STRUCTURE AND FUNCTION OF THE RESPIRATORY EPITHELIUM IN THE TRACHEAL GILLS OF MAYFLY LARVAE

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Mayfly larvae possess tracheal gills formed as lamellar gills or gill filaments. They occur most often to the abdomen in several combinations (Fig. 1). According to the function the lamellar and filamentous gills are differed in the distribution and arrangement of the tracheoles in the epithelia.

The fine structure of the respiratory epithelium of filamentous gills has been investigated in caddisfly larvae (WICHARD, 1973) and stonefly larvae (WICHARD and KOMNICK, 1974a). Their tracheation is similar to the tracheation of the respiratory epithelium in filamentous gills of mayfly larvae (Fig. 2).

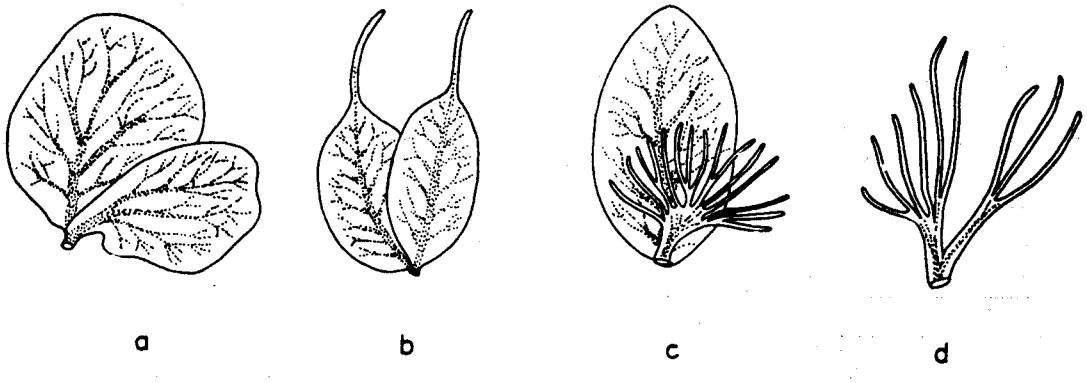

Fig. 1. Combinations of lamellar and filamentous gills

The tracheols run inside the epithelium just below the cuticle, where they are immersed in extracellular tubes which are formed by deep invaginations of the plasma membrane. They are arranged nearly parallel to each other and to the length of the gill filaments. Here the tracheoles are surrounded by a thin cytoplasmic sheath of the tracheoblasts. The uptake of oxygen is related to the respiratory surface of the tracheal gills under the condition that oxygen passing the cuticle is caught by the tracheoles only and does not lost from the tracheal respiration by diffusion between the tracheoles. In consequence to the high efficiency there are two extreme types of tracheation:

1. The subcuticular tracheoles are of equal diameters and equidistantly spaced probably at twice the radius of their catchment area. This arrangement ensures that total oxygen diffusing across the respiratory gill surface is taken up by the tracheoles with a minimum of tracheolar material. This type of tracheation is found in tracheal gills of caddisfly larvae (WICHARD, 1973).

2. The subcuticular tracheoles are densely packed at interspaces generally not exceeding the tracheolar diameters. This type of tracheation bases on a surplus of tracheolar material. It is found in stonefly larvae (WICHARD and KOMNICK, 1974a) and in mayfly larvae (Fig. 2).

In lamellar gills now the tracheolar distribution pattern of the respiratory epithelium is characterized by a rich ramification in nearly radial orientation (Fig. 3). The branched tracheoles run again underneath the cuticle in extracellular tubes and are surrounded by a thin cytoplasmic sheath of the tracheoblasts. Two extreme types of tracheation are also observed in lamellar gills:

1. The ramified system ensures that oxygen diffusing across the gill surface is not always caught by the tracheation because the distances between the branched tracheoles increase in distal direction often to a space greater than twice the radius of the tracheolar catchment area, so that oxygen is diffusing between the tracheoles. This type of tracheation is found in the caudal lamellae of damselfly larvae and also in the lamellar gills of mayfly larvae. In this case the surface of the tracheal gills is larger than the respiratory surface in term of the diffusing theory of respiration. In addition to the respiratory function the epithelium is filled with numerous chloride cells which are involved in osmoregulation by the absorption of ions (WICHARD and KOMNICK, 1971).

