

## Topography of nervous system in two pouched paramphistomes

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**Abstract.** Using the indigogenic technique for localizing the non-specific esterases, the complete nerve arrangement in *Fischoederius elongatus* and *Gastrothylax crumenifer*, the paramphistome parasites in the rumen of cattle, has been visualized. In *F. elongatus*, of the three pairs of anterior nerves given off from the cerebral ganglia, two are ventral and one is dorsal in disposition. The nerves running posterior from the cerebral ganglia include two pairs of ventral nerves and one of dorsals. Throughout their course the two ventrals of either side are joined to each other by several loop-like connectives. In *G. crumenifer*, the overall nerve arrangement is somewhat similar to that in *F. elongatus*; the connectives joining the posterior ventrals of each side are not loop-like. The course of all the nerves and the innervation to the various parts of the body is traced in both the species.

**Keywords.** Nervous system; paramphistome; trematoda; digenea; *Fischoederius elongatus*; *Gastrothylax crumenifer*.

### 1. Introduction

In recent years, the association of non-specific esterases (NSE) with the nervous system has been successfully exploited by many workers for the demonstration of the fine nerve arrangements and other components of the nervous system in several trematode species (Mishra and Tandon 1984). Based on the localization of the esterases, the nervous organization has been described in some more digenetic flukes, namely, *Encyclometra colubrimurorum*, *Echinostoma revolutum*, *Schistosoma spindalis*, *Isoparorchis hypselobagri*, *Singhiatrema najai* and *Euparadistomum herpestesi* (Kishore and Shyamasundari 1980; Krishna 1981; Rao *et al* 1982; Simha and Fernandez 1982; Fernandez *et al* 1982; Kishore *et al* 1982).

Among the paramphistome flukes most of the available accounts on the nervous system are based on histological observations (Gupta and Dutta 1967; Lee 1971). However, the pattern of nerve distribution has been visualized in toto in *Fischoederius cobboldi*, a pouched paramphistome of bovines (Mishra and Tandon 1984). This study revealed significant deviations from the studies on the sectioned material.

The present communication also deals with the topography of the nervous system in entire in two more pouched paramphistome species, namely, *Fischoederius elongatus* (Poirier 1883) Stiles et Goldberger, 1910 and *Gastrothylax crumenifer* (Creplin 1847) Poirier 1883.

### 2. Material and methods

Live specimens of *F. elongatus* and *G. crumenifer* were collected in 0.9% saline from the rumen of cattle slaughtered at the local abattoirs. The procured material was fixed and processed for localization of NSE as described elsewhere (Mishra and Tandon 1984).

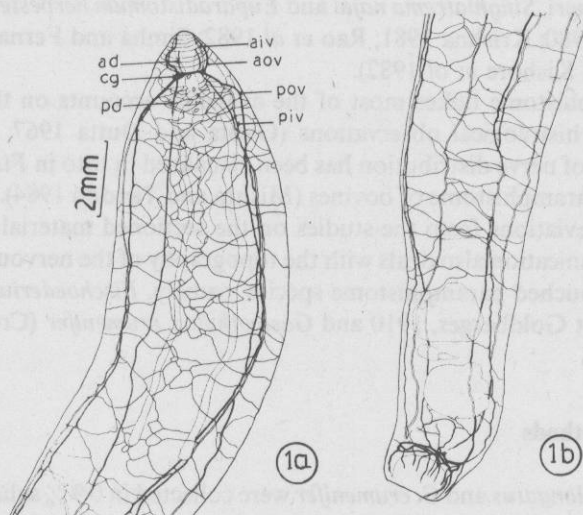
### 3. Observations

Conforming to the commonly observed pattern in many other trematode species, in *F. elongatus* also three pairs of nerves run cephalad and three pairs caudad from the brain mass which comprises two cerebral ganglia connected with a thick band-like cerebral commissure and lies immediately posterior to the pharynx and dorsal to the oesophagus (figures 1, 2).

