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# First record for the sunfish *Mola mola* (Molidae: Tetradontiformes) from the Egyptian coasts, Aqaba Gulf, Red Sea, with notes on morphometrics and levels of major skeletal components

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## ABSTRACT

The sunfish *Mola mola* is recorded for the first time from the Egyptian waters at Abu Galum Protectorate Area (South Sinai), Aqaba Gulf, Red Sea. The present study conducted to give information on morphometric characters, anatomy and levels of major elements in skull, vertebrae and paraxial parts of its skeletal system. These elements comprised Ca, P, Na, K, Mg, S, Cl, Zn and Cu and their levels were estimated. The results exhibited that Ca and P were the main components in skull and were the most dominant elements in paraxial skeleton in addition to remarkable ratios of Na and Cl. Cu was detected with very low ratios only in paraxial skeleton parts. The annuli in examined vertebrae were counted and showed that, this fish may be in its second age group.

## INTRODUCTION

The sunfish *Mola mola* (Linnaeus, 1758) is widely distributed in the tropical and temperate oceans and seas around the world. It is the most common species in the Tetraodontiformes (Acanthopterygii: Pisces) family Molidae (Winterbottom, 1974), and considers the largest and heaviest bony fish reaching up to 3 m in length and more than 2000 kg in weight (Santini and Tyler, 2003). It has characteristic body shape, therefore it attracts attentions of many marine biologists (Johnson and Britz, 2005), particularly the osteological characteristics of this species (Winterbottom, 1974 and Tyler, 1980).

The diagnostic characters of all species of family Molidae are well documented. They are characterized by laterally compressed bodies with truncate shape in the posterior (Fraser-Brunner, 1951). The true caudal fin is absent but replaced with pseudocaudal fin (clavus); the pelvic fin and girdles are also absent and there is no spines in the median fins (Tyler, 1980). However, little is known about its biology (Matsuura and Tyler, 1998; Sagara *et al*., 2005), physiology especially nervous system (Nakae and Sasaki, 2006) and visceral anatomy (Chanet *et al*., 2012).

Sunfish is a pelagic zooplanktivores, feeds primarily on gelatinous zooplankton (Fraser-Bruner 1951). However, Bass *et al*. (2005) found brittle-star in the gut of ocean sunfish, which refers that this fish maybe feed on the sea bottom organisms, changing the common reported feeding habits as it considers pelagic zooplanktivore.

Sunfish rarely found near the shallow water but mostly lives in relatively mid-water depths (Sims *et al.*, 2009a). Cartamil and Lowe (2004) recorded different movement's regimes in sunfish. The ocean sunfish *M. mola* (73–151 cm in total length) mostly dives consequently during the day to depths of 50 m, but some individuals were also recorded in depths of 400 m. This indicates that the sunfish rarely seen in the shallow water or coastal areas due to its slow movements as it depends mostly on the dorsal and anal fins for swimming, this slow movements consequently attracts large predators, such as large sharks (Fergusson *et al*., 2000), orcas and sea lions (Thys *et al*., 2015).

Due to slow movement of sunfish, the cleaning behavior of some species of angle and butterfly fishes to the ectoparasites of sunfish *M. mola* was reported, thus, the intense cleaning efforts reduce markedly the loads initial effect of parasite (Konow, 2006).

The ocean sunfish has high economic importance around the world. The fisheries of ocean sunfish in gillnet and trawls worldwide, represents from 70 to 95% of the total catch in the Mediterranean Sea (Silvani *et al.*, 1999; Tudela *et al.*, 2005), and from 29 to 76% in the fisheries of South African mid-water trawl (Petersen and McDonell, 2007), but it represented from 14 to 61% of the total catch in California's DGN fishery (National Oceanic and Atmospheric Administration (NOAA, unpublished data). After the wide spread distribution of the sunfish in different oceanic habitats, some studies in its ecology, biology, trophic role, reproduction, fisheries bycatch were performed (Cartamil and Lowe, 2004; Petersen and McDonell, 2007).

