POST-HATCHING MORPHOGENESIS OF THE FINS OF THE COMMON CARP FISH (CYPRINUS CARPIO L.)

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ABSTRACT

The present study was carried out on 45 common carp fish (Cyprinus carpio L.) ranging from 1-56 days-old post hatching in an attempt to describe the morphogenesis of the fins during the larval and juvenile stages of development. The newly hatched larvae were reared for 56 days-old and the specimens were collected periodically and prepared as usual for the light microscopic studies. The obtained results revealed that, in the larval stage (1-28 days-old), the fin rudiments of one day old larvae were represented only by a pair of pectoral fin paddle carrying an apical ectodermal ridge and by a continuous membranous median fin fold. The pectoral fin folds appeared to be clearly developed in larvae of 6 days-old while those of the dorsal, tail and pelvic fins were recognized in larvae of 16 days-old, but those of the anal fins were detected later on at 23 days-old. Differentiation of both fin blades and actinotrachial fibers were firstly detected in those of the pectoral fin in 16 days-old larvae, while those of dorsal, tail and pelvic fins were observed in larvae of 23 days old. In juvenile stage (29-56 days-old), the fin blades and actnotrachial fibers of the anal fins were observed in 30 days-old juvenile fish. The acellular bony demirays were detected firstly in the pectoral fin blades of juvenile fish of 40 days-old, followed by those of the dorsal, tail, pelvic and anal fin blades of 48 days-old juvenile fish. Meanwhile, the formation of the typical cellular bony demirays was detected in all fins at end of this study in juvenile fish of 56 days-old. As well, the fin epidermis appeared much thicker and contained mucous and club cells. Meanwhile, the fin corium was formed of fibrous meshwork containing many blood vessels and nerve bundles.

INTRODUCTION

It is generally accepted that the fins are a broad surfaced folds of the skin which contains especial supporting structures, fin rays which are designated as actinotrachia and lepidotrachia

(15; 16; 18 and 21). The fins of the teleosti are not only primarily organs of locomotion but also they can be modified to form a broad-sucking pad, defensive weapons as well as organs of copulation and camouflage, (16). The early developmental and structural features of the fin buds have been described in some of teleosti by (5; 10; 11; 13; 22 and 7). Yet, there is no attention on this subject in the common carp fish. This work was intended to describe the development of the fins in these fish, as they are one of the most successful and favorable fish for culturing in Egyptian water.

MATERIAL AND METHODS

The present study was carried out on 45 common carp fish (Cyprinus carpio L.) ranging from 1-56 days-old post hatching. The newly hatched larvae were collected at one day-old from Abbasa fish farm at Sharkia province, incubated and reared in an electrically aerated ponds under a suitable environmental and nutritional conditions until 56 days-old post hatching. The specimens were collected periodically and segregated into larval and juvenile stages (Table 1) according to the chronological events of development and description given by (2). The selected specimens were fixed in Bouin s fluid and 10% buffered neutral formalin, processed with the standard histological techniques and sectioned at thickness of 5um and the sections were stained with H&E, AB/PAS adopted by (2).

RESULTS

The organization of the fins of the present fish was studied during the larval and juvenile stages of development.

Larval stage (1-28 days-old), in one day-old post hatched larvae, the fin rudiments of the single or median fins were still undifferentiated and represented by a continuous median fin fold started caudal to the head and encircle the body and tail at its median plane. Meanwhile, the rudiments of the paired or bilateral fins were represented only by swimming pectoral paddle while those of the pelvic fins were still absent (Fig. 1). The median fin fold was an epithelial fold of one cell layer of flattened epithelial cells continuous with the general covering epithelium of the body and enclose a relatively empty subepithelial space (Fig. 2). As well, the pectoral fin paddle was formed of an epithelial envelope, similar to that of the median fin fold but it revealed a narrow apical ectodermal ridge. The core of such paddle was filled-up with two lateral subepithelial sheets of dense myotoms and one axial or central sheet of mesenchymal cells. Furthermore, the entire distal end of such paddle contained only aggregated mesenchymal cells, also, the apical

ectodermal ridge had neither myotoms nor mesenchymal cells (Fig. 3).

In larvae of 6 days-old, the epithelial layer of the pectoral paddle and its apical ectodermal ridge was formed of 2-3 layers of cuboidal epithelial cells. The mesenchymal and myotomal sheets which constitute the proximal part of the paddle were thought to be involved in formation of the proximal endoskeletal fin rays "radii" and fin musculature which fulfill the movement of the fins and permit its articulation with the pectoral girdle. Meanwhile the apical ectodermal ridge was much elongated and its core was filled-up with dense mesenchymal extension thereby the pectoral fin fold was formed (Fig. 4). At the same time the epithelial layer of the median fin fold was formed of 1-2 cell layer of cuboidal cells, while the cavity of such fold revealed evidence of migrated mesenchymal cells. As well, the median fin fold showed two minute contralateral epithelial outpockings assumed to be the prospective pelvic fin rudiments (Fig. 5).

In larvae of 9 days-old , the epithelium of the median fin fold becomes thickened into 2-5 cell layers of cuboidal cells and rested upon a distinct basal lamina. Also the core of such fold revealed more mesenchymal cells and apparent fibroblasts especially along its dorsal and tail end thereby the fin folds of the dorsal and tail fins were formed (Fig. 6). At the same time, the pelvic fin rudiments were clearly observed on both sides of the median fin fold at sites of the future pelvic fins. Such buds were formed of dense conical masses of migrated mesenchymal cells covered by an epithelial envelope continuous with that of the body surface. On the other hand, the intermittent part of the median fin fold located in between the pelvic buds appeared not more than an epithelial out-pocking enclosing an empty space (Fig. 7).

In 16 days-old larvae, the dorsal and anal fin folds were clearly differentiated along the dorsal and tail plane of the median fin fold. As well, the ventral part of the median fin fold caudal to the anal aperture revealed local condensation of migrated mesenchymal cells thereby the anal fin fold was differentiated (Fig. 8). At the same time, the pectoral folds showed progressive developmental changes as they differentiated into a broad fin blades. Such blades were formed of an epithelial envelope and connective tissue core. The epithelial envelope was formed of stratified squamous epithelium which was built-up of normal epithelial cells and revealed scarcely scattered club cells. On the other hand, the core of the developed blades was formed of loose meshwork of connective tissue fibers and fibroblasts and revealed scattered blood vessels and free blood cells. Furthermore, the epidermal basal lamina appeared more thicker and gave rise to disintegrated collagenic strip thereby the early differentiated collagenic actinotrachia were formed at the subepidermal space in close contact with the basal lamina. Each actinotrachia was formed of two symmetrical segments of straight homogeneous lamina with much less closely apposed spindle-shaped fibroblasts (Fig. 9).

