

Comparative study on the adaptations for air-breathing and jumping in amphibious fish, *Alticus kirkii* and non-amphibious fish, *Gambusia affinis holbrokii*

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Abstract: The present work aimed to comparative study on the adaptations in morphology, structures of skin and muscles of Kirk's blenny, *Alticus kirkii* and mosquito fish, *Gambusia affinis holbrokii* for understand how to air-birthing and jumping in amphibious fish, *A. kirkii*. 42 of *A. kirkii* were collected from intertidal zone of Ras Mohamed in Sharm El-Sheikh and 12 of *G. affinis holbrokii* were obtained from EL-Sayeda Aisha market during April, 2017. Results showed that the epidermis of *A. kirkii* can absorb air via cutaneous adaptations; thin epidermis, rich with blood capillaries, highly vascularization and contain three types of mucous cells that permit enhanced perfusion during aerial exposure. While, in the skin of *G. affinis holbrokii* contain one type of mucous cells. The giant cells and club cells are not found. The jumping of *A. kirkii* above the rocks is taken by movement of caudal peduncle with many adaptations in morphometric and structure of skin and muscles in this area. The short of head and trunk and low body weight in the fish helps in jumping of the fish. The caudal peduncle length was stretching for helps in easy encircling during jumping. The stratum spongiosum in the dermis is much thicker and composed of reticular connective tissue dispersed in loose areolar connective tissue for flexibility and bending of caudal peduncle. The stratum compactum is thinner and built up of fibrous connective tissue for reinforcement of caudal peduncle. The adipocytes were large in size, found between dermis and muscles and uses for energy and increasing of spaces. The structure of skin in caudal peduncle of *G. affinis holbrokii* was adapted to thrashing movement of this fish. The dermis layer is reduced. The adipocyte layer and red muscles are absent. The axial muscles in caudal peduncle of *A. kirkii* consists of superficial red layers (slow red muscles) which used mainly for sustained energy efficient swimming and deep white layers (fast white muscle) which used at high swimming speeds. They are sources of high energy and high speeds for intense contraction which required in jumping. The structure of axial muscles in caudal peduncle of *G. affinis holbrokii* was consists of white layers (fast white muscle) only.

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Key words: Comparative, adaptations, Amphibious, *Alticus kirkii*, *Gambusia affinis*

1. Introduction

Amphibious fishes are those known to utilize both aquatic and terrestrial habitats and spend periods of time out of water as normal parts of their life histories (Gordon, 1998). They are distributed in many marine and fresh water habitats in tropical, subtropical and temperate regions (Sayer and Davenport, 1991). The terrestrial activities of amphibious fishes are closely related with feeding, courting and defending territories (Murdy, 1989). The fish were air-breathing when on land and respiration depends largely on gas transfer via the skin (Park *et al.*, 2006 and Harabawy & Mekawy, 2011).

Graham (1997) estimated that there are 374 species of air-breathing fishes. Of these, some are amphibious and breathe air mainly when out of water. Among amphibious species, most of which are found in the littoral zones of marine habitats, some species of rockskipper of the family Blenniidae spend almost all of the time out of water. For example, Gordon *et al.* (1985) reported that *Alticus kirki* spends >80% of its

time on rock surfaces above the edge of the sea. Bhikajee & Green (2002) mentioned that fishes which spend most of their lives out of water are inherently interesting and have potential for providing information regarding factors that likely led to the early origin of air-breathing.

Blennis are a large group of small fishes. The body is elongate with blunt headed and scales less with a long continuous dorsal fin. There may be a deep notch between the spinous and soft portions of the fin and the last dorsal ray is often connected by a membrane to the caudal fin. Their pelvic fins were distinctly anterior to the pectorals. The anal fin contain two spines (first may be imbedded in females) and pelvic fins supported by one spine and 2 – 4 rays. Mot blennis are bottom dwelling territorial fishes that lay adhesive eggs often guarded by the male. Many species have tentacles or cirri on the head, usually above the eye; some have a fleshy crest on top of the head. The mouth is low on the head and the teeth usually numerous, slender and close-set. Most species

are well-camouflaged, often similarly patterned to one another and cryptic inhabitants of rocky shorelines, reef flats or shallow seaward reefs (Randall, 1983 and Lieske & Myers, 2004).