Recently, Santini and Tyler (2003) defined the relationship between the recently known genera of family Molidae, depending on morphological and molecular data. Furthermore, *Mola mola* was reported in wide range of all oceans and seas from warm waters to temperate regions (Froese and Pauly, 2010). Jawad (2013) reported the known records of this fish from the Eastern Pacific Ocean, British Columbia, Canada, Peru and Chile, also from Japan and Australia in the Western Pacific. In addition to the records from Scandinavia to South Africa in the Eastern Atlantic Ocean including western Baltic and Mediterranean Sea, furthermore from Newfoundland, Canada to Argentina in the Western Atlantic Ocean. Other records reported from Oman Jawad (2013) and from Arabian Gulf, Kuwait (Al-Baz *et al.*, 1999).

The Red Sea Egyptian coasts extend about 1386 km along the Red Sea proper and associated Gulfs of Suez and Aqaba (Head, 1987). These coasts have extended areas of sandy and rocky shores, with small areas of mud flats in addition to coral reefs (Jones, 1987; Hellal, *et al.*, 1997; El-Sayed, 2002; Fouda *et al.*, 2003). Abu Galloum Protected Area is one of the characterized areas distributed along the coasts of the Gulf of Aqaba, South Sinai. It is one of the four South Sinai Protected Areas comprise Ras Mohammed, Nabq and Taba. Abu Galum was declared a protected area by the Prime Minister's decree No. 1511 of 1992 as “A Managed Resource Protected Area” or as “Multiple Use Management Area” (PAE, EEAA, 2006). The marine part of this area is characterized by extensive areas of intertidal and subtidal zones with high diversity of coral reefs (stony and soft corals) and various sandy depressions, in addition to rocky and sandy shores. Stony corals provide important structural habitat for microbes, invertebrates and fishes. The offshore of coral reefs increased sharply in depth which provides preferable environment for the mid-water and deep water organisms (Salem, 2014).

The present study throw lights on the record of sunfish *M. mola*, for the first time from the Egyptian Red Sea coasts with notes on its morphometric measurements and levels of major skeletal inorganic minerals.

## MATERIALS AND METHODS

### Sampling:

A large female (188cm) sunfish, *M. mola* was observed by one of the local men, and it was suffering from attack by large predatory fish, losing its anal fin. On first May 2017 this fish was collected by Mr. Ahmed El-Sadek from Abu Galum Protectorate Area, Aqaba Gulf, South Sinai, Egypt, then transferred into large freezing facility in Sharm-El-Shiekh for further preservation and later investigation.

On 18 May 2017, a team of 5 persons from different scientific authorities represented by Al-Azhar University (1), National Institute of Oceanography and Fisheries (2), in addition to the Egyptian Environmental Affair Agency (2) were arrived to carry out all available investigations which continued for two days. During this period, the morphometric and meristic measurements including total length, standard length, body depth, etc. were taken. Morphometric and meristic measurements were followed those given by Tyler (1980) and Jawad (2013).

In addition, several samples of bone parts (6) and (5) vertebrae from different regions of vertebral column and paraxial skeleton parts were separated and put in labeled plastic bags and taken for further laboratory investigations and analyses at Laboratory of Marine Biology, Faculty of Science, Al-Azhar University, Nasr City, Cairo.

### X-ray microanalyser examination (EDX):

At the laboratory, vertebrae were cleared from associated tissues, dried at room temperature and examined under light binocular microscope for counting annual rings. For X- ray microanalyses, three samples of each vertebra, skull and paraxial bone parts were taken. Each sample was dried at room temperature. For scanning, the specimens were examined under X-ray microanalyser (Module Oxford 6587 INCA x-sight) attached to JEOL JSM 5500 LV scanning electron microscopy (SEM) at 20 KV after coating with gold sputter coater (SPI-Module). All X-ray microanalyser examination (EDX) and scanning were carried out at the Regional Center of Mycology and Biotechnology, Al-Azhar University, Cairo, Egypt.

## RESULTS

### General morphology

The specimen collected (Fig. 1) of sunfish *M. mola* has a laterally compressed body shape, measured 188cm total length (TL), 143cm standard length, 43cm body height and reaches 30 cm maximum body depth just in the posterior head region. The body divided into head, trunk and pseudo-tail region; but has very short rounded, undulated cuadal fin (clavus). Its head measured 41cm in length (preopercular opening length) and depressed from the dorsal surface giving truncate shape dorsally with projecting midline connecting the rounded rostrum to the dorsal fin (Fig. 1f). Dorsal fin has 18 soft rays only without spines and measured 61cm from its base to the vertical edge (maximum height) and has wide distance between dorsal fin base to anal fin base reaches 66cm; while pectoral fin has 11 soft rays only and measured 23cm. Eyes are large, semicircular shape measured 7.7 x 6 cm in dimensions. Gill opening (operculum), lies behind eyes directly and measured 9.5cm. This fish has rough thick skin varied from 3-5 cm in thickness, covered with modified scales known as denticles, which are widely separated from each other (Fig. 1e).

