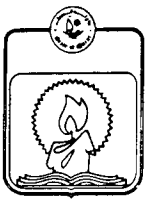


University of Qatar

QATAR UNIVERSITY SCIENCE BULLETIN

(Qatar Univ. Sci. Bull.)

VOL. 10 1990

Published by the Faculty of Science
University of Qatar

Qatar Univ. Sci. Bull. (1990), 10: 239–251

COMPARATIVE DEVELOPMENT STUDIES ON THE LATERAL CANAL SYSTEM IN *CYPRINUS CARPIO* AND *GAMBUSIA AFFINIS AFFINIS*

By

AL-ZAHABY, A.S.; EL-ASSY, Y.S.*; EL-ATTAR, A.E. and AWAD, G.S.

Faculty of Science, Cairo* and Zagazig Universities, Egypt

Key words: Comparative development studies on the lateral line.

ABSTRACT

The lateral line canals and the neuromasts situated inside their lumina are described in two fishes differing in their feeding habits. There are 20 canal neuromasts in the bottom feeder *Cyprinus carpio*, while in the surface feeder *Gambusia affinis affinis* there are 8 neuromasts only. Thus the canal system is well developed in the first species than in the second one. The canals open to the exterior through fine canaliculi with fine pore which are also great in number in *Cyprinus carpio*.

INTRODUCTION

The study of late development of the canal system in bony fishes has been investigated by many authors as Pehrson (1944), Jarvik (1947), Lekander (1949), Gosline (1949), Bergeijk and Harris (1962), Reno (1969), Jakubowski (1965, 1966a,b & 1967a,b) and Bhargava (1987).

The present investigation deals with the study of the canal system in different embryonic stages of two fishes varying in their feeding habits; *Cyprinus carpio* (Family: Cyprinidae) as a bottom feeder fish and *Gambusia affinis affinis* (Family Cyprinodontidae) which is a surface feeder fish.

MATERIALS AND METHODS

The post-hatching stages of *C. carpio* (14, 18, 30 and 32 mm. total body length) were collected from the Serew Fish Farm. Those of *G. affinis affinis* (10, 17, 20 and 27 mm. total body length) were taken from Muess River in Sharkia Province.

The specimens were immediately fixed in Bouin's solution and decalcified by Gooding and Stewart's fluid. The heads of all fishes were dehydrated, cleared and embedded in wax under vacuum.

Transverse serial sections of 6 u thickness were stained with Harris haematoxylin (Drury *et al.,* 1980) and drawn using camera lucida. Reconstruction for the dorsal and lateral sides of all specimens have been carried out according to the graphic method described by Gaunt (1971) and Verraes (1974).

OBSERVATIONS

I. *Cyprinus carpio*

Individual variation of the number of canal elements has been met with in fishes of the same age and length. Even in the same individual the number of canal elements may differ on both sides as found by Lekander (1949) and Pehrson (1949). Thus, it is preferable to describe the canal elements on one and the same among the various investigated specimens to avoid confusion.

Fishes of total body length 14 mm. There are no signs of canal system except for the formation of the lines of superficial neuromasts on the head (Fig. 1).

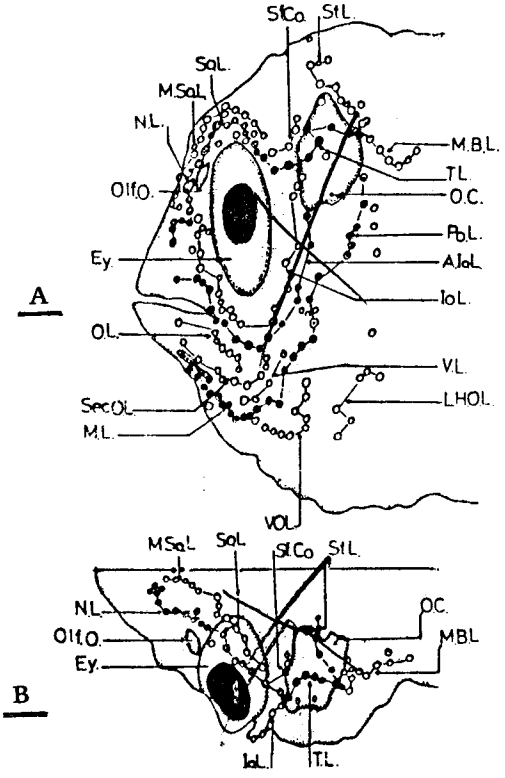


Fig. 1: Graphic reconstruction of the lateral line system of 14 mm. stage of *Cyprinus carpio.* X 25. A: Lateral view, B: Dorsal view.

