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Taxonomy and morphological study on the vertebrate remains of Shark and rays fauna from the Middle and Late Eocene succession, Fayoum Depression, Egypt

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Abstract: Well preserved vertebrate remains of Shark and ray fauna from the Middle and Late Eocene succession of Fayoum depression, at Gebal Qasr El-Sagha area have been documented and studied in details. Four stratigraphic sections are measured, described and sampled in the field at Hussein Wally Village, Birket Qarun, Qasr el-Sagha and Wadi el-Afreet. Lithostratigraphically, the studied succession is divided into three formations arranged from base to top into Gehannam, Birket Qarun and Qasr el-Sagha formations. This Eocene sequence provides by far the most complete view of the endemic African vertebrate fauna. Identification of the basic pattern of fish remains and taxonomic evaluation revealed that the recorded shark and rays taxa belong to 3 classes, 7 orders, 12 families, 18 genera, and 21 species. The identified taxa are macro-scale, collected on the surface, and known either from teeth or rostral remains. A taxonomic account and detailed morphologic description of the fossils shark, rays and bony fish teeth have been achieved. The depositional environments in the studied Middle-Late Eocene age sequence are interpreted. The abundance of recognized vertebrate fauna indicates environments varying from open marine shelf with low energy conditions to restricted marine shallow water conditions. However, the frequent distribution of macrofauna with intense bioturbation in sandstones of Birket Qarun Formation is a good indicator of restricted shallow water conditions.

Key words: Taxonomy**,** Vertebrates remains, Eocene, Stratigraphy, Fayoum depression

Introduction:

The Fayoum depression was subjected to many geological and archaeological studies over 200 years, as it holds a rich heritage of best paleontological and archeological sites in the world. Among these studies (Said et al. 1972; Butzer 1976; Wendorf and Schild 1976; Kozlowski 1983; Hassan 1985, 1986, 1997; Said 1990; Hendrickx and Vermeersch 2000). The depression hosts an unique heritage in terms of vertebrates and mammals fossils. It has been known as a repository of Paleogene vertebrates and has attracted the attention of scientists worldwide (e.g., Kirk and Simons 2001;Simons 2005; Lewis and Simons 2007;Simons et al. 2007; Antar 2011; Adnet et al. 2011; Underwood et al. 2011) . The Middle and Late Eocene represented an important period in the evolution of sharks and rays and saw the establishment of 'modern-type' trophic systems (Underwood et al. 2011).

The Eocene rocks around and to the west of the Fayoum depression comprise a thick succession of shelf marine rocks representing environments from open shelf to restricted lagoon. The stratigraphy of the area has been documented by several authors (e.g. Beadnell 1905; Said 1962; Iskander 1943; Allam et al. 1991; Gingerich 1992; Shama and Shided 1994; Abdullah et al. 1997; Dolsonet al. 2002; Ismail and Abd El-Azeam 2008; Abu El Ghar 2012). However, a considerable lateral variation within parts of the succession has caused problems with applying a lithostratigraphical scheme (Strougo 2008).

The Fayoum depression has a fundamentally important role to play in developing an understanding of Egyptian prehistory, in particular during the Epipalaeolithic – Neolithic time. This depression has been inhabited by humans as early as 8500 BP. The first significant occupation by humans, which is documented archaeologically, occurred during the epipalaeolithic and Neolithic Age, around 8200 BP. (Hassan 1986). During this time clear traces of human impact on the Fayoum

depression could be observed in the old Fayoum lake sediments (Zalat 2015).

Description of study area

The Fayoum depression occupies nearly triangular depression, located between latitudes 29° 00' – 29° 45' N and longitudes 30° 00' – 31° 10' E, immediately to the west of the Nile Valley and about 90 km to the south west of Cairo (Fig.1).The depression covers an area of approximately 1700 km^2 and it lies below sea level. The Fayoum is separated from the Nile Valley in the east by a ridge running south from the Giza plateau. The ridge is approximately 8-10 km wide at its northern boundary, but narrows to 2.5km in the south. Its surface is flat and slopes downward northwesterly from 32 m above mean sea level to 45 m below mean sea level at Qarun Lake, which is the lowest part of the depression.The Fayoum depression is carved out of the Middle- Upper Eocene bedrock of the Western Desert of Egypt, and is surrounded by escarpments from all sides. The Eocene sequence is differentiated into four rock units including Wadi El-Rayan, Gehannam, Birket Qarun and Qasr El-Sagha Formations.

Material and Methods

Four stratigraphic sections are measured, described and sampled in the studied area. The first section (I) is located in south west Qarun Lake at Hussein Wally Village, between Longitude29°27′ 56″N and Latitude 30°23′36.8″ E. The second section (II) is obtained from the cliffs bordering the south western shore of lake Qarun and far about 4Km east from the first section, between longitude 29°27`47.1″ N and Latitude 30°26`1.0″ E. The third section (III) is measured at Qasr El-Sagha Temple, between Longitude 29°36`3.2″ N and Latitude 30°40`13.9″ E. The last section (IV) is located far about 3.5 Km N-E Qasr El-Sagha Temple (Wadi El-Afreet Section), between Longitude 29°37`10.3″ N and Latitude 30°41`54.8″ E. A total of 130 samples are collected from the studied sections and investigated in details for paleontological and microfacies analyses.

Lithostratigraphy

The general lithostratigraphic units for Middle-Upper Eocene sequences proposed by Beadnell (1905) and modified later by Said (1962) are the most suitable and will be followed herein. The Umm Rigl Member of Gingerich (1992) is used herein to define the lowermost strata of the Qasr El-Sagha Formation in the Hussein WalleyVillage and Birket Qarun sections. Moreover, the Temple and the Dir Abu Lifa members of Qasr El-Sagha Formation suggested by Bown and Kraus (1988) in the vicinity of Qasr El-Sagha Temple are adopted. Three rock units are recognized as follows from the base to the top; Gehannam, Birket Qarun and Qasr El-Sagha Formations. The last formation is included Umm Rigl, Temple and Dir Abu Lifa members.

Gehannam Formation

Author: Said (1962**)**

Type locality and Type section: The Garret Gehannam, south west Fayoum Provence. It is contained about 35m of gypsiferous claystone, marly limestone, marly sandstone, glauconitic sandstone and marls (Said 1962).

Measured sections: The base of the formation is not exposed, but it is likely that the lowest sample was from a level quite high in the formation. About 15 to 20m of this formation are exposed in the base of Hussein Walley Village and Birket Qarun sections respectively.

Boundaries: In the west Fayoum area, the Gehannam Formation conformably overlies El Gharaq Formation and underlies the Birket Qarun Formation.

Description: The exposed section of upper part Gehannam Formation in the west south Qarun Lake is distinguished mainly by gypsiferous calcareous claystones and shale with marl intercalations (Fig. 3). The beds are bioturbated, sometimes glauconitic and contain a diverse, open marine fauna. The upper part of the Gehannam Formation passes upwardly into the mudstones and sandstones of the Birket Qarun Formation.

Birket Qarun Formation

Author: Beadnell (1905)

Type locality and type section: It is represented in cliffs bordering the northern shore of lake Qarun (Said 1962), and the type-section is thus the steep-faced precipitous escarpment described by Beadnell (1905).

Measured sections: This formation is well developed in the two studied sections at south-western end of Lake Qarun. Its thickness of about 38m at Hussein Wally Village section and increase to about 52.5m at Birket Qarun section (Fig. 3).

Boundaries: The Birket Qarun Formation conformably overlies the Gehannam Formation by stratigraphic gradual contact and underlies the Qasr El Sagha Formation.

Description: In the studied sections, the Birket Qarun Formation consists mainly of mudstone, siltstones and, heavily bioturbated calcareous sandstones, and trace fossil banks at its top part. The lower part of this formation is arranged in coarsening-upward sequences starting with claystones, siltstones and ending with fine to medium sized sandstone. This sandstone characterizes by golden yellow color, carbonate concretions, calcareous, fossiliferous thin beds with trace fossils in parts. The size and numbers of carbonate concretions

increase upwardly and to north direction in the studied area. The upper part of the Formation consists mainly of brownish yellow sandstone with some shale layer intercalations. The shale change in thickness laterally and characterizes by *Thalassinoides* trace fossils. On other hand the top most sandstone bed at the contact with superimposed Qasr El-Sagha Formation is highly bioturbated by *Rhizoliths* trace fossils.

