

Observations on the Postembryonic Development of the Olfactory Organs in *Sarotherodon galilaeus* Linnaeus (Teleostei, Cichlidae)

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ABSTRACT. The postembryonic development of the olfactory organs was studied in five developmental stages of the Nile cichlid fish *Sarotherodon galilaeus* (= *Tilapia galilaea*) including two buccal stages (5 and 7 mm) and three postbuccal ones (9, 12 and 58 mm total length).

In the buccal stages, the olfactory organ on each side is simple and represented by the olfactory epithelium and a narrow olfactory chamber opening externally through a single aperture on the dorsolateral surface of the snout. As development proceeds in the postbuccal stages, however, two accessory nasal sacs are developed: a dorsomedial sac and a ventrolateral sac, both are connected with the main olfactory chamber. Based on the analysis of position of the accessory nasal sacs, in relation to the surrounding skeletal parts of the head, the mechanism of water pumping may have been operated by the respiratory movements as well as movements of the jaws in opening and closing of the mouth.

Although the anatomy and structure of the olfactory organs have been described in some adult forms of teleost fishes by various investigators (Bateson 1889, Burne 1909, Derscheid 1924, Van den Berghe 1919, Liermann 1933, Teichmann 1954, Branson 1963, Pfeiffer 1965, Ojha & Kapoor 1974), the development of these organs has received little attention; Verraes (1976) studied the postembryonic development of the nasal organs and some surrounding skeletal elements in *Salmo gairdneri*.

The present study is one of a series dealing with the developmental anatomy of the head components in cichlid fishes (Ismail 1979, Verraes and Ismail 1980, Ismail *et al.* 1982, Ismail and Elshabka 1982, Ismail 1984).

A morphological description of the olfactory organs in five postembryonic developmental stages of *Sarotherodon galilaeus** is reported herewith. The development of olfactory organ in relation to its surrounding parts of the head, such as the chondrocranium and the osteocranium, were compared to give some functional interpretations of the water pumping mechanism in the olfactory chamber.

Material and Methods

Adult male and female specimens of *Sarotherodon galilaeus* were brought from Al-Serwe Fish Research Station at Al-Manzalah, Egypt, and were bred in the laboratory at 26-30°C. Several developmental stages were collected.

Five postembryonic stages were used in the study, including two buccal stages and three postbuccal ones. The buccal stages of 5 and 7 mm total length were collected from the buccal cavity of both parents. The postbuccal stages were of 9, 12 and 58 mm total length.

Specimens were fixed in Bouin's and 4% formalin fixatives. Postbuccal stages were decalcified in EDTA solution. Serial transverse paraffin sections of 7-10 μ thickness of the head of the studied specimens were made and stained with Mallory's aniline blue technique.

Graphical reconstructions were made following a technique described by Ver-raes (1974a).

Results

It is generally recognized that the olfactory mucosa in vertebrates differentiates from left and right nasal placodes (Torrey 1967). The development of the olfactory organ in teleosts starts from an ectodermal origin, and the ontogeny of the organ remains ectodermal throughout life (Bertmar 1972).

In the 5 mm (TL) buccal stage larvae of *S. galilaeus*, the olfactory organs are discernible as two lateral thickenings of the epidermis in the snout area, representing the olfactory epithelium on both sides (Fig. 1A).

In the 7 mm (TL) buccal stage larvae, the olfactory epithelium is invaginated and appears club-shaped in cross section, with a narrow cavity representing the beginning of the olfactory chamber (Fig. 2B). The latter opens to the exterior through a single narrow aperture representing the nostril or olfactory opening and

* Recently, the systematic position of *Tilapia galilaea* has been revised by Tre-wavas (1982). According to this author, this species belongs to the genus *Sarotherodon*.

occupying a dorsolateral position in the ethmoid region of the head. Posteriorly, the olfactory tissue is protected laterally by the lamina orbitonasalis, and ventrally by part of the ethmoid plate (Fig. 1B & C).