**Digestive system:**

The obtained fish was dissected and all internal organs were observed. Digestive system starts with the tri-angular mouth (Fig. 1a), leading to short pharynx, then to muscular esophagus leading to cylindrical stomach, reaches 40 cm in length, followed by a relatively long intestine reaches to 460 cm in length. The small intestine ends with relative wide rectum which opens to the exterior with the anus opening measured 2.4 cm in diameter (Fig. 2 a, b, c). This fish has relatively long digestive canal measured about 503 cm and represents 267.6 cm relative gut length.

The digestive glands were represented by two lobes of liver and long lobulated pancreas which opens at the junction between intestine and pyloric stomach. Liver was more conspicuous and composes of two lobes, (right and left lobes) with enlargement of right or left lobes than the other one.

It is worth to mention that, due to long period before transferring to freezing most parts of liver and pancreas were destroyed and have faint brownish color. Also, no evidence for any traces of food remains was detected in stomach or intestine.

**Reproductive system:**

Genital system of the examined sunfish (Fig. 2 d) composes of two lobulated green ovaries lying in the postero-dorsal portion of the body cavity just posteriorly to the intestine and open to the outside on the female genital opening which measured 3cm, behind anus. It was difficult to determine any types of maturity stages due bad status of fish ovaries.

**Life coloration:**

The examined sunfish (Fig. 1a) has gray color covers most of its body regions except some white scratches appear on certain regions may as result of transferring. However, this color appears darker in the upper regions and gradually becomes lighter downward. Head region has some white marks on lateral surface; while dorsal and pectoral fins have white edges surround the main gray color of these fins.

**Ecological field notes:**

The present specimen was observed alive by local people in the collected site. They told that, it was observed moves horizontally near the shore due loss of its anal fin. Its movements were unstable and it was try to keep itself in the normal vertical position. The careful examination for the base of fish anal fin indicated that, it was probably attacked by some sharks in the open water; therefore it refuge to the shallow water for sheltering and escaped from predation. This was supported by the field observations of some rangers at Abu Galum Protectorate who observed two sharks near the collection site, about 100 meter aside it, where the fish was at depth of twenty meters.

**X-ray microanalyser examination**

The laboratory investigations show that, the skeletal system of *M. mola* composes mainly of cartilaginous component (Fig. 1g). It was found that, paraxial skeleton have light calcification or less calcified (Table 1, and Fig. 4), while skeleton of head and all vertebrae have relative denser calcification. These results indicated that, Ca, Na, K, Mg, P, S, Cl, Zn and Cu were the main elements in fish skeleton, but the ratios of these elements varied significantly between different calcified regions.

The obtained results showed that, there are remarkable variations in levels of these elements in vertebrae as shown in Table (1) and Figure (4). These data indicated that, both of $Cl^-$ and $Na^+$ represented the highest ratios varied from 34.10 to 43.75 % for $Cl^-$ and from 30.62 to 51.76 % for $Na^+$ with averaged 39.03±4.83 and 40.28±10.69. On the other hand, other elements were represented by very low ratios averaged 2.28±3.08, 7.29±3.66, 3.87±1.39, 5.99±2.04 and 1.25±0.38 % for Ca, K, Mg, P and S, respectively, but no evidence for Zn or Cu occurrence was detected (Table 1 and Fig. 4).