Qasr El Sagha Formation

Author: Beadnell (1905)

Type locality and Type section: It is located at Qasr El Sagha Temple with a thickness175 m of alternating series of clays and limestone with sands and sandstone in the upper beds.

Measured sections: The Qasr El Sagha Formation is recorded in all studied sections and distinguished by three members. Um Rigl Member, the lower part of the Qasr El Sagha Formation attains 51m at Birket Qarun section and 31m at Hussein Walley Village section. In addition to the two upper members (Temple and Dir Abu Lifa) are measured at Qasr El Sagha and Wadi El Afreet sections by 88m and 95 respectively (Fig. 3).

Boundaries: In the studied area, the Qasr El Sagha Formation conformably overlies the Birket Qarun Formation and conformably and/or unconformably underlies the Gabel Qatrani Formation.

Description and subdivisions: The Qasr El Sagha Formation consists mainly of a thick succession of dark gypsiferous mudstones with thin hash fossiliferous reddish bed intercalations, and overlain by friable, cleaned washed, cross bedded sandstones and ends with an extensively hard yellow carbonate layer known as the Bare Limestone (very hard dolomitic limestone).

Results and Systematic description

The recorded vertebrate remains from the studied Eocene successions are investigated in detail. The results of vertebrate identification show 21 species belong to 18 genera, 12 families, 7 orders and 3 classes. The recognized fish assemblage has clear ecological affinities with Eocene Tethyan fauna and also has common elements with Eocene myliobatids, Carcharhinidae, Triakidae and Hemigaleidaefishes. The most commmon taxa are included *Hexanchus agassizi* Cappetta, *Pristis lathami* Galeotti, *Otodussokolovi* (Jaekel), *Macrorhizoduspraecursor* (Leriche), *Cretolamna twiggsensis* (Case), *Galeocerdo latidens* (Agassiz), *Negaprion frequens* (Dames)*Rhinoptera sherburni* Arambourg, *Carcharodon carcharias* Linnaeus, *Galeocerdo cuvieri*Péron & Lesueur 1822*, Xiphiorhynchus aegyptiacus*Weiler, *Rhynchobatus* sp., *Carcharias* sp., *Negaprion* sp*., Aetobatus* sp., *Galeocerdo* sp*., Rhizoprionodon* sp*., Leidybatis* sp., and *Eutrichiurides* sp.

The classification followed here after Compagno et al. 2005

Class Chondrichthyes Huxley 1880
Subclass Elasmobranchii Bonapart 1836
Cohort Euselachii Hay 1902
Subcohort Neoselachii Compango 1977
Super order Squalomorphii Compagno 1973
Order Hexanchiformes Buen 1926
Suborder Hexanchoidei Garman 1913
Family Hexanchidae Gray 1851
Genus *Hexanchus* Rafinesque1810

***Hexanchus agassizi* Cappetta 1976**
Pl. 1, fig. 15.
2013 *Hexanchus agassizi*, Otero et al., Fig. 5: 1-6
2014 *Hexanchus* cf. *agassizi*, Carlsen & Cuny, Fig. 16 E–F

Description: The best preserved tooth measures 11 mm mesio-distally, 6 mm apico-basally and 1.7 mm labio-lingually. The tooth is worn. It is comb-shaped with a main cusp and seven accessory cusps regularly decreasing in size distally. All cusps are leaning apicodistally. The mesial cutting edge of the main cusp has no serration and no heel. It is convex in the basal two thirds and straight near the apex. The distal cutting edge is concave in the basal part and convex in the apical part. The lingual face is convex, the labial face almost flat.

Geological distribution: The genus is known since the Early Jurassic to Recent (Cappetta, 1987), with a cosmopolitan distribution. Ward (1979) describes the teeth of *Hexanchus agassizi*, from the Lower Eocene of England. *Hexanchus agassizi* is known from south-western France and from the London Clay of England (Adnet 2006). Carlsen & Cuny Fig (2014) 16E–F (Early-Middle Eocene Denmark).Ypresian of England, Eocene of New Jersey, and the Oligocene of Australia and the the Lower Oligocene of ex-U.S.S.R. (Cappetta, 1987). Eocene *Hexanchus* has been described from Seymour Island, Antarctica (Cione and Reguero, 1994).

Known geologic range: Cretaceous – Oligocene (Otero et al. 2012)

***Hexanchus* sp.**
2006 *Hexanchus* sp. Adnet, Fig.3
2006 *Hexanchus griseus* Adnet, Fig. 2 (A-L),

Remarks: Small teeth, with very distinct cutting edges and wide crown. The recorded taxon is similar to *Hexanchus* sp. and *Hexanchus griseus* (Bonnaterre, 1788) that reported by Adnet (2006) from late Ypresian/early Lutetian, south−western France.

Order: Rajiformes Berg, 1940
Suborder Pristioidei CAPPETTA 1980
Family: Pristidae BONAPARTE 1838
Genus *Pristis* Latham, 1794

***Pristis lathami* Galeotti, 1837**
Pl.1, fig. 18
2012 *Pristis lathami* Galeotti, Diedrich, Fig. 14 (18).
2012 *Pristis lathami* Galeotti, Zalmout et al., Fig. 5O-P

Description: The tooth is 45 mm long, 15 mm wide and 7 mm thick at the base of the crown. The proximal half of the tooth is thickest, and the tooth tapers distally to a much thinner 3 mm. The anterior edge of the tooth is thick and blunt, while the posterior edge is concave, a shallow gutter that runs from the base of the tooth to the distal end. The vertebrae is rounded and has concentric lines in internal view and longitudinal lines in side view.

Geographic distribution: *Pristis lathami* is known from lower and upper Eocene deposits in Africa and North America (Cappetta, 1987). Eocene of the Paris Basin (Casier, 1949). In Egypt the species is known from the Eocene of the Fayoum and Bahariya regions (Stromer, 1905B; Case and Cappetta, 1990; Underwood et al., 2011; Murray et al., 2011; Adnet et al., 2011). Late Eocene Qattara depression, Egypt (Zalmout et al. 2012), late Eocene of South Carolina and North America (Cicimurri 2007), Southern North Sea (Diedrich 2012**).** Farther east, *Pristis lathami* is known from the Eocene of Qatar (Casier, 1971). Middle–Late Eocene, southwestern Morocco (Adnet et al. 2010)

Known Geologic range: Early to Late Eocene.

***Pristis aquitinicus* Delfortrie 1872**
1959 *Pristis aquitinicus,* Delfortrie**,** Ghosh , p. 67, pl. 88, Figs. 7, 8.
2013 *Pristis aquitinicus* Delfortrie**,** Sharma and Patnaik, Fig. 5: J, K.

Description**:** The anterior surface is tapering gently towards the tip thereby increasing the curvature while the posterior surface is straight and has a broad sulcus. Length of about 22 mm and width 21 mm.

Geographic distribution: The fossil remains of the genus *Pristis* ranging in age from Lower Eocene to Recent (Sharma and Patnaik2013)**.** It is reported from Miocene of India (Sharma and Patnaik2013). Cappetta (1970) also reported *P. aquitanicus* from the Middle Miocene of Southern France

Known Geologic range: Early to Late Eocene.

Suborder Rhynchobatoidei Flower 1941
Family: Rhynchobatidae Garman, 1913
Genus: *Rhynchobatus* Müller and Henle, 1837

***Rhynchobatus* sp.**
2010 *Rhynchobatus* sp.Adnet et al., Fig. 4 E.
2011 *Rhynchobatus* sp.Underwood et al., Fig. 7 (X).
2011 *Rhynchobatus* sp.Antar Fig. 29 (O)
2013 *Rhynchobatus* sp.Sharma and Patnaik**,** Fig. 5: F.