The leaping blenny, *Alticus kirkii* is an amphibious blenny that occurs abundantly in rocky intertidal areas in the Red Sea region (Klausewitz, 1964). The fish are small, reaching no more than 12 cm S.L. (standard length) as adults. They are diurnal, highly social and spend most of their active time out of water, above but near the tidally varying water line and able to leap from one pool to another. On land they actively graze on attached algae and interact in complex ways with their conspecifics and other species in their habitat (Randall, 1983; Brillet, 1986 and Brown *et al.*, 1991 & 1992).

The modifications and functional morphology of air-breathing and respiration in intertidal fishes in fresh water and marine species have been investigated (Graham, 1997 & 2011; Taylor, 2000; Taylor *et al.*, 2003 & 2008; Park *et al.*, 2003, 2004 & 2006 and Harabawy & Mekkawy, 2011). There are no available studies concerning the comparison between air-breathing and non-air-breathing fishes in morphology, structures of muscles and skin to detection how to leaping and air birthing in amphibious fish, *A. kirkii*.

Therefore, the present work aimed to comparative study on the adaptations in morphology, structures of skin and muscles of Kirk's blenny, *Alticus kirkii* and mosquito fish, *Gambusia affinis holbrokii* for understand how to air-breathing and jumping in amphibious fish, *Alticus kirkii*.

2. Material and methods

1. Specimens collection:

A total of 54 specimens; 42 of Kirk's blenny, *Alticus kirkii* (Figure 1) and 12 of mosquito fish,



Figure (1): A photograph of Kirk's blenny, *Alticus kirkii*

Gambusia affinis holbrokii (Figure 2) formed the materials for the present study. Specimens of *A. kirkii* were collected from intertidal zone of Ras Mohamed in Sharm El-Sheikh, during April, 2017. Hand net was the main fishing method used to collect the fish. Specimens of *G. affinis holbrokii* were obtained from EL-Sayeda Aisha market during April, 2017. Wherever possible fish were examined fresh or preserved in 10% formalin solution for latter examination. Two species were transported to the laboratory of marine biology in Zoology Department, Faculty of Science, Al-Azhar University. In the laboratory, fish were taxonomically identified, as far as possible up to genera according to Lieske & Myers (2004) and then the following studies were carried out.

2. Morphometric characters:

To study morphometric characters of *A. kirkii* and *G. affinis holbrokii*, the following measurements were recorded for each fish: total length (T.L.); standard length (St.L.); head length (H.L.); eye diameter (E.D.); body depth (B.D.); trunk length (Tr.L.); caudal peduncle length (C.P.L.) and caudal peduncle depth (C.P.D.). The shape and the color of the fish were also described and recorded.

3. Histological studies of muscles and skin:

Small pieces (5 mm) of head, trunk and caudal peduncle in *A. kirkii* and *G. affinis holbrokii*, fixed in alcoholic Bouin's fluid for at least 48 hours, dehydrated in ascending concentrations of ethyl alcohol, cleared in xylene and embedded in wax (M.P.: 58°C). Vertical sections in skin and longitudinal sections in muscles of caudal peduncle were cut at 4-6 μ in thickness stained with Harris's haematoxylin and eosin (Humason, 1979) for routine histological examination. Finally, the slides were microscopically examined then photographed and described.



Figure (2): A photograph of mosquito fish, *Gambusia affinis holbrokii*

3. Results

1. Morphological studies:

The body of Kirk's blenny, *Alticus kirkii* is elongate in shape with median crest on head. Caudal

fin rays simple; segmented anal fin rays 23 to 28; pelvic fins with 3 or 4 segmented rays. Standard length attains 66.67 - 95.56% with an average of 85.02 ± 5.42 in the total length. The head is comparatively short and

laterally compressed. Head length attains 13.03 - 24.62% (average 18.43 ± 2.53) of the standard length. The mouth is ventral in position with incisiform teeth. Eyes are relatively large; eye diameter represented 25.84 - 53.33% (average 41.53 ± 8.29) of the head length. Trunk length attains 23.93 - 35.01% with an average of 29.12 ± 3.52 in the standard length. Body depth represents 13.39 - 23.54% (average 17.30 ± 2.09) of the standard length. Caudal fin rounded and caudal peduncle length attains 54.85 - 72.41% (average 61.46 ± 3.47) of the standard length. Caudal peduncle depth attains 9.72 - 15.56% with an average of 12.30 ± 1.78 in the standard length. The colour of the fish is brown to tan with double dark bars which join dorsally. Dorsal fin is alternating diagonal lines of dark brown and pale tan. Anal fin have a narrow black of submarginal band and the tips of the rays is whitish (**Table 1 and Figure 1**).

