The Excretory Systems of Three *Ditylenchus* spp.[1]

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Abstract: In *Ditylenchus dipsaci* the morphologically different anterior and posterior regions of the terminal excretory duct are separated by a constriction. Immediately posterior to the constriction is a valve-like structure composed of dense pieces integral with the wall of the duct. The posterior region is sometimes dilated at intervals along its length. The same structures are present in *D. myceliophagus* and *D. destructor*, but the dense pieces appear less well developed. A possible mode of action for the excretory system is discussed. *Key Words:* Excretory duct, Morphology, *Ditylenchus*.

The tylenchoid excretory system is characteristically asymmetric and tubular with the single lateral canal confined to one chord. A long terminal duct leads posteriorly from the excretory pore to the lateral canal and a large sinus nucleus is present in the wall of the lateral canal (2). Additional structures have, however, been reported in the excretory system of some tylenchs. Luc (9) noted a thickening in the wall of the excretory duct of *Radopholus lavabri* Luc; Coomans (4) reported a "small spherical body" in the excretory duct of *Rotylenchus goodeyi* Loof & Oostenbrink which became indistinct after fixation; Geraert (7) reported that a thickening of the wall of the excretory canal was more marked in *Pratylenchus* spp. Filipjev than in *Paratylenchus* spp. Micoletzky, and Ellenby & Smith (6) showed an ampulla on the excretory duct of larvae of *Heterodera rostochiensis* Wollenweber. Sanwal (10) reported a "beak-like structure" occurring in the terminal duct of *Radopholus gracilis* DeMan immediately behind the excretory pore; he also noted differences in the appearance of the terminal duct between living and dead nematodes.

Debray & Maupas (5) and de Bruyn Ouboter (1) reported a constriction and ampulla in the terminal duct of *Ditylenchus dipsaci* Kühn which Cobb (3) had not seen. Wu (12) observed the excretory system of *D. destructor* and found an excretory canal, excretory sinus and associated large nucleus from which a long sclerotized terminal duct led to the exterior. We have examined and compared the excretory systems of *D. dipsaci*, *D. myceliophagus* J. B. Goodey and *D. destructor* Thorne and report here some structures not previously described.

MATERIALS AND METHODS

D. myceliophagus and *D. destructor* were extracted by modified Baermann funnel (8) from cultures on *Agaricus bisporus* (Lange) and *Chaetomium* (Kunze ex Fr.) sp., respectively. *D. dipsaci* was obtained from daffodil (*Narcissus* sp. L.). After extraction, nematodes not used immediately were stored at 4 C until needed. For examination, they were mounted alive in distilled water and photographed after becoming quiescent; most nematodes could still recover mobility after 2–3 hr of quiescence. For examination of dead specimens the nematodes were killed by gentle heat, iodine (8) or hot formaldehyde:acetic acid (11).

RESULTS AND DISCUSSION

All the structures usually associated with the tylenchoid excretory system were seen in live specimens of *D. dipsaci* and are illustrated in Fig. 1. In contrast, the internal morphology of heat-killed specimens was so

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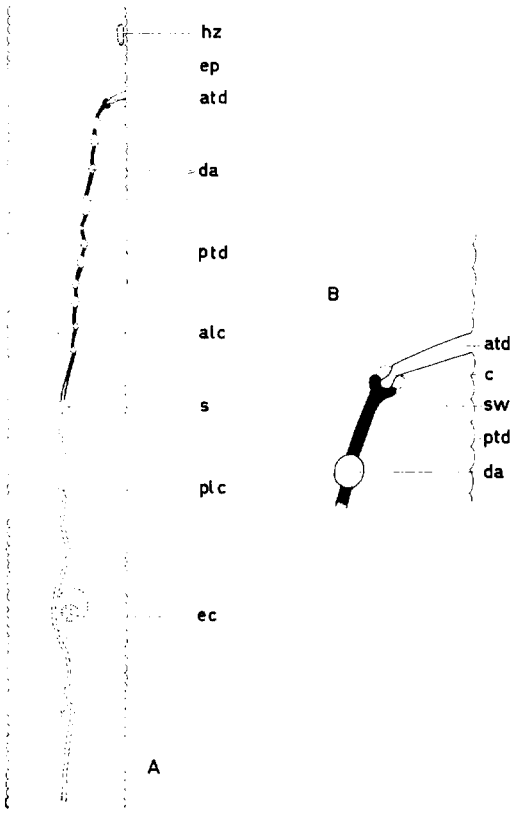

FIG. 1. Diagram of the excretory system of *Ditylenchus dipsaci*. **A.** General View; **B.** Detail showing the junction of anterior and posterior regions of the terminal duct. Abbreviations: *alc*—anterior region of lateral canal; *atd*—anterior region of terminal duct; *c*—constriction surrounded by muscle; *da*—dilated areas in terminal duct; *ec*—nucleus of excretory cell; *ep*—excretory pore; *hz*—hemizonid; *plc*—posterior region of lateral canal; *ptd*—posterior region of terminal duct; *s*—sinus; *sw*—swelling and valve-like structure.

disrupted that only the excretory pore and the anterior region of the terminal duct were visible; killing with iodine caused less disruption. Similar loss of definition in fixed specimens was reported by Coomans (4).

