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Regional ultrastructural differences of the scolex and neck tegument of *Proteocephalus macrocephalus* (Eucestoda: Proteocephalidae)

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Abstract. Structural differences of microtriches and distal cytoplasm of the tegument in the apical and lateral suckers, scolex proper and neck of *Proteocephalus macrocephalus* (Creplin,1815) were studied. The microthrix border in the apical sucker is formed by filamentous microtriches only. The frontal and lateral parts of scolex bear mainly filamentous microtriches, but seldom short conoid types occur. The transitional zone between scolex and neck is covered mainly with short conoid microtriches. The neck bears blade-like microtriches. In the apical and lateral suckers, the basal plasma membrane of the distal cytoplasm adheres to the basal lamina at some points only, forming thus a lacunal system at the base of the sucker tegument. In the scolex proper and neck region, the basal plasma membrane of the tegument is connected continuously with the basal lamina. The distal cytoplasm is penetrated by two types of gland cell ducts and ciliate sensory receptors. Possible functions of different parts of the microthrix border are discussed.

The tegument of cestodes is a very important structure because the tapeworms lack a gut and all nutritive material must pass through the body surface, and waste materials must be eliminated through it. The amplification of the surface is achieved by the presence of microtriches. The shape, size and numerical density of the microtriches vary both between species and different regions of the same worm. The tegument ultrastructure of adult *Proteocephalus macrocephalus* (Creplin, 1815) has been studied in SEM by Andersen (1979) and Scholz (1989). In TEM this species has not yet been studied.

MATERIALS AND METHODS

Specimens of *Proteocephalus macrocephalus* (Creplin, 1815) collected from the intestine of eels *Anguilla anguilla* (Linnaeus) taken from the river Lužnice (Tábor, Czech Republic) were fixed in 3% glutaraldehyde in 0.1 M cacodylate buffer (pH 7.2) for 2h at 4°C, postfixed for 2 h at 4°C in 2% OsO_4, dehydrated through an acetone series and embedded in Durcupan. Series of ultrathin sections from the scolex and neck regions (Fig. 1) were cut with a Reichert-Jung Ultracut E ultramicrotome, post-stained with uranyl acetate and lead citrate and viewed in a Philips 420 transmission electron microscope at 80 kV. Semithin sections were stained in toluidin blue.

RESULTS

Scolex

Frontal part. The tegument of the frontal part, around the apical sucker (Figs. 2-5), differs from the tegument covering the remaining parts of the scolex, i.e. the part between and behind the suckers. The tegument of the frontal part of the scolex bears two distinct types of microtriches – numerous filamentous and occasionally, solitary distributed short conoid microtriches. Both types of microtriches consist of a proximal cylindrical base separated from a distal electron dense shaft by a transverse (basal) plate. In filamentous microtriches the base is slim and the thin shaft is two or three times longer than the base (Figs. 2-5). In transverse section both base and shaft have a round form (Figs. 6, 7). The conoid microtriches have a wide and short base and shaft (Figs. 4, 5). The apical plasmalemma covering the microtriches bears a glycocalyx (Fig. 5). The basal plasmalemma of the tegument is continuously connected with the basal lamina (Figs. 2, 3). This part of tegument

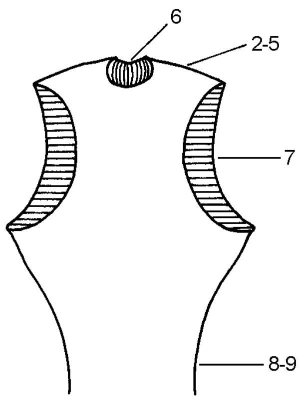

Fig. 1. Scheme of scolex of *Proteocephalus macrocephalus* indicating the location of the micrographs (Figs. 2-9).

