Egypt. J. Aquat. Biol. & Fish., Vol. 16, No. 1: 61 - 71 (2012) ISSN 1110 –1131

Larval development of two atherinid fish species from the Red Sea, Egypt

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ABSTRACT

Larvae of the family Atherinidae were collected throughout a period of 15 years from different areas in the Gulf of Aqaba and Red Sea proper from Hurghada to Shalteen by plankton nets of 500µm. Atherinid larvae were identified by using different identification guides. Larvae were illustrated by camera lucida and photographed by Nikon camera fixed on an Olympus microscope XZ. The morphometrics and sizes of all collected larvae were measured using an eye-piece micrometer. Very large number of larvae were collected and used for the description of all developmental stages. The smallest size of *Atherinomorus lacunosus* was 5 mm and the largest size was 20 mm. whereas the smallest size of *Hypoatherina temmincki* was 3mm and the largest was 5mm.

Key words: Fish larvae, Atherinidae, Red Sea, Aqaba Gulf

INTRODUCTION

Atherinids are small schooling fishes which are closely associated with surface waters during all stages of life. A few species are found around coral reefs. Atherinids are planktivorous, usually preyed upon by seabirds and fish, and are often used as fish bait. There are 8 Indo-Pacific genera containing 20 species (Watson, 1996) of which only two genera, *Atherinomorus* and *Hypoatherina* containing one and two species respectively occur in the Red Sea (Dor & Goren, 1994; Golani & Bogorodsky, 2010). Atherinids produce large (0.5-3.5 mm), spherical, demersal eggs usually covered with adhesive filaments for attachment to algae or other substrates (Watson, 1996).

Larvae hatch at approximately 4 mm with yolk remaining, pigmented eyes, and jaws that are functional or very nearly so. There is dorsal pigment generally on the midbrain and gut and often on the dorsal midline of trunk and tail (Leis and Rennis, 1983; White *et al*., 1984; Watson, 1996).

Atherinid larvae are easily distinguished by a distinctive larval pigmentation pattern and a reduction in preanal length. They are elongate, laterally compressed and shallow bodied with a broad head and a very short compact gut mass. The gut increases in length with increasing body size and extends to about 50% of the body length in late postflexion larvae. They have 35-47 myomeres of which 4-17 myomeres are preanal, this number increases as the body length increases. The head is rounded with a short snout. Mouth is small and terminal reaching about the mideye. The eye is round to ovoid (Leis & Rennis, 1983).

The adult ichthyofauna has been extensively studied since Forsskal (1775) who was the first to describe Red Sea fishes. Since that time much work has been carried out on the adult fishes of the Red Sea (Gohar and Latif, 1959; Randall, 1983; El-Etreby et al., 1999 and Farghal, 2009). However, very few works have described the early stages of Red Sea fishes because of the difficulties of sampling and identification. Larvae of some Indo-Pacific fishes have been described in many occasions (Leis & Rennis, 1983; Leis & Trnski, 1989; Neira *et al*., 1998; Leis &

Carson-Ewart, 2002) and Atlantic areas (Moser, 1984; Moser, 1996; Richards, 2005). In the Red Sea, few studies have been carried out to deal with the description and development of the early stages of fishes (Abu El-Regal, 1999, 2008; Faroukh, 2001). Therefore, the aim of this work is to study the developmental stages of the larvae of the family Atherinidae which is represented in the Red Sea by two species, *Atherinomorus lacunosus* and *Hypoatherina temmincki*.

MATERIAL AND METHODS

Fish larvae were collected by a plankton net of 500µm from different areas in the Red Sea including Sharm El-Sheikh, Hurghada, Safaga, and Shalateen. Larvae were preserved in buffered 5% formalin solution in seawater on board, sorted, measured and identified to the nearest taxa. Measurements were expressed as proportions of the body length. Certain measurements were routinely taken; others were made whenever relevant. Flexion larvae were included in the preflexion larvae. All measurements were taken to the nearest 0.1 mm, then the larvae were placed in separate labeled vials and preserved in 70% ethanol for further investigation.