In larvae of 23 days-old, the dorsal, tail and pelvic fin folds were clearly differentiated into a broad fin blades similar in its architecture to those of the pectoral fin which have been described in the previous age (Fig. 10 & 11). Moreover, the remainder part of the median fin fold which lifted beyond differentiation of the anal fin was disintegrated completely (Fig. 10 &11).

Juvenile stage (29-56 days-old), the anal fin blades appeared well-differentiated and had thick stratified squamous epithelium rested on thick epidermal basal lamina and revealed subepidermal actinotrachial fibers (Fig. 12).

In juvenile fish of 40 days-old, the epidermis of the developed fins revealed a great variation in its thickness and gave rise to inward evagination or epidermal pegs in relation to sites of the future lepidotrachia. The collagenic segments of the preexisting actinotrachia fibers were being to leave the subepidermal space and migrated to occupy the center of the fin core. Such segments were being to developed into strongly curved or c - shaped rods of acellular homogeneous lamina with closely apposed fibroblasts and/or ostioblasts onto the surfaces thereby the early differentiated demirays of the future lepidotrachia were formed (Fig. 13).

In juvenile fish of 48 days-old, the covering epidermal layer of the developed fins became more thicker and revealed numerously detected club cells. The developed demirays of the lepidotrachia were oriented deeply in the loose connective tissue corium of the pectoral, dorsal, tail and anal fins and became separated from the epidermal surface by a connective tissue sheet. Moreover, the proximal endoskeleton and musculature of the pectoral fin were observed (Fig.14)

In juvenile fish of 56 days-old, the general architecture of the developed fins assumed that of the mature fish. The epidermis revealed a great variation in its thickness and contained much number of goblet-like mucous and club cells but with some exception that the epidermis on the inner surfaces of the paired fins was thinner and had no club cells. The epidermal surface of the fins revealed many convolution in relation to sites of the fin lepidotrachia (figs. 15 &16). The connective tissue corium of the fins was a fibrous meshwork containing numerous blood vessels and nerve bundles especially in between the demirays of the lepidotrachia. The demirays of each lepidotrachia were being to be formed of ossified rods. Each rod was formed of typical cellular ossified matrix with clearly deposited osteocytes and closely apposed oseoblasts onto the surfaces. Moreover, the demirays of the firstly located lepidotrachia of the fins were fused or jointed with each other (Fig. 16 & 17).

DISCUSSION

The present study revealed that the organization of the fins in the common carp fish Cyprinus

carpio L.) followed a definite basic pattern which developed early during the larval stage and reached a more complex form during the juvenile stage. In one day-old Cyprinus carpio larvae, the initial pectoral fin rudiments were recognized in the form of a pectoral paddle carrying an apical ectodermal ridge similar to that described in the newly hatched larvae of Salmo trutta fairo (5); Killi scheli (22) and Clarias lazera (7). As well, the median fin rudiments of one day-old were resemled that described in the newly hatched larvae of Salmo trutta gairdenri (9) and Clarias lazera (7). On the other hand, the pelvic fin rudiments were still absent in such newly hatched larvae of the present stufy. Similar observation was recorded in the newly hatched larvae of Coregonus lavaretus (21); Salmo trutta gairdenri (12; 10; 11 and 13) and Clarias lazera (7). The larval fin folds were not only locomotory organs but, also provide a large respiratory and perhaps execretory surface as the respiratory organ were not yet developed in the newly hatched larvae (16).

In the growing larvae of salmo trutta fairro (5); Killi scheli (22) and Clarias lazera (7), the pectoral fin fold was differentiated from the preexisting apical ectodermal ridge. Similar finding was observed in the present study in larvae of 6 days-old. The pelvic fin rudiments of the growing larvae of Salmo trutta gairdenri (12; 9; 10 and 11) and Clarias lazera (7) were recognized in the form of an epithelial out pocking filled-up with mesenchymal cells. Such outpocking was located on either side of the median fin folds at sites of the future fins. Such pelvic fin rudiments were detected in the present fish larva of 9 days-old. The present study revealed that the fin folds of the median fins were differentiated within the primitive membranous median fin fold in order of dorsal, tail and anal fin folds similar order pattern of differentiation was noticed in larvae of Salmo trutta gairdneri (9) and Clarias lazera (7). The sub epidermal space of the developed fin folds or blades revealed tiny rods of collagenic actinotrachial fibers (8; 3; 9; 10 and 13). Similar finding was detected in the pectoral fin fold of 16 days-old larvae; in dorsal, tail and pelvic fin folds of 23 days-old larvae and later on, in the anal fin fold of 30 days-old larvae during the present study. The actinotrachial fibers of the fin fold were derived wholly from the migrated mesenchymal cells that colonized the fin fold (8 and 3). Meanwhile, (9; 14 and 13) concluded that, the actinotrachail fibers were firstly derived from the collagen epidermal basal lamina but the invaded mesenchymal cells were involved in the further formation of such actinotrachia. Such pattern of actinotrachail differentiation was detected in the present study. The role of the epidermal basal lamina in formation of the actinotrachia fibers was confirmed by the statement of (6) who said that, some of the embryonic epithelial cells produce collagen involved in the composition of the basal lamina and typical striated collagen fibers. The actintrachial fibers constitute the initial skeletal framework of the developed fin fold and provide a mophogenetic templat for development of subsequent lepidotrachia (17; 3; 18; 21; and 13). The actinotrachia werte though to be consisted of

scleroprotein "elastoidin" intermediate type between collagen and elastin (8; 3 and 14). Meanwhile, (9; 10 and 13) concluded that the actinotrachial rods were consisted of collagen.