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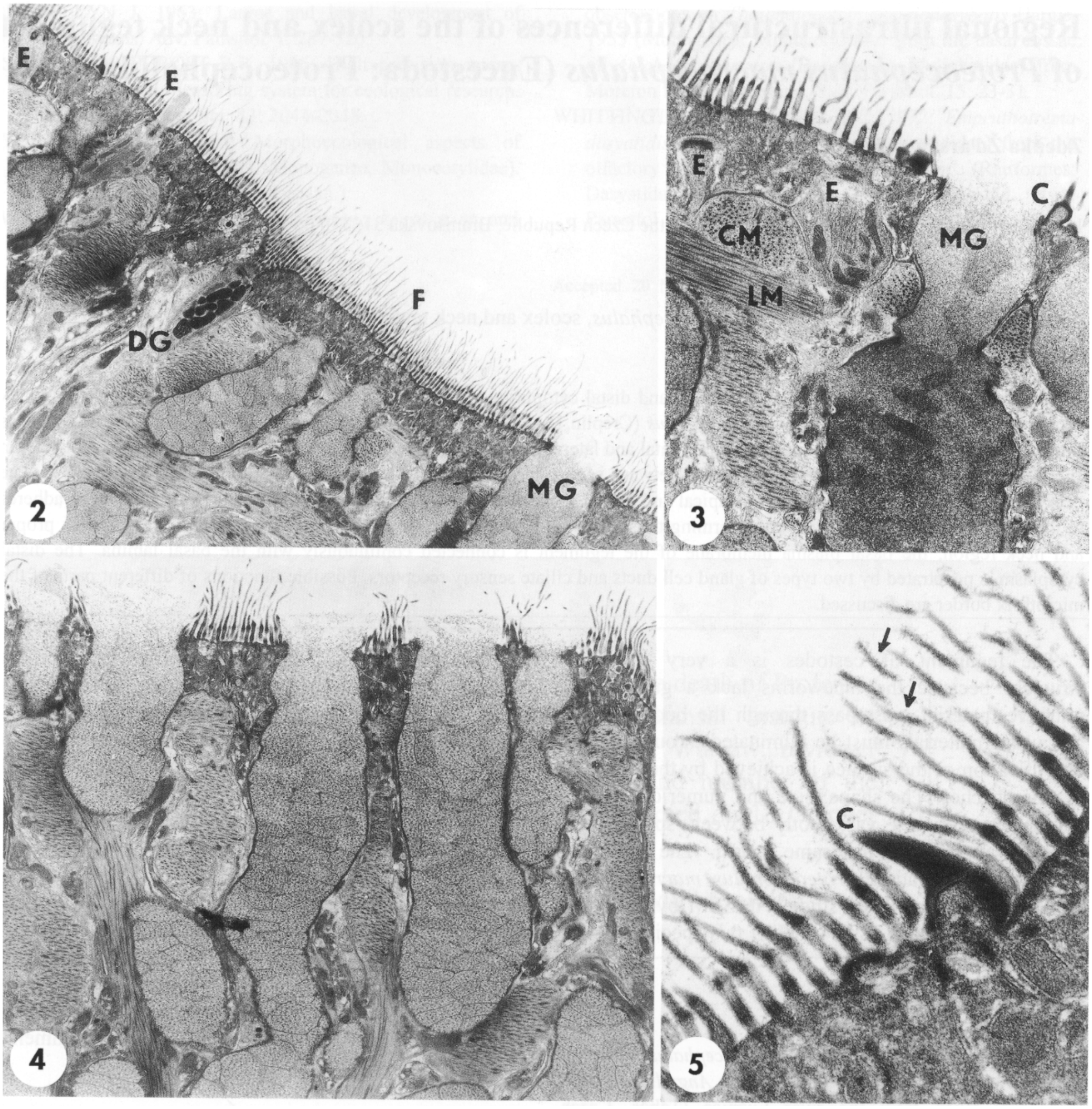
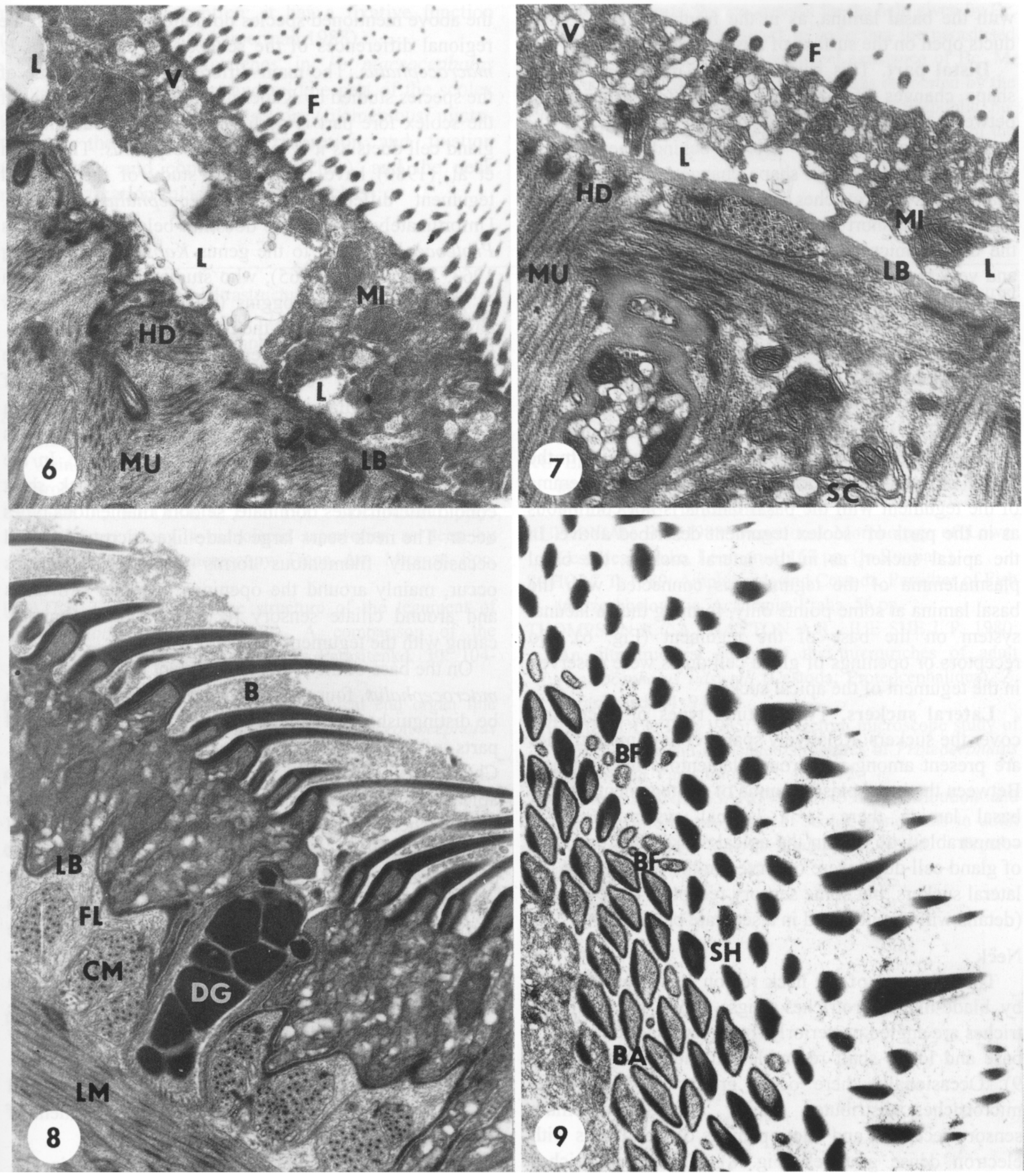