The identification of larvae based on the literature and the expertise of other specialists. The literature used for the identification of larvae included Leis and Rennis, (1983); Moser, (1984), Houde *et al*., (1986); Moser, (1996); Abu El-Regal, (1999, 2008); Faroukh, (2001), Leis and Carson-Ewart, (2004); Richards, (2005); and other scattered papers for identification of species that will be listed in the references.

In some cases the identification of larvae was kindly confirmed by some specialists. Leptocephali were identified by Michael J. Miller from the Ocean Research Institute, University of Tokyo, Japan. Acanthuridae, Carangidae, Mugilidae and Myctophidae were confirmed by Tom Trnski from the Australian Museum, Australia. Larvae of Synodontidae and Priacanthidae were confirmed by Benjamin Victor USA.

Characters used in the description of larvae

Morphometrics

The larvae were measured under a binocular microscope equipped with eyepiece to the nearest 0.1mm. The routinely measured morphometrics included; total length, standard length, preanal length, predorsal length, head length, snout length, eye diameter, and body depth.

Body shape

The following categories (Leis & Carson-Ewart, 2004), which relate the body depth (BD) to the body length (BL) that refers to the standard length (SL) in the postflexion larvae and the total length (TL) in the preflexion larvae have been used in the description. The larvae were considered to have very elongate body when the body depth formed less than 10% of the body length, and very deep when the body depth formed more than 70% of the body length as shown in the Table1.

Table 1: the relationship between body depth and body length

Very elongate	Elongate	Moderate	Deep	Very deep
BD<10%BL	BD=10-20%BL	BD=20-40% BL	BD=40-70% BL	BD>70% BL

Head and gut were very important and characteristic features of the family Atherinidae. The criteria used to describe both of head and gut according to their relationship to the total body length are presented in Tables 2, 3.

Table 2: Relationship between head length and body length

Small Head	Moderate Head	Large Head
HL<20%BL	HL=20-30%BL	HL>33%BL

Table 3: Relationship between gut length and body length

Short gut	Moderate gut	Long gut	Very long
PAL <30%BL	PAL =30-50%BL	PAL =50-70%BL	PAL >70%BL

The identified larvae were described in details, illustrated and photographed when possible. The illustration process took place by a stereomicroscope equipped with a camera lucida and photographed by Nikon camera fixed on an Olympus microscope XZ.

Abbreviations used in description of the fish larvae.

D	Dorsal fin
A	Anal fin
P1	Pectoral fin
P2	Pelvic fin
C	Caudal fin
BL	Body length
TL	Total length
SL	Standard length
HL	Head length
SnL	Snout length
ED	Eye diameter
BD	Body depth
PDL	Predorsal length
PAL	Preanal length

RESULTS

Atherinid larvae have elongate, laterally compressed and shallow bodies with a broad head and a very distinctive short compact gut mass that increases in length with increasing body size. The gut may extend to about 50% of the body length in late postflexion larvae. The larvae have 35-47 myomeres of which 4-17 myomeres are preanal, this number increases as the body length increases. The head is rounded with a short snout. Mouth is small and terminal and reaches about the middle of the eye which is round to ovoid. Larvae are characterized by a distinctive larval pigmentation pattern that is markedly different between the two described species. *Atherinomorus lacunosus* larva has one row on the dorsal side of the body whereas, *Hypoatherina temmincki* larva has two rows of melanophores in the position of the dorsal fin and only one raw away from positions of dorsal fin (Fig.1).