Description**:** A small tooth; crown enamel is having a granular texture**,** the lingual face is flat, concave on each side separated by a moderate medial uvula, the terminal end of the median uvula is pointed, lateral uvulae absent; root massive and extends beyond the lingual face of the crown; root lobes divided on both the sides by a deep nutritive groove and a small foramina.

Geographic distribution: It is recorded from Middle to Late Eocene of the Fayoum area (Underwood et al., 2011), Late Eocene of the western Desert, Egypt (Adnet et la., 2010), Langhian of Loupian, Herault, Southern France (Cappetta, 1987) and from Oligocene Chandler Bridge Formation of South Carolina, U.S. (Cicimurri and Knight, 2009). *Rhyncobatus* teeth have also been reported from the Maastrichtian of Morocco (Arambourg, 1952), the Miocene of Japan (Itoigawa *et al*., 1985) and Miocene of India (Sharma and Patnaik, 2013).

Known geologic range: Maastrichtian to Miocene.

Suborder Myliobatoidei Stingrays
Super family Myliobatoidea Compango 1973
Family: Myliobatoidea Bonaparte 1838
Genus: *Myliobatis* Cuvier 1817

***Myliobatis* sp.**
1972 *Myliobatis* sp., Welton, Plate 1, p. 167, Fig. 8.
2011 *Myliobatis* sp., Antar, Fig 29 J-J1
2011 *Myliobatis* sp., Underwood et al., Fig. 4 (G).
2012 *Myliobatis* sp. Otero et al ., Fig. 3: T
2013 *Myliobatis* sp., Sharma and Patnaik, Fig. 3(A).

Description**:** Teeth broader than length, with hexagonal contour in shape and rectilinear outline; the length is about 28 mm and the width of about 7-9 mm, the crown is as thick as the root, flat and quite convex, being displaced anteriorly with respect to the root. The crown and the root are well separated by a minor groove. The basal surface of the root is flat with 23 root lobes separated by grooves. The tooth is much broader than long.

Geographic distribution: The genus *Myliobatis* is known since the Early Paleocene to Recent, with a cosmopolitan distribution (Cappetta, 1987). *Myliobatis* sp. has been described from the Paleocene to Eocene of western Africa including Angola, Egypt, Morocco, Togo and Nigeria (Cappetta 1987; Cook et al. 2010). Middle Eocene of Kutch (Mishra, 1980), Miocene Coaledo Formation along the Oregon coast Welton (1972), Miocene of Baripada Beds, Orissa (Sahni and Mehrotra,1981), Eocene of Subathu Formation, Bilaspur area and Himachal Pradesh (Singh, 1985, Kumar and Loyal, 1987), Eocene Vastan lignite Mine of Cambay Shale, Gujarat (Rana *et al*., 2004), Lower Eocene Panandro lignite field, Gujarat (Bajpai *et al*., 2002), Early Eocene Kapurdi Formation of Rajasthan (Rana *et al.*, 2006), Eocene deposits of Fayoum and western

Desert, Egypt (Case and Cappetta, 1990; Antar, 2011; Underwood et al., 2011),Miocene of India (Sharma and Patnaik, 2013). The genus also has been recognized on Seymour Island, Antarctica (Kriwet, 2005).

Known geologic range: Campanian to Recent.

Genus: *Aetobatus*Blainville1816

***Aetobatus* sp.**

2011 *Aetobatus* sp. Antar, Fig. 29 (M).as
2011 *Aetobatus* sp. Underwood Fig. 4 (F)
2013*Aetobatus* sp. Sharma and Patnaik Fig. 4: E, F, G

Description: One sample is collected and well preserved. Root is quite distinctive with small vertical lines along it and has smooth edges. The crown lacks the hexagonal shape which is usually associated with myliobatids. The contact between root and crown is straight. Crown is slightly serrate and less thickness than root. The occlusal surface is smooth. The root is nearly as high as the crown and is divided into longitudinal ridges and grooves. The length is about 6mm and width of about 6mm**.**
Geographic distribution: *Aetobatus* teeth have been described from the Lower Miocene of the western coast of India (Sahni and Mishra, 1975).
Known geologic range: Middle Eocene to Lower Miocene

Genus: *Leidybatis* Cappetta, 1986
Leidybatis sp.
Pl.1, fig.17

Description: Teeth broad with rectangular shape. The length is about 28-32 mm and the width of about 7-9 mm, Root is thick and distinctive with small serration along it and has smooth edges. The contact between root and crown is straight. Crown is slightly serrate and less thickness than root. The root is nearly as high as the crown and is divided into longitudinal ridges and grooves.
Known geologic range: Middle to Late Eocene

Order: Myliobatiformes Compagno, 1973
Family: Rhinopteridae Jordan and Evermann, 1896
Genus: *Rhinoptera* Cuvier, 1829
Type species: *Myliobatis marginata* Saint−Hillaire, 1817, Recent, Mediterranean Sea.

Remarks: The Rhinopteridae are comprised of a single genus, *Rhinoptera* (Cappetta 2004)..

Geographic distribution: The genus is known from the Paleocene in North and West Africa, and Europe (Cappetta 2004), and Lower Miocene of Switzerland and France and most other marine Neogene deposits (Leriche 1927; Cappetta 1970).

***Rhinoptera sherburni* Arambourg 1952**
Pl.1, fig.16

1952 *Rhinoptera* aff.*sherburni*Arambourg, Plate XXXII, Figs. 15-24.
2013 *Rhinoptera sherburni* Arambourg**,** Sharma and Patnaik(Fig.4: H, I)

Description**:** The teeth are medium size, with 8-10mm length, and 4-6 mm width, hexagonal in shape; teeth possess a prominent but thin lingual shelve; labial face is more upright, the lingual root overhangs the crown by a distinct margin, the crown is thick. Upper surface of root is slightly curved and smooth. The contact between root and crown is very slightly curved. The crown is serrate and curved in middle area and become straight towards edges.
Geographic distribution: *Rhinoptera sherborni* has been reported from the early Eocene of Virginia (Kent, 1999); the Middle Eocene of England (Kemp *et al*., 1990), Eocene Nigeria (White, 1926), Morocco (Arambourg, 1952) and Uzbekistan (as *Rhinoptera* cf. *sherborni,* Case et al., 1996) and the late Eocene of Egypt (Murray et al., 2011). Fossil record of *Rhinoptera* extends back upto the Late Palaeocene (Cappetta, 1987, 2006), Middle–Late Eocene, southwestern Morocco (Adnet et al. 2010), Miocene of India (Sharma and Patnaik2013), Madagascar (Wallett, 2006).

Known geologic range: Paleocene to Miocene

Order Lamniformes BERG 1958
Family: Odontaspididae Müller and Henle, 1839
Genus: *Carcharias* Rafinesque, 1810

***Carcharias* sp.**

2012*Carcharias* sp.Zalmout et al. Fig. 3B-E
2012 *Carcharias* sp. Diedrich Fig. 14 (7-8)
2013*Carcharias* sp. Otero et al., Fig. 3: 1-4

Description: The recorded taxon is small-sized not larger than 2 cm, with length 15-18 mm, and width 5-8mm. The crown sharp having smooth enamel in both labial and lingual surfaces; the cutting edge is complete and reaches the base of the crown; slender root branches with medial groove and deep depression between them; In some specimens the root of tooth is partially broken and arched. The contact between root and crown is arched. Crown is thin and long and has smooth edges and surface in lingual and labial view are ended with very acute end.