In the 9 mm (TL) postbuccal stage larvae, the cavity of the olfactory chamber is wider than that of the buccal stage. An accessory ventral olfactory sac has developed as a ventrolateral prolongation of the olfactory chamber (Fig. 2A). This sac may be comparable with the lacrimal sac in *Perca* and *Pleuronectes* (Liermann 1933) and the ventral accessory sac in *Sebastes* (Johnson and Brown 1962) and *Labeo rohita* (Ojha and Kapoor 1973).

In the 12 mm (TL) postbuccal stage, the olfactory chamber bulges dorsomedially to form a second accessory olfactory sac, smaller than the ventral one (Fig. 2B). Both sacs lie in communication with the main olfactory chamber.

Two accessory olfactory sacs in the 58 mm stage of the species studied are larger than those in the 12 mm (TL) larvae (Fig. 3C & 4B). The ventrolateral sac appears in lateral view as an elongate triangular bag-like structure (Fig. 5B) with a narrow anterior end and a wide posterior one. Anteriorly, it extends into the space confined among the lacrimal bone laterally (a canal bone developing in parasagittal plane), the palatine bone dorsally, surrounding the anterior extremity of the palatoquadrate, and the shaft of the maxillary bone ventrally (Fig. 3A & B). Posteriorly, the ventrolateral sac is bound laterally by the lacrimal bone and medially by the lateral ethmoid and palatine bones (Fig. 4B).

The ventral sac, at its connection with the olfactory chamber, is bound ventrally with the soft epithelial tissue forming the roof of the buccopharyngeal cavity (Fig. 3C & 4A).

The dorsomedial sac is smaller than the ventral one. It is bounded dorsally by the nasal bone, which also provides a dorsal covering to most of the olfactory chamber (Fig. 3C, 4B & 5A and B). Medially, the dorsal sac is bounded by the rostral cartilage, bearing dorsally the premaxillary pedicles, and ventrally by the ethmoid plate and its associated lateral ethmoid bone (Fig. 3C, 4B and 5A).

In the 58 mm (TL) juveniles, the olfactory epithelium gives rise to few folds resembling villi, extending out laterally into the expanding olfactory chamber (Fig. 4A), thus increasing the epithelial surface. Similar folds were described by Verraes (1976) in 97-day old *Salmo gairdneri*.

Discussion

The study of the postembryonic development of the olfactory organs in five developmental stages of *Sarotherodon galilaeus* reveals that these organs increase in size with the gradual increase in the size of the fish. That phenomenon may be correlated with the transition of young fishes from buccal to postbuccal life, in

which they become free in movement and also much more active. No direct evidence has shown the functional efficiency of the olfactory organ increases with an increase in its olfactory surface. Pipping (1926) and Moulton and Beidler (1967) believe that it does not; Wunder (1957), on the other hand, suggests that it does.

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Abbreviations used in the figures

D.A.S.	Dorsal accessory sac	NA	Nasal bone
E.PL	Ethmoid plate	OLF.CH	Olfactory chamber
EP	Epidermis	OLF.E	Olfactory epithelium
L.E	Lateral ethmoid bone	OLF.OP	Olfactory opening
L.J	Lower jaw bones	OLF.T	Olfactory tissue
LA	Lacrimal bone	PAL	Palatine bone
LA.OR	Lamina orbitonasalis	PM	Premaxilla
LIG.I	Ligament between premaxillary and maxillary bones	PV	Prevomer
LIG.II	Ligament between maxilla and lower jaw bones	R.C.	Rostral cartilage
MA	Maxilla	S.O.C.	Supraorbital canal
		V.A.S.	Ventral accessory sac