Mosquitofish, *Gambusia affinis holbrokii* is small, dull grey, with a large abdomen, and have

rounded dorsal and caudal fins and an upturned mouth towards the surface. The body is distinctly elongated, laterally compressed. Standard length attains 72.26 - 83.77% with an average of 79.24 ± 3.5652 in the total length. The head is comparatively short; dorso-laterally compressed. Head length attains 21.93 - 30.27% (average 26.44 ± 2.18) of the standard length. The mouth is terminal in position; crescentic in shape; slightly directed upwards; slightly protrusible, due to the presence of free maxilla. Eyes are relatively large; eye diameter represented 26.58 - 47.46% (average 39.28 ± 6.28) of the head length. Gill opening is relatively small. Trunk length attains 30.59 - 48.10% with an average of 38.61 ± 5.52 in the standard length. Body depth represents 22.35 - 33.46% (average 28.17 ± 3.07) of the standard length. Caudal peduncle length attains 32.18 - 46.30% (average 38.65 ± 4.56) of the standard length. Caudal peduncle depth attains 18.43 - 29.18% with an average of 22.16 ± 3.49 in the standard length (**Table 1 and Figure 2**).

Table (1): Morphometric characters of *Alticus kirkii* collected from Ras Mohamed, Sharm El-Sheikh and *Gambusia affinis holbrokii* obtained from EL-Sayeda Aisha market.

Characters	<i>Alticus kirkii</i>		<i>Gambusia affinis holbrokii</i>	
	Range	Mean \pm SD	Range	Mean \pm SD
Standard length / Total length (%)	66.67 - 95.56	85.02 \pm 5.42	72.26 - 83.77	79.24 \pm 3.56
Head length / Standard length (%)	13.03 - 24.62	18.43 \pm 2.53	21.93 - 30.27	26.44 \pm 2.18
Eye diameter / Head length (%)	25.84 - 53.33	41.53 \pm 8.29	26.58 - 47.46	39.28 \pm 6.28
Trunk length/ Standard length (%)	23.93 - 35.01	29.12 \pm 3.52	30.59 - 48.10	38.61 \pm 5.52
Body depth / Standard length (%)	13.39 - 23.54	17.30 \pm 2.09	22.35 - 33.46	28.17 \pm 3.07
Caudal peduncle length / Standard length (%)	54.85 - 72.41	61.46 \pm 3.47	32.18 - 46.30	38.65 \pm 4.56
Caudal peduncle depth / Standard length (%)	9.72 - 15.56	12.30 \pm 1.78	18.43 - 29.18	22.16 \pm 3.49

2. Skin structure:

The integument of *A. kirkii* in different regions of the body (crest, head, lateral side of trunk and caudal peduncle) is consists of two distinct principal layers: the outer layer and the inner layer. The outer thin layer is the epidermis which essentially cellular in structure, comprised of a multilayered epithelium that usually includes specialized cells. The inner thick layer is the dermis which is primarily a fibrous structure with relatively few cells, although it may contain nerves, blood vessels, adipose tissue and pigment cells (**Plate 1A, B & C**).

The epidermis is built up of a stratified squamous epithelium, its cells are arranged in several layers one above the other. These layers are not uniform. The cells of the basal layer are columnar, while those near the surface are flattened. This accounts for naming the epidermal epithelium by its name. The cells in between are polygonal, while those lying on the surface itself are dead. Accordingly the basal layer is known by the germinative or Malpighian layer, and the superficial layer consist of the superficial cells. The nuclei of these cells decrease gradually in size as their cells approach the surface (**Plate 1B & C**).