Geographic distribution**:** Fossils of *Carcharias*have been found all over the world, especially in the Cretaceous, Eocene, Miocene and Oligocene sediments of Europe, United States, Australia and Africa (Cappetta and Case, 1975a,b, Cappetta, 1987, Otero et al., 2013, Zalmout et al., 2012, Diedrich 2012).Southern North Sea (Diedrich 2012),Late Eocene Qasr El Sgha, Fayoum (Underwood et al. 2011), Late Eocene of Qattara depression, Egypt (Zalmout et al. 2012), Pliocene Farol das Lagostas locality, Angola (Antunes 1978).
Known geologic range: Maastrichtian to Pliocene**.**

Family Otodontidae Gückman 1964
Genus *Otodus* Jordan and Hannibal, 1923

***Otodus sokolovi* (Jaekel, 1895)**
Pl.1, figs.1-4
2010 *Carcharocles sokolovi* Jaekel**,** Adnet et al. Fig.3 a1,2
2011 *Carcharocles sokolowi* Jaekel, Antar, Fig.24
2011 *Otodus* (*Carcharocles*) *sokolowi* Jaekel, Underwood et al. Fig.4 A
2012 *Otodus* cf. *sokolovi* Jaekel, Zalmout et al. 2012, Fig. 3F-BB
2012*Carcharocles sokolovi*Jaekel**,** Diedrich**,** Fig.10 (9-10)

Description: Large teeth that may reach 60 to 80 mm in height and 45-65 mm in width. Central blades are large and bear fine and regular strong serrations along both cutting edges. The teeth have two divergent lateral cusps which are triangular in shape, serrated and wide.

Geographic Distribution: This species is recorded from middle Eocene of Syria, Jordan (Cappettta et al., 2000, Mustafa and Zalmout, 2002; Smadi et al., 2003; Mustafa et al., 2005), middle Eocene of Fayoum, Egypt (Stromer, 1905A; Case and Cappetta, 1990; Vliet and Abu el Khair, 2010; Underwood et al., 2011), Middle–Late Eocene, southwestern Morocco (Adnet et al., 2010), and Nigeria, Congo, and Angola (White, 1926; Dartevelle and Casier, 1942, 1943, 1949, 1959),Late Eocene Qattara depression (Zalmout et al. 2012), In North America *Otodus* (*Carcharocles*) is known from North Carolina (Bourdon and Chandler, 2007), the Barnwell Formation in Georgia (Case and Borodin, 2000), and middle Eocene of Alabama (White, 1956), middle and late Eocene Tethyan deposits in North Africa, the Middle East, and North America (Zalmout et al. 2012).

Known geologic range: Middle Eocene-Lower Oligocene.

Family: Lamnidae Müller & Henle 1838
Genus *Carcharodon* Müller & Henle, 1838
***Carcharodon carcharias* Linnaeus, 1758**
Pl.1, fig. 9
1973 *Carcharodon carcharias* Linnaeus, Mehrotra *et al.*, p. 191-192, pl. 2, figs. 2, 6 a-b.
1981 *Carcharodon carcharias* Linnaeus, Sahni and Mehrotra, p. 112-113.
1998 *Carcharodon carcharias* Linnaeus, Tiwari *et al.*, p. 12, pl. 1, fig. 5, 6.
2009 *Carcharodon carcharias* Linnaeus, Mondal *et al*., pl. II, figs. 1-4.
2010 *Carcharodon carcharias* Linnaeus, Andreev and Motchurova, Fig. 2 a, b

Description: The tooth is having height equal or greater than the width. Length 22 mm and width 16 mm. Tooth composed of root and crown. Root is broken except small part and appeared slightly curved and crown is broad in upper part and become narrow towards lower part and has sharp end and serrate edges and has longitudinal lines in ligual and labial view. Serrations of the cutting edges are uniform, and relatively coarser towards the base in larger specimens. Mesial edge is more concave than distal edge, mesial concavity shows wide variations, some are feebly concave or straight. Labial surface is flat, however at the tip it may be slightly inwardly curved. The base of the root may be feebly bifurcated or flat.

Geographic distribution: This species is recorded from Farol das Lagostas, Angola. (Andreev and Motchurova 2010), Miocene Chesapeake Bay at Calvert Cliffs in Maryland. USA, Lowery et al. (2011),Early Pliocene of Spain, Early – Middle Miocene of Greens mill run, north carollina, western and Eastern USA, South Africa, Australia and Late Eocene Qasr El-Sagha Formation Egypt (Zalmout et al. 2012).

Known geologic Range: Eocene to Early Pliocene.

Genus *Macrorhizodus* Glikman, 1964
Type species: *Isurus praecursor* (Leriche, 1905).
***Macrorhizodus praecursor* (Leriche, 1905)**
Pl.1, fig.5
2011 *Cosmopolitodus praecursor (Macrorhizodus praecursor),* Leriche, Antar, Fig.25: A-B7.
2012 *Macrorhizodus praecursor* Leriche**,** Zalmout et al., Fig. 4A-V
2012 *Isurus praecursor* Leriche,Diedrich, Fig.11 (1-10).
2012*Macrorhizodus* (*Isurus*) *praecursor* Leriche,Otero et al., Fig. 3: L, M
2013 *Macrorhizodus praecursor* Leriche**,** Otero et al., Fig. 3: 28-34

Description: Medium to relatively large sized lamniform teeth with high, slender and triangular crown that becomes broader toward the base, being labio-lingually compressed; flat labial face with soft enamel and smooth folds near the root; lingual face is convex with some cracks in the enamel; root is slightly massive, basally flattened. The teeth may reach 40-44 mm in total height anteriorly, and 30-32 mm in total width laterally.

Geographic distribution: *Macrorhizodus praecursor* is widely known from all middle and late Eocene Tethyan deposits of Europe, North America and some late Eocene marine vertebrate localities in Egypt (Adnet et al., 2011), Middle to Late Eocene of the Seymour Island in Antarctica (Cione and Reguero, 1994), Priabonian of the southernmost Chile (Otero et al., 2012b). Eocene deposits in Belgium, Syria, Nigeria, Togo, Guinea Bissau and England (Cappetta, 1987). Middle-Late Eocene of Chesapeake Bay, U.S. (Kent, 1994),southwestern Morocco (Adnet et al. 2010) and Southern North Sea (Diedrich (2012).Late Eocene of Qattara depression, Egypt (Zalmout et al., 2012).

Known Geologic range: Middle - late Eocene

Family: Cretoxyrhinidae Gluckman 1958
Genus: *Cretolamna* GLUCKMAN 1958

***Cretolamna twiggsensis* Case, 1981**
Pl.1, figs.11-12
1981 *Lamna twiggsensis* Case, pl. 3, Figs. 3–8
1990 *Cretolamna twiggsensis* Case, Case & Cappetta, pl. 3, Figs. 40–55
2007 *Cretolamna twiggsensis* Case, Adnet et al., Figs. 6.21 and 6.22
2011 *Brachycarcharias twiggsensis* Case, Underwood et al., Fig. 4L–M
2011 *Cretolamna twiggsensis* Case, Adnet et al, Fig. 3A
2012 *Brachycarcharias twiggsensis* Case, Zalmout et al., Fig. 4W-X

Description: Teeth are relatively large; with height up to 20-25mm and 15-18 mm width, the cusp is high, quite triangular in upper teeth and not very thick. The root lobes are elongated and their ends are often rounded. The upper anterior tooth has two divergent lobes with a height less than the crown, the anterior –lateral teeth have vertical central blade, slightly sigmoidal in shape and had a wide base, with pointed edge and having two small diverted lateral cusps.

Geographic distribution: the genus is nearly worldwide, Early Cretaceous-Early Eocene. African distribution and occurrence: Morocco, Angola, Democratic Republic of the Congo, Niger, Nigeria and Egypt; Late Cretaceous-Eocene (Cappetta 1987). The species extends to palaeotropical seas between the Caribbean, western Tethys (Case, 1981; Case & Borodin, 2000) and oriental Tethys (Casier, 1971; Case & Cappetta, 1990; Case & West, 1991; Adnet *et al.* 2007). It is recorded from Egypt (Mokkatam to Wadi Hitan areas), both in Bartonian and Priabonian deposits (Case and Cappetta, 1990 and Underwood et al., 2011), middle and late Eocene of the Fayoum and Qattara depression, Western Desert of Egypt (Case and Cappetta 1990; Strougo et al., 2007; Underwood et al., 2011; Adnet et al., 2011; Zalmout et al. 2012), the species is recorded elsewhere from Pakistan (Adnet et al., 2007), Middle–Late Eocene of southwestern Morocco (Adnet et al., 2010) and Georgia, USA (Case, 1981; Case and Borodin, 2000).