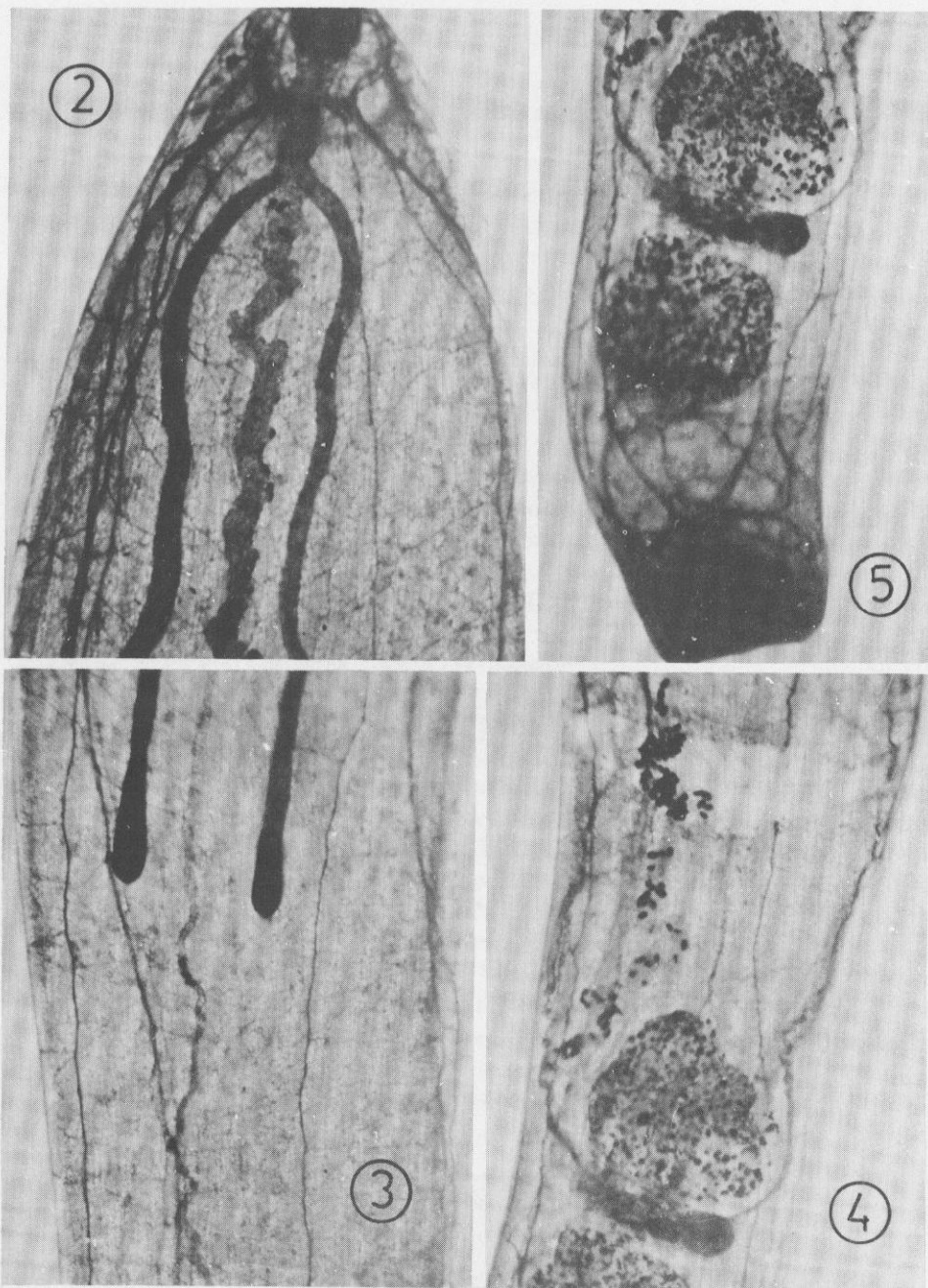
Of the anterior nerves, there is one pair of dorsal nerves and 2 pairs of ventral nerves. The dorsal nerves arise from the inner border of the cerebral ganglia and supply the oral tip and the dorsal surface of the pharynx and tegument. The lateral walls of the pharynx are supplied by the antero-inner ventral nerves that arise from the antero-median facet of the ganglia. The antero-outer ventral nerves, arising from the outer lateral side of the cerebral ganglia, innervate the whole ventral surface of the pharynx. Thin transverse connectives, completely encircling the pharynx, join all the anterior nerves with one another. Very fine branches from these are observed pentering out into the circumpharyngeal tegument.

