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Scanning electron microscopy of the gills of *Trachurus mediterraneus*

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Summary. Scanning electron micrographs have shown a significant difference in surface sculpture of the epithelial cells of the secondary lamellae and those of the gill filaments. The filament epithelium is covered with many microridges which appear to be interrupted periodically by swellings of various sizes. The secondary lamellae have few microridges.

The gills of *Trachurus mediterraneus* are similar to those of other carangid fish in having a relatively large surface area[2]. This is achieved by the high frequency of the secondary lamellae (40/mm) although each of them is smaller than those of similar-sized species which are less active. The secondary lamellae are relatively thin (12 μm) and the space between them is a little wider.

In this way water is brought into close contact with the gas exchange surfaces. The shape of the secondary lamellae varies along the length of each filament, being more triangular at the tip and rectangular at the base of the filaments. These differences are clearly visible under the scanning electron microscope as are differences in their surface architecture. Pieces of gill filament were removed from fish and fixed in 2% glutaraldehyde in phosphate buffer (pH 7.35) and after critical point drying were observed in a Phillips scanning electron microscope.

The surface of the epithelial cells which cover the secondary lamellae are characterized by many microvilli of varying densities (fig. 1). Boundaries between individual epithe-

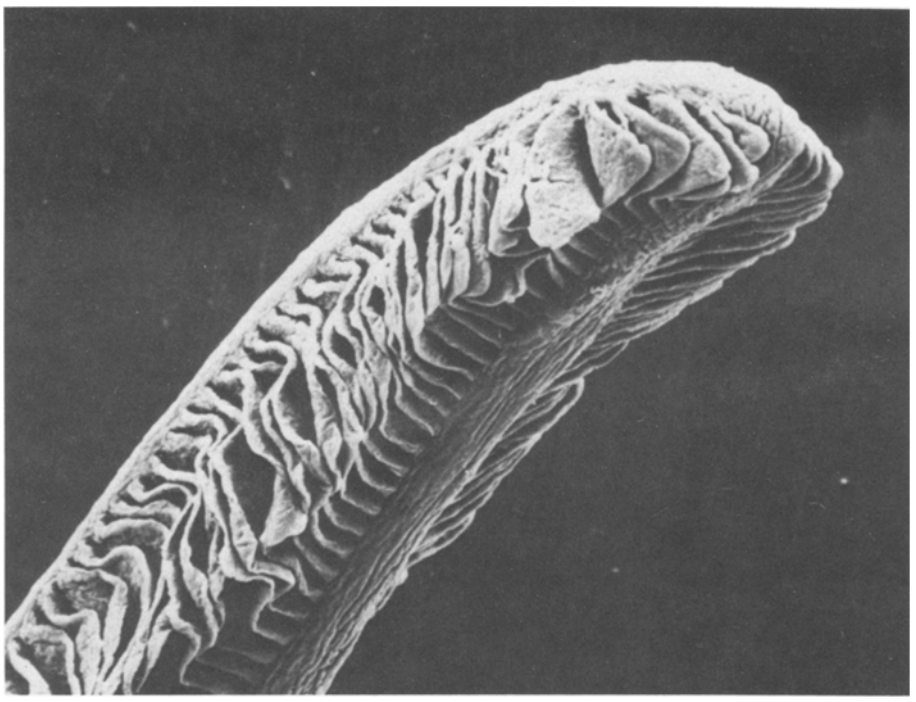

Figure 1. *T. mediterraneus* scanning electron micrograph of a single gill filament showing variations in lamellar shape in different regions of the filament (× 135).

Figure 2. Surface of the epithelium in the crypt region of a gill filament showing difference in appearance of the surface of the secondary lamella (microvilli) and of the gill filament (microridges) (×2100).

lial cells are not always clearly defined but are usually quite visible. The general pattern of the surface of these cells is similar in different parts of each secondary lamella and there does not appear to be any correlation between the position on the lamella and the size of the microvilli. There is some suggestion they are more sparsely distributed where the secondary lamellae arise from the filaments. In this position a distinction can be made between the surface sculpturing of epithelial cells on the secondary lamellae and those of the gill filaments which are covered more generally with microridges. Such a difference has also been observed in some species of air-breathing fishes[4]. The microridges on the filament epithelial cells are also of interestiin that periodically they seem to be expanded in the form of a villus-like structure. Such an appearance has not been found previously on the gill filaments of other fishes.

The filaments also have other cell types which can be recognized by their surface sculpturing. In the crypts between secondary lamellae chloride cells are present with characteristic pits and microvilli in the apical region of the cells. On the leading and trailing edges of the filaments mucous cells are also present but few in number. Very few mucous or chloride cells are found on the secondary lamellae themselves.

Thus the surface of the gills of *Trachurus mediterraneus* although fairly typical have shown a number of special features in which they differ from those of other species that have so far been investigated. The clear differentiation between the microvillous surface of the secondary lamellae and the microridged filament surfaces is more clear cut than has been observed in most species of fish and certainly differs from those of the yellowtail *(Seriola quinqueradiata)*[2] which is also a carangid fish. The latter has well developed microridges on both the filaments and secondary lamellae. Moreover the type of microridges present on the gills of *Trachurus* is unlike that observed in any other species. The presence of villus-like expansions along the length of the microridges appears to be normal and not due to a local concentration of mucus during fixation as persistent mucus has rather a different appearance in this material. Because of the difference between the surface of this species and that of the yellowtail it is difficult to envisage that there is any specific link between the surface pattern and their function in relation to gas exchange. Both fish probably show great dependence on ramjet ventilation as was indicated by studies on pressure changes within the buccal and opercular cavities of another species of *Trachurus*[5]. It is difficult to know whether a surface covered with microridges or one covered with microvilli would have greater or less effect on local microturbulence at these surfaces.

No indication has been obtained of the detailed nature of the surface in a living fish but from the study so far the results are not at variance with the view that normally the ridges and villi are embedded in a mucous coat. Possibly such a coating is especially important in fast swimming species if the mucus contains material capable of reducing the drag forces at the water/gill interface. Under polluted conditions it is known that the mucus on the surfaces may become coagulated and in extreme instances the whole pattern of the packing of the secondary lamellae changes and effectively reduces the surface area and increases the drag on the water of the ventilatory current.

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