Known geologic range: Middle–Late Eocene

Order Carcharhiniformes
Family:Carcharhinidae Jordan & Evermann, 1896
Genus ***Galeocerdo*** Müller and Henle, 1837
Type species: *Galeocerdo cuvieri* Peron and Le Sueur, 1822

***Galeocerdo cuvieri*Péron & Lesueur, 1822**
Pl.1, fig. 14
1973 *Galeocerdo cuvieri* Péron & Lesueur, Mehrotra *et al.*, p. 184, pl. 1, fig. 3.
1981 *Galaeocerdo cuvieri* Péron & Lesueur, Sahni and Mehrotra, p. 109, pl.2, fig. 12.
2009 *Galeocerdo cuvieri* Péron & Lesueur, Mondal *et al.*, Pl.I, figs. 11-12.

Description: Tooth large with 23-30 mm long and 18-21 mm width, sub-triangular, irregular in shape, broader than high and highly oblique. Crown is labio-lingually thickened; the mesial cutting edge has a deep notch, distal margin strongly convex; both cutting margins are serrated; strength of serrations becomes weak to obsolete near the apex; at distal cutting edge strength of serrations are coarser at the middle, decreases towards the base and the apex, whereas mesial edge serrations are finer and uniform. Mesial heel is extended, with numerous denticles, size of the denticles increases proximally. On the labial surface a prominent triangular pit is present at the middle near the root; labial surface bears few longitudinal striations; crown-root boundaries at both faces are convex, convexity more pronounced in lingual side. Root higher than crown; in cross-section it is labio-lingually arched and thicker at the middle part; in profile the tooth deflects outward.

Geographic distribution: *G. cuvieri* has been reported from the lower Miocene beds of different localities in Gujarat (Mehrotra *et al.* 1973). Miocene from baripada, Orissa (Mondal et al 2009). The type species, *Galeocerdo cuvier*(Peron and Le Sueur 1822), is extant and can be found in all tropical and temperate seas, including those of Madagascar (Smale 1998; Cappetta 2004). Pliocene of Italy (Lawley 1876), South Africa (Davies 1964), and North Carolina (Cappetta 2004).

Known geologic range: Middle Eocene to Pliocene.

***Galeocerdo* sp.**
1990 *Galeocerdo* sp. Case and Cappetta, 1990, plate 5, figs 92-95.
2010 *Galeocerdo* sp. Andreev and Motchurova, fig. 5 a-c; fig. 6
2002 *Galeocerdo* sp. Bajpai and Thewissen, txt-fig.2f.

Description: Root of the tooth is arched and elongate and has linear groove in mid line in lingual view and smooth in labial view. The contact between root and crown is slightly arched.
Geographic distribution: Late Eocene of El-Sagha Formation (Case and Cappetta, 1990). Teeth of *Galeocerdo* have previously been reported in Egypt by Stromer (1905a) and Priem (1897b). Eocene of Minqar Tabaghbagh, western Desert, Egypt (Vliet and Abu El-Khair 2010). This species is recorded from Upper Miocene of Angola. . (Andreev and Motchurova2010).

Known Geologic range: Eocene to Upper Miocene.

Genus *Carcharhinus* Blainville, 1816
Type Species: *Carcharias melanopterus*Quoy and Gaimard, 1824

***Carcharhinus* sp.**
2010 *Carcharhinus* sp. AndreevP, Motchurova, Fig. 5 c, d
2010 *Carcharhinus* sp. Adnet et al. Fig.3 G.

2011 *Carcharhinus*sp. 1, Antar, Fig. 28 C
2012 *Carcharhinus* sp1.Zalmout et al., Fig. 5E-F.

Description: The teeth are relatively small up to 11 mm height and 11-12mm width. Cusp is flattened labially and triangular in shape , extends mesiodistally into shoulders; the shoulders are sharp and separated from the main blade by slightly developed notches. Lingually, it is convex and the apex curved labially and has no lateral cusplets. The roots have a shallow furrow in the middle of the lingual portion.

Geographic distribution: Middle–Late Eocene, southwestern Morocco (Adnet et al. 2010), Middle and Late Eocene deposits of Fayoum and Qattara depressions, Egypt (Underwood et al. 2011, Zalmout et al., 2012)

Known Geologic range: Middle and Late Eocene**.**

Genus *Negaprion* Whitley, 1940

***Negaprion frequens* (Dames, 1883)**
Pl.1, fig.10
1908 *Carcharias* (*Aprionodon*) aff. *frequens* Priem, pl.15, Fig. 6–7
1971 *Aprionodon frequens* Casier, pl. 1, Fig. 6
1990 *Carcharhinus frequens* Dames**,** Case & Cappetta, pl. 5, Figs. 102– 107; pl.7, Figs. 143–148 and 151–159
1990 *Negaprion frequens* Dames**,** Case and Cappetta, Plate 7, 147–147.
2011 *Carcharhinus* aff. *frequens* Dames**,** Adnet et al., Fig. 3G–H
2011 *Negaprion frequens* Dames**,** Underwood et al., Fig. 5V
2012 *Negaprion frequens,* Dames**,** Zalmout et al., Fig. 5, A-D

Description: Teeth of are relatively small, ranging from 7 to 12 mm in total height, from 5 to 12 mm in total width (mesiodistally), and from 2 to 3 mm in lingolabial thickness in the middle of the root. The upper teeth have a crown of triangular outline with a cusp slightly slanted distally, while the lower teeth generally have a slender cusp with smooth cutting edges than never reach the heels, except on some lateral teeth. The cutting edges are always unserrated and are not disconnected from the cutting edges of lateral heels which are totally smooth. The root lobes have enlarged and rounded ends.

Geographic distribution: It is recorded from the Miocene of Europe (Leriche 1926; Leriche 1957; Antunes and Jonet 1970; Cappetta 1970), North Africa (Arambourg 1952), North and South America (Longbottom 1979), and India (Mehrotra et al 1973; Sahni and Mehrotra 1981), Angola (Antunes 1978), middle Eocene of the Midra and Saila shales of Qatar (Casier, 1971), Late Eocene of Birket Qarun and Qasr el-Sagha formations, Fayoum area (Case and Cappetta, 1990; Underwood et al., 2011), late Eocene of Jordan (Cappetta et al., 2000; Mustafa and Zalmout, 2002), and the late middle Eocene to late Eocene of southwestern Morocco (Adnet et al., 2010), Miocene fishes from baripada beds, Orissa (Patnaik et al**.,** 2014).

Known geologic range: Eocene to Pleistocene.

Genus: *Rhizoprionodon* Whitley 1929
Type species: *Carcharias* (*Scoliodon*) *crenidens* Klunzinger, 1880.

Rhizoprionodon sp.
Pl.1, figs. 7-8
1990 *Rhizoprionodon* sp., Case& Cappetta, pl.7. Figs. 160–163
1991 *Rhizoprionodon* sp., Case & West, pl. 3. Figs. 2–4
2011 *Rhizoprionodon* sp., Adnet et al., Fig. 3P–Q
2012 *Rhizoprionodon* sp., Zalmout et al., Fig. 5K
2013 *Rhizoprionodon* sp., Otero et al., Fig. 6: 3-8
2014 *Rhizoprionodon* sp., Sharma and Patnaik**,** Pl. 4, figs. 9, 10

Description:Teeth are small, up to 7-8mm height and 8-10mm width, and 2-3mm thick, cusp small and is bent backward with extended crown at the base. Both the cutting edges are sharp, smooth without any serration. The mesial cutting edge is long slightly concave and recurved towards the apex and the distal edge is short; the mesial cutting edge is sigmoidal. The lingual face is convex and the labial face is flat. The distal heels are rounded with cusplet. The crown overhangs the root. The root low and broad, median nutritive groove is present in the lingual face of the root. The basal margin of the root concave to straight.