Figs. 2-5. Tegument of frontal scolex part of *Proteocephalus macrocephalus*. **Fig. 2.** Tegument of the frontal scolex part densely covered with filamentous microtriches (F). The distal cytoplasm is penetrated by a mucous gland cell duct (MG), a duct of a gland cell with electron dense granules (DG) and two ciliate sensory endings (E) (× 6,300). **Fig. 3.** Filamentous microthrix border of the frontal scolex part with a solitary conoid microthrix (C) near the opening of a mucous gland cell duct (MG). CM – circular musculature, LM – longitudinal musculature, E – sensory endings (x 11,600). **Fig. 4.** Frontal scolex tegument with filamentous microtriches perforated by many mucous gland cell ducts (× 8,900). **Fig. 5.** Detail of the microthrix border of the frontal scolex part with a solitary conoid microthrix (C) among filamentous microtriches. Arrows – glycocalyx (× 32,200).

is penetrated by many ducts of mucinous gland cells (Figs. 2-4), few ducts of glands with electron dense granules (Fig. 2), and ciliate receptors (Fig. 2). Details of the gland cells were published by Žďárská and Nebesářová (1999), and the structure of sensory receptors will be published in a separate paper. The distal cytoplasm contains electron lucid vacuoles, few mitochondria and very seldom small lipid droplets.

Lateral part. The tegument between the suckers bears mainly filamentous and short conoid microtriches; the conoid microtriches are relatively sparse. The basal plasmalemma of the tegument is continuously con-



Figs. 6-9. Tegument of apical and lateral suckers, and of neck region of *Proteocephalus macrocephalus*. **Fig. 6.** Tegument of the apical sucker. Filamentous microtriches only (F) form the microthrix border. Between the basal plasmalemma of the tegument and lamina basalis (LB) there is a lacunal system (L). The distal cytoplasm contains electron lucid vesicles (V) and mitochondria (MI). HD – hemidesmosomes, MU – musculature (× 18,900). **Fig. 7.** Tegument of the lateral sucker with tangential sectioned filamentous microtriches (F), electron lucid vesicles (V), mitochondrion (MI) and lacunal system (L) on the base. LB – lamina basalis, SC – subtegumental cell, HD – hemidesmosomes, MU – musculature (× 29,500). **Fig. 8.** Neck tegument with blade-like microtriches (B) perforated by a duct of a gland cell with electron dense granules (DG). LB – lamina basalis, FL – fibrous layer, CM – circular musculature, LM – longitudinal musculature (× 18,900). **Fig. 9.** Transverse section of bases (BA) and shafts (SH) of blade-like microtriches and bases of some filamentous microtriches (BF) in the neck region (× 18,900).

nected with the basal lamina, as in the frontal part. No gland ducts open on the surface of this part of tegument.

Distal part. This part is a more interesting part in shape changes of microtriches. The transitional zone between the inner part of lateral suckers, and the tegument covering the scolex behind them, show considerable microthrix shape changes. The number of filamentous microtriches decrease and that of conoid increase. In a short distance from this transitional zone, the conoid microtriches disappear and only blade-like and very few filamentous microtriches are present. This part of tegument is penetrated by ducts of gland cells with electron dense granules, which are identical with the gland cells of the neck region.

Apical sucker. The tegument of the apical (fifth, terminal) sucker bears filamentous microtriches only (Fig. 6). The apical pore, formed after retraction of the apical sucker, is covered by the frontal tegument. In the apical sucker the connection of the basal plasmalemma of the tegument with the basal lamina is not continuous as in the parts of scolex tegument described above. In the apical sucker, as in the lateral suckers, the basal plasmalemma of the tegument is connected with the basal lamina at some points only, forming thus a lacunal system on the base of the tegument (Fig. 6). No receptors or openings of gland cell ducts were observed in the tegument of the apical sucker.