There are three types of mucous cells; (1) The small mucous cells are numerous, round or oval in shape with greater diversity in size and forms. They are much more concentrated in the upper layers than in the middle and lower ones of the epidermis. The type found near surface is rounded in shape. The crescent nuclei are housed in a cytoplasmic basal process. This type of cell is found in different regions of the body (crest, head, lateral side of trunk and caudal peduncle) (**Plate 1A, B, E and Plate 2A, B, & C**). (2) The giant mucous cells are abundant, large in size and round, polygonal or elongate in shape with greater diversity in size and forms. They are occupying the majority of middle layers and much more concentrated in the middle layers than in the upper and lower ones of the epidermis. This type of cell is found in different regions of the body (crest, head) (**Plate 1A, B & C**). (3) The club cells (alarm cells) are confined to the deeper epithelial layers touching their rounded heads with the layers of flattened epithelium. They are fewer in number, very faint in color and close to the Malpighian layer, being oval in shape with different sizes. The cytoplasm of the club cells is homogeneous, stained faint red with haematoxylin and eosin and contains one oval nuclei in the central region. This type of cell is found in the head and caudal peduncle regions (**Plate 1A, B & C and Plate 2A**).

A large number of fine blood capillaries in the form of circles containing some erythrocytes below the columnar cells accompanied by dermal collagen are found in different regions of the body (crest, head, lateral side of trunk and caudal peduncle). The diffusion distance between the capillary endothelial cells and the outer edge of the epidermis is very low (**Plate 1A, B, C & E and Plate 2A**).

The dermis is consisting of a connective tissue differentiated into two distinct layers, the outer layer is built of fibrous and collagenous connective tissue, hence called the stratum compactum, while the inner of which is built up of an areolar connective tissue, hence called the stratum spongiosum. The dermis layer is rich in blood vessels and nerve fibers which are connected with the cells of the epidermis. It also contains cells which are irregular in shape, lies close to the stratum compactum and appear full of the black granules, hence called melanophores (**Plate 1B & C**).

The skin of *G. affinis hollobrokkii* in different regions of the body (head, lateral side of trunk and caudal peduncle) is made up of usual two layers, an outer epidermis and an inner dermis. Epidermis is typically very thin, composed superficially of several layers of flattened, moist epithelial cells. The deepest layer is a zone of active cell growth and multiplication, known as a columnar germinative layer next to the dermis. Live cells of epidermis are in contact with the medium via mucous covering without cornified layer.

There are unicellular mucous glands that discharge the mucous that forms the slimy outer covering of fishes. Mucous cells are numerous, variation in size, rounded or ovoid in shape and concentrated near the surface of the epidermis. The giant cells, club cells and blood capillaries are not found (**Plate 1D & F**).

The dermal layer of the skin is made up of a stratum spongiosum, just beneath the epidermis and a deep stratum compactum. It contains pigment cells, blood vessels, nerves and cutaneous sense organs and origin of scales (**Plate 1D & F**).

3. Jumping:

The jumping of *A. kirkii* above the rocks is taken by movement of caudal peduncle with many adaptations in structure of skin and muscles in this area. The dermis of caudal peduncle is consisting of a connective tissue differentiated into two distinct layers, the outer thick layer towards the epidermis, the stratum spongiosum and the inner thin layer towards the muscles, the stratum compactum. The outer layer is much thicker and composed of reticular connective tissue dispersed in loose areolar connective tissue for flexibility and bending of caudal peduncle. The inner layer is built up of fibrous connective tissue for reinforcement of caudal peduncle. There are thick layer of a large droplet of adipocytes between dermis and muscles. The adipocytes are large in size, uniform in shape and arrangement in one layer for energy and increasing of spaces (**Plate 2A, B & C**).

The axial muscles in caudal peduncle of *A. kirkii* are un-branched and elongated fibers. It consists of superficial red layers (slow red muscles) and deep white layers (fast white muscle). The former are small in cross section and correspond to aerobic muscle fiber type. The latter (anaerobic fibers) are large in cross section and are always predominant (**Plate 2E**). They are used for intense contraction like required in jumping.

The structure of skin and muscles in caudal peduncle of *G. affinis hollobrokkii* are adapted to thrashing of this fish. The dermis layer is reduced. The axial muscles in caudal peduncle are white layers (fast white muscle) only. The adipocyte layer and red muscles are absent (**Plate 2D & E**).

4. Discussion

Rockskippers were occurring primarily on relatively exposed rocky shorelines. They are also diurnal, but was herbivores, grazing on algal growths on rocks, barnacle shells, etc. They spend over 90% of their time, both day and night, out of water, but move up and down the intertidal zone with tidally changing sea levels (**Gordon, 1998**).