Geographic distribution: This genus is relatively common in worldwide Eocene marine deposits, Fayoum and Qattara depression, Egypt (Case and Cappetta, 1990; Strougo et al., 2007; Underwood et al., 2011), from Pakistan (Case and West, 1991; Adnet et al., 2007), Middle to Late Eocene. Río Baguales Formation (Otero et al. 2012).*Rhizoprionodon* sp. is recorded from the Eastern Coast of India (Patnaik et al**.,** 2014**)**.

Known geologic range: Middle Eocene to Miocene.

Class: Osteichthyes Huxley, 1880
Order: Perciformes Bleeker, 1859
Family: Trichiuridae Rafinesque, 1810
Genus: *Eutrichiurides* Casier 1944

***Eutrichiurides* sp.**
Pl.1, fig.13
1966 *Eutrichiurides* sp. pl.3, fig. 30
2004 *Eutrichiurides* sp. Rana et al., Fig. 3 (41)

Description: Teeth long and slender with conical shape; height up to 33 mm and width of about 8 mm. Apex small chisel-like, about one-tenth of basal part; slight keel along the edges extend towards base; basal part laterally compressed with vertical ridges and grooves. It

has irregular surface and longitudinal lines on lingual and dorsal view.

Geographic distribution:*Eutrichiurides* is an extinct genus of prehistoric bony fish. This genus is recorded from the Cretaceous age at the Khouribga Plateau, Morocco, the Early-Mid Eocene, Monmouth County, the Early Eocene (Ypresian) of the lower part of the Jaisalmer basin (Cappetta 1987).
Known geologic range: Cretaceous -Eocene

Class Actinopterygii (sensu Nelson, 1994)
Division Teleostei Muller, 1844
Order Perciformes Bleeker, 1859
Suborder Xiphioidei Swainson, 1839
Family Xiphiidae Swainson, 1839
Subfamily Xiphiorhynchinae Regan, 1909
Genus *Xiphiorhynchus* van Beneden, 1871
Type *Species-Xiphiorhynchus elegans* van Beneden, 1871

***Xiphiorhynchus aegyptiacus*Weiler, 1929**
1929 *Xiphiorhynchus aegyptiacus*.Weiler, Taf. I , Fig. 4.

Description: Elongate vertebrae, thin thickness in the middle that become broad towards lower and upper edges and has knobs in labial view. Height of about 12-15 mm and width 8-13 mm.In cross section, the rostrum contains two types of longitudinal canals, an unpaired central canal and two pairs of lateral nutrient canals, and both types vary as to how far they extend distally. The dorsal pair of lateral nutrient canals is positioned closer to the mid-line than the ventral pair of lateral nutrient canals.

Known Geologic range: Eocene

Summary and conclusion

The studied Eocene succession exposed at the northern part of Lake Qarun is differentiated into three rock units arranged from base to top: Gehannam, Birket Qarun and Qasr El-Sagha formations. Qasr El-Sagha Formation is distinguished into three members: Um Reigl, Temple and Abu Lifa members. Paleontologically, the vertebrate faunal content of the studied sections is investigated. A total of 21 sharks species are recorded and suggest that they occupied a wide range of ecological niches. Some of the recorded species are limited in their stratigraphical range and show potential to be used, as biostratigraphical indicators through the Eocene sedimentary sequences. The upper part of Gehannam Formation yields vertebrate remains such as the Shark and ray teeth, marine mammal skeletons. Vertebrate remains of great white shark *Macrorhizodus praecursor* (Leriche), *Otodus sokolovi*, *Pristis lathami,Pristis aquitinicus*, and*Carcharias* sp., in addition to some traces fossils, *Thalassinoides* and *Rhizoliths*are common in Birket Qarun and Qasr El-Sagha Formations. The marked variations in abundance of the recognized vertebrate faunas reflect distinct environmental conditions that control the distribution of many species. The water depth is considered one of the important ecological factors beside the eutrophic state of the water.

The depositional environments in the studied area during Middle-Late Eocene age are interpreted. The abundance of the vertebrate faunas indicates palaeoenvironments varying from open marine shelf with low energy conditions to restricted marine shallow water conditions. However, the abundance of microfauna within calcareous shale and malrs of Gehannam Formation indicate an open shallow marine shelf with low energy conditions. The frequent distribution of macrofauna with shallow water shark taxa and intense bioturbation in sandstones of Birket Qarun Formation is a good indicator of restricted shallow water conditions. Horizontal laminations consisting of alternating shale, siltstone and sandstone with dolostones sheets that show cyclic changes in layer thickness of Temple Member resemble tide-dominated estuaries environment, which cut off by incised valley fill heterolithic sediments of Abu Lifa Member.

References

Abdallah, A., Abuol Ela, N., Shama, K. and Abdel Aziz, S.(1997). Biostratigraphy of the Temple Member (Qasr El-Sagha Formation, Late Eocene) north El Fayum depression: Egypt. J. Geol. 41(1): 541-578.

Abu El Ghar, M. S. (2012). Sequence stratigraphy and cyclicity in the Middle Eocene of the Fayoum ranges, Western Desert, Egypt: Implications for regional sea level changes. Marine and Petroleum Geology, 29 (1): 276-292.

Adnet, S. (2006).Nouvelles faunes de sélaciens (Elasmobranchii, Neoselachii) de l'Éocène des Landes (Sud-Ouest, France).Implication dans les connaissances des communautés d'eaux profondes.Palaeo Ichthyologica, 10: 1-128

Adnet, S., Cappetta, H. and Nakaya, K. (2006).Dentition of etmopterid shark Miroscyllium (Squaliformes) with comments on the fossil record of lanternsharks. Cybium, 30 (4): 305-312.

Adnet, S., Antoine, P.O., Hassan Baqri, S.R., Crochet J.-Y., Marivaux L.,JL. Welcomme J-L., and Métais, G. (2007). New tropical carcharhinids (chondrichthyes, Carcharhiniformes) from the late Eocene–early Oligocene of Balochistan, Pakistan: Paleoenvironmental and paleogeographic implications Journal of Asian Earth Sciences 30: 303–323.

Adnet, S., Cappetta, H. and Tabuce, R. (2010). A middle-late Eocene vertebrate fauna (marine fish and mammals) from southwestern Morocco; preliminary report: age and palaeobiogeographical implications. Geological Magazine, 147: 860-870.

Adnet, S., Cappetta, H., Elnahas, S. and Strougo, A. (2011). A new Priabonian Chondrichthyans assemblage from the Western desert, Egypt: Correlation with the Fayum Oasis. Journal of African Earth Sciences, 61: 27–37.

Allam, A., Shama, K. and Zalat, A. (1991).Biostratigraphy of the Middle Eocene succession at Mishgigah, Wadi El Rayan, Libian Desert, Egypt. Journal of the African Earth Sciences; 12(3): 449-9.

Andreev, P. and Motchurova, N. (2010).Fossil Elasmobranchii and Actinopteryg II. Bulletin of the Natural History Museum, 3: 115-129

Antar, M.S.M. (2011). Paleo-environments of the exposed Eocene Sediments between Wadi El-Hitan and east Siwa in the Egyptian Western Desert based on their faunal content especially the vertebrates. Ph.D Thesis, Zagazig University, Faculty of Science, Geology Department, 257 pp.

Antunes, M.T.(1978). Faunes ichthyologiques du Neogene superieur d'Angola, leur age, remarques sur Ie Pliocene marin en Afrique australe. Ciencias da Terra (UNL), Lisboa, 4: 59-90.

Antunes, M.T. and Jonet, S. (1970). Requins de l' Helvétien supérieur du Tortonien de Lisbonne.*Revista da Faculdade deCiências da Universidade de Lisboa 2, C*, 16(1): 119-280.

Arambourg, C. (1952). Les Vertébrés fossiles des gisements de phosphates (Maroc, Algérie, Tunisie). Service Géologique du Maroc, Notes et Mémories 92: 1-372.