Fishes of total body length 18 mm. The canal system begins to develop by sinking of some of the primary superficial neuromasts below the epidermal level. This is followed by the appearance of epithelial thickenings between the formed neuromasts especially inthe anterior areas of the superaorbital and the operculomandibular lines. The thickenings invaginate inwards forming a groove in which the sinking neuromasts in future become localized (Fig. 2 and 3).

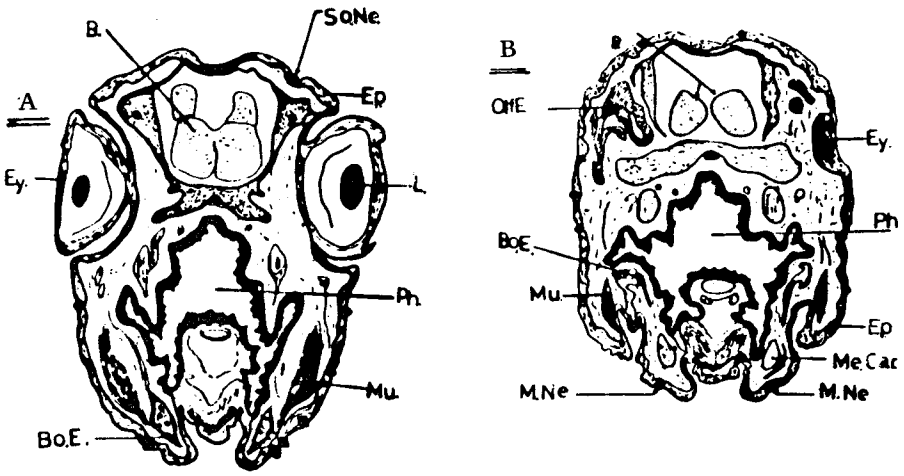


Fig. 2: Camera lucida drawings of transverse sections in the head of 18 mm. stage of *Cyprinus carpio.* X 25. A: Optic region showing supraorbital neorumast. B: Mandibular region showing mandibular neuromast.

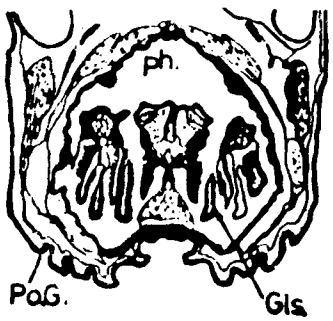


Fig. 3: A camera lucida drawing of transvers section in the opercular region of 18 mm. stage of *Cyprinus carpio,* showing invagination of the preopercular goove. X 19.

Fishes of total body length 30 mm. The two ends of the invaginating thickenings fused together transforming the grooves into canals opening on the surface through fine pores. The anterior and posterior extremities of the canals are still in the form of furrows (Fig. 4).

The incomplete supraorbital canal (So.C) begin just above the taenia marginalis anterior (T.Mar A.) of the cranium (Fig. 4). It extends posteriorly above the epiphyseal bridge (E.P.B.) and taenia marginalis posterior (T.Mar.P.). The pores (Pr.) of the supraorbital canal are displaced to tubular canaliculi (Cs.). The supraorbital canal open to the surface through four pores (Fig. 4, 1-4). Neuromasts of the supraorbital canal, located inside its lumen, increase in number and become surrounded by bony elements (Figs. 4 & 5). The superficial neuromasts at the anterior and posterior extremities of this canal begin to sink also in the epidermis showing the future extension of the canal (Fig. 4).