In agreement with (21; 11 and 13) the early differentiated lepidotrachia of the present fins were developed within the preexisting actinotrachial fibers. Meanwhile, (17; 12 and 4) concluded that this lepidotrachia were derived exclusively from the invading mesenchymal cells at the interface between the basal lamina and the preexisting actinotrachia. The growing lepidotrachia constituting by acellular bony demirays. Hence, the fully organized ones were formed of typical cellular bony demirays characterized by presence of osteoblasts and osteocytes (19; 15; 17; 4; 21 and 12). Similar findings were observed in the present juvenile fish of 56 days-old. The lepidotrachia constitute the permanent fin skeleton, each lepidotrachium was consisted of two symmetrical parallel bony elements, demirays spatially separated in distinct collagenous network containing blood vessels and nerve bundles (17;4; 18; 21 and 13). This finding was in accordance with that observed in the present juvenile fish of 56 days-old. The lepidotrachia of the fins were formed without endochondral sequence by deposition of osteocytes and osteoblasts around the initially formed acellular matrix (19; 15; 17 and 21). Similar observations were detected in the present study. The present study revealed that the demirays of the firstly located lepidotrachium were fused to form a single hard-ossified ray similar to that described by (19; 18 and 15). Such hard lepidotrachia serve as defensive weapons and to divide the approaching water current in order to reduce the exerted forces of the current (16 and 18). The present study agreed with that of (20 and 18) as the fins had no true dermal layer but revealed a corium of fibrous meshwork. But disagreed with the finding of (7) in Clarias lazera in which the fins revealed a true dermal layer of compact collagenic bundles. The fin buds does not protruded in a similar way to that reported in the limb buds of the tetrapods, this morphological difference was revealed to the flattened shape of the fin fold compared to the cylindrical shape of the tetrapod limb buds (11).

Table (1): The collected specimens for the present study:

Stage	Number of specimens	Age/day
I-Larval stage	8	1
	5	6
	4	9
	4	16
	4	23
	4	28
Juvenile stage	4	29
	3	30
	3	40
	3	48
	3	56

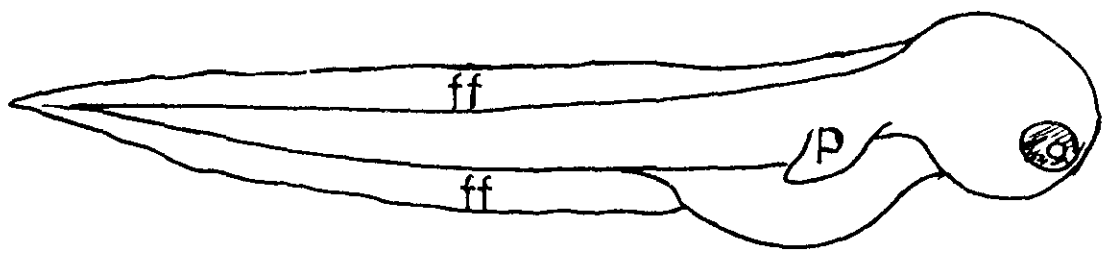

Fig. (1) : Illustrative diagram for the newly hatched larva of one day old showing, continuous median fin fold (ff), pectoral fin paddle (p).

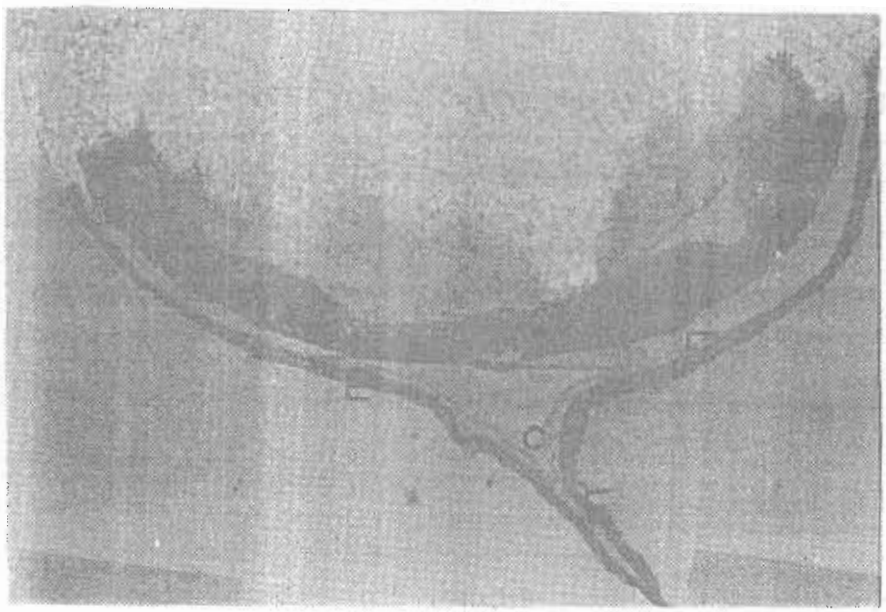

Fig. (2): A photomicrograph of cross section of the median fin fold of one day old larva showing, thin epithelial envelope (E), empty subepithelial cavity (c), and covering epithelium of the body (E) (H&E stain, X 400).

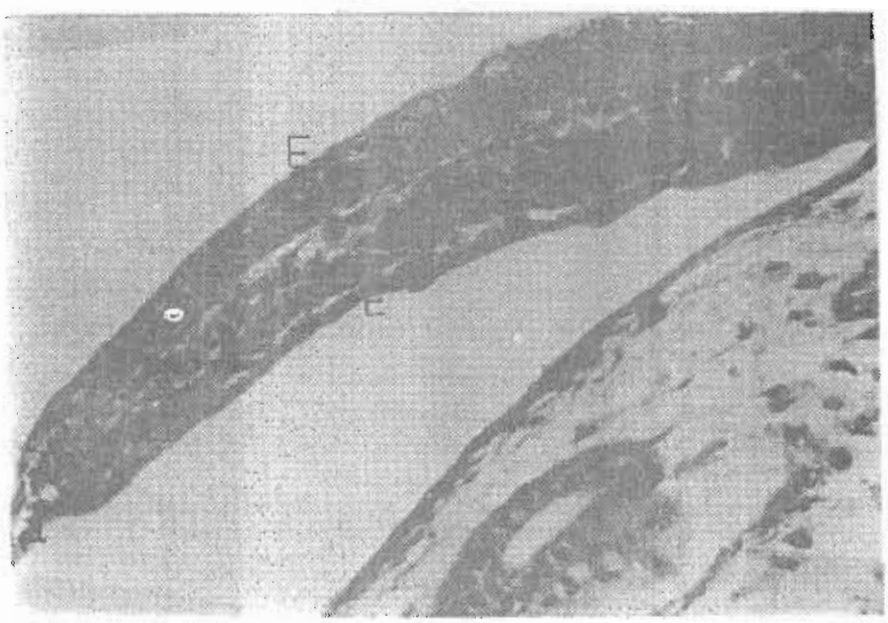

Fig. (3): A photomicrograph of longitudinal section of the pectoral paddle of one day-old larva showing, thin epithelial envelope (E), subepidermal myotomal sheets (M), axial mesenchymal sheet (m), distal mesenchymal condensation (c) and apical ectodermal ridge (a). (H&E stain, X 400).