Gibb et al. (2013) mentioned that the prone jumps of *Alticus kirkii* was executed when fish bend the body to bring the tail cranially, place the tail

against the substrate in close proximity to the head, and push off with the tail while straightening the body to leap away from the starting position. From another side, **Bayliss (1982)** noticed that, the thrash movement of the mosquitofish, *Gambusia affinis holbrokii* was voluntarily stranding them to escape predators. **Gibb**

et al. (2013) mentioned that the thrash is producing a series of side-to-side axial muscle contractions. This behavior may eventually serve to lift the fish off the substrate, but is relatively ineffective in moving the fish away from the starting position.

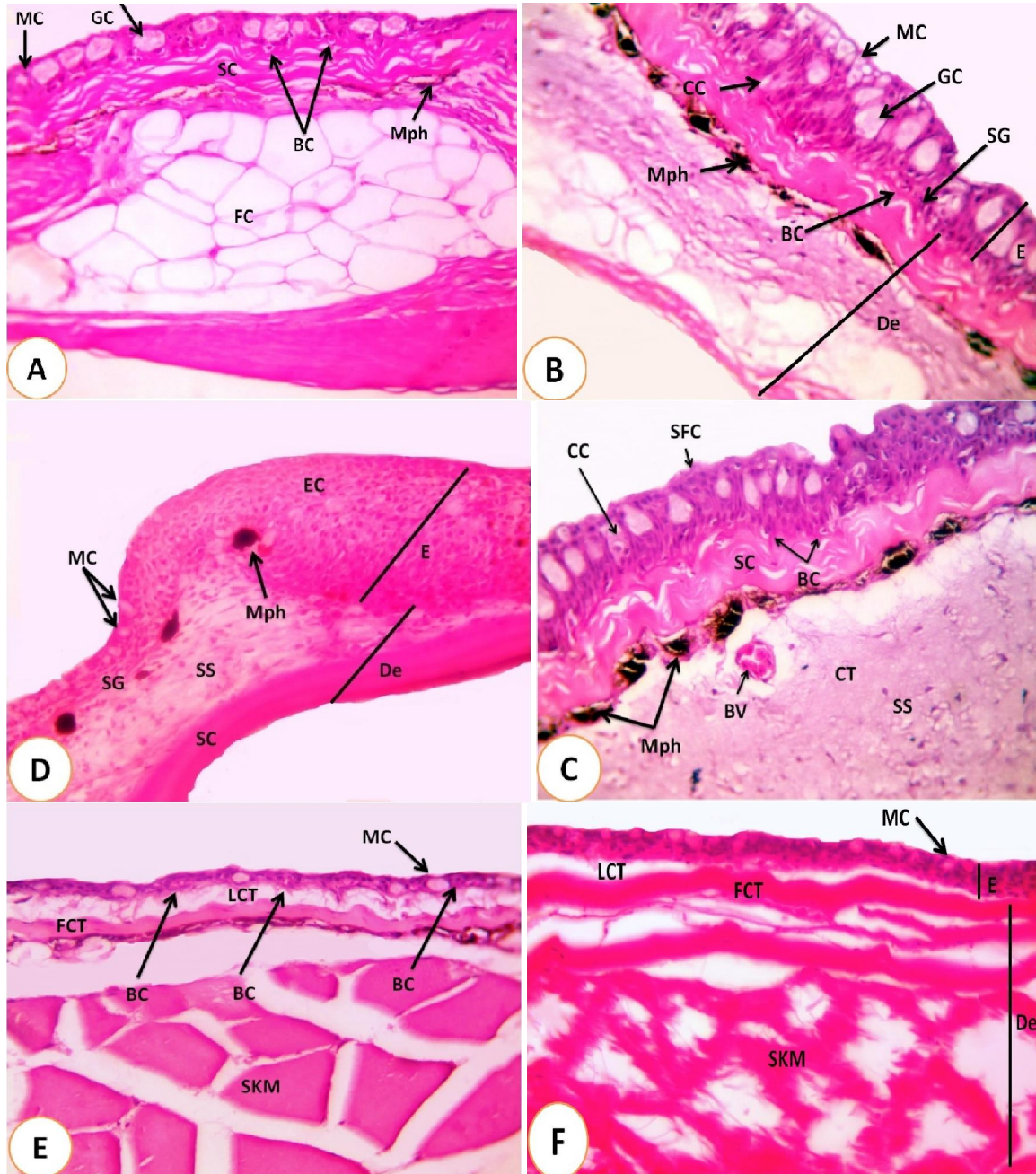


Plate (1): Photomicrographs of T.S. in (A) crest of *A. kirkii*, (B and C) head of *A. kirkii*, (D) head of *G. affinis*, (E) trunk of *A. kirkii* and (F) trunk of *G. affinis*, histological sections showing: Blood Capillary (BC), Blood Vessel (BV), Connective Tissue (CT), Club Cell (CC), Dermis (D), Fat Cell (FC), Epidermis (E), Epithelial cell (EC), Fibrous connective tissue (FCT), Giant Cell (GC), Loose connective tissue (LCT), Mucous Cell (MC), Melanophores (Mph), Skeletal Muscle (SKM), Stratum Compactum (SC), Superficial cell (SFC), Stratum Germinativum (SG) and Stratum Spongiosum (SS) {A, B, C, D, E and F (H & E; X 400)}.