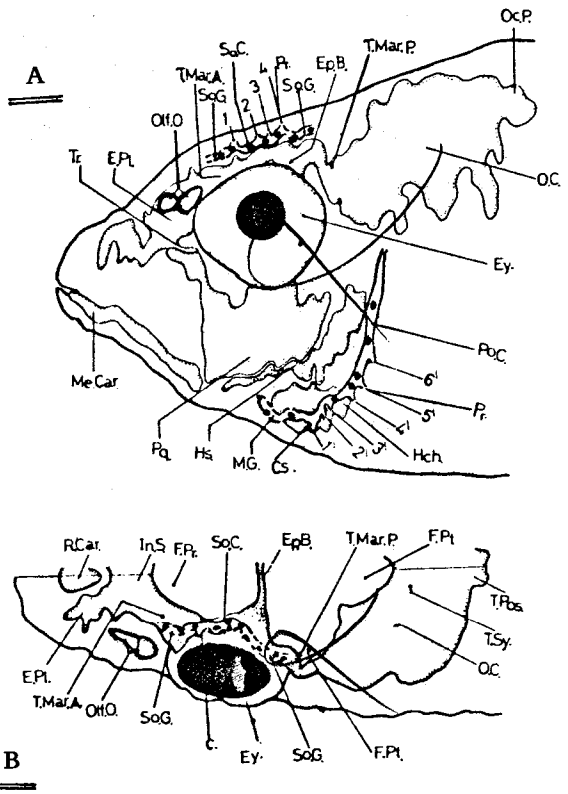


Fig. 4: Graphic reconstruction of the canal system and some replacing bones of 30 mm stage of *Cyprinus carpio*. X 15. A: Lateral view. B: Dorsal view.

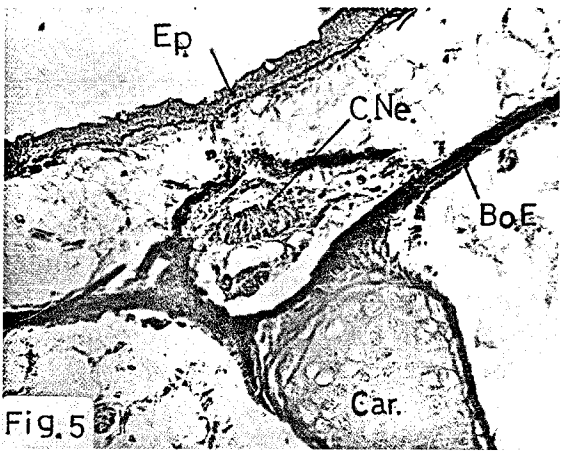


Fig. 5: Photomicrograph of a transverse section in the optic region of 30 mm. stage of *Cyprinus carpio*, showing the second neuromast of the supraorbital canal surrounded by bony elements. X 225.

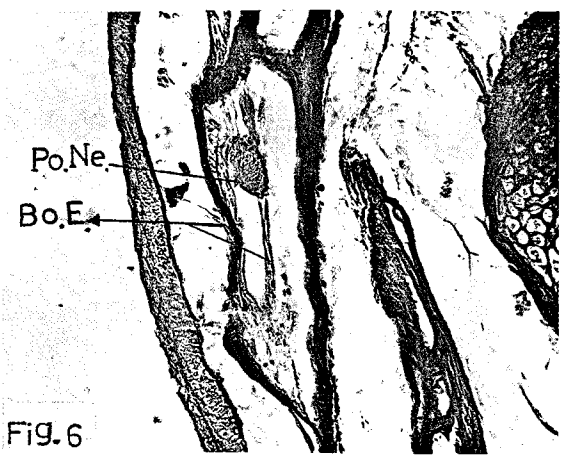


Fig. 6: Photomicrograph of a transverse section in the opercular region of 30 mm. stage of *Cyprinus carpio*, showing the second neuromast of the preopercular canal surrounded by bony elements. X 225.

The incomplete preopercular canal (Po. C.) is deeply embedded in the tissues of the operculum and surrounded by some bony elements (Fig. 6). It has no connection with the temporal canal (T.C.). It starts just antero-lateral to the hypoceratohyal (Hch.), and passes posteriorly to the hyosymplecticum (HS.) The preopercular canal then turns dorsally to terminate slightly near the otic capsule (Fig. 4). The pores (pr.) of the preopercular canal (4-6 in number) are also displaced to the terminal ends of tubular canaliculi (Cs.). Neuromasts of this canal are also 4 to 6 in number, and located inside its lumen (Figs. 4 and 6).

Fishes of total body length 32 mm. The supraorbital canal (So. C.) extends backwards from the poterior margin of the nasal opening to the epiphyseal bridge (Fig. 7B). At the junction of the epiphyseal bridge with the taenia marginalis posterior (T. Mar. P.), the supraorbital canal turns lateraly (Fig. 7B) taking its way on the dorsolateral region of the head over the taenia marginalis posterior to connect with the temporal canal (Figs. 7A and B). The lumen of the supraorbital canal contains seven well developed neuromasts, and opens to the exterior through eight terminal pores (T.Pr.) (Fig. 7A) as found in the adult condition.