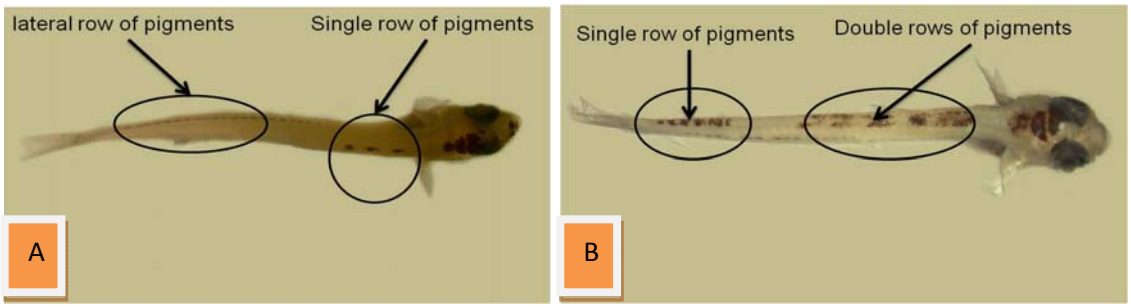

Fig.1: Pigmentation pattern of atherinid fish larvae A) *Atherinomorus lacunosus*, B) *Hypoatherina temmincki*

1. Atherinomorus lacunosus

Body of *Atherinomorus lacunosus* is very elongate with 35-39 myomeres with a short gut ranging from 20-40% of the body depth. The smallest collected and examined larva was 3.6 mm which was in the preflexion stage. Doral and anal finfolds were still present. There is a gap between the anus and the anal fin origin. Pectoral fin is well developed. One melanophore is present on the anterior portion of the dorsum, on the brain and on the gut, and a series of melanophores occurs on the midlateral surface of the body (Fig. 1).

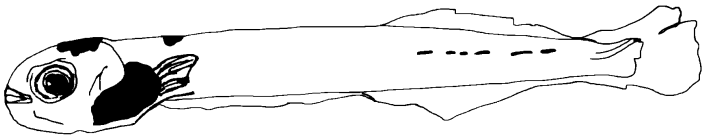

Fig.1 a: 5 mm larva of *Atherinomorus lacunosus*

The preanal length forms 15% of the body length, the head length forms 20% of the body length and the body depth forms 10% of the body length (Table 4).

Table 4: Meristics of *Atherinomorus lacunosus*

Myomeres			Fins				
Preanal	Postanal	Total	D	A	P1	P2	C
4-17	32	35-47 (35-39)	VI-VII+I, 8-10 (VI+I,8-10)	I,9-13 (I,9-13)	15-19	I,5	9+8

The larvae of 5 mm have the preanal length of 25% of the body length. In the larvae of 9 mm, the dorsal fin anlage is present and, pectoral and caudal fins are well developed, anal and dorsal fins are not yet formed. The preanal length forms 25% of the body length, the head length forms 16% of the body length and the body depth forms 10% of the body length (Fig.2).

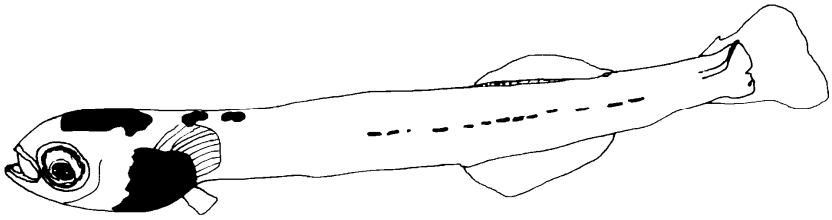

Fig. 2: 8 mm larva of *Atherinomorus lacunosus*

The notochord started to be flexed at 6.2 mm. At 14.5 mm, the anal and second dorsal and pelvic fins are formed. Three melanophores occur on the dorsal

side of the body. One large stellate melanophore in addition to small melanophores are present behind the eye and one on the snout. The preanal length forms 27% of the body length, the head length forms 17% of the body length and the body depth forms 11% of the body length (Fig. 3).

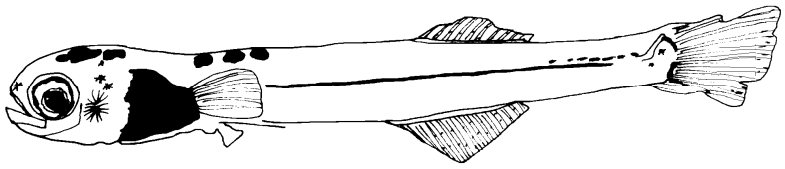

Fig. 3: 14 mm larva of *Atherinomorus lacunosus*

At 17.5 mm all fin elements including the first spiny dorsal fin are formed. The preanal length forms 30% of the body length, the head length forms 18% of the body length and the body depth forms 13% of the body length (Fig. 4).