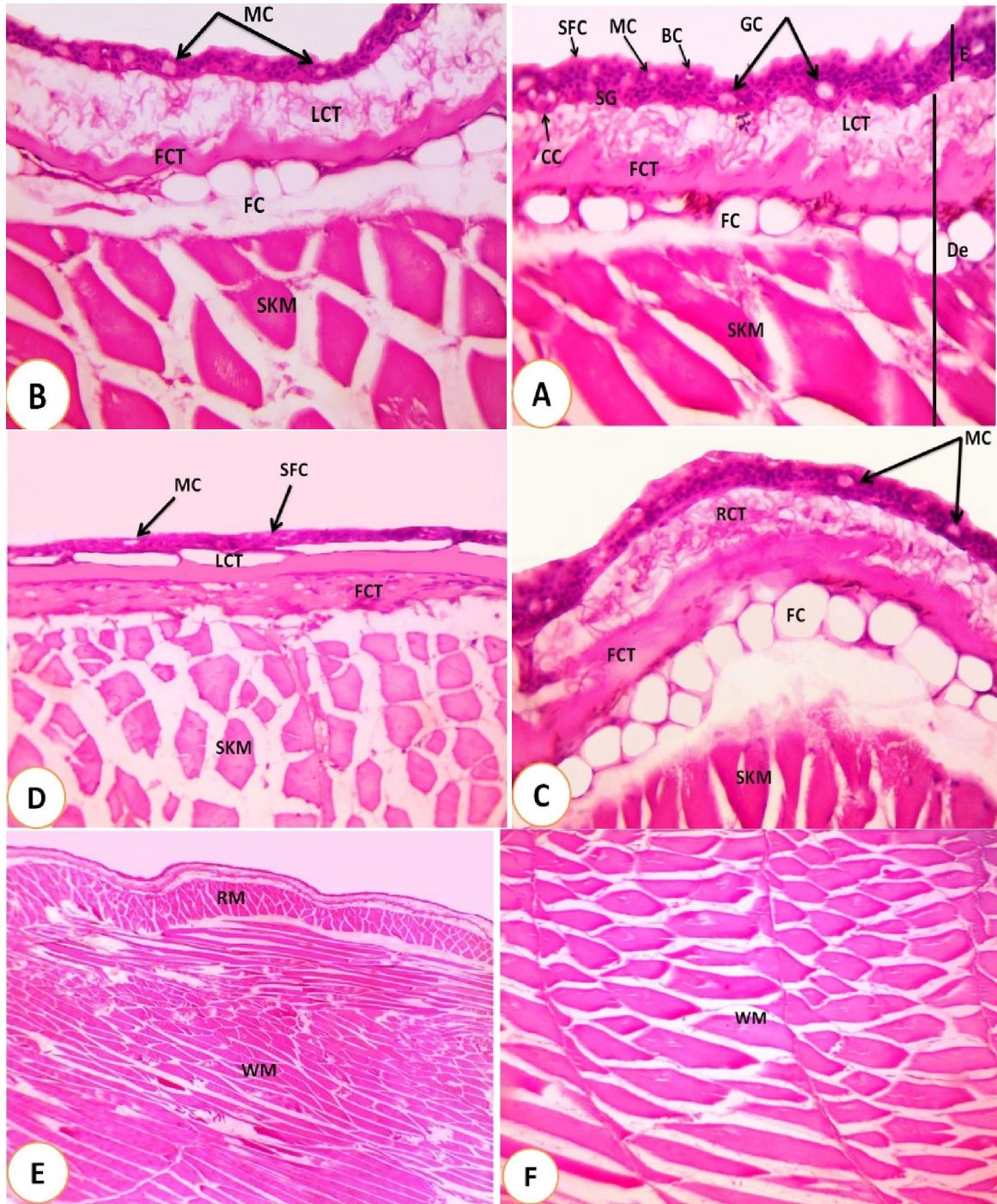


Plate (2): Photomicrographs of T.S. in (A, B and C) caudal peduncle of *A. kirkii*, (D) peduncle of *G. affinis*, (E) L.S. in skeletal muscle of *A. kirkii* and (F) L.S. in skeletal muscle of *G. affinis*, histological sections showing: Blood Capillary (BC), Connective Tissue (CT), Club Cell (CC), Dermis (D), Epidermis (E), Epithelial cell (EC), Fat Cell (FC), Fibrous connective tissue (FCT), Giant Cell (GC), Loose connective tissue (LCT), Mucous Cell (MC), Red Muscle (RM), Reticular Connective Tissue (RCT), Skeletal Muscle (SKM), Superficial cell (SFC), Stratum Germinativum (SG) and White Muscle (WM) {A, B, C and D (H & E; X 400), E (H & E; X 40) and F (H & E; X 100)}.

In the present study, the body shape of *A. kirkii* is elongated, so that the pressure of the body weight on the skin is reduced. The percentages of head length, trunk length, body depth and caudal peduncle depth of *A. kirkii* are lower than that recorded in *G. affinis hollobrokkii*. This means that, the head and trunk lengths of *A. kirkii* were short and restricted to small size area. The body depth and caudal peduncle depth of the fish was little for low weight. The spread of pelvic fins, short of head and trunk and low body weight helps in leaping of *A. kirkii*.

In the present study, the percentage of caudal peduncle length of *A. kirkii* is higher than that recorded in *G. affinis hollobrokkii*. This means that, the caudal peduncle length is stretching for helps in easy encircling during jumping. This result is similar to that obtained by **Bhikajee and Green (2002)**. They mentioned that, *Alticus monochrus* is an amphibious blenny that inhabits exposed and moderately exposed rocky shores and remains above the water line on moist or wet substrata. Rapid terrestrial locomotion is accomplished by leaping during which the entire body leaves the substratum. The body is flexed with the tail nearly touching the head and then rapidly straightened, propelling the fish through the air. Leaping is the primary means of rapid movement on land and across the surface of water.