The post cephalic longitudinal nerves comprise a pair of postero-dorsals and two pairs of postero-ventrals (figures 3, 4). The postero-dorsals originate from the inner facet of the cerebral ganglia and are superficially placed nerves. Fine branches of these nerves innervate the gut, reproductive system and excretory bladder. The postero-dorsals of the two sides are joined with each other by thin transverse connectives throughout their course; the connectives, in turn, are connected to one another by still thinner, 2-3 longitudinal connectives, thus forming a nerve net under the dorsal surface of the body.

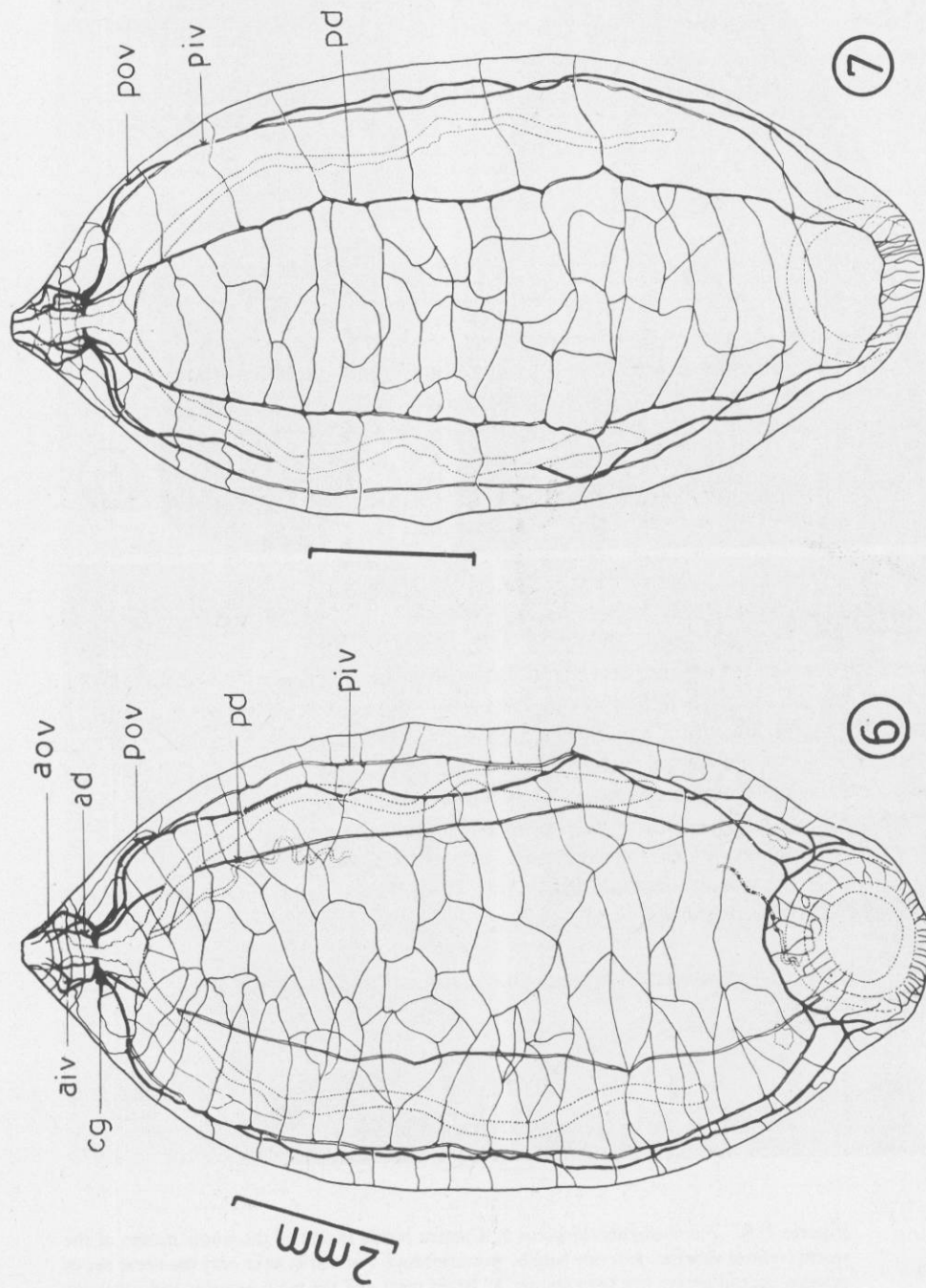
The postero-inner ventral nerves arise from the postero-ventral border of the cephalic ganglia and terminate in the region of the acetabulum. The postero-outer ventral nerves arise from the lateral aspects of the brain. Initially they run lateral to the inner ventrals for some distance but thereafter are seen changing their course and running inner to the latter at places. A thin, longitudinal lateral connective joins the