Table 1: The mean (±SD) percentages and ranges of estimated minerals in different skeletal parts of *Mola mola* from Abu Galum Protectorate Area, Gulf of Aqaba, South Sinai, Egypt, scanned with dispersion X-ray microanalyzer (EDX).

| Items | Elements | Ca | Na | K | Mg | P | S | Cl | Zn | Cu |
|---|---|---|---|---|---|---|---|---|---|---|
| **Vertebrae** | **Min.** | 0.14 | 30.62 | 3.07 | 2.29 | 4.5 | 1.03 | 34.1 | 0 | 0 |
| | **Max.** | 5.83 | 51.76 | 9.44 | 4.88 | 8.32 | 1.68 | 43.75 | 0 | 0 |
| | **Mean** | 2.28 | 40.28 | 7.29 | 3.87 | 5.99 | 1.25 | 39.03 | 0 | 0 |
| | **±SD** | ±3.08 | ±10.69 | ±3.66 | ±1.39 | ±2.04 | ±0.38 | ±4.83 | | |
| **Skull** | **Min.** | 44.27 | 5.37 | 2.63 | 0.4 | 21.96 | 2.13 | 15.95 | 0.15 | 0 |
| | **Max.** | 49.28 | 8.84 | 2.85 | 0.83 | 24.02 | 3.24 | 18.01 | 1.25 | 0 |
| | **Mean** | 46.68 | 6.61 | 2.74 | 0.61 | 22.81 | 2.70 | 17.07 | 0.79 | 0 |
| | **±SD** | ±2.51 | ±1.95 | ±0.11 | ±0.22 | ±1.08 | ±0.56 | ±1.04 | ±0.57 | |
| **Paraxial skeleton** | **Min.** | 21.97 | 21.86 | 1.96 | 1.77 | 12.55 | 2.69 | 4.45 | 0.26 | 0.16 |
| | **Max.** | 32.35 | 34.87 | 3.14 | 4.15 | 16.85 | 5.23 | 17.61 | 3.34 | 2.61 |
| | **Mean** | 28.21 | 28.33 | 2.54 | 2.92 | 15.22 | 3.69 | 16.12 | 1.39 | 1.59 |
| | **±SD** | ±5.49 | ±6.51 | ±0.59 | ±1.19 | ±2.33 | ±1.35 | ±1.59 | ±1.82 | ±1.27 |

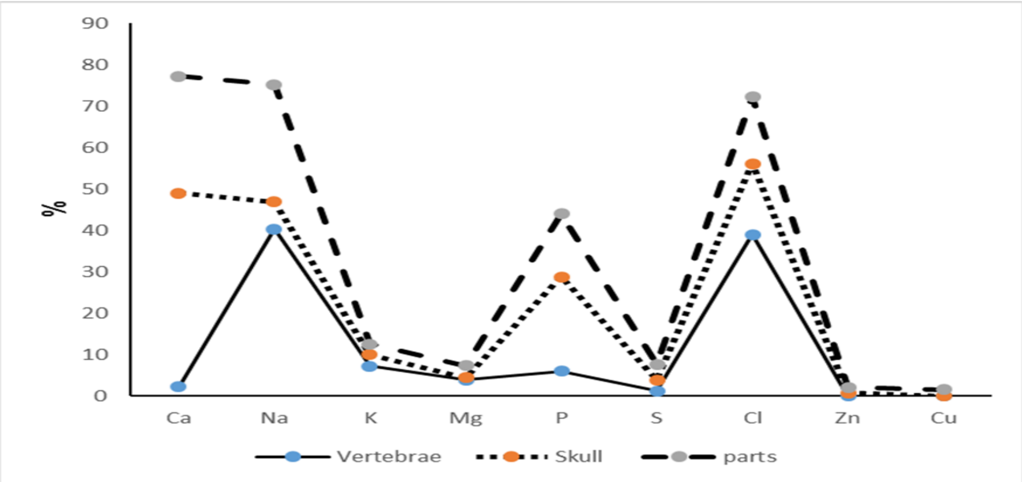


Fig. 4: The percentages of estimated minerals detected in different skeletal parts of *M. mola* scanned with dispersion X-ray microanalyzer (EDX).

In skull, the ratio of Ca was the highest, varied from 44.27 to 49.28 with averaged 46.68±2.51 %. This indicates to an increase precipitation of Ca in head skeleton and was accompanied with sharp decline in Na and Cl ratios which were averaged only 6.61±1.95 and 17.07±1.04%, respectively. On the other hand, P ratios increased significantly and came in the second order 22.81±1.08%. However, slight decline in K and Mg ratios was detected, but ratios of S were increased slightly, while Zn was detected with low ratios averaged 0.79±0.57% (Table1 and Fig. 4).

Generally, these results indicated that, both of Ca and P constitute at least 70 % of sunfish head skeletal components.