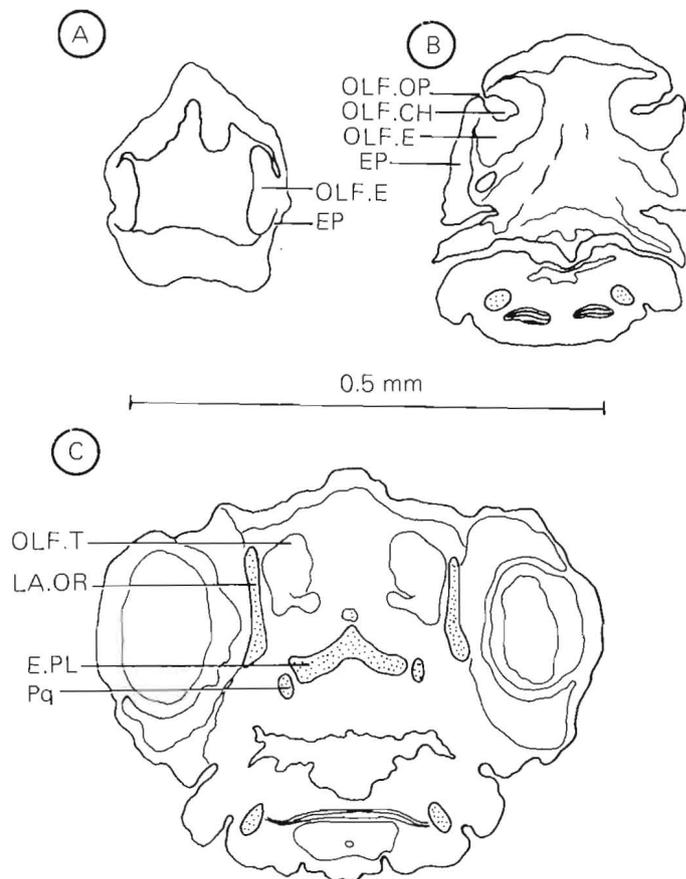


Fig. 1. **A.** transverse section through the olfactory region of a 5 mm stage of *Sarotherodon galilaeus*, showing the olfactory epithelium as a thickening part of the epidermis. **B.** same, through the anterior part of the olfactory region of a 7 mm stage, showing the invagination of the olfactory epithelium and the development of the olfactory chamber. **C.** same, through the posterior part of the olfactory region of a 7 mm stage.

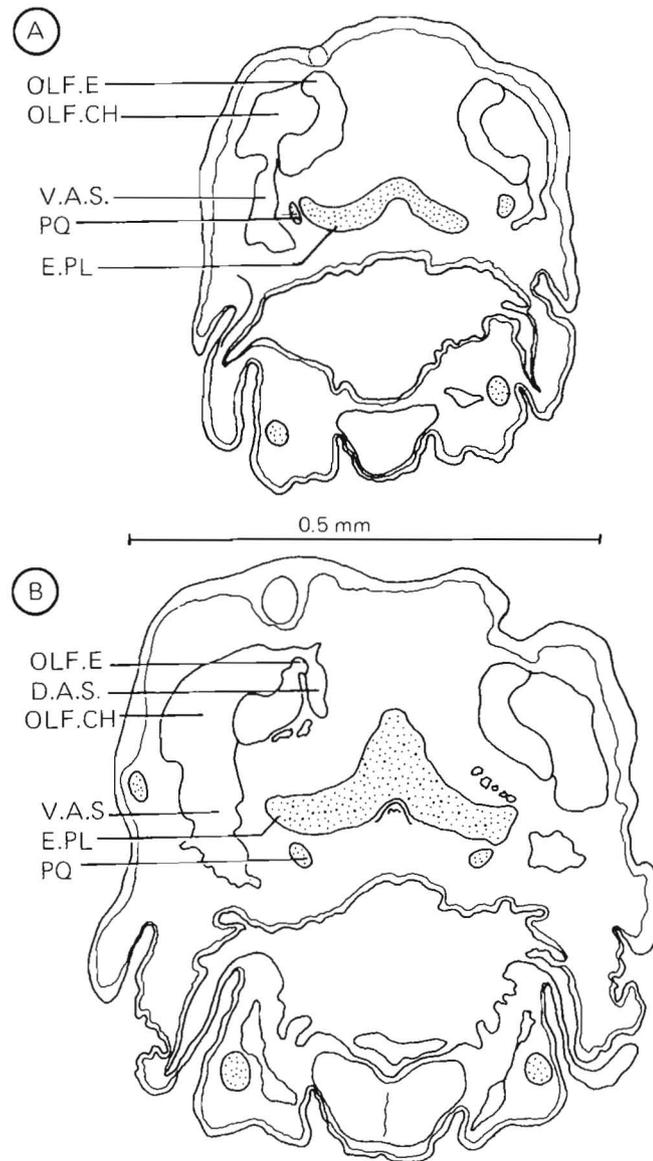


Fig. 2. **A**, transverse section through the olfactory region of a 9 mm stage of *Sarotherodon galilaeus*, to show the ventrolateral accessory sac. **B**, same, through the olfactory region of a 12 mm stage, to show the dorsomedial accessory sac.