In live nematodes the lateral canal could readily be seen in the middle third of the body, appearing as a light grey tube against the darker grey of the rest of the nematode. In this region the prominent nucleus of the excretory cell was found in association with the posterior lateral canal and in a plane slightly above it when viewed laterally (Fig. 2a). In one specimen an anterior lateral canal, seen near the median pharyngeal bulb, was traced to a sinus located at its junction with the posterior lateral canal, confirming the observations of Debray & Maupas (5), de Bruyn Ouboter (1) and Wu (12). From this sinus the terminal duct extends anteriorly and ventrally, and morphologically distinct anterior and posterior regions could be seen. The posterior region appeared to be thick-walled except where dilated at irregularly spaced intervals (Fig. 2b). Unlike Wu (12), we hesitate to attribute the appearance of the terminal duct in any specimens we examined to sclerotization since it is apparently heat labile. The anterior region was short, with thin parallel walls, and terminated at the excretory pore a short distance posterior to the hemizonid (Fig. 3a). Sanwal (10) considered the dilations in the terminal duct of *Radopholus gracilis* to be artifacts resulting from death but their presence in live specimens of *D. dipsaci* precludes this explanation.

A constriction separated the posterior and anterior regions of the terminal duct. In some specimens there was a suggestion of a sphincter muscle around this constriction but its structure could not be adequately resolved. Immediately posterior to the constriction a valve-like structure appeared to block the terminal duct causing pressure and a swelling in the duct at this point. In other specimens no constriction or dilated areas were seen in the terminal duct and the position of the valve-like structure was marked only by two dense pieces (Fig. 3b) with a clear passage between them, suggesting that the duct was open. Thus, the terminal duct in live specimens of *D. dipsaci* appeared to

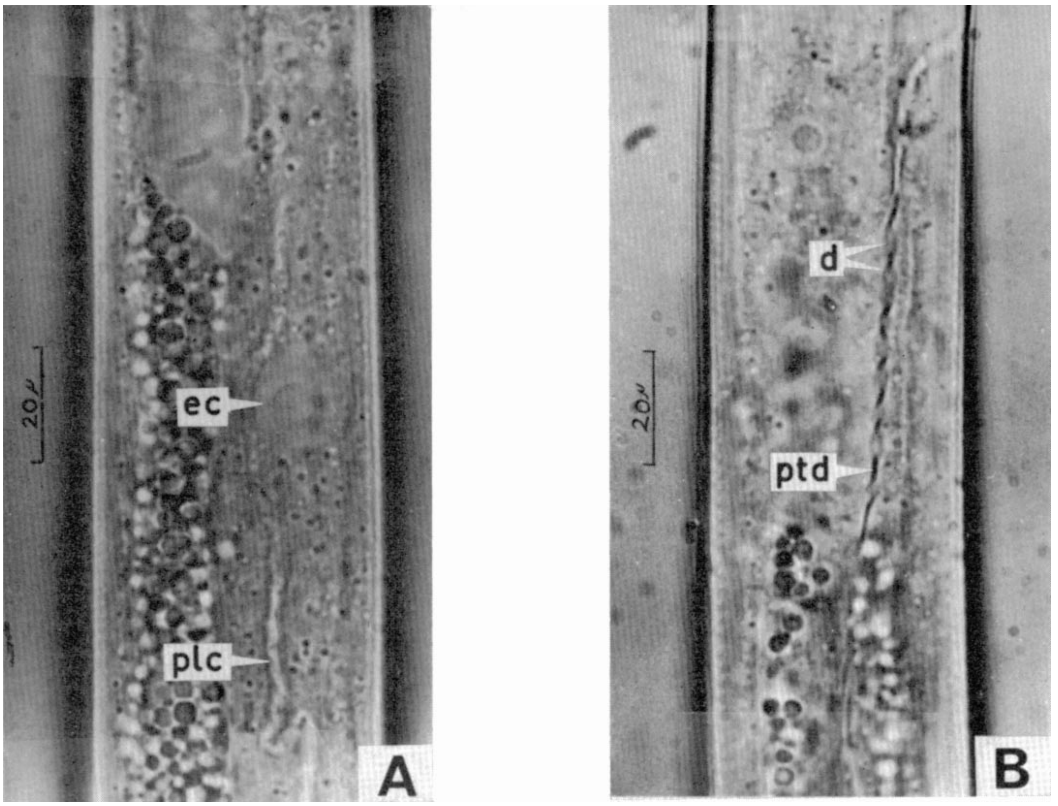

FIG. 2. The excretory system of *D. dipsaci*. **A.** Gland cell (*ec*) in relation to lateral canal (*plc*); **B.** Terminal duct (*ptd*) showing dilations (*d*).

have two different states, either closed or open. The conflict between the reports of Cobb (3), Debray & Maupas (5), and de Bruyn Ouboter (1) may be explained if Cobb examined specimens with open ducts in which no constriction or dilations were visible while those seen by the other authors had the ducts closed making the structures visible.