In paraxial skeleton, both of Ca and Na have similar ratios, averaged 28.21±5.49 and 28.33±6.51 %, respectively (Table 1 and Fig. 4). It was also observed that, the ratios of P and Cl were increased and averaged 15.22±2.33 and 16.12±1.59 %, respectively; while K, Mg and S were represented with low ratios as in other skeletal parts with averaged 2.54±0.59, 2.92±1.19 and 3.69±1.35 % respectively. On the other hand, level of Zn increased to 1.39±1.82% comparable with that recorded in head, while Cu appeared in these parts only and averaged 1.59±1.27 %.

It is obvious that, paraxial skeleton parts have higher ratios of Ca and Na followed by considerable ratios of P and Cl, in addition to nearly similar ratios of other elements that recorded in both skull and vertebrae, but Cu is the only element recorded in paraxial skeletal parts (Table 1 and Fig. 4).

**Annual growth rings:**

The annual rings (Fig. 3a-h) for 3 different vertebrae were counted. The careful examination by using binocular microscope demonstrated that, there are 3 regions of dense annuli which may be indicate to or represent three years or (periods) age for this fish. The first annuli compose of condensed rings, followed by second condensed region represents the second annuli which had the same characters of the first, but less in width, while the third region is largest and composed of 10-12 thin rings.

On the other hand, X-ray scan showed three annual condensed bands indicated by alternative dark and translucent very fine rings (Fig. 3f). The first band beings the most calcified and appears as a continuous region in the vertebrae. It represents the first age period, followed by faint two spaced lighter bands represent the following two years age periods, which considers as $2^+$ age group. In addition, some clear longitudinal calcified lines were detected.

## DISCUSSION

The ocean sunfish *Mola mola* is recognized by its unique rounded body shape due to lacking the caudal peduncle and caudal fin. It was surprising to sight and record for the first time at the Northern part of the Red Sea, particularly the Gulf of Aqaba at the Egyptian coasts. It was suffering from attack by large predator, may be sharks. The recorded sunfish was recognized based on the characteristics given by (Fraser-Brunner, 1951).

The morphometric measurements ratios (item/TL) in the present specimen were lower than those recorded on other specimens in other localities outside Red Sea. The ratios of eye diameter, preopercular opening length, dorsal fin height and body depth ratios estimated 4.1, 21.8, 32.4 and 15.9% in the present specimen. The ratios of these items averaged 4.8, 33.5, 48.2 and 69.8% respectively, for those reported by Jawad (2013) from Oman and also for that reported by Brito (2003) from Chile (Eastern South Pacific). Moreover, the meristic measurements such as the number of fin soft rays were variable, reaching 18 in the dorsal fin of the present specimen compared with 16 soft rays those reported by Brito (2003) and Jawad (2013). This may be attributed to increasing in latitudes, where this fish was recorded at higher latitudes varied between 28° and 29° N compared with those recorded in Gulf of Oman (22°N) and Chile at the southern hemisphere.

It is well known that, the fish ageing is important to obtain and analyze the population structure; therefore, vertebrae were used as tools to determine the annual rings (Maceina and Sammons, 2006). In the present specimen, the annual rings or annuli were microscopically represented by 3 differentiated regions, of them, the first and second are condensed, but the third was represented by 10-12 finely separated rings. These regions were confirmed by using the x-ray scan.

As it well known that, the sunfish, *M. mola* is considered as a long age bony fish; however, it is difficult to confirm that every obvious band considers as one year mark of the present specimen. Therefore, these results indicate that, there are at least 3 periods of growth in this fish: (1) juvenile stage represented by rapid growth lines in the first band; (2) premature stage which is represented by the second band and (3) mature or adult stage which was represented by the third band. Consequently, these annuli may be indicated to at least 3 years age group. However, further studies are needed to confirm the accuracy of vertebral ageing in sunfish, since there is not enough available information (Al-Baz *et al.*, 1999; Brito, 2003; Jawad, 2013). On the other hand, this fish lives in relatively mid water which is characterized by slow variations in temperature gradient, which is reflected in uneven ring formation or indistinct annual growth line formation.