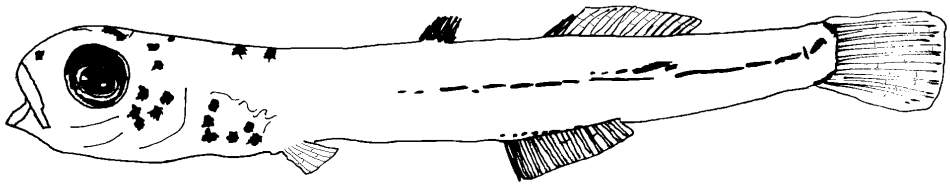

Fig. 4: 17 mm larva of *Atherinomorus lacunosus*

Table 5: Morphometrics of *Atherinomorus lacunosus*

BL	HL	SnL	PDL	PAL	BD	ED
3.6	17.2	20.0	0.0	22.4	12.1	50.0
4.1	16.9	0.0	0.0	23.1	10.8	0.0
4.8	20.0	25.0	0.0	25.0	11.7	41.7
5.0	18.0	22.2	0.0	25.0	12.0	38.9
5.5	16.4	0.0	0.0	20.0	10.9	0.0
5.6	21.4	26.7	0.0	21.4	11.4	33.3
6.0	16.7	30.0	0.0	26.7	10.0	0.0
6.2	16.1	30.0	0.0	25.8	9.7	0.0
6.5	15.4	30.0	0.0	21.5	9.2	50.0
6.6	20.7	29.4	0.0	0.0	0.0	0.0
7.0	22.9	25.0	0.0	28.6	11.4	37.5
7.2	20.0	22.2	0.0	24.4	11.1	36.3
7.5	13.3	40.0	0.0	26.7	13.3	60.0
7.6	18.9	27.8	61.1	23.2	10.5	33.3
8.0	18.8	20.0	0.0	27.5	10.0	40.0
8.1	15.4	30.0	0.0	21.5	9.2	50.0
8.2	14.6	25.0	0.0	23.2	9.8	41.7
8.5	15.3	38.5	0.0	23.5	11.8	53.8
9.0	16.7	33.3	61.1	22.2	8.9	40.0
9.5	17.9	29.4	0.0	26.3	10.5	41.2
10.0	15.0	26.7	60.0	24.0	8.0	46.7
10.5	19.0	25.0	0.0	23.8	14.3	40.0
11.0	18.2	25.0	0.0	27.3	13.6	40.0
12.0	20.8	20.0	0.0	25.0	5.0	32.0
12.5	20.0	25.0	63.0	27.0	11.0	40.0
13.0	21.5	25.0	47.7	32.3	14.6	35.7
13.1	20.0	33.3	0.0	30.5	14.3	42.9
15.0	20.8	20.0	66.7	25.0	12.5	36.0
15.0	23.3	28.6	50.0	29.2	16.7	35.7
17.5	22.9	31.3	48.6	41.4	14.3	31.3
20.0	25.0	25.0	46.9	46.9	15.6	0.0

2. Hypoatherina temmincki

The key feature of *Hypoatherina temmincki* is the presence of two dorsal rows of pigments on the position of the dorsal fin and only one row away from position of dorsal fin (Fig. 5). The smallest examined larva of *H. temmincki* was 3 mm. It was preflexion stage.

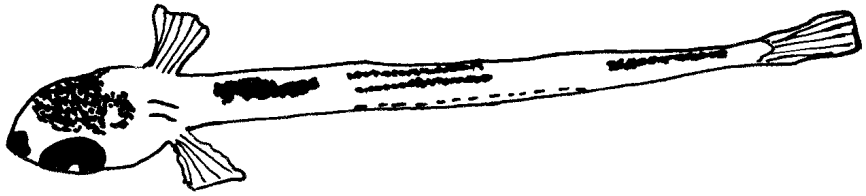

Fig. 5: The position of the melanophores

In the larvae of 5.5 mm length, notochord begins to be flexed, and the larvae are in the preflexion stage. No fins are formed, no fin anlage. Pectoral bud is present but without rays. The preanal length forms 34% of the body length, the head length forms 19% of the body length and the body depth forms 12% of the body length (Fig. 6).