Figures 1a, b. For caption, see next page.



**Figures 1–5.** *Fischoederius elongatus* 1. Camera lucida sketch of the whole mount of the worm (ventral view); a. anterior half; b. posterior half. For clarity sake only the nerve net of postero-ventral nerves has been shown. 2. Brain mass and the main anterior and posterior nerves ( $\times 12.3$ ). 3. Posterior longitudinal nerves in the midbody region ( $\times 12.3$ ). 4. Posterior longitudinal nerves in the gonadal and pregonadal region ( $\times 12.3$ ). 5. Terminal course of the posterior nerves and innervation of the acetabulum.



Figures 6-7. For captions, see page no. 138.

antero- and the postero-outer ventral nerves of the same side. Along most of their length the two postero-ventrals (*i.e.*, outer and inner) of either side are joined with each other by many, rather conspicuous but thin, laterally placed loop-like connectives, which appear C- or tilted V-shaped. Fine branches from these loops constitute a nerve net on the midventral side and innervate the tegument and the wall of the ventral pouch. The tributaries of the postero-ventrals also innervate the reproductive system, vitellaria and the opening of the ventral pouch. The postero-dorsals are connected only to the postero-outer ventrals, and not to the inner ventrals, by means of lateral connectives. While the postero-inner ventrals are deep seated in the parenchyma, the postero-outer ventrals are superficially lodged.

All the posterior longitudinal nerves join with one another and form a conspicuous ring-like nerve just in front of the anterior border of the acetabulum. Gradually tapering branches given out from this nerve and further secondary fine branches of these innervate the sucker (figures 1b, 5).

Neuroanatomy of *Gastrothylax crumenifer*, also having three pairs each of anterior and posterior nerves, follows the same pattern as that of *F. elongatus* (figures 6–8). The origin, position and naming of the anterior and posterior nerves are the same as described for *F. elongatus*. All the anterior nerves of both the sides are joined with one another by means of thin connectives encircling the pharynx. However, a conspicuous circumpharyngeal nerve basket is not formed.

The postero-outer and inner ventral nerves send branches towards the median axis, which ramify and anastomose with one another, thus constituting a nerve net on the ventral surface (figure 9). Both these nerves also send branches towards the lateral body wall.