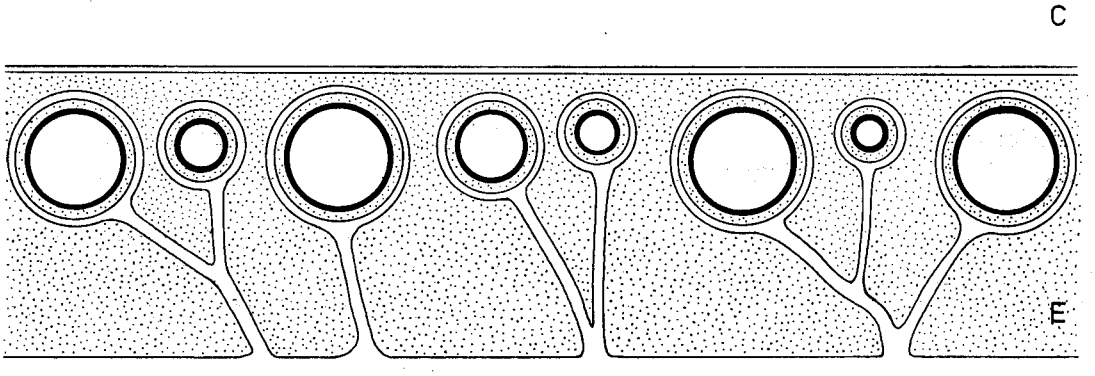

Fig. 2. Diagram of the respiratory epithelium of filamentous gills with a surplus of tracheoles. C — cuticle, E — epithelium

2. The subcuticular tracheoles are so densely packed that their distances can not increase to a space greater than twice the radius of the catchment area. The tracheoles run therefore nearly parallel to each other. This type of tracheation requires a surplus of tracheolar material for an optimum functional efficiency. It is observed in the rectal tracheal gills of dragonfly larvae (GREVEN and RUDOLPH, 1973; WICHARD and KOMNICK, 1974b).

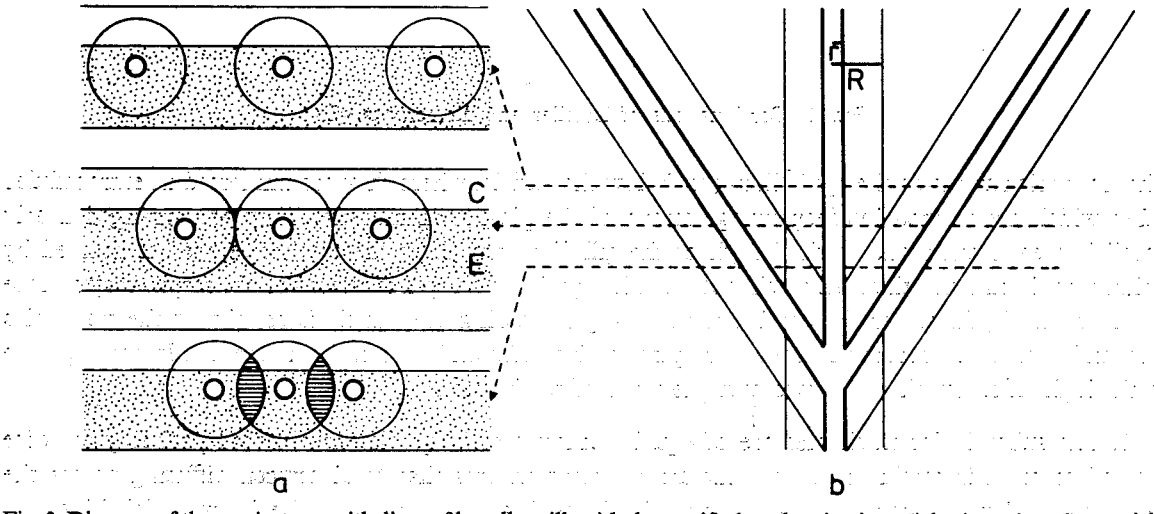

Fig. 3. Diagram of the respiratory epithelium of lamellar gills with the ramified tracheation in radial orientation. C — cuticle, E — epithelium, r — tracheolar radius, R — radius of the tracheolar catchment area

The observations indicate that there are fine-structural differences between the filamentous and lamellar gills of mayfly larvae and that only the filamentous gills are high respiratory efficiency whereas in lamellar gills the surface area is not fully utilized according to the respiratory function.

SUMMARY

Structure and function of the respiratory epithelium in the tracheal gills of mayfly larvae

The respiratory epithelium of the tracheal gills of mayfly larvae has numerous tracheoles, which are extracellulary located in deep indentations of the plasma membrane just below the cuticle. The tracheoles of the gill filaments, when compared with the tracheation of the lamellar gills, are extremely densely packed at interspaces normally not exceeding the tracheolar diameters.

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