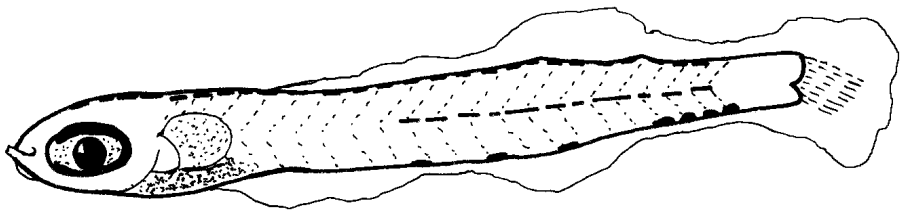

Fig. 6: 3 mm larva of *Hypoatherina temmincki*

At 6 mm, the larvae are in the postflexion stage. Pectoral bud is present, and second dorsal and anal fins begin to form, a great gap is present between the anus and the origin of the anal fin. The preanal length forms 30% of the body length, the head length forms 16% of the body length and the body depth forms 12% of the body length. Two rows of pigment are present in position of the dorsal fin and only one row apart from the position of the dorsal fin. There are also two ventral rows and one midlateral row of pigments (Fig. 7).

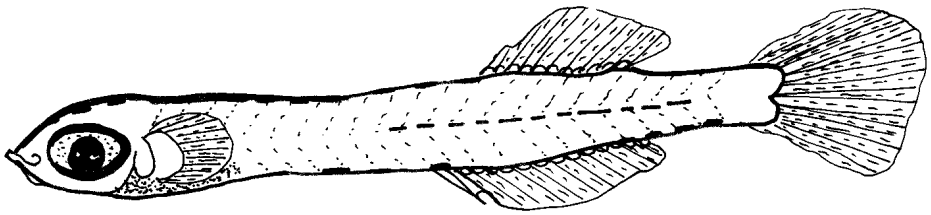

Fig. 7: 6mm larva of *Hypoatherina temmincki*

At 8 mm, the anal and second dorsal fin are complete, the anlage of the first spiny dorsal fin is present. Pigment appears on the caudal fin base. At 12 mm, the first spiny dorsal fin is present, pelvic bud is formed. Pigments appear on the upper and lower jaws, and on the caudal peduncle (Fig. 8).

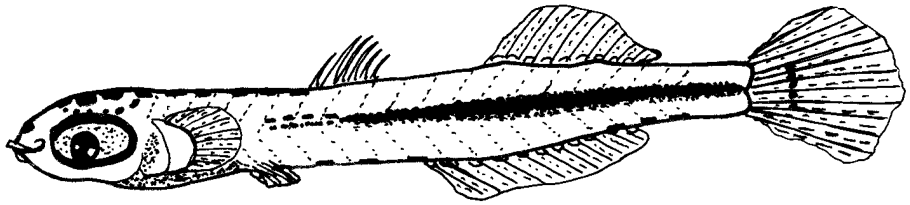

Fig. 8: 12 mm larva of *Hypoatherina temmincki*

The pre-anal length forms 31% of the body length, the head length forms 16% of the body length and the body depth forms 13% of the body length (Table2).