The suprafrontal commissure (Sf.Co.), which has neither pores nor neuromasts, is still in the form of an invaginated groove and does not connect with the supraorbital canal (Fig. 7).

In the species studied, the temporal canal (T.C.) runs from the posterior end of the supraorbital canal to the posterior margin of the otic capsule. The temporal canal extends posteriorly to join the main body canal (M.B.C.). In the temporal canal, there are six pores opening ventrally, except the two most anterior ones which open dorsally. In this stage, there are two neuromasts inside the temporal canal, besides three neuromasts at the junction with supratemporal canal (Fig. 7A and B).

The supratemporal (St. C.) canal is well developed. It extends upwards from the middle part of the temporal canal and then runs forward, but the two canals of both sides do not connect with each other. In the supratemporal canal, there are five neuromasts and four pores opening dorsally to the outside (Fig. 7A & B).

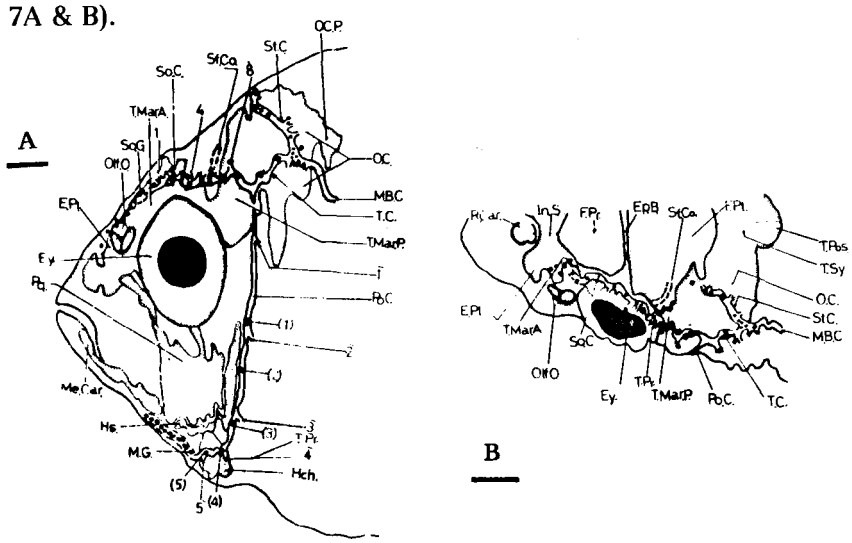


Fig. 7: Graphic reconstruction of the canal system of the head and some replacing bones of 32 mm. stage of *Cyprinus carpio*. X 11. A: Lateral view. B: Dorsal view.

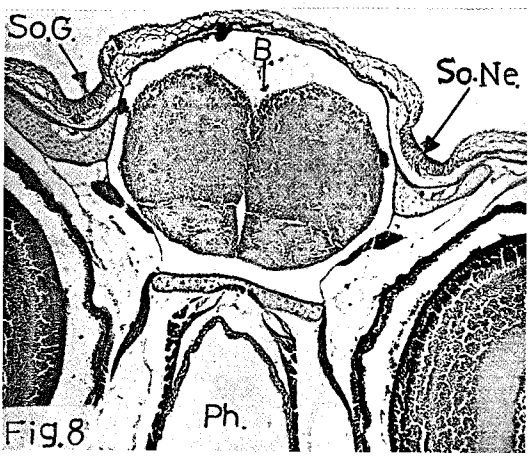
The preopercular canal (Po. C.) extends above the hypoceratohyal (Hch.) upwards to the taenia marginalis posterior (T. Mar. P.), but does not connect with the temporal canal (Fig. 7A). Between the posterior margin of Meckel's cartilage (Me. Car.) and the anterior margin of the hypoceratohyal (Hch.), there is a groove containing ten neuromasts and connected to the anterior end of the preopercular canal. The groove indicates the beginning of the formation of the mandibular canal which is incomplete in this stage. In the outer wall of the preopercular canal there are five canaliculi ending with five terminal pores. In this canal, there are five neuromasts.

In this stage, the infraorbital canal does not show any signs of appearance except a slight thickening of the epidermis especially between the neuromasts.