Bajpai, S. and Thewissen, J.G.M. (2002).Vertebrate fauna from Panandhro lignite field (Lower Eocene), District Kachchh, western India.Curr. Sci., v. 82 (5): 507–509.

Beadnell, H.J.L.(1905).The topography and geology of the Fayum Province of Egypt.Survey Department of Egypt, Cairo, 101 pp.

Bourdon, J. and Chandler,R. (2007).The Castle Hayne Formation. Middle Eocene Sharks and Rays of North Carolina. http://www.elasmo.com.

Bown, T.M. and Kraus M. J.(1988). Geology and paleoenvironment of the Oligocene Jebel Qatrani Formation and adjacent rocks, Fayum Depression, Egypt: U.S. Geological Survey Professional Paper, 1452: 1-60.

Butzer, K.W.(1976). Early Hydraulic Civilisation in Egypt, a Study in Cultural Ecology. The University of Chicago Press, Chicago.

Cappetta, H. (1970).Les sélaciens du Miocène de la région de Montpellier.Palaeovertebrata, mém, ext., 1- 139.

Cappetta, H. (1976). Selaciens nouveaux du London Clay del'Essex (Ypresien du Bassin de Londres): Geobios, 9 (5): 551-574.

Cappetta, H. (1987). Chondrichthyes II. Mesozoic and Cenozoic Elasmobranchii, in Schults, H.P., Kuhn, O.(eds.), Handbook of Paleoichthyology: v.3B, 193pp., Stuttgart, New York: Gustav Fischer Verlag,

Cappetta, H. (2004).Handbook of Paleoichthyology 3B.Chondrichthyes 2 Mesozoic and Cenozoic Elasmobranchii. 193 pp., ISBN 10: 3899370465 ISBN 13: 9783899370461

Cappetta, H. (2006). Elasmobranchii Post-Triadici, (Index specierum et generum). In: W. Riegraf (ed.). Fossilium Catalogus, I: Animalia, v.142, pp. 1-472. Backhuys Publishers, Leiden.

Cappetta, H., Pfeil, F. and Schmidt-Kittler, N. (2000).New biostratigraphical data on the marine Upper Cretaceous and Palaeogene of Jordan. Newsletters on Stratigraphy 38: 81–95.

Carlsen, A.W. and Cuny, G. (2014).A study of the sharks and rays from the Lillebælt Clay (Early–Middle Eocene) of Denmark, and their palaeoecology. Bulletin of the Geological Society of Denmark, Vol. 62: 39–88.

CASE, G.R. (1981).Late Eocene selachian from south-central Georgia. Palaeontographica, Abteilung A176: 52–79.

Case, G.R. and Borodin, P.D.(2000).Late Eocene selachians from the Irwinton Sand Member of the Barnwell Formation (Jacksonian), WKA mines, Gordon, Wilkinson County, Georgia. Münchner Geowissenschaftliche Abhandlungen, (A: Geologie und Paläontologie) 39: 5–16.

Case, G.R. and Cappetta, H.(1990).The Eocene selachian fauna from the Fayum depression of Egypt. Palaeontographica, Abteilung A 212 (1–6): 1–30.

Case, G.R. and West, R.M.(1991).Geology and paleontology of the Eocene Drazinda shale member of the Kirthar formation, central Western Pakistan. Part II: late Eocene fishes. Tertiary Research 12 (3–4): 105–120.

Case, G.R., Udovichenko, N., Nessow, L., Averianov, A. and Borodin, P.(1996).A Middle Eocene Selachian Fauna from the White Mountain Formation of the Kizylkum Desert, Uzbekistan. C.I.S. Palaeontographica Abteilung A 242: 99–126.

Casier, E. (1949).Contributions à l'étude des poissons fossiles de la Belgique.VIII. Les Pristidés éocènes.Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, 25: 1-52.

Casier, E.(1971). Sur un matériel ichthyologique des ''Midra (and Saila) Shales'' du Qatar (Golfe

Persique). Bulletin de l'Institut Royal des Sciences Naturelles de Belgique 47 (2): 1–9.

Cicimurri, D.J. (2007). A partial rostrum of the sawfish *Pristis lathami* Galeotti, 1837, from the Eocene of South Carolina. Journal of Paleontology, 81: 597-601.

Cicimurri, D.J. and Knight, J.L.(2009). Late Oligocene sharks and rays from the Chandler Bridge Formation, Dorchester County, South Carolina, USA. Acta Palaeontologica Polonica 54 (4): 627–647.

Cione, A.L. and Reguero, M. (1994).New records of the sharks Isurus and Hexanchus from the Eocene of Seymour Island, Antarctica. Proceedings of the Geologists Association 105: 1-14.

Compagno, L.J.V., Didier, D.A. and Burgess, G.H. (2005). Classification of Chondrichthyan Fish In: Fowler, S.L., Cavanagh, R.D., Camhi, M., Burgess, G.H., Cailliet, G.M., Fordham, S.V., Simpfendorfer, C.A. and Musick, J.A (eds). Sharks, Rays and Chimaeras: The Status of the Chondrichthyan Fishes. *Status Survey*. IUCN/SSC Shark Specialist Group. 461 pp. IUCN, Gland, Switzerland and Cambridge, UK

Cook, T.D., Murray, A.M., Simons, El. L., Attia, Y.S. and Chatrath, P.(2010).A Miocene selachianfauna from Moghra, Egypt.Historical Biology, 22: 1-3: 78-87.

Dartevelle, E. and Casier, E. (1942). Les poissons fossiles de l'Angola. Comunicações dos Serviços Geológicos de Portugal, 22: 99-109.

Dartevelle, E. and Casier, E. (1943). Les poissons fossiles du Bas-Congo et des régions voisines. Annales du Musée du Congo Belge, Sér.A (Minéralogie Géologie, Paléontologie), 3: 1-200.

Dartevelle, E. and Casier, E. (1949). Les poissons fossiles du Bas-Congo et des régions voisines. Annales du Musée du Congo Belge, Sér.A (Minéralogie Géologie, Paléontologie), 2: 205-255.

Dartevelle, E. and Casier, E. (1959). Les poissons fossiles du Bas-Congo et des régions voisines. Annales du Musée du Congo Belge, Sér. A (Minéralogie Géologie, Paléontologie),2(3): 257-568.

Diedrich, C.G. (2012). Eocene (Lutetian) Shark-Rich Coastal Paleoenvironments of the Southern North Sea Basin in Europe: Biodiversity of the Marine Fürstenau Formation Including Early White and Megatooth Sharks. International Journal of Oceanography Volume 2012: 1-22. doi:10.1155/2012/565326

Dolson, J., El Barkooky, A., Wehr, F., Gingerich, P.D., Prochazka, N. and Shann, M.(2002). The Eocene and Oligocene Paleoecology and Paleogeography of Whale Valley and the Fayoum Basins: Implications for Hydrocarbon Exploration in the Nile Delta and Eco-Tourism in the Greater Fayoum Basin. Cairo 2002, AAPG/EPEX/ SEG/EGS/EAGE Field trip-guidebook: 1–79.

Ghosh, B.K. (1959).Some fossil teeth from the tertiary deposits of Orissa. Jour. Palaeont, 33(4): 675-679.

Gingerich, P.D.(1992). Marine mammals (Cetacea and Sirenia) from the Eocene of Gebel Mokattam and Fayum, Egypt: stratigraphy, age and paleoenvironments. Papers on Paleontology 30: 1–84.

Hassan, F.A.(1985). Radiocarbon chronology of neolithic and predynastic sites in upper Egypt and the Delta. African Archaeological Review 3: 95-116.

Hassan, F.A.(1986). Holocene lakes and prehistoric settlements of the Western Faiyum. Egyptian Journal Archaeological Science 13: 483-501.

Hassan, F.A.(1997). The dynamics of a riverine civilization: a geoarchaeological perspective on the Nile valley, Egypt. World Archaeology 29 (1):51-74.

Hendrickx, S. and Vermeersch, P.(2000).Prehistory from the Palaeolithic to the Badarian culture. In: Shaw, I. (Ed.), The Oxford History of Ancient Egypt. Oxford University Press, Oxford: 17-43.