Table 6: Morphometrics of *Hypoatherina temmincki*

TL	HL/Tl	SnL/HL	PDL/TL	PAL/TL	BD/TL	ED/HL
5.0	20.0	20.0		30.0	14.0	50.0
5.1	19.6	20.0		25.5	9.8	50.0
5.5	18.2	30.0		21.8	9.1	40.0
5.5	18.2	30.0		21.8	9.1	40.0
5.6	20.0	0.0		27.8	11.1	0.0
6.0	16.7	30.0		28.3	10.0	60.0
6.0	20.0	41.7		31.7	16.7	50.0
6.3	15.9	0.0		27.0	9.5	50.0
6.5	18.5	0.0		29.2	9.2	41.7
6.5	16.9	0.0		23.1	12.3	0.0
6.8	23.5	20.0	64.7	27.1	11.8	35.0
7.0	21.4	20.0	64.3	28.6	8.6	33.3
7.2	20.0	0.0	66.7	27.8	11.1	0.0
8.0	20.0	18.8	0.0	25.0	12.5	43.8
8.5	21.2	27.8	67.1	29.4	11.8	27.8
8.5	21.2	27.8	67.1	29.4	11.8	27.8
8.6	20.9	27.8	66.3	29.1	11.6	27.8
9.5	21.1	0.0	0.0	26.3	10.5	0.0
10.0	28.0	25.0	0.0	33.0	10.0	32.1
10.8	18.6	37.5	0.0	29.1	10.5	43.8
11.0	20.0	36.4	0.0	34.5	9.1	40.9
12.0	23.3	28.6	0.0	31.7	10.8	35.7

DISCUSSION

Larvae of coral reef fishes are difficult to identify because they are morphologically different from the adults. This is due primarily to three factors. First, larvae do not hatch fully developed, so the larval stage is a developmental stage during which many structures first appear or proceed to a functional state. Second, reef fish eggs are typically small (pelagic eggs larger than 1.5 mm are rare), so newly hatched larvae are small. Third, larvae have morphological features that are presumably adaptations to pelagic existence. Indeed, some larval forms have been described as new genera or even placed in families different from the adults. Few

species have been described and larvae of many families are totally unknown (Leis & Rennis, 1983).

Identification of fish larvae is very important for other ecological and biological studies of fishes. Minor errors in identifications of larval fishes can lead to major misinterpretation of ecological and taxonomic phenomena. Fish larvae identification and taxonomy are largely based on adult characteristics. Usually, larvae possess fewer characters than adults and are more fragile. Identification can, therefore, be difficult and must be based on a combination of character states (Powles & Markle, 1984). In the present study, identification of larvae was based on larval morphology and geographical distribution and spawning season and in some cases characters of the adults.

A great deal of identification of any group depended on an integrated image or appearance of the larvae in question. When examining the larvae, an impression should be taken about how the larval body looks like regarding the length, depth, the gut length, distribution of pigments and the myomere numbers (Leis and Rennis, 1983).

Larvae of family Atherinidae are characterized by three main features that make them easily distinguished from other families. These features include the very characteristic pigmentation pattern, the reduction of the gut and the absence of head spination.

Among the most taxonomically useful larval characters used to distinguish atherinid larvae from other families, generally at the specific or generic level, is the pigment pattern. Usually each species has a distinct larval pigmentation pattern. In some, the number and placement of individual melanophores are diagnostic, while in others, the location, shape and size of groups of melanophores are key characters. The problem associated with the usefulness of pigmentation patterns is the widespread distribution of some patterns. For instance, the presence of a row of small melanophores along the ventral midline just behind the anus to the tip of the tail (Kendall *et al*., 1984).

In the case of the family Atherinidae, the absence of the ventral row of pigments typical of the order Atheriniformes helps to distinguish the larvae of *Atherinomorus lacunosus*. One of the most important and distinctive features of the family Atherinidae is the absence of head spination.

Gut characters of fish larvae include length and shape as well as the development of trailing hindgut in some. In the present study, the gut shape and length played a great role in separating larvae into families. Siganid larvae and mullid larvae have short rounded gut. The gut of atherinid larvae is very short compared to other larval groups. The gut of members in the family Atheirindae never increase than 50% of the body length in all developmental stages compared to the related members of clupeid, synodontid and hemirhmphid where the gut length formed more than 70% of the body length.