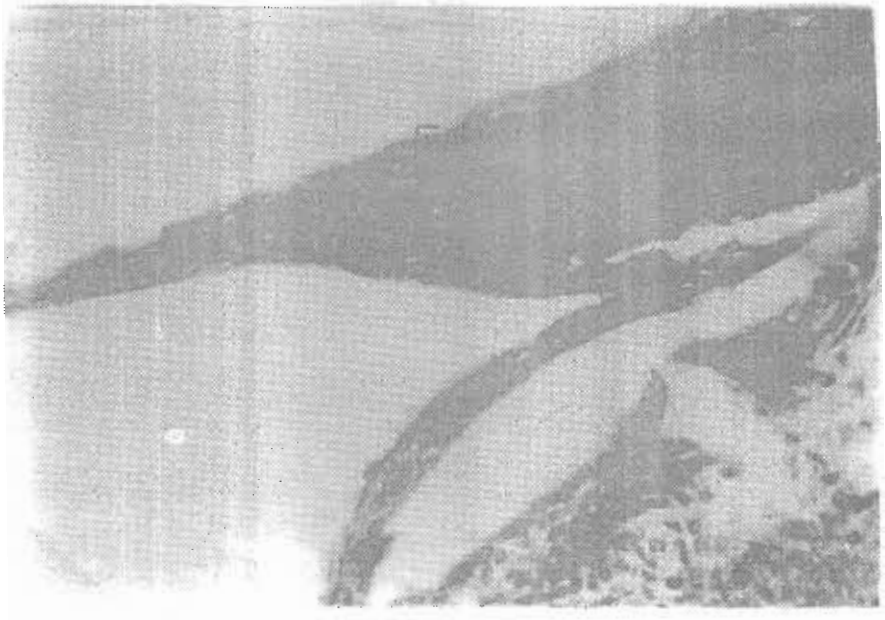

Fig. (4): A photomicrograph of longitudinal section of the pectoral fin fold of 6 days- old larva showing, epithelial envelope (E) and dense mesenchymal extension (M) (H&E stain, X stain400).

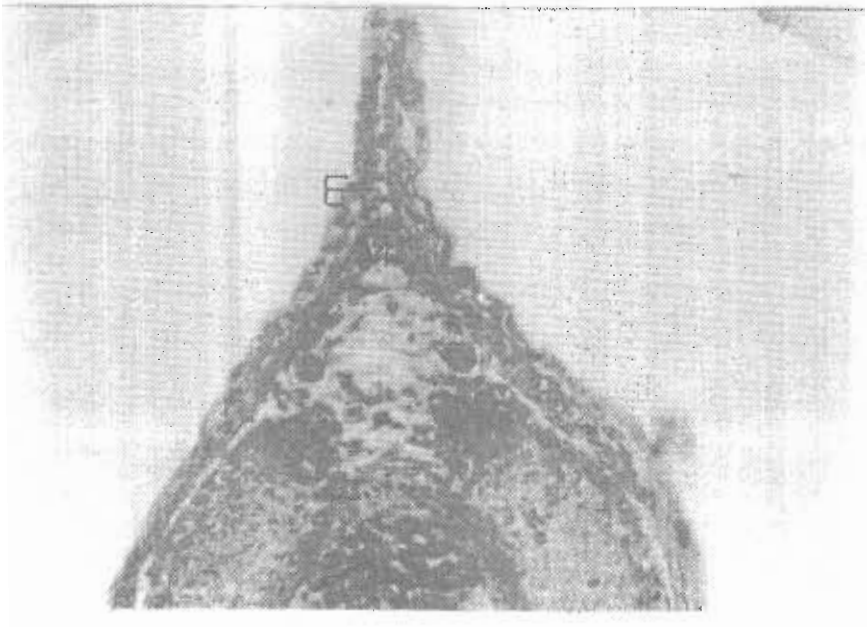

Fig. (5): A photomicrograph of cross section of the median fin fold of 6 day old larva showing, epithelial envelope (E) and migrated mesenchymal cells (M) (H&E stain, X 400).

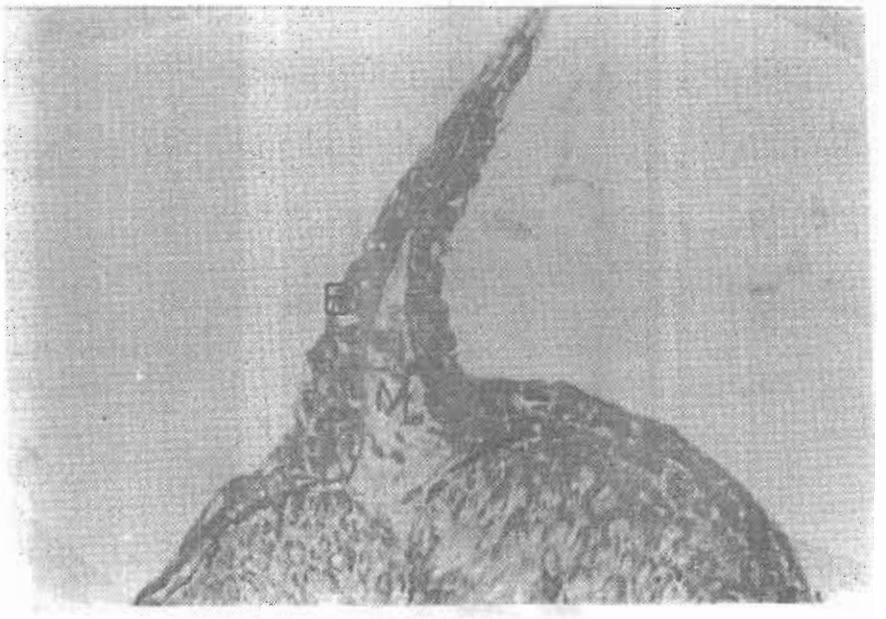

Fig. (6): A photomicrograph of cross section of the dorsal fin fold of 9 days-old larva showing, thick epidermal layer (E) and colonized mesenchymal cells (M) (H&E stain, X400).