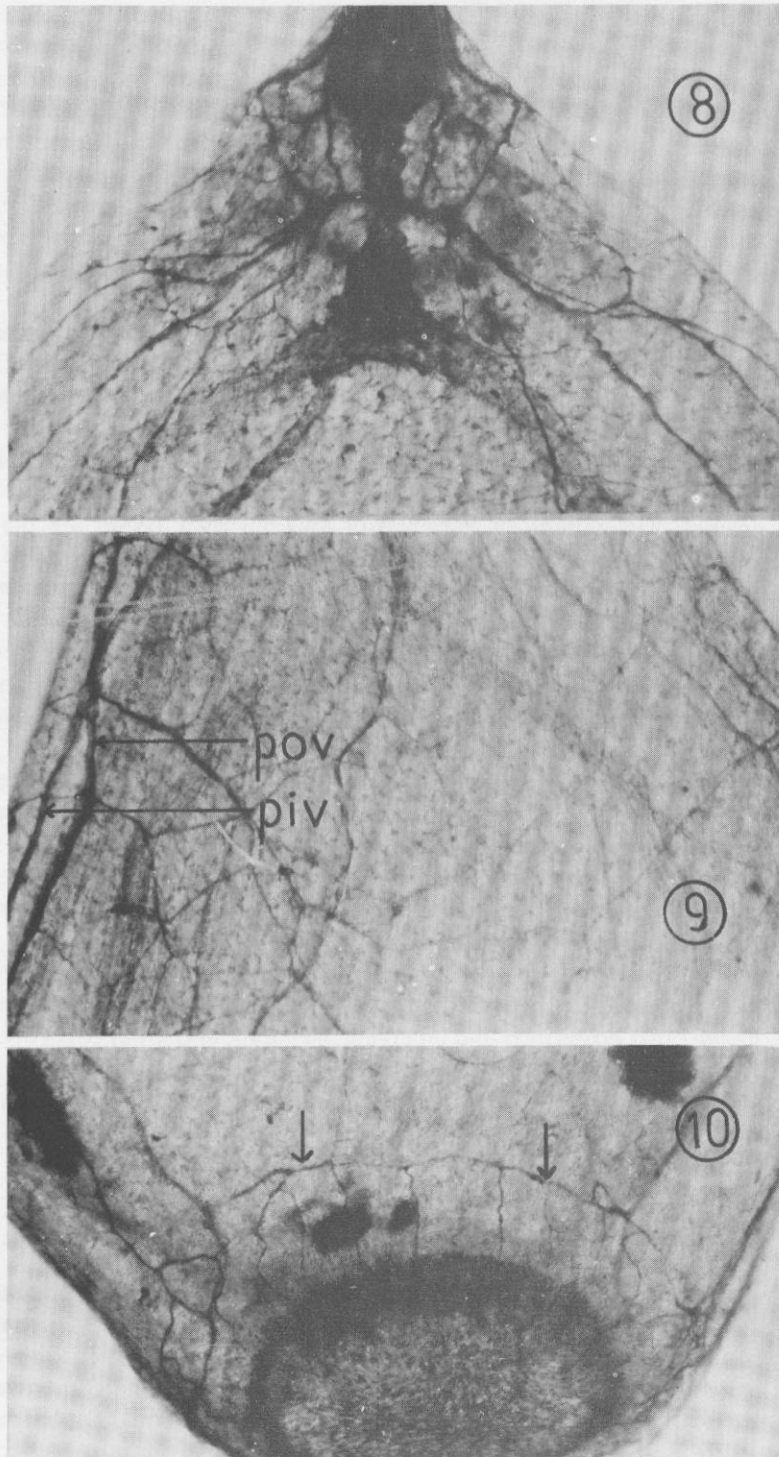
Each postero-outer ventral nerve bifurcates just a little anterior to the acetabulum: the inner branch meets its fellow of the other side, making a thin transverse connective (figure 10) many fine branches from which supply the rim of the sucker; the outer branch innervates the lateral walls and the floor of the latter. Likewise, the postero-inner ventral also bifurcates, its inner branch joining the transverse connective and the outer branch joining its counterpart from the postero-outer ventral.

A dorsal nerve net is also constituted by the transverse and longitudinal nerve connectives of the postero-dorsals (figure 11). Both the postero-dorsals of either side join with each other posteriorly and innervate the middle and lower edges of the sucker (figure 12).