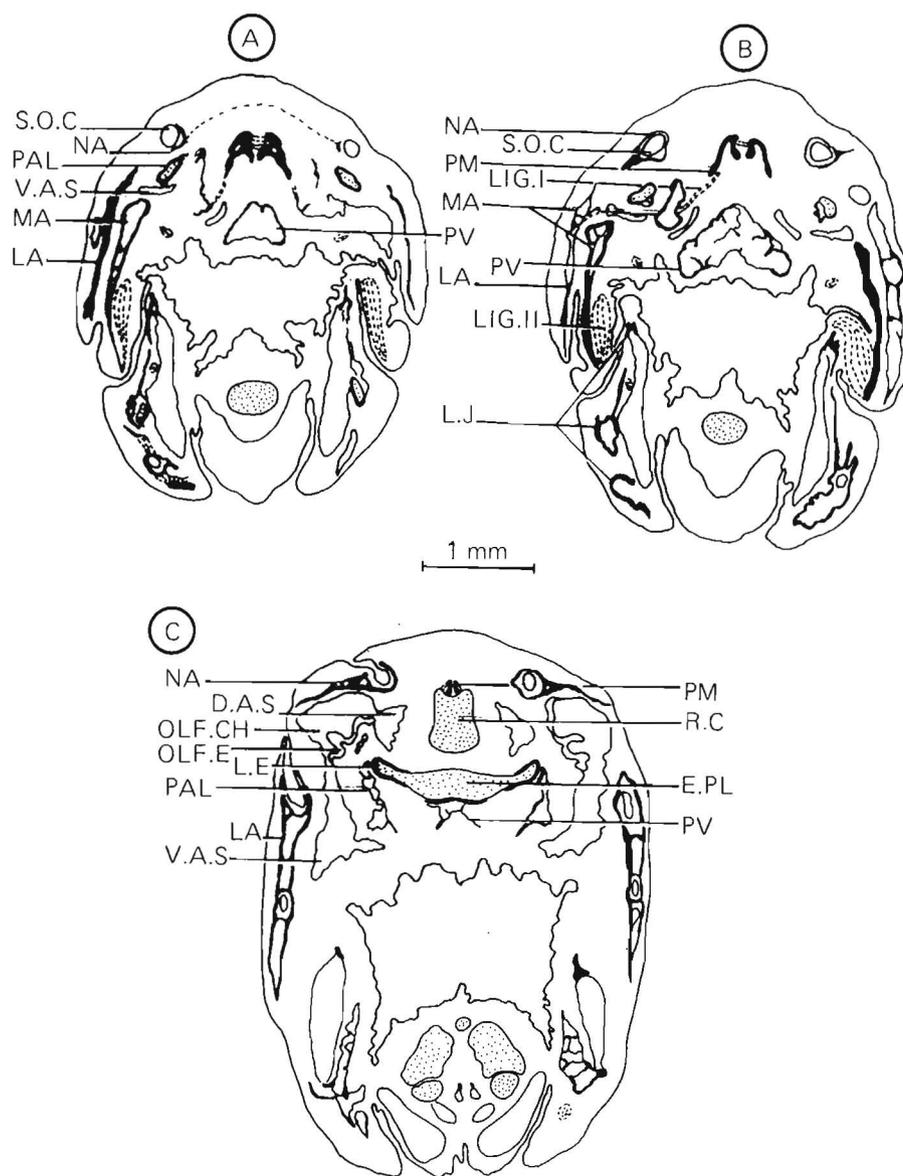


Fig. 3. A, B and C: successive transverse sections through the olfactory region of a 58 mm stage of *Sarotherodon galilaeus* in antero-posterior direction, to show the relation between the olfactory organs and the surrounding parts of the head.