Despite of there is no statistically difference ($P>0.05$) between the analyzed three types of skeleton (skull, vertebrae, paraxial skeleton) but the results indicated that, skull bones were the most calcified part of the skeleton due to increased ratios of Ca which averaged 46.68 ± 2.51%, and it was followed by P which came in the second order and averaged 22.81±1.08%. On contrast, the ratios of these elements declined sharply in vertebrae (averaged 2.28 ±3.08 and 5.99±2.04% respectively), which may be give more flexibility for vertebral column to deep dive and movements which agreed with Cartamil and Lowe (2004). The unclassified or weakly calcified skeleton of the sunfish may be attributed to its occurrence in relative mid water of low temperature which agree well with that reported by Sambasiviah *et al*. (1985) where the inability to synthesize calcium at low temperature is prevail in the depth, therefore the endoskeleton of deep sea fishes is either un-calcified or strongly weak.

Moreover, sunfish bones consist mainly of organic and inorganic matrix (minerals) especial calcium ($Ca^{2+}$) and phosphate ($PO_4^{3-}$) which form the harden compound (calcium phosphate) for the fish bone (Tongchan, 2011). Consequently, the present results supported that the main bone hardened compound is calcium phosphate, because of Ca and P are proportionally related to each other in this analysis (Fig. 4). Generally, the compound of both of Ca and P constitute 70% at least of sunfish skull components, in addition to other trace amounts of K, Mg, S, Zn and Cu.

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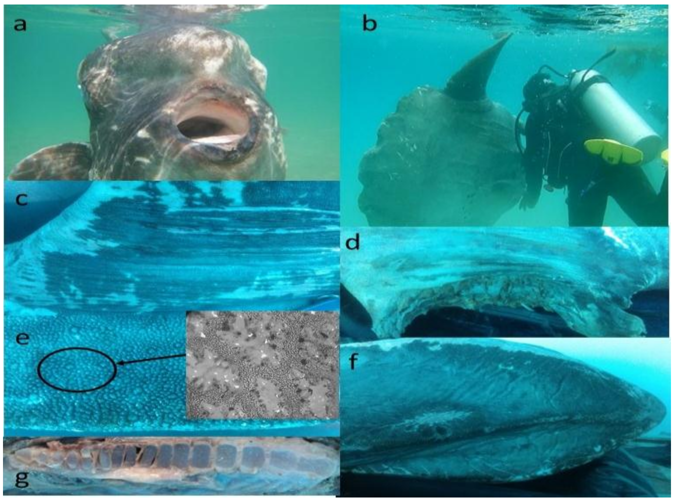

Fig. 1: Underwater photo and life coloration of *Mola mola,* from Aqaba Gulf, Red Sea, Egypt; female, TL 188 cm. a, anterior view; b, side view; c-g, after death (frozen); c, dorsal fin base lateral view; d, attacked anal fin ventero-lateral view; e, skin (close up) lower lateral part of the body; f, head region dorsal view; g, dissected fin internally shows large percentages of cartilage.

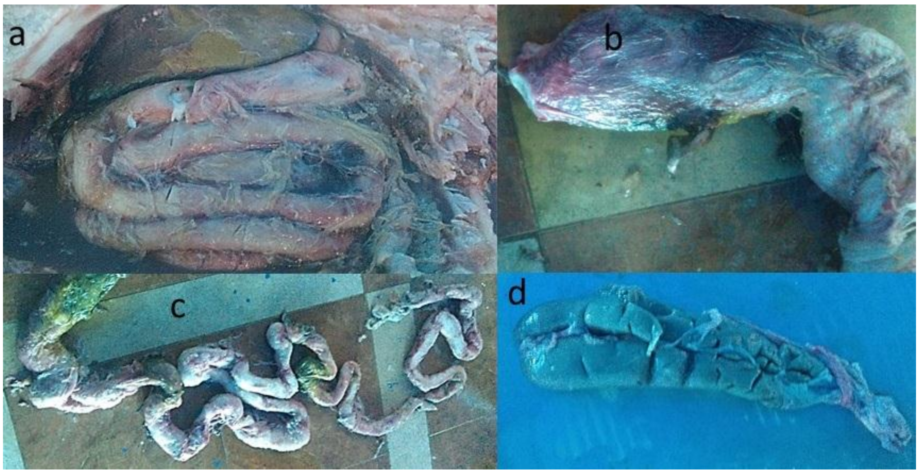

Fig. 2: Dissected visceral organs of *M. mola,* from Aqaba Gulf, South Sinai, Egypt; female, TL 188 cm. a, general viscera; b, stomach; c, digestive tract; d, gonads.