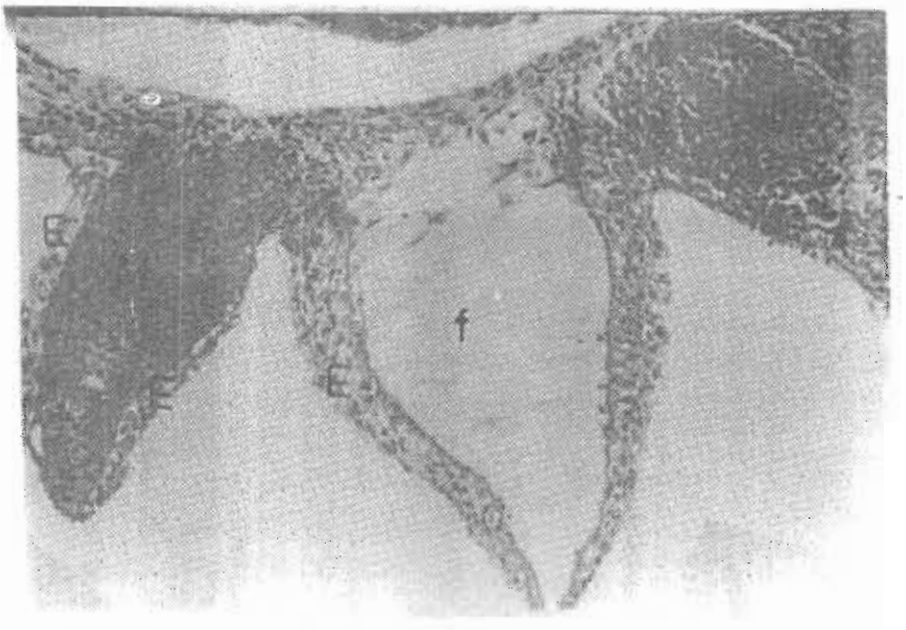

Fig. (7): A photomicrograph of cross section of the pelvic fin fold of 9 days-old larva showing, epithelial envelope (E) and dense mesenchymal core (M). Note the transit part of the median fin fold (f) (H&E stain, X400)

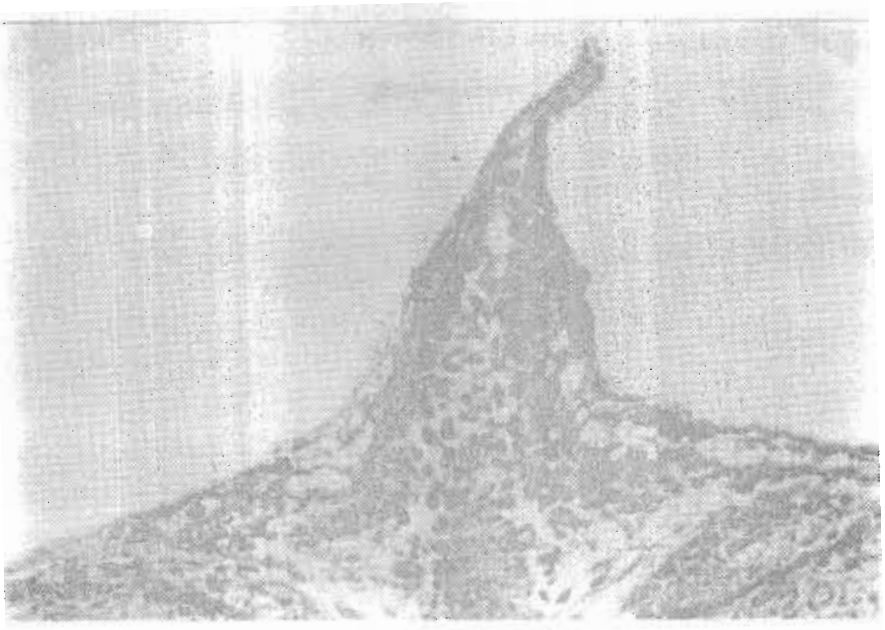

Fig. (8): A photomicrograph of cross section of the anal fin fold of 16 days-old larva showing, epithelial envelope (E) and mesenchymal core (M) (H&E stain, X 400).

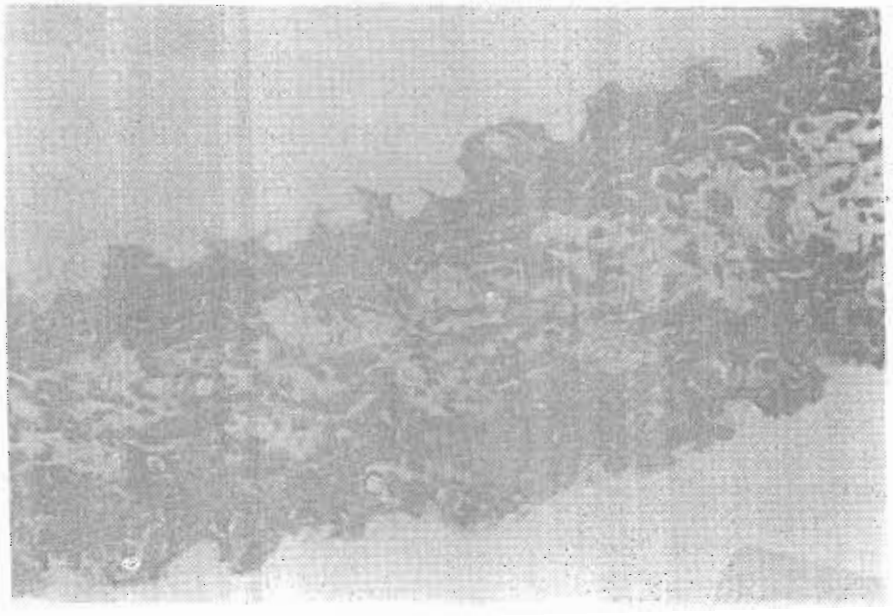

Fig. (9): A photomicrograph of cross section of the pectoral fin blades of 16 days-old larva showing, stratified squamous epithelial layer (E) , scattered club cells (c), corium of loose connective tissue (t) and actinotrachial segments (a) (H&E stain, X 400).