Lateral suckers. Two distinct types of microthrix cover the suckers. Relatively sparse conoid microtriches are present among numerous filamentous microtriches. Between the basal plasmalemma of the tegument and the basal lamina there is a lacunal system (Fig. 7) comparable with that in the apical sucker. No openings of gland cell ducts were observed in the tegument of the lateral suckers, but some sensory receptors were present (details will be published in a separate paper).

Neck

The tegument of the neck region is densely covered by blade-like microtriches (Figs. 8, 9). These microtriches are angled posteriorly. In transverse section, both base and lower shaft resemble flattened triangles (Fig. 9). Occasionally there occur groups of filamentous microtriches distributed mainly around the ciliate sensory receptors and duct openings of gland cells with electron dense granules (Fig. 8). These microtriches differ from the filamentous microtriches of the frontal scolex part and suckers in that they have a short shaft. The basal plasmalemma of the neck tegument is continuously connected with the basal lamina (Fig. 8).

DISCUSSION

Regional differences of the tegument arrangement in adults of the genus *Proteocephalus* have been studied in TEM by Kuperman (1980) in *Proteocephalus exiguus, P. torulosus, P. cernuae* and *P. percae*. The results for the above mentioned species do not correspond with the regional differences of the scolex-neck tegument of *P. macrocephalus*. The main difference is that in none of the species studied by Kuperman (1980) the tegument of the scolex fore part is perforated by numerous mucous gland cell ducts as it is in *P. macrocephalus*. Thompson et al. (1980) have published a study of the regional tegument differences in *Proteocephalus tidswelli*. Unfortunately this cestode does not belong to the genus *Proteocephalus,* but to the genus *Kapsulataenia* Freze, 1963. Threadgold (1965), who studied the tegument in *P. pollanicola*, and Coggins (1980) in *P. ambloplitis* have not paid attention to the regional differences.

In the microthrix border of *P. macrocephalus* we detected on the scolex and neck three types of microtriches – filamentous, conoid and blade-like. On the scolex, there are present mainly filamentous microtriches, seldom short conoid forms occur. In the transitional zone between the scolex and neck short conoid microtriches dominate, seldom filamentous types occur. The neck bears large blade-like microtriches and occasionally filamentous forms arranged in groups occur, mainly around the openings of gland cell ducts and around ciliate sensory receptors, both communi-cating with the tegument surface.

On the base of the regional tegument differences in *P. macrocephalus*, four types of tegument arrangement can be distinguished: tegument of the fore, middle and hind parts of the scolex and the tegument of the neck. Characteristic of the scolex fore part (excluding the apical sucker) is the tegument with filamentous microtriches perforated by numerous mucous gland cell ducts and solitary ciliate sensory endings. The tegument of the middle part (i.e. the lateral suckers and the part among them) differs from the foregoing one in that it is not perforated by gland cell ducts. The hind part of the scolex bears the tegument with conoid and filamentous microtriches perforated by gland cell ducts with electron-dense granules. The neck is covered by the tegument with blade-like microtriches and perforated by ducts of the gland cells with electron-dense granules. Ciliate and nonciliate receptors were identified in all regions of the scolex and neck except the tegument of the apical sucker.

Microtrichial polymorphism, like that in *P. macrocephalus*, has been described in several other cestodes (Threadgold 1965, Braten 1968, Berger and Mettrick 1971, Jha and Smyth 1969, Featherston 1972, Andersen 1975, 1979, Hayunga and Mackiewicz 1975, Thompson et al. 1980, Kuperman 1988, Grytner-Ziecina et al. 1995). The diversity of microtrichial structure indicates a diversity of functions, but the functional significance of different types of microtriches remains speculative. Only the basal part of the microtriches is engaged in the nutritional role. The dense distal shaft is not involved in absorption; it has a fixative function (Thompson et al. 1980, Kuperman 1988).

The types of microtriches in *P. macrocephalus* suggest that the fore part and middle part of the scolex could be involved in resorption (filamentous microtriches); the hind part in resorption and fixation (filamentous and conoid microtriches), and the neck mainly in fixation (blade-like microtriches).

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