Iskander, F. (1943). Geological Survey of the Gharag elsultany sheet no.68/54: Standard Oil Company, Egypt s. a.,reports,51:p.1-29.

Ismail, A.S.A. and Abd El-Azeam, S. (2008).Biostratigraphy and paleoenvironment of the Middle-Upper Eocene Ostracods from west Fayoum province-Bulletin of the Faculty of Science Zagazig University; 30: 261-4.

Itoigawa, J., Nishimoto, H. and Karasawa, H. (1985).Miocene fossils of the Mizunami group, central Japan. 3. Elasmobranchs. Monograph of the Mizunami Fossil Museum, 5: 1–89.

Kemp, D., Kemp, L. and Ward, D. (1990).An illustrated guide to the British Middle Eocene vertebrates, 59 pp. David Ward, London.

Kent, B.W. (1994). Fossil Sharks of the Chesapeake Region. Egan Rees and Boyer (Eds.): 146 pp. Maryland.

Kent, B.W. (1999).Part 3.Rays from the Fisher/Sullivan Site.In "Early Eocene vertebrates and plants from the Fisher/Sullivan Site (Nanjemoy Formation) Stanford County, Virginia. Virginia Division of Mineral Resources, Publication, 152: 39-51.

Kirk, E.C. and Simons, El.L. (2001). Diets of fossil primates from the Fayum Depression of Egypt: a quantitative analysis of molar shearing. Journal of Human Evolution40: 203-229

Kozlowski, J.K.(1983). Qasr el-Sagha 1980: Contributions to the Holocene Geology, the Predynastic Settlements in the Northern Fayum Desert. Panstwowe Wydawnicto Naukowe, Warsaw.

Kriwet, J. (2005). Additions to the Eocene Selachian fauna of Antarctica with comments on Antarctic selachian diversity. Journal of Vertebrate Paleontology 25 (1): 1-7.

Kumar, K. and Loyal, R.S. (1987). Eocene Ichthyofauna from the Subathu Formation, northwestern Himalaya, India. Jour. Palaeont. Soc. India, 32: 60-84.

Leriche M. (1926). Les poisons Néogénes de la Belgique. Mémoires de Museé Royal du d'Histoire Naturelle de Belgique 32:367–472.

Leriche, M. (1927).Les poissons de la Molasse Suisse. Mémoires de la Société Paléontologique Suisse, 46: 1-119.

Leriche, M. (1957). Les poisons neogenes de la Bratagne, de l'Anjou et de la Touraine. Mem. Geol. Soc. France, N. Ser., 36, Mem. 81: 1-61, Paris.

Longbottom, A.E. (1979). Miocene shark's teeth from Ecuador. Bulletin of the British Museum natural History, Geology, 32 (1): 57-70.

Lowery, D., Godfrey, S.J. and Eshelman, R.(2011). Integrated Geology, Paleontology, and Archaeology: Native American use of Fossil Shark Teeth in the Chesapeake Bay Region. Archaeology of Eastern North America 39:93-108.

Mehrotra, D.K., Mishra, V.P. and Srivastava, S. (1973). Miocene sharks from India. Rec. Res. Geol. Hindustan Publishing Corporation, Delhi: 180-187.

Mondal, S., Das, S. Mallick,S. and Adhikary, D. (2009). Miocene shark teeth assemblages and ancillary fish taxa from baripada, orissa: taxonomic revision and a global Palaeobiogeographic overview. Journal of the Palaeontological Society of India Volume, 54(2): 135-152

Murray, A.M., Cook, T.D., Attia, Y.S., Chatrath, P. and Simons, El.L.(2011). A freshwater ichthyofauna from the Late Eocene Birket Qarun Formation, Fayum, Egypt. Journal of Vertebrate Paleontology 30: 665–680.

Mustafa, H.A. and Zalmout, I.S.(2002).Elasmobranchs from the late Eocene Wadi Esh- Shallala Formation of Qa' Faydat ad Dahikiya, east Jordan. Tertiary Research 21: 77–94.

Mustafa, H.A., Zalmout, I.S., Smadi, A.A. and Nazzal, J.S. (2005).Review of the middle Eocene (Lutetian) selachian fauna of Jebal eth Thuleithuwat, east Jordan. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 237: 399-422.

Otero, R.A., Oyarzún, J.L., Soto-Acuña, S., Yury-Yáñez, R.E., Pawellek, T. and Adnet, S., Cappetta, H., Metais, E., Salem, M., Brunet, M. and Jaeger, J.-J. (2012). Discovery of an earliest Pliocene relic tropical fish fauna in a newly detected cliff section (Sabratah Basin, NW Libya). Neues Jahrbuch für Geologie und Palaontologie, Abhandlungen, 266: 93-114

Patnaik, R., Sharma, K.M., Mohan, L., Williams, B.A., Kay,R. and Chatrath,P. (2014). Additional Vertebrate Remains from the early Miocene of Kutch, Gujarat. Special publication of the palaeontological society of India, No. 5: 335-351. ISBN: 978-81-926033-2-2

Priem, F.(1905).Sur les poissons fossiles de l'Eocène moyen d'Egypte.Bulletin de la Société géologique de France 5: 633–641.

Priem, F.(1908).Sur des vertébrés de l'Eocène d'Egypte. Bulletin de l'Institut Egyptien 5 (2): 1–3.

Rana, R.S., Kumar, K. and Singh, H. (2004).Vertebrate fauna from the subsurface Cambay Shale (Lower Eocene), Vastan Lignite Mine, Gujarat, India. Current Science, 87 (12): 1726-1733

Rana, R.S., Kumar, K., Loyal, R.S., Sahni, A., Rose, K.D., Mussell, J., Singh, H. and Kulshreshtha (2006).Selachians from the Early Eocene Kapurdi Formation (Fuller's Earth), Barmer District, Rajasthan, India.Jour. Geol. Soc. India, v. 67: 509-522.

Sahni, A. and Mehrotra, D.K. (1981).Elasmobranch from the coastal Miocene sediments of peninsular India. Biological Memoirs, 5 (2): 83-121.

Sahni, A, and Mishra, V.P.(1975).Lower Tertiary vertebrates from western India. Monograph of the Paleontological Society of India, Lucknow, 3: 1-48.

Said, R. (1962). The Geology of Egypt: 377 pp. Elsevier Publishing Co, Amsterdam, New York.

Said, R. (1990). Cenozoic: in Said,R. (ed.), The Geology of Egypt. pp. 451-486, Balkema, Netherlands.

Said, R., Wendorf, F., Albritton, G., Schild, R., Kobusiewicz, M.(1972). Remarks on the Holocene geology and archaeology of Northern Faiyum Desert. Archaeologica Polana 13: 7-22.

Shama, K. and Shided, A. (1994).Contributions to the Microfiches and Paleogeological Investigation of the Middle and Upper Eocene Sediments in Fayoum area. Bull. Fac. of Sci., Assiut Univ. Egypt, 23 (2-f): 381-418.

Sharma, K.M. and Patnaik, R. (2013).Additional Fossil Batoids (Skates and Rays) from the Miocene Deposits of Baripada Beds, Mayurbhanj District, Orissa, India. Earth Science India, Vol. 6 (IV): 160 – 184.

Simons, El.L. (2005). Eocene and Oligocene Mammals of the Fayum, Egypt, First International Conference on the Geology of the Tethys, Cairo University, November: 439-450.

Simons, El.L.,Seiffer, E.R., Ryan, T.M. and Attia, Y.(2007).A remarkable female cranium of the early Oligocene anthropoid Aegyptopithecus Zeuxis (Catarrhini, Propliopithecidae).National Academy of Sciences of the USA PNAS.104 (21):8731-8736

Singh, R. (1985).Contribution to the palaeontology and Biostratigraphy of the Subathu Formation of Simla Hills region. Himachal Pradesh. Unpublished Ph.D. thesis, Panjab University:1-199.

Smadi, A.A., Abu