Both tail-flip and prone jumps are characterized by a two-phase movement consisting of body flexion followed by extension—a movement pattern that is markedly similar to the aquatic fast-start (**Gibb et al., 2013**). In the present study, the jumping of *A. kirkii* above the rocks is taken by movement of caudal peduncle with many adaptations in structure of skin and muscles in this area. The stratum spongiosum in the dermis is much thicker and composed of reticular connective tissue dispersed in loose areolar connective tissue for flexibility and bending of caudal peduncle. The stratum compactum is built up of fibrous connective tissue for reinforcement of caudal peduncle. The adipocytes were found between dermis and muscles were large in size and uses for energy and increasing of spaces. The structure of skin in caudal peduncle of *G. affinis hollobrokkii* was adapted to thrashing of this fish. The dermis layer is reduced. The adipocyte layer and red muscles are absent.

Muscles were a major source of energy consumption and heat generation and, therefore, there has been a long standing interest in the mechanisms that underlie muscle energetic properties (**Alves-Costa et al., 2015**). In the present study, the axial muscles in caudal peduncle of *G. affinis hollobrokkii* consists of white layers (fast white muscle) only. While, the axial muscles in caudal peduncle of *A. kirkii* consist of superficial red layers (slow red muscles) and deep white layers (fast white muscle). They were used in

release high energy and high speeds for intense contraction which required in jumping. This result is agreed with **Rescan et al. (2001)**. He mentioned that the axial muscle of most teleost species consists of a deep bulk of fast-contracting white fibres (anaerobic fibers) and a superficial strip of slow-contracting red fibers (aerobic fibers).