II. *Gambusia affinis affinis*

The canal system of *Gambusia* develops only in the supraorbital and operculomandibular regions of the head.

Fishes of total body length 10 mm. In this stage, the canal system begins to develop. The first sign of its formation is the sinking of some of the developed neuromasts below the epidermal level in the supraorbital and opercular regions (Figs. 8 and 9).



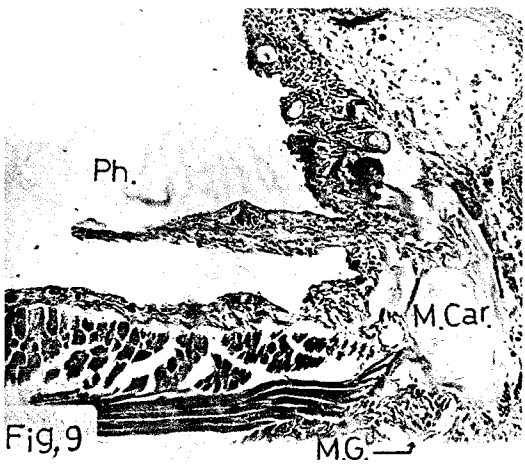


Fig. 8: Photomicrograph of a transverse section in the optic region of 10 mm. stage of *Gambusia affinis*, showing sinking of the supraorbital neuromast inside the supraorbital groove. X 113.

Fig. 9: Photomicrograph of a transverse section in the mandibular region of 17 mm. stage of *Gambusia affinis* affinis, showing sinking of the mandibular neuromast inside the mandibular groove. X 226.

Fishes of total body length 17.5 mm. The sinking of the neuromasts continues and the invaginating grooves appear. The supraorbital groove (So. G.) begins just above the olfactory opening, and extends posteriorly above the anterior half of the eye (Fig. 10). This groove still appears as an open furrow, showing no pores. In the supraorbital groove, there are three elongated neuromasts (I-III); the second being the longest.

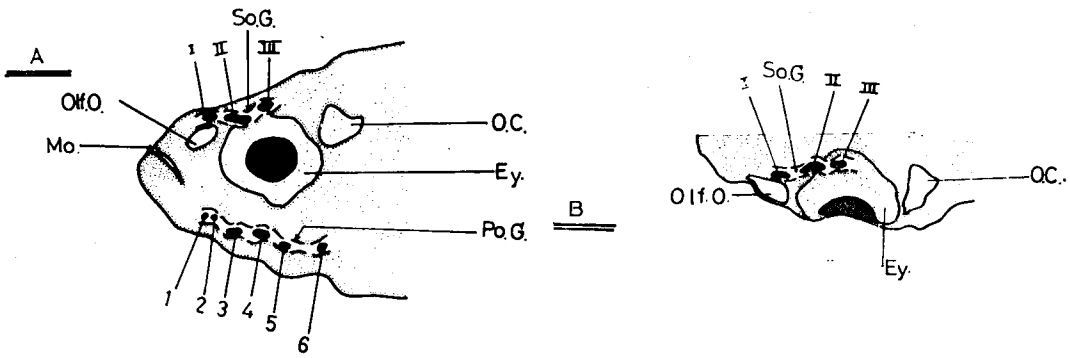


Fig. 10: Graphic reconstruction of the supraorbital and preopercular grooves of 17.5 mm. stage of *Gambusia affinis affinis*. X 16. A: Lateral view. B: Dorsal view.

The preopercular groove (Po. G.) is deeply embedded in the tissues of the operculum, but not yet in the bone. This groove extends below the eye, beginning at the level of the nostril and terminates at the level of the anterior edge of the otic capsule (Fig. 10A). Also, the preopercular groove still shows no pores. The groove has six neuromasts; the third and fourth being more elongated.

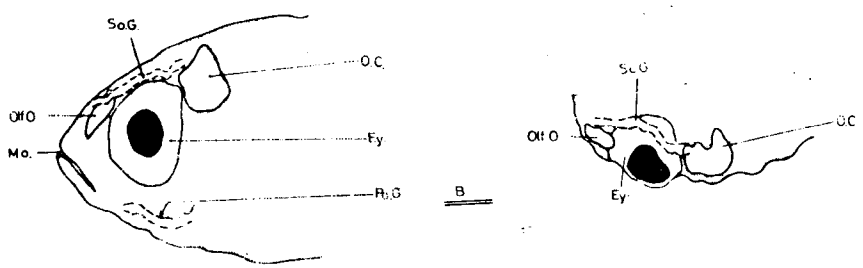


Fig. 11: Graphic reconstruction of the supraorbital and preopercular grooves of 20 mm. stage of *Gambusia affinis affinis*. X 10. A: Lateral view. B: Dorsal view.