Neither the dense pieces nor the valve-like structure and the swelling associated with them in *D. dipsaci* were seen in the terminal ducts of *D. myceliophagus* and *D. destructor*. However, the walls of the ducts appeared slightly thickened and the thickenings are probably homologous with the dense pieces in *D. dipsaci* and with the structures reported by Luc (9), Geraert (7), Sanwal (10), and Coomans (4) in the excretory duct of other tylenchs. Wu (12) did not report thickening of the terminal duct of *D. destructor* near the excretory pore. However, the excretory systems of all three species showed similarities in the position of the excretory cell, presence of dilated areas in the posterior region of the terminal duct, and the proximity of the excretory pore to the hemizonid. When specimens of *D. myceliophagus* died beneath the coverslip, the dilations in the terminal duct disappeared and material was extruded from the excretory pore.

Although no movement was observed in the excretory system of living nematodes, its structural features suggest it may function in the following way. Waste material is col-

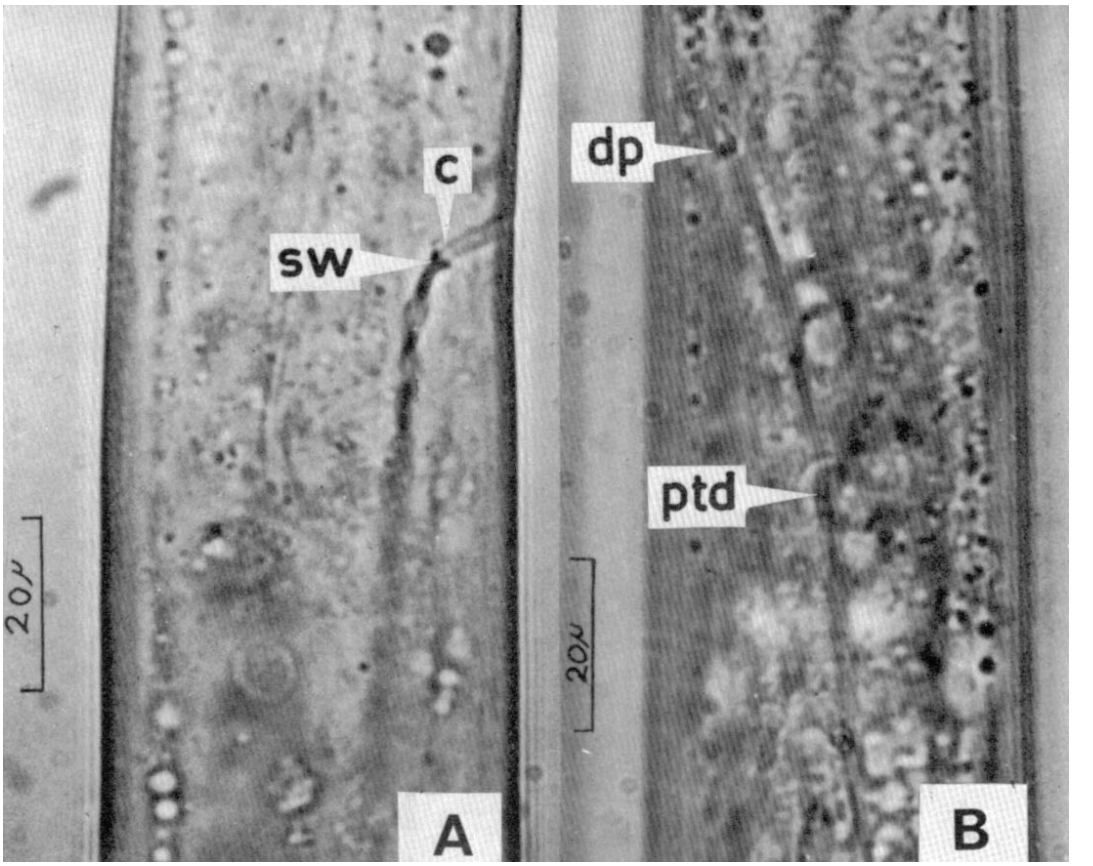

FIG. 3. Junction of anterior and posterior regions of terminal duct in *D. dipsaci*. **A.** Constriction (*c*), swelling and valve-like structure (*sw*). **B.** *D. dipsaci* showing dense pieces (*dp*) open.

lected in the thin-walled lateral canal and moves towards the excretory pore. In the thick-walled terminal duct, waste material concentrates into small ovoid globules which cause dilations in the terminal duct and which are eventually released to the exterior via the excretory pore. The constriction at the junction of the anterior and posterior regions of the terminal duct is caused by a muscle operating the valve-like structure containing the dense pieces, which controls release of excretory material. The live nematode may open the valve-like structure when necessary, but on the death of a nematode, it opens involuntarily and releases the contents.

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