The red muscle fibers were commonly confined to a narrow strip along the lateral line and constitute less than 10 % of the myotomal musculature. The red muscle fibers (slow fibers) were used mainly for sustained energy efficient swimming. The characteristic of this muscle type are good capillary supply, high amount of mitochondria, lipid droplets and glycogen stores. The white muscle fibers (fast fibers) were used at high swimming speeds. White muscle fibers constitute 90-95% of all muscle in most fish species and tightly packed with myofibrils. The mitochondria, lipid droplets and myoglobin are present in very low levels (**Sanger & Stoiber, 2001 and Kiessling et al., 2006**). The red and white muscles in fish were used for intense contraction like required in escape or hunting situations (**Genten et al., 2009**).

Harabawy and Mekkawy (2011) concluded that, the principle structure of skin in *A. kirkii* was evident on different body regions with significant variability in epidermal thickness, diffusion distance, blood capillary number and mucous cell number. Such variability reflects the variability of their role in air-breathing respiration.

In the present study, the integument of *A. kirkii* in different regions of the body consists of the outer thin layer, the epidermis and the inner thick layer, the dermis. A large number of fine blood capillaries in the form of circles containing some erythrocytes below the columnar cells accompanied by dermal collagen were found in different regions of the body. The diffusion distance between the capillary endothelial cells and the outer edge of the epidermis was very low. The epidermis was thin layer, large number of fine blood capillaries below the columnar cells and very low diffusion distance, due to more efficient of air-breathing respiration. While, in the skin of *G. affinis hollobrokkii* contain one type of mucous cells. The giant cells, club cells and blood capillaries are absent. The result in *A. kirkii* was confirmed by **Harabawy and Mekkawy (2011)**. **Zander (1972)** concluded that the skin in some blenniid fish is highly vascularized to improve gas exchange and temperature regulation and the fins are provided with hooks to enhance its grip on the rocks.

The lack of water around fish above the rocks, found many physical, physiological and sensory challenges to the fish such as regulate body fluid, thermal balance, effective gaseous exchange, nitrogenous excretion and tolerate the consequences of

non-regulation (Sayer, 2005 and Harabawy & Mekkawy, 2011).

In the present study, mucous cells in the epidermis of *A. kirkii* are abundant with greater diversity in size and forms. This may be due to secret huge amount of mucous over the body to prevent of desiccation. Harabawy & Mekkawy (2011) concluded that the secret huge amount of mucous over the body of *A. kirkii* to maintain the aqueous content of the body and give resistance and protection against the desiccation, physical abrasions and other biotic and abiotic factors.

The roles of fish mucous were involved in many biological activities, such as respiration, defense against pathogenic microorganisms, parasites, pollutants, swimming, ionic and osmotic regulation, reproduction, excretion, disease resistance, communication, feeding and nest building (Shephard, 1994; Calabro *et al.*, 2005; Sayer, 2005; Mazlan *et al.*, 2006). In addition to direct solar radiation will also control in survival fish out of water (Harabawy & Mekkawy, 2011).

The club cells (alarm cells) not open to the surface and require damage to release their contents. When the part of fish skin damage, club cells release fright substances and hence reliably indicate the presence of an actively foraging predator (Chivers and Smith, 1998 and Brown, 2003). Some studies have suggested that the club cells were a part of the immune system of the fish; the first evidence that alarm substance have an immune function against pathogens, parasites, general injury to the epidermis and the environmental challenges was recorded by Chivers *et al.* (2007) and emphasized by Halbgewachs *et al.* (2009). These authors revealed that the club cells of ostariophysan fish are part of the innate immune system and that the alarm function of the cells that evoke anti-predator responses in nearby shoal mates evolved secondarily. In contrast with Chivers *et al.* (2007) stated that predation pressure does not influence alarm cell production in fishes, but alarm cell production is stimulated by exposure to skin penetrating pathogens, skin penetrating parasites and correlated with exposure to UV radiation, also, suppression of the immune system with environmentally relevant levels of cadmium inhibits alarm cell production of fishes.

Conclusion

From the above findings, it can be concluded that the epidermis of *Alticus kirkii* can absorb air via cutaneous adaptations; thin epidermis, rich with blood capillaries, highly vascularization and different types of mucous cells that permit enhanced perfusion during aerial exposure against *Gambusia affinis*. The jumping of *Alticus kirkii* above the rocks is taken by movement

of caudal peduncle with many adaptations in morphometric and structure of skin and muscles in this area against *Gambusia affinis*.

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