat (Chitwood and Chitwood, 1950).

Various aspects pertaining to the secretory-excretory system of nematodes have been comprehensively reviewed by Chitwood and Chitwood (1950), Weinstein (1960), de Coninck (1965), Lee (1965), Crofton (1966), Waddel (1968), Bird (1971), Bird and Bird (1991), Singh and Johal (2001), Lee (2003), Altun and Hall (2009) and Basyoni and Rizk (2016). Prior to this, scattered bits of information on the excretory system were found in the literature of the nineteenth century.

RESULTS AND DISCUSSION

The fact that lateral vessels in nematodes are enclosed within the hypodermal cords was discovered by Bojanus (1817) in *Parascaris equorum*. Mehlis (1831) discovered a single gland in *Contracaecum spiculigerum* and paired gland like bodies in strongylids. In *Oswardo crizia*, Bagge (1841) recorded the existence of a ventral pore connected with paired lateral canals. None of these authors was able to associate these structures with the function of excretion. It was the painstaking efforts of Schneider (1858, 1860 and 1866) who critically assessed these bits of information and proposed the function of excretion of chemical wastes to this system of canals.

An H-shaped tubular excretory system was described by Buetschli (1873), Jaegerskioeld (1901), Magath (1919) and Toernquist (1931) in oxyuroids. It comprised a pair of lateral canals running in the respective hypodermal cords, communicating by means of transverse canals which in turn joined to form a median terminal duct opening to outside by a ventrally placed excretory pore.

The H-type of excretory system of parasitic nematodes is reported to be derived from the ventral gland or renette (Cobb, 1890 and 1925). On the other hand, Chitwood and Chitwood (1950) claimed that the H-type of excretory system is primitive and simple ventral gland of marine species is arrested in its development and is pedomorphic. Sprent (1962) observed the developmental anatomy of the excretory system of ascaridoids and concluded that both the tubular and glandular types of excretory system are basically derived from a single gland cell.

According to Chitwood and Chitwood (1950) and Bird (1971), two types of excretory systems were found in case of nematodes, namely glandular and tubular, the later type having several variations. Common to both of the types was the excretory pore, generally located in the anterior mid-ventral line close to the nerve ring, but its position varied in a few forms. Golovin (1902) suggested that during development the excretory pore was formed as an invagination of the hypodermis which got fused with the excretory sinus and subsequently with the lateral canals. Bird (1959) observed that the position of excretory pore was located near the basal region of the oesophagus in *Meloidogyne javanica*.Maggenti (1962) reported an exception in *Tylenchulus* where this opening was situated at the posterior end of the body.

In *Chromadora quadrilinea*, Chitwood and Chitwood (1950) recorded the simplest type of excretory system in the form of a ventral gland (renette) opening to the exterior by the way of a median duct. The duct was dilated to form an ampulla and was lined by the cuticle at its terminus. The looping of the excretory duct was observed in *Plectus* (Maggenti, 1961), whereas in *Phocanema* a long ribbon-like gland measuring 1 cm. in length was present (Davey and Kan, 1965). Waddel (1968) in *Stephanurus* observed some granulation in the glandular part of the excretory system. Later on in 1970, Narang examined the ultrastructure of excretory gland in a number of species and reported it as a unicellular structure about 450 µm long, containing golgi bodies, endoplasmic reticulum and secretory granules in its cytoplasm. Lee (2003) also found that the tubular excretory system consists of a single ventral gland cell or renette, located in the body cavity and connected directly to the excretory pore.

Another modification in the excretory system of *Hysterothylacium haze* was observed by Yoshinaga *et al* (1989) where the left filament contained a large excretory nucleus and the excretory duct was confined to the left side of the commissure.

In Rhabditids and Strongylids, a rhabditoid type of excretory system consisting of a terminal duct, paired subventral glands and an excretory sinus connected with paired lateral canals was described by Rzewuski (1887) in *Strongylus paradoxus*, Stadelman (1891) in *Strongylus convolutes*, Looss (1905) in *Ancylostoma duodenale*,Chitwood (1931) in *Oesophagostomum dentatum*, Waddel (1968) in *Stephanurus dentatus* and Johal (1993) in *Oesophagostomum columbianum.*

In *Oesophagostomum dentatum* and *Strongylus edentatus* the lateral excretory canals do not empty directly into the excretory sinus but by the way of the subventral glands (Chitwood and Chitwood, 1950). However, Waddel (1968) found that in these two genra the canals diverging from the sinuses and connected with the lateral excretory channels are although in intimate contact with the subventral glands yet their continuity is not interrupted by the latter.In *Oesophagostomum columbianum*, Johal (1993) found that the lateral excretory canals are connected by transverse extensions which join ventrally to form a bridge like structure communicating with the excretory sinus mid-ventrally. A duct from each subventral gland communicates with the excretory sinus. In *Haemonchus contortus*, Singh and Johal (2001) observed that the communication of the lateral excretory canals with the excretory sinus is by the way of subventral glands. The latter are in close proximity with the lateral excretory canals at one end and the excretory sinus at the other end.

Ultrastructure of the different parts of excretory system was discussed by a number of workers such as Ishikawa (1987) who described the lateral canal cells of *Ascaris lumbricoides suum* and visualized mitochondria, golgi complex, agranular and granular endoplasmic reticulum, ribosomes, lysosome-like dense bodies, secretory granules and glycogen particles in the cell cytoplasm and luminal surface of the canal was covered with numerous microvilli like processes probably associated with water and electrolyte transport across the lateral canal. A canal lumen surrounded by the cytoplasm of the canal cell was observed.

Vegni-Talluri and Dallai (1989) described the ultrastructure of the excretory system of *Toxocara canis* infective larvae and found it to be composed of 2 elongate columns. The cytoplasm contained an abundant endoplasmic reticulum and an extensive golgi complex from which many vesicles of variable density were seen to originate. Strote and Bonow (1995) made ultrastructural observations of the developing excretory system of the infective larvae of *Onchocerca volvulus*. This system was found to be consisting of an anterior cuticle-lined excretory channel enclosed by the cytoplasm of excretory cells and an ampulla like structure. The inner surface of the ampulla revealed a small number of single microvillus and the cytoplasm in this area was rich in golgi bodies and endocytic vesicles.

A considerable variability seemed to occur in the structure of excretory system of nematodes and in many parasitic forms its function in the larval stages appeared to be different from that of the adult stage and its morphology appeared to be governed by the physiological state of the environment (Bird, 1971). He ascribed the function of secretion of various enzymes, hormones or protective mucoproteins to the glandular type of excretory system. On the other hand, in larval nematodes, the canal system pulsate rhythmically and in some species it has been shown to play an osmoregulatory role as in *Ancylostoma tubaeformae* (Croll *et al*, 1972). Wharton and Sommerville (1984) too, studied the ultrastructure and pulsation cycle of excretory ampulla of the infective larva of *Haemonchus contortus* and confirmed the above mentioned osmoregulatory function of the excretory system.

Bird (1971) regarded that the subventral glands vary in size in different nematode species and this difference is a reflection of their physiological state. In *Strongylus vulgaris* the subventral glands are largest in the young 4th stage larva during its active migratory stage when it moves from the lumen of the intestine into the mucus membrane of the crypts. The fact that the glandular type of excretory system is secretory in function whereas tubular type is associated with excretion was established by Bird (1971) and Johal (1993). The subventral glands of *Oesophagostomum columbianum* are large structures full of dark secretory globules extending from the ventricular portion of the intestine running along the oesophageal bulb and terminating near the nerve ring. Johal (1993) also found that the independent opening of the subventral glands into the excretory sinus suggest that they have another role rather than excretion which is performed by the lateral canals since some excretory vesicles and tubules are found in them. Singh and Johal (2001) found that the excretory system of *Haemonchus contortus* represents a transitional phase where the glandular type is gradually replaced by the tubular type of more advanced forms. In this trichostrongylid nematode the subventral glands are comparatively small structures having empty space in their substance and are full of numerous globules. The excretory glands are more closely associated with lateral excretory canals and probably convey the products of excretion from the lateral excretory ducts to the excretory sinus through them.

Sifting of the literature revealed that scanty information existed as far as the histochemistry of excretory organs in nematodes was concerned. Mostly, the association of enzymes, like leucine aminopeptidase, non-specific esterases, proteases and acetyl-cholinesterases, with the subventral glands was suggested by Rogers (1965) and Rothwell*et al* (1973). The presence of proteins, peptides and free amino acids in the excretory organs of various nematodes was reported by Rogers (1969), Rothstein (1970) and Wright (1975). Ishikawa (1987) observed the presence of glycogen particles in the cytoplasm of the lateral canal cell of *Ascaris lumbricoides suum* and Johal (1993) reported the presence of lipids in the subventral glands and proteins in the cuticular walls of lateral excretory ducts of *Oesophagostomum columbianum*

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