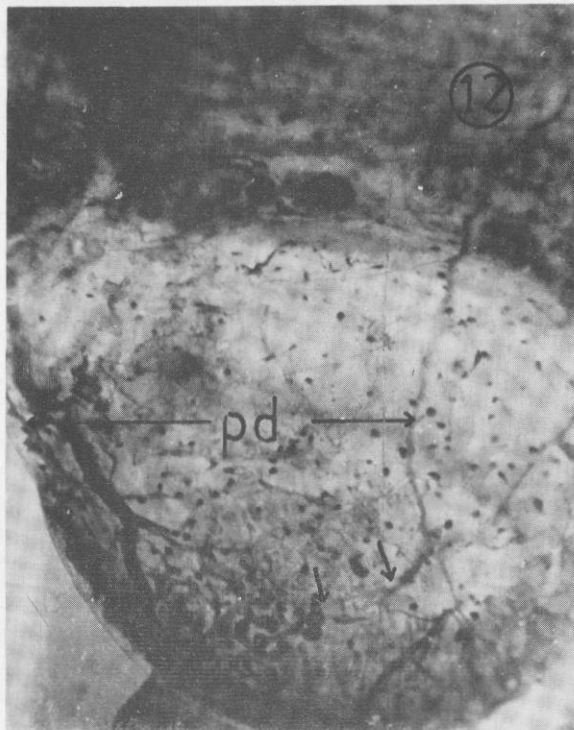
The innervation to the various regions and organs of the body is the same as observed in *F. elongatus*.

#### 4. Discussion

The neuroanatomy of *F. elongatus* and *G. crumenifer*, as revealed by the indigogenic technique for localization of non-specific esterases, shows many deviations from the description given for these species by Lee (1971) and Brandes (1898). In the pre-cerebral region there are three pairs of nerves in both these species. The additional pairs of lateral and pharyngeal nerves referred to by Lee and Brandes could not be traced in the present study. Brandes has reported 2 accessory (dorsal and ventral) anterior nerves in *F. elongatus* and 3 accessory anterior nerves in *G. crumenifer*. However, no such nerves were observed in the present study. Lee has stated the splitting of one of the anterior



**Figures 8-10.** For captions, see page no. 138.



**Figures 11-12.** For captions, see page no. 138.

ventral nerves into two, thus mentioning the occurrence of 3 ventral branches on both sides. In the present study all the anterior nerves are found running singly up to the tip; ring-like transverse connectives, joining the anterior nerves of both the sides of the system and encircling the pharynx, are conspicuous. Lee has mentioned only a few poorly developed anterior ventral commissures. Fukui (1929) also mentioned some transverse commissures in an unspecified Japanese amphistome but did not state which nerve they connect. Anterior commissures were not figured by Brandes (1898).

The occurrence of three pairs of posterior longitudinal nerves is the most constant feature of the system in the species investigated. In our findings there is one pair of posterior dorsal nerves and two pairs of posterior ventral nerves proceeding singly up to the acetabulum; the posterior inner and outer ventral nerves correspond to the ventral and lateral nerves in Lee's description. Lee has reported fusion of the lateral and ventral nerves in the pre-acetabular region and also of the ventral and dorsal nerves in the acetabular region. Union between the posterior nerves was also reported by Brandes in *G. crumenifer* and *F. elongatus*.

In both these paramphistomes the presence of an additional pair of collateral nerves resulting from the splitting of the ventral cord has earlier been described (Brandes 1898; Otto 1896; Lee 1971). However, no such nerves were observed in the present study. Fukui (1929) also did not refer to the existence of collateral ventral nerves. In *F. elongatus* all the posterior longitudinal nerves join in the immediate pre-acetabular region to form a thick circular plexus from which many branches emerge in the posterior direction, supplying the whole wall and floor of the sucker. The presence of posterior transverse connection between the nerves of the two sides was also reported by both Brandes and Lee in *F. elongatus*. According to Brandes, the ventral and dorsal nerves in the acetabular region split into several branches, some entering the acetabulum while others participate in the formation of a complete commissural ring around the acetabulum. Contrary to Lee's (1971) observations that in *F. elongatus* the acetabular nerve is solely derived from the ventral cord, ours are in conformation with those of Brandes in that the acetabulum is supplied by both the posterior ventrals and dorsal nerves. In the post-cerebral region, conspicuous transverse connectives connect the three pairs of nerves with one another and with their counterparts establishing a direct communication between the two sides of the system. Lee has mentioned only a few ventral commissures and 1 or 2 poorly developed dorsal commissures. Under the present investigation, the pair of oesophageal nerves (Lee 1971) or a single unpaired oesophageal nerve (Brandes 1898) were not present.