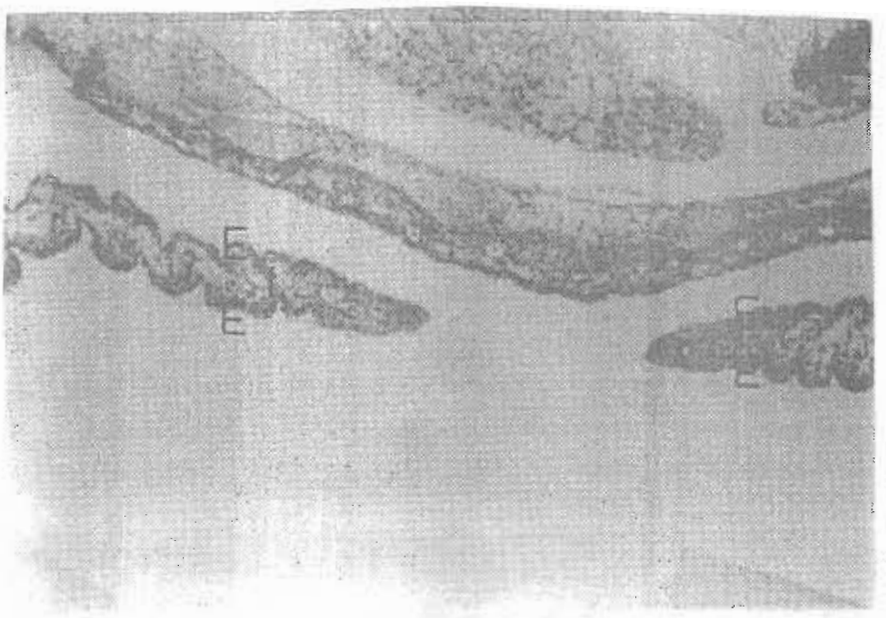

Fig. (10): A photomicrograph of cross section of the pelvic fin blade of 23 days-old larva showing, stratified squamous epithelium (E) and loose connective tissue corium (t). Note disappearance of the transient part of the median fin fold. (H&E stain. X 400).

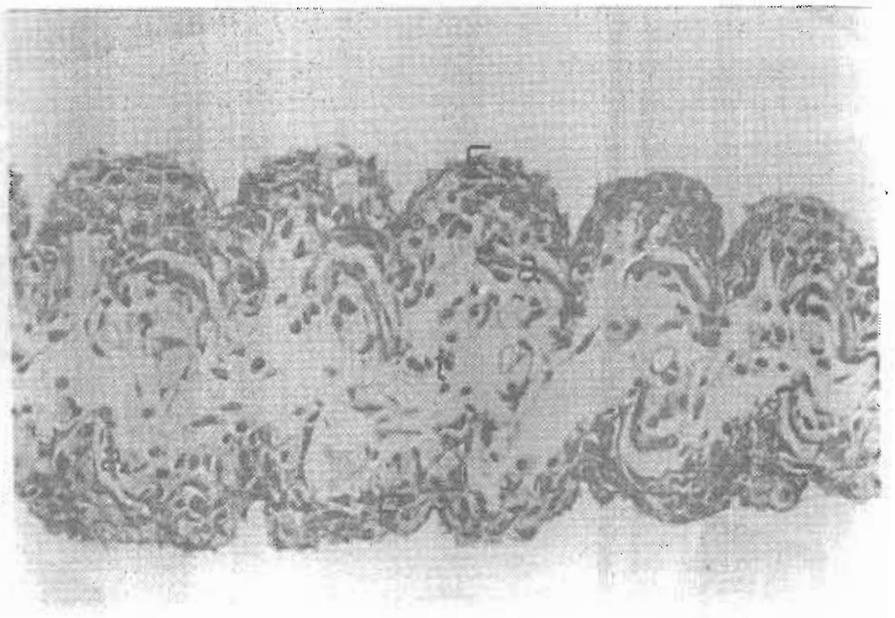

Fig. (11): A photomicrograph of cross section of the tail fin blade of 23 days-old larva showing,, epidermis (E), loose connective tissue corium (t)and segments of the actinotrachia (a) (H & E stain. X 400).

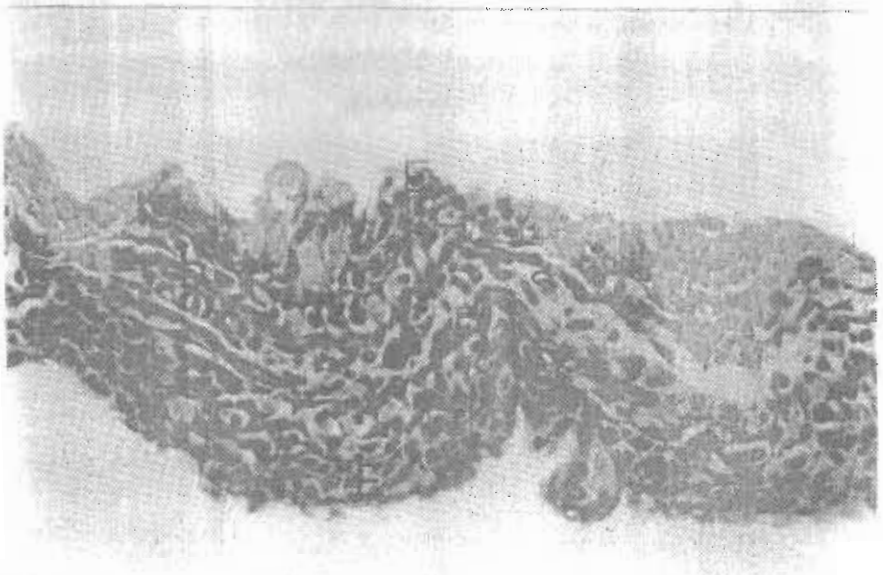

Fig. (12): A photomicrograph of cross section of the anal fin blade of 30 days- old juvenile fish showing,, thick epidermal layer (E), clear basal lamina (b), segments of the actinotrachia (a) (H&E stain, X 400).