Fishes of total body length 20 mm. The edges of the supraorbital and preopercular grooves, described in the preceding stage, roll up but do not fuse together. The supraorbital groove extends anteriorly above the olfactory opening and posteriorly above the otic capsule (Fig. 12).

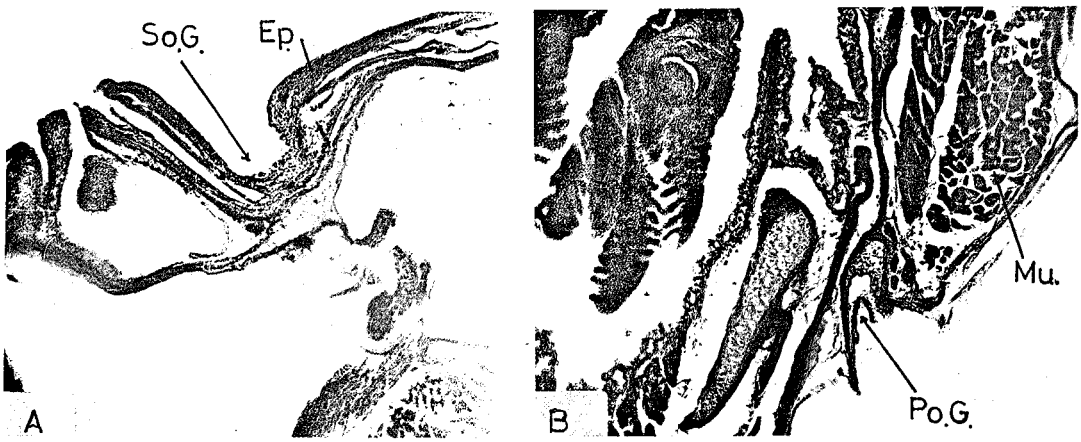


Fig. 12: Photomicrographs of transverse sections in the head region of 20 mm stage of *G. affinis affinis* showing:

A: The open superorbital groove. X 113. B: The open preopercular groove. X 113.

Fishes of total body length 27 mm. In this stage, the supraorbital groove resembles in its construction that of the preceding stage, except for the addition of a fourth elongated neuromast inside it

The preopercular groove takes the shape of an inverted "L" Fig. 13 A). The horizontal limb transforms into a canal estending horizontally below the eye. This canal opens to the exterior through two fine pores, and it contains three elongated neuromasts. The vertical limb of the "L" remains as a groove taking a vertical position behind the ventral half of the eye. It contains a single elongated neuromast occupying most of its length.

In this stage, the mandibular groove (M.G.) begins to appear from the mandibular line of the superficial neuromasts and extends along the lower jaw in front of the preopercular canal (Fig. 13A). In the mandibular groove, there are four neuromasts. in addition to two superficial neuromasts on each side anteriorly.

By studying the alizarin-stained preparations of 35 mm. stage of *Gambusia*, it has been found that the pattern of the canal system is nearly the same, as described in the latter stage, except for the transformation of the supraorbital and mandibular grooves into canals. Here, the observed canals appear surrounded by dermal bones of the skull.

DISCUSSION

The canal system of *Cyprinus carpio,* which is a bottom feeder fish, is more developed than that of the surface feeder fish *Gambusia affinis affinis.* In the latter species, there are no temporal, supratemporal or infraorbital canals, besides the reduction of the supraorbital and preopercular canals. There are 20 canals neuromasts in the adult specimens of *Cyprinus* and 8 only in *Gambusia.*

Gosline (1949), in dealing with the development of the canal system of the Cyprinodontidae, stated that the preopercular canal is either reduced to a canal with two pores or is completely absent. He also referred to the absence of closed canals in Amblyopsoidea. The same author, in his description of the canal system of *Nevadensis mionectes* and *Variegatus variegatus,* stated that there is neither a posterior extension of the supraorbital canal nor a supratemporal one across the back of the head.

Such reduction recorded in the members of family Cyprinodontidae was expected during the present studies of the canal system in *Gambusia affinis affinis* which is a surface feeder fish belonging to the same family.

