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Development of the Secondary Lamellae in the Olfactory Epithelium of *Anabas testudineus*

Asad Rafi Rahmani
and Sardar Mahmood Khan

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The olfactory organs of the fish lie in front of the eye in the snout in the form of parallely arranged lamellae. In few fishes, for example, *Oncorhynchus* (Pfeiffer, 1963), *Salmo gairdneri* (Holl, 1965), *Salmo trutta* (Bertmar, 1972) and *Lota lota* (Devitsyna, 1972), the primary lamellae develop secondary folds that increase the olfactory surface. Except Bertmar (1972), the development of secondary folds has not been described so far. This study, therefore, has been undertaken to investigate the sequential development of secondary lamellae (folds) in the olfactory epithelium of an anabantoid fish, *Anabas testudineus* (Bloch).

Materials and methods

Specimens of *Anabas testudineus* of 4 cm to 13 cm were taken and their olfactory rosettes were dissected out and fixed in Bouin's and Zenker's fluids. The rosettes embedded in paraffin vertically and horizontally were cut at 6～8 μm thickness, stained with Mallory's aniline blue collagen stain or Delafield's haemotoxylin and counter stained with eosin.

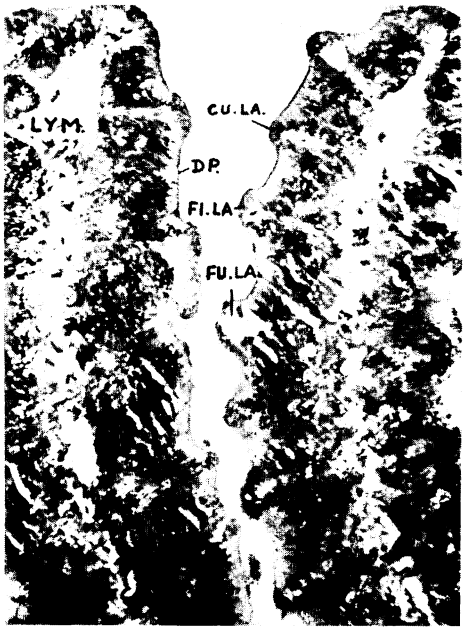
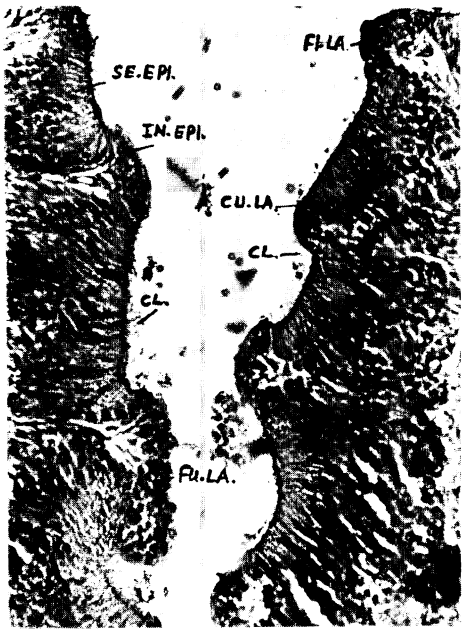


Fig. 2. Vertical section of the olfactory lamellae of an adult *Anabas testudineus* to show various stages of secondary lamellae. ×380. CU.LA., cuneiform lamella; DP., depression; FI.LA., filiform lamella; FU.La., fungiform lamella; LYM., lymph.

Results

The olfactory rosette in *Anabas testudineus*

Fig. 1. Vertical section of the olfactory rosette of a young *Anabas testudineus* (secondary lamellae are not yet developed). ×380. CE.CO., central core; DP., depression; FO. OLF., folium olfactorium; OLF.N., olfactory nerve; SE.EPI., sensory epithelium.



bears seven to ten parallely arranged lamellae (Fig. 1), which arise from the floor of the olfactory chamber. Each lamella consists of a submucosa or central core of reticular and collagenous connective tissue. The central core is surrounded by sensory epithelium known as mucosa. The mucosa consists of ciliated pseudostratified columnar epithelium. Basement membrane separates the central core from the sensory layer.

In young fish (4～6 cm) most of the primary lamellae are covered by receptor and supporting

Fig. 3. Details of the olfactory primary lamellae of an adult *Anabas testudineus*. ×600. CL., cilia; CU.LA., cuneiform lamella; FI.LA., filiform lamella; FU.LA., fungiform lamella; IN.EPI., indifferent epithelium; SE. EPI., sensory epithelium.