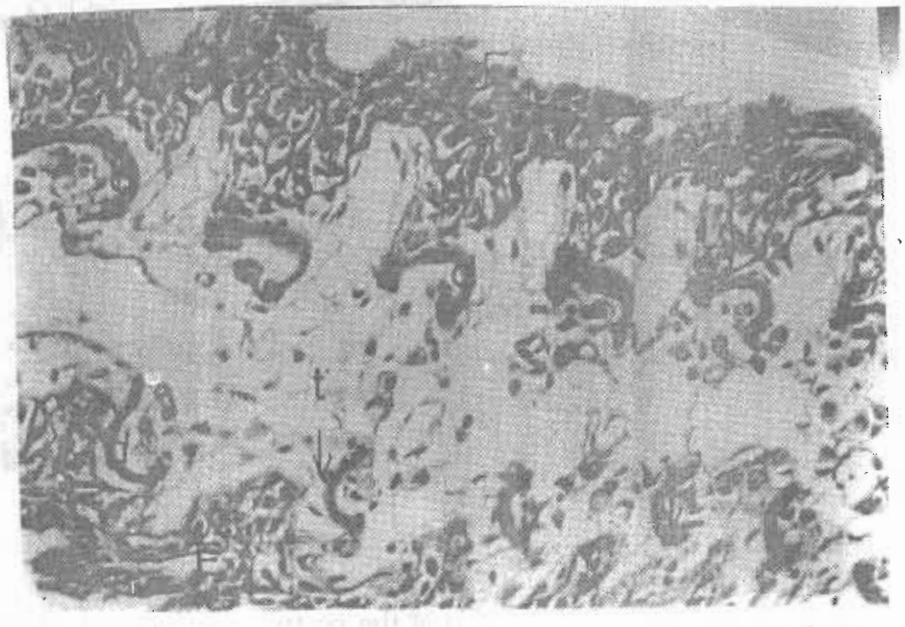

Fig. (13): A photomicrograph of cross section of the pectoral fin blade of 40 days- old juvenile fish showing, epidermal layer (E), epidermal pegs (p), curved demirays (d) of lepidotrachia, deposited fibroblasts and osteoblasts (arrow) and loose connective tissue corium (t) (H&E stain, X 400).

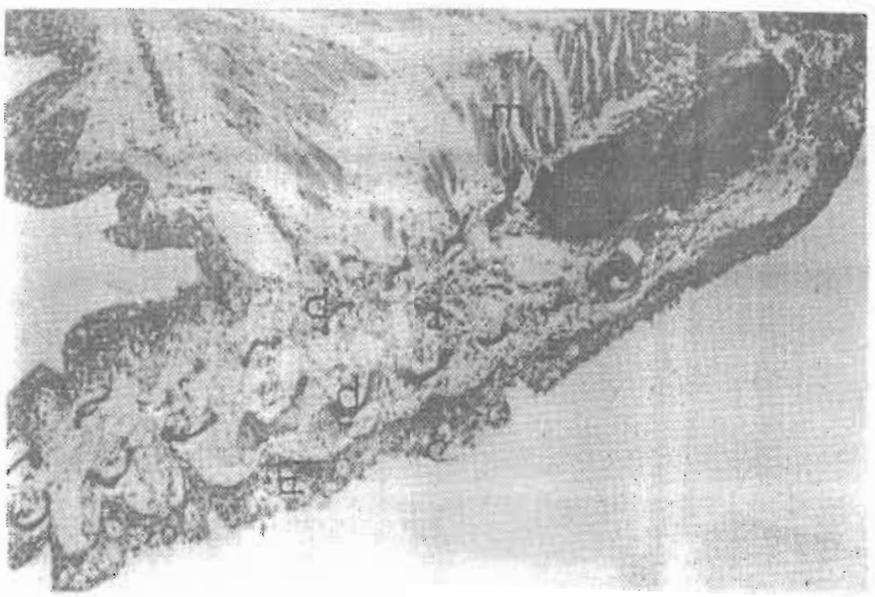

Fig. (14): A photomicrograph of cross section of the pectoral fin blade of 48 days-old juvenile fish showing. , epidermal layer (E), club cells (c), deeply located demirays (d) subepidermal connective tissue sheet (t) and loose connective tissue corium (t). Note the proximal endoskeletal fin radii (f) and fin musculature (m) (H&E stain. X 200).

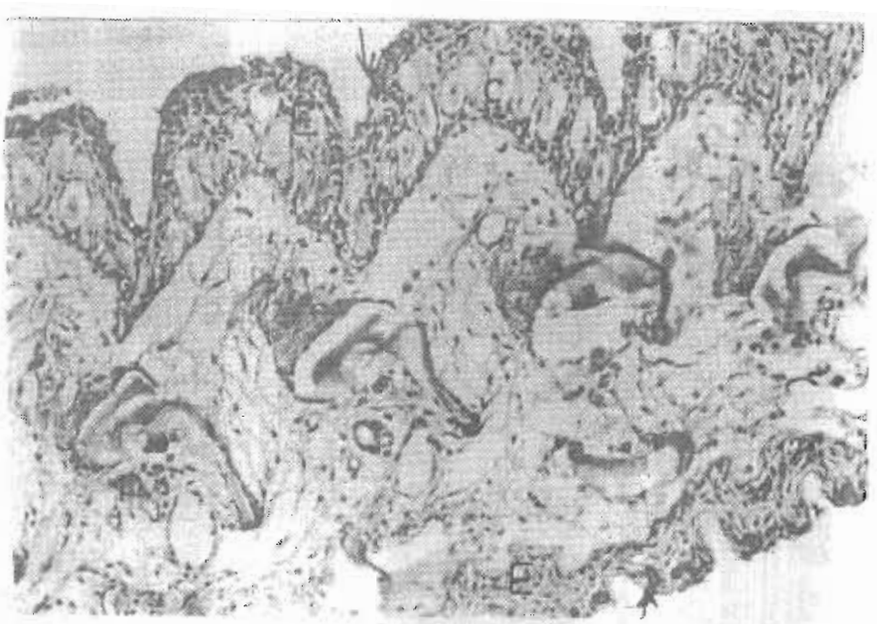

Fig. (15): A photomicrograph of cross section of the pectoral fin blade of 56 days- old juvenile fish showing,, epidermal layer (E), club cells (c) and goblet-like mucous cells (arrow) (AB/PAS stain, X 400).