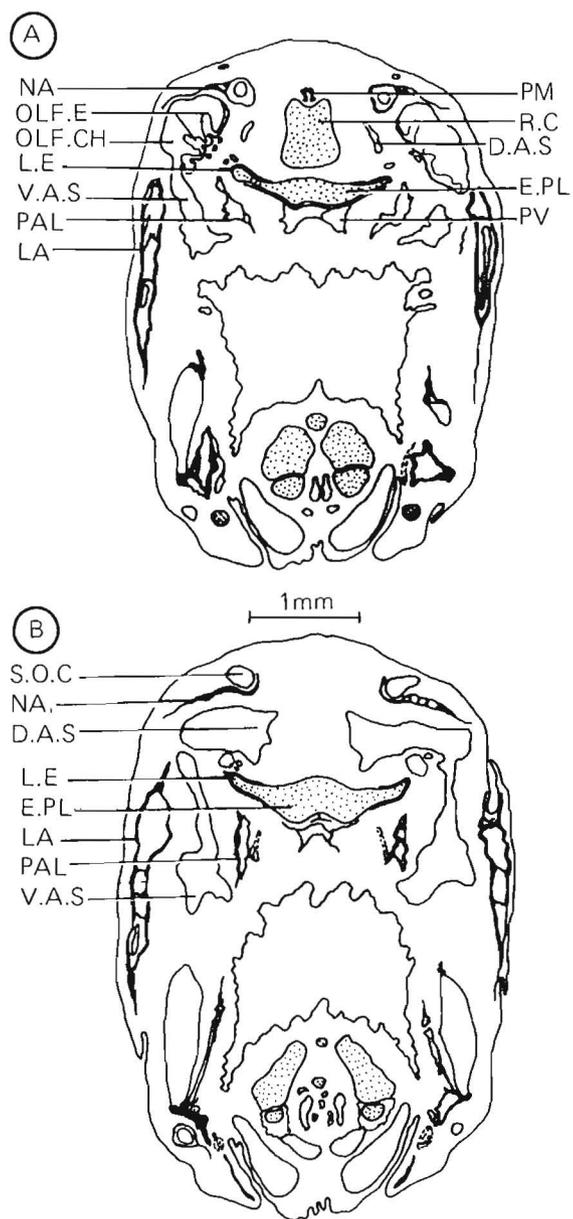


Fig. 4. **A**, transverse section in the olfactory region of a 58 mm stage of *Sarotherodon galilaeus*, to show the differentiation of the olfactory epithelium into folds. **B**, same, through the posterior part of the olfactory region of a 58 mm stage, to show the relation of accessory sacs with the surrounding skeletal parts of the head.