On the other hand, in dealing with the study of the lateral line system of *Hybopsis* (Cyprinoid fish), Reno (1969) noticed a great number of pores usually present in the species which lives in dusk water. He also mentioned that, in some specimens, certain aspects of the canal system are plastic and highly responsive to environmental influences. However, more stable lateral line characteristics do not show such plasticity in association with particular environments.

In *Cyprinus carpio,* some of these stable characteristics such as the presence of the suprafrontal canal, supratemporal canal (commissure), and the connections of the temporal canal with the supra and infraorbital canals are observed. In addition, the shape of specific canals, completeness and position of certain bony elements, and overall canal patterns are also found.

Jarvik (1947) studying *Polypterus* (subclass palaeopterygii) and Bialowice and Jakubowski (1971) studying *Gaidropsarus mediterraneus* (subclass Neopterygii), observed that the canals of these fishes are accompanied by superficial lines of neuromasts. In the present work, the above condition of superficial lines and canals is well represented in *Cyprinus* than in *Gambusia.*

As regards the function of the canal neuromasts, the electrophysiological studies of Bergeijk and Harris (1962) reveal that canal neuromasts of the fishes are able to perceive sounds of low frequency and locate the source of sounds at a distance smaller than one wave length. Jakubowski (1974) demonstrated that the canal neuromasts receive stimuli by the so called canal endolymph.

LIST OF ABBREVIATIONS

A.Io.L.	:	Accessory infraorbital line	M.Ne.	:	Mandibular neuromast
B.	:	Brain	M.So.L.	:	Medial supraorbital line
Bo.E.	:	Bony elements	Mo.	:	Mouth
C.Ne.	:	Canal neuromast	Mu.	:	Muscle
Cs.	:	Canaliculus	Me.car.	:	Meckle's catilage
Car.	:	Catilage	N.L.	:	Nasal line
E.Pl.	:	Ethmoid plate	Ne.	:	Neuromast
Ep	:	Epidermis	O.L.	:	Oral line
Ey	:	Eye	Oc.P.	:	Occipital plate
Ep.B.	:	Epiphyseal bridge	Olf.E.	:	Olfactory epithelium
F.Pr.	:	Fontanella prepinealis	Olf.O	:	Olfactory opening
F.Pt.	:	Fontanella postpinealis	Ph.	:	Pharynx
Gls.	:	Gills	Pq.	:	Platoquadrate
Hs.	:	Hyosymplecticum	Pr.	:	Pore
Hch.	:	Hypoceratohyal	Po.C.	:	Preopercular canal
In.S.	:	Internasal septum	Po.G.	:	Preopercular groove
Io.L.	:	Infraorbital line	Po.L.	:	Preopercular line
L.	:	Lens	Po.Ne.	:	Preopercular neuromast
L.H.O.L.	:	Lower horizontal opercular line	R.Car.	:	Rostal cartilage
			So.C.	:	Supraorbital canal
M.G.	:	Mandibular groove	So.G.	:	Supraorbital groove
M.L.	:	Mandibular line	So.L.	:	Supraorbital line
M.B.C.	:	Main body canal	St.C	.	Supratemporal canal
St.L.	:	Supratemporal line	T.Sy.	:	Tectum synoticum
Sf.Co.	:	Suprafrontal commissure	T.Pos.	:	Tectum posterius
So.Ne.	:	Supraorbital neuromast	T.Mar.A.	:	Taenia marginalis anterior
T.C.	:	Temporal canal	T.Mar.P.	:	Taenia marginalis posterior
T.L.	:	Temporal line	Tr.	:	Trabecula
T.Pr.	:	Temporal pore	V.L.	:	Vertical line
			V.O.L.	:	Vertical opercular line

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دراسات تطورية مقارنة على جهاز القنوات الجانبية في سمكتي المبروك سيبرينس كاربيو والجامبوزيا جامبوزيا أفينس أفينس

الاحمدي شفيق الذهبي و يحيى السعيد العاصي و عبد البديع السيد العطار وجمال علي عوض

تم دراسة وتوزيع قنوات الخط الجانبي لسمكتي المبروك والجمبوزيا حيث وجد ان جهاز الخط الجانبي متطور جداً ومعقد في المبروك ، بينما هذا الجهاز مختزل وبسيط في الجامبوزيا .