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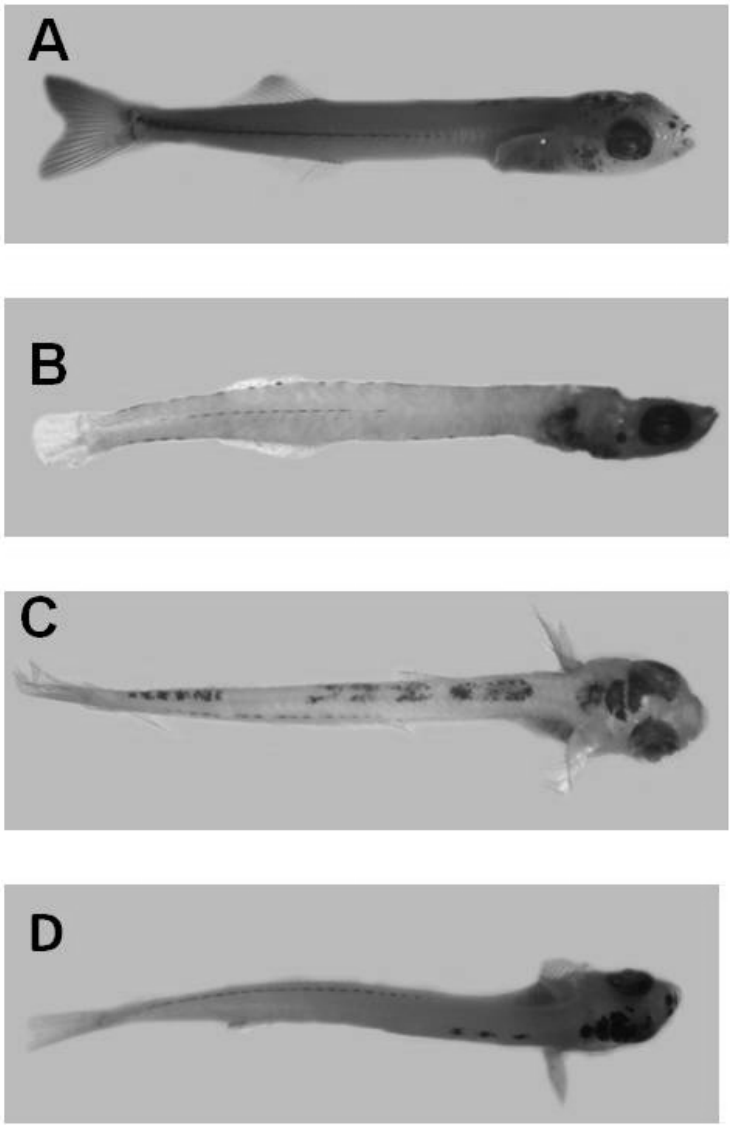

Fig. 9: a. ***Atherinomorus lacunosus***

b. Dorsal view of ***Atherinomorus lacunosus*** showing single row of pigment

c. ***Hypoatherina temmincki***

d. Dorsal view of ***Hypoatherina temmincki*** showing double row of pigment

ARABIC SUMMARY

تطور اليرقات فى نوعين من أسماك فصيلة الأثيرينيدى بالبحر الأحمر، مصر

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تم جمع يرقات فصيلة الأثرينيدى من أسماك الشعاب المرجانية بالبحر الأحمر خلال 15 سنة من خليج العقبة ومناطق مختلفة بالبحر الأحمر من الغردقة وحتى شلاتين باستخدام شبكة بلانكتون سعة فتحاتها 500 ميكرون. تم تعريف اليرقات باستخدم أدلة تعريف مختلفة وتم رسمها باستخدام كاميرا لوسيدا وتم تصويرها باستخدام كاميرا نيكون مثبتة على ميكروسكوب أوليمبوس إكس زد وتم أخد القياسات باستخدام عدسة. تم استخدام عدد كبير من اليرقات فى عملية الوصف والتعريف وتتبع مراحل التطور المختلفة. بالنسبة لنوع Atherinomorous lacunosusكان أقل طول تم تسجيله هو 5 مم وأكبر طول هو 20 مم أما بالنسبة لنوع *Hypoatherina temmincki* كان أقل طول هو 3 مم ،اكبر كول هو 12 مم.

يعتبر هذا البحث هو الأول فى سلسلة تتناول تعريف ووصف يرقات أسماك الشعاب المرجانية بالبحر الأحمر.