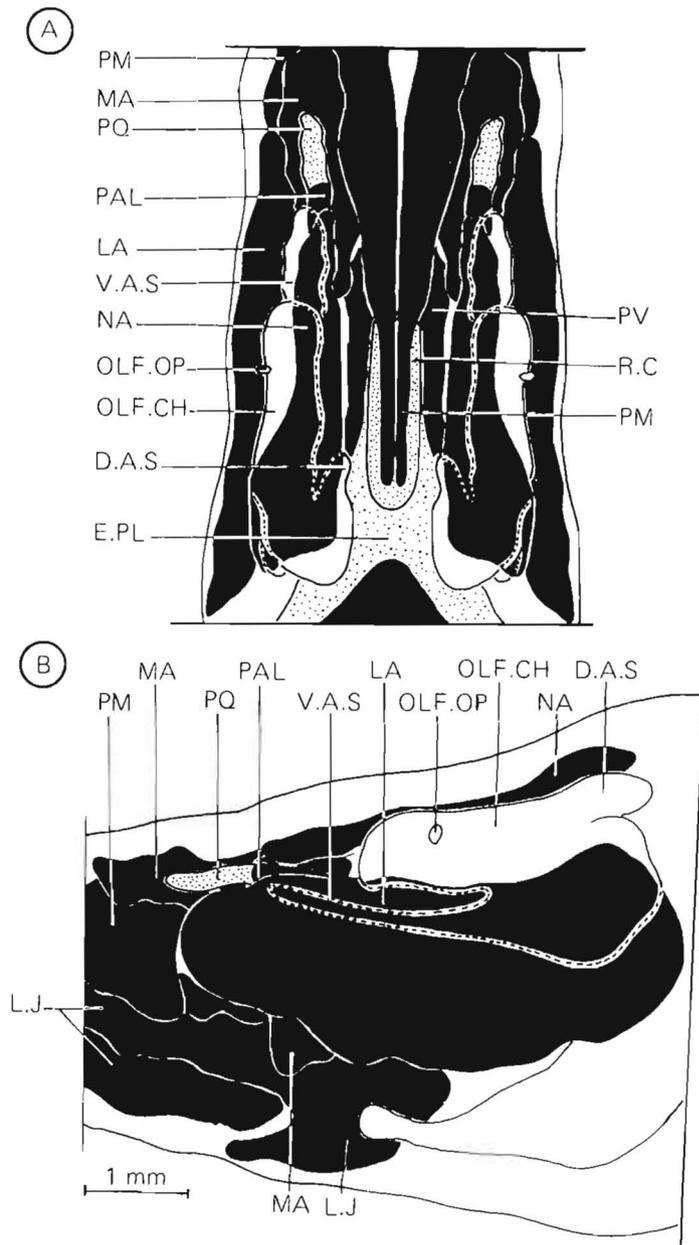


Fig. 5. Graphical reconstructions of the olfactory region of a 58 mm stage of *Sarotherodon galilaeus*. **A**, dorsal view; **B**, lateral view.

ملاحظات على التكوين ما بعد الجنيني لأعضاء الشم في سمك الساروثيرودون جاليلوس (= البلطي الجاليلي)

ممتاز هاشم إسماعيل

قسم الحيوان - كلية العلوم - جامعة الزقازيق - الزقازيق - مصر

يتضمن هذا البحث دراسة التكوين ما بعد الجنيني لأعضاء الشم في سمك البلطي الجاليلي، والذي يسمى حالياً بالساروثيرودون جاليلوس، وهو أحد أسماك النيل العظمية. وقد أختير لهذه الدراسة خمسة أطوار تكوينية تضم طورين من المرحلة الفمية هما ٥، ٧ مم طول، وقد تم الحصول عليها من التجويف الفمي للأبوين، وثلاثة أطوار من المرحلة ما بعد الفمية، وهي المرحلة التي تنتقل فيها اليرقات من التجويف الفمي للأبوين إلى الخارج وتصبح حرة المعيشة وهم ٩، ١٢، ٥٨ مم طول.

ويبدأ ظهور عضو الشم في الأطوار الفمية على شكل تغلظ جانبي من طبقة البشرة في منطقة البوز يمثل الطلائية الشمية، وسرعان ما ينغمد هذا الجزء المتغلظ للداخل ويصبح مزوداً بتجويف وسطى ضيق نسبياً يمثل بدايه تكوين الحجرة الشمية التي تفتح بدورها للخارج على جانب مقدم الرأس بفتحة شميه مفردة. وفي الاطوار ما بعد الفمية، لوحظت زيادة حجم الحجرة الشمية بشكل ملحوظ مع تكون ثنيات في النسيج الشمي، الأمر الذي أدى إلى زيادة مساحة سطحه.

إضافة إلى ذلك، لوحظ تكوُّن أكياس شميّة مساعدة ممثلة
بكيّسين على كل جانب، أحدهما بطني جانبي كبير نسبياً
والآخر ظهري وسطي صغير نسبياً؛ وكلاهما متصل بالحجرة
الشميّة.

وقد تضمن البحث مناقشة ميكانيكية ضخ الماء عبر
أعضاء الشّم وذلك بناء على التحليل المورفولوجي لوضع
الأكياس الشميّة المساعدة، وذلك في علاقتها بأجزاء الرأس
الأخرى المحيطة بها. ويمكن القول بأن عملية ضخ المياه
عبر أعضاء الشّم قد تتم بفعل حركات التنفس بالاضافة إلى
حركه الفكوك خلال فتح وغلق الفم.