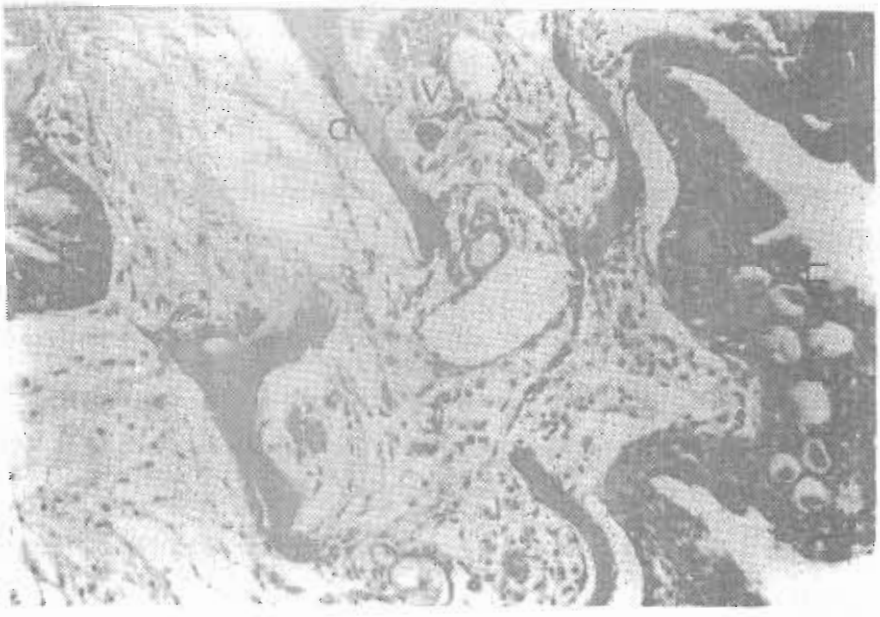

Fig. (16): A photomicrograph of cross section of the pelvic fin blade of 56 days- old juvenile fish showing,, epidermis (E), ossified demirays (d), blood vessels (v), nerve bundles (n) and loose connective tissue corium (t) (H&E stain, X400)

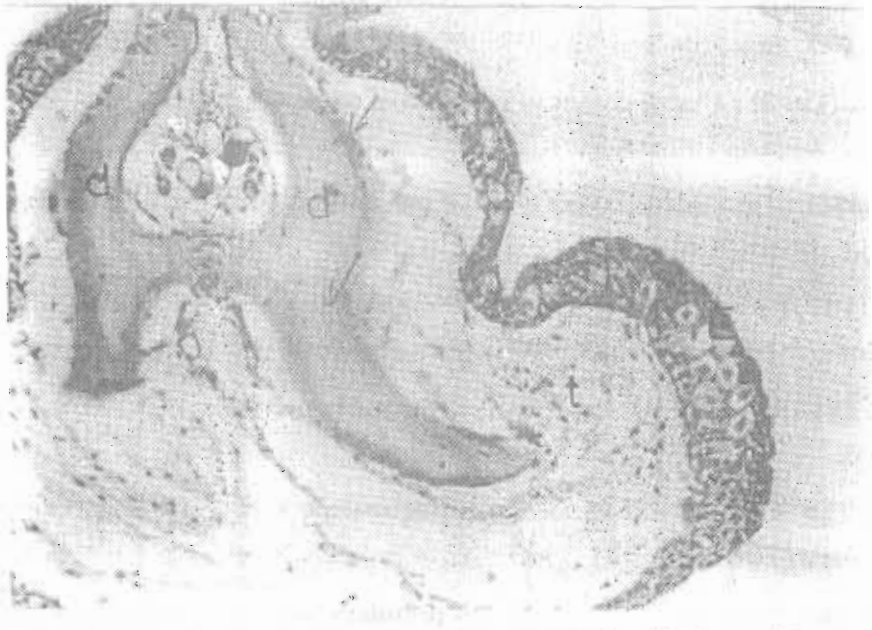

Fig. (17): A photomicrograph of cross section of the dorsal fin blade of 56 day old juvenile fish showing, epidermis (E), fin corium (t), ossified demirays (d) osteoblasts and osteocytes (arrow). Note the fusion between the demirays constituting the lepidotrachia. (H&E stain, X 400).

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الملخص العربى

تطور الزعانف فى أسماك المبروك العادى مابعد الفقس

صلاح المرسى المرسى

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لقد أجريت هذه الدراسة على عدد ٤٥ عينة من أسماك المبروك العادى والتى تراوحت أعمارها مابين ١-٥٦ يوم وقد جمعت العينات خلال مرحلتى اليرقة والطور اليافع وجهزت للدراسة بالميكروسكوب الضوئى وبينت النتائج الآتى :

أولاً : فى مرحلة اليرقة (١-٢٨ يوم) وجدت بدائيات الزعانف فى اليرقات حديثة الفقس ممثلة بزوج من المجاديف الصدرية تحتوى على قمة مضغية وبطية زعنفية وسطية. ولقد ظهرت ثنايات الزعانف الصدرية واضحة عند عمر ٦ يوم بينما ظهرت طيات كل من الزعنفة الظهرية والزيلية والحوضية وكذلك الشرجية على مر ١٦ و ٢٣ يوم بالتتابع، وقد تميز النصل الزعنفى والإشعاعات الشعرية الليفية بالزعنفة الصدرية عند عمر ١٦ يوم وبالزعنفة الظهرية والزيلية عند عمر ٢٣ يوم. فى مرحلة الطور اليافع (٢٩-٥٦ يوم) : قد إكتمل تميز النصل الزعنفى والإشعاعات الشعرية الليفية للزعانف بظهورها فى الزعنفة الشرجية على عمر ٣٠ يوم ولقد أظهرت بشرة وادمة أو لب الزعانف تطورات واضحة حيث تميزت الإشعاعات الحرشفية شبه العظمية بالزعانف الصدرية على مر ٤٠ يوم بينما ظهرت بالزعانف الظهرية والزيلية والحوضية والشرجية على عمر ٤٨ يوم. بينما ظهرت الحراشيف العظمية فى كل الزعانف على عمر ٥٦ يوم. كما ظهرت طبقة الشرة سميكة وتحتوى على خلايا سباتية وأخرى مخاطية سبة كاسية وأيضاً ظهر لب الزعانف مكوناً من نسيج ضام ليفى مفكك غنى بالأوعية الدموية والألياف العصبية عند عمر مابين ٤٨-٥٦ يوم.