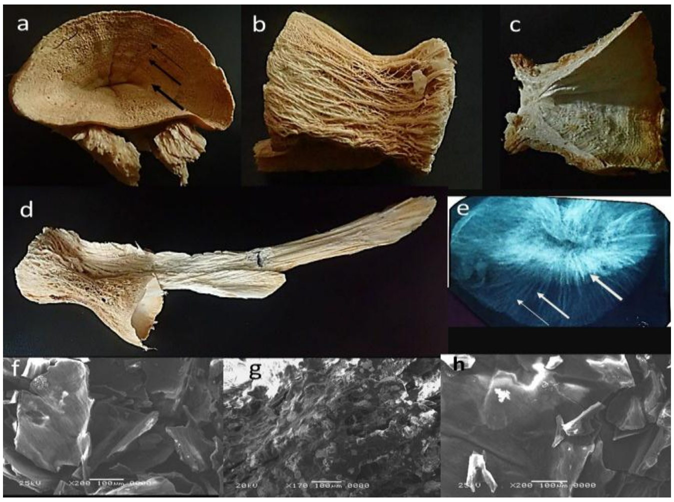

Fig. 3: Shows skeletal parts of *M. mola* from Aqaba Gulf, Red Sea, Egypt; a-e, dried vertebrae; a, anterior view; b, side view; c, bilateral divided vertebra longitudinally; d, whole vertebrae with neural spine lateral view; e, X-ray vertical scan showing calcification marks (arrows indicated annual rings); f-g, vertical SEM for f, skull, g, vertebrae and h, paraxial skeleton part.

## ARABIC SUMMARY

**تسجيل أول ظهور لسمكة الشمس مولا مولا من السواحل المصرية بخليج العقبة ، البحر الأحمر مع بعض الملاحظات على الصفات الظاهرية ومستويات العناصر الرئيسية المكونة للهيكل**

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تقدم هذه الدراسه أول تسجيل لسمكة الشمس (*Mola mola*) من الشواطئ المصرية لمحمية أبوجالوم الواقعة على خليج العقبة – جنوب سيناء، ومن شمال البحر الأحمر قاطبة، وهى من أنواع الأسماك التي لم يثبت تسجيلها قبل ذلك فى البحر الأحمر. وقد أجريت فى هذه الدراسة بعض القياسات لتقديم معلومات عن الصفات الظاهرية، والمورفومترية والتشريح لبعض الأعضاء الداخلية مع تقدير مستويات العناصر الرئيسية في الجمجمة والفقرات وأجزاء أخرى من نظامها الهيكلي. ولقد أوضحت النتائج تسجيل وتقدير قيم ٩ عناصر رئيسية شملت الكالسيوم Ca والصوديوم (Na) والبوتاسيوم (K) والمغنسيوم (Mg) والفوسفور( P ) والكبريت (S) والنحاس (Cu) والزنك (Zn) والكلور(C) ، تم تقدير مستوياتها فى كل جزء على حدة مع توضيح أوجه الاختلاف في قيمها بين المناطق المختلفة من الجهاز الهيكلي لهذه السمكة.

وعلى الرغم من أن التحليل الإحصائى لم يظهر فرقا معنويا ($P>0.05$) بين نسب تلك العناصر في المناطق الثلاث في الهيكل العظمي لهذه السمكة إلا أن النتائج أظهرت أن عظام الجمجمة كانت الأكثر تكلسا من باقى الأجزاء بسبب زيادة نسب الكالسيوم والفسفور (Ca, P) وارتفاع قيمهما في عظام الجمجمة عن غيرها في المناطق الأخرى بالإضافة إلى نسب ملحوظة من الصوديوم (Na) والكلور( Cl) ، كما تتباين نسب هذه العناصر فى الأجزاء الأخرى من الهيكل. كما تم تقدير العمر باستخدام حلقات الفقرات حيث اشارت النتائج إلى ظهور ثلاث حلقات عمرية تم فحصها حيث أظهرت أن هذه السمكة قد تكون في فئتها العمرية الثالثة.

وعلى الرغم من النتائج المتحصل عليها والتي تعد كمؤشرات على انتشار هذا النوع بالمياه المصرية إلا أنه يستلزم متابعة هذا النوع من الأسماك بالبيئة البحرية بالشواطيء المصرية وإجراء المزيد من الدراسة على عدد أكبر من الأفراد.