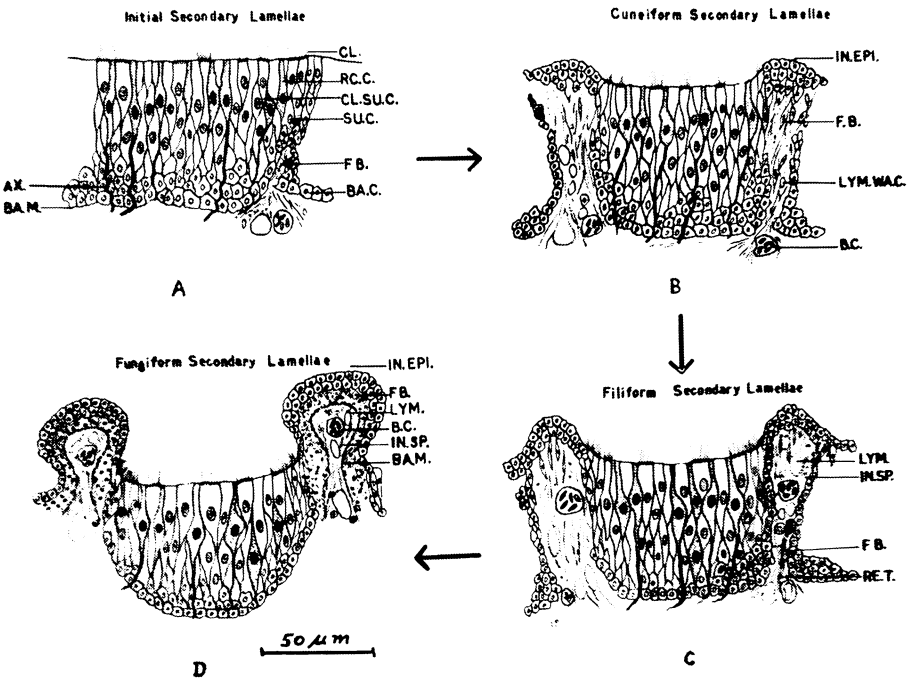


Fig. 4. Diagrammatic representation of the developmental stages of the secondary lamellae in the olfactory organ of *Anabas testudineus*. AX., axon; BA.C., basal cell; BA.M., basement membrane; B.C., blood capillary; CL., cilia; CL.SU. C., ciliated supporting cell; F.B., fibroblast; IN.EPI., indifferent epithelium; IN.SP., intercellular space; LYM., lymph; LYM.WA.C., lymphatic wandering cell; RC.C., receptor cell; RE. T., reticular tissue; SU.C., supporting cell.

cells (Figs. 1, 4A). As the fish becomes adult (8～13 cm) the central core projects offshoots towards the surface almost at equal distance (Fig. 4A). The cells of the mucosa above the dermal offshoot undergo rapid multiplication and soon small outgrowths occur in the epithelial lining. These outgrowths are termed as initial secondary foldings by Bertmar (1972). These foldings mainly consist of non-ciliated cells. Cuneiform secondary lamella (Fig. 4B) represents the second stage. In this stage the submucosa undergoes further penetration so the non-ciliated cells get pushed outwards and the secondary lamellae become wedge-shaped or cuneiform (Figs. 2, 3, 4B). The cells of the indifferent epithelium have prominent nuclei and show various stages of cell division. The nuclei are circular and lie superficially, unlike those present in the depressions where the elongated nuclei of the sensory cells are located quite away from the surface of the cells.

The third stage is the transformation of cuneiform lamellae into filiform lamellae (Fig. 4C). This stage is characterized by the appearance of lymph spaces in the head of the secondary lamellae. In the final stage, the filiform lamellae become broad and fungiform (Fig. 4D). The greater part of these secondary lamellae are now occupied by lymph and inter-cellular spaces. Only a thin boundary of cells is present on the margin of the head and neck of the fungiform lamella (Figs. 3, 4D). Often the reticular tissue of the central core is penetrated up to the neck of the fungiform lamella.

Discussion

Four stages are identified in the development of secondary lamellae in the olfactory rosette of *Anabas testudineus*. The developmental process does not differ from *Salmo trutta* (Bertmar, 1972) except in the following minor detail. Bertmar (1972) reported that at the preliminary stage some cells aggregate into little depressions and the boundaries of the depressions result in the formation of secondary lamellae. It is implicit that the depressions are precursor of secondary lamellae. In *Anabas testudineus*, the initial secondary lamellae are first pushed out by the proliferation of basal cells and thus the region between these lamellae obviously appears sunken or furrowed. It means that the initial secondary lamellae are precursor of depressions. Nonetheless, remaining steps of development of the secondary lamellae in *Anabas testudineus* and *Salmo trutta* are similar.

In *Lota lota* (Devitsyna, 1972) the sensory cells are located at the apex of the secondary lamella but in *Salmo trutta* (Bertmar, 1972), *Oncorhynchus keta* (Yamamoto and Ueda, 1977) and *Anabas testudineus* the apex consists of non-ciliated cells while the depression is occupied by sensory cells. The development of the secondary lamella in *Anabas testudineus* and *Salmo trutta* is almost similar. Devitsyna (1972) has not described the developmental stages of the secondary lamella in *Lota lota*. Presumably the development is different from *Anabas testudineus* resulting in this disparity in the location of sensory cells.

Teichmann (1954) in *Salmo gairdneri*, Pfeiffer (1963) in *Salmo* and *Oncorhynchus* and Holl (1965) in *Salmo trutta* and *S. gairdneri* found secondary lamellae. Yamamoto and Ueda (1977) think that "the occurrence of the secondary folds seems to be an almost unique feature of salmonids." However, Devitsyna (1972) has found secondary folds in *Lota lota* (Gadidae). Among the two anabantoids studied by the authors, the secondary folds (lamellae) are present in *Anabas testudineus* but not in *Colisa fasciata*. The presence of secondary folds, therefore, is not a unique feature of salmonids and it may be present in other families.

Acknowledgment

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(Section of Ichthyology and Fisheries, Department of Zoology, Aligarh Muslim University, Aligarh, India)

キノボリウオの嗅上皮の二次薄板の発達

Asada Rafi Rahmani・Sardar Mahmood Khan

キノボリウオ *Anabas testudineus* の嗅上皮ロゼットの二次薄板の発達に4段階が同定された．この発達過程は，初期段階を除いて，*Salmo trutta* の場合 (Bertmar, 1972) と大差はない．二次薄板の存在は，以前の研究者が考えていたようなサケ科魚の診断的特性ではない．