The genital atrium is innervated by branches of both the posterior ventral nerves. A pair of transverse genital nerves reported by Lee could not be traced here. Our findings agree with those of Brandes who stated that these nerves do not occur in the paramphistomes he examined.

Otto (1896), in his study of amphistomes, found only three pairs of anterior nerves. The same author stated that the anterior dorsal and ventral nerves of *G. gregarius* (*Carmyerius gregarius* (Loose 1896)) Stiles et Goldberger 1910 occur immediately below the surface and are probably connected with pharyngeal nerves at the anterior end. He further maintained that these nerves send off branches posteriorly to connect with the posterior cords. Fukui 1929 also reported that the same nerves in some Japanese unspecified amphistome give off paired branches which turn caudad. In the present study the anterior nerves are situated slightly deeper in the parenchyma and do not give off branches to join the posterior nerves. Our observation tally with those of Lee (1971) for *F. elongatus* and *Parorientodiscus magnus*.

A ventro-lateral connective between the antero- and the postero-outer ventrals in *F. elongatus* and *G. crumenifer* seems to correspond to the accessory nerve of anterior lateral and posterior lateral nerves as reported in *P. magnus* (see Lee 1971). The ring-like anterior commissures described in *P. magnus* show a similarity to those observed by us in *F. elongatus* and *G. crumenifer*.

A comparison of the nerve pattern among the pouched paramphistomes, *F. elongatus*, *G. crumenifer* and *F. cobboldi*, brings out some notable variations. The nerve distribution in the pre-cerebral region of *F. elongatus* and *G. crumenifer* is simple in not possessing a conspicuous circumpharyngeal nerve basket which is a prominent feature in *F. cobboldi* (see Mishra and Tandon 1984). The C- or tilted V-shaped (= >) connectives of the postero-outer and postero-inner ventrals in *F. elongatus* are conspicuous by their absence in *F. cobboldi* and *G. crumenifer*. In *F. elongatus* all the posterior nerves join and form a circular connective anterior to the acetabulum and thus do not terminate individually in the posterior sucker as in *F. cobboldi* and *G. crumenifer*. An interesting aspect of the present study as compared to other trematodes is the presence of a dorsal and ventral nerve net, thus providing a direct communication system between all the posterior nerves.

Simha and Rao (1977) and Fernandez *et al* (1982) have mentioned about the ganglionated nature of nerves in *Singhiatrema longifurca* and *S. najai*, respectively. No ganglionated thickening were observed in the parasites under the present investigations. Nevertheless all the anterior and posterior nerves are well developed.

The present observations as well as the so far available descriptions on the nervous system in paramphistomes clearly reveal that the system cannot be regarded as a primitively developed one.

### Acknowledgements

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**Figures 6-12.** *Gastrothylax crumenifer*. 6-7. Camera lucida sketches of the nervous system in the whole mount of the worm in ventral and dorsal view, respectively. 8. Brain mass and the main anterior and posterior nerves ( $\times 72$ ). 9. Postero-ventral nerves and their nerve net as seen in the bifurcal region ( $\times 72$ ). 10. Postero-ventrals bifurcating and forming a transverse connective (arrow) just anterior to the acetabulum ( $\times 72$ ). 11. Postero-dorsals and their nerve net ( $\times 23$ ). 12. Postero-dorsals joining medially (arrow) in the acetabular region ( $\times 23$ ).

(Abbreviations. ad—antero-dorsal nerve; aiv—antero-inner ventral nerve; aov—antero-outer ventral nerve; cg—cerebral ganglion; pd—postero-dorsal nerve; piv—postero-inner ventral nerve; pov—postero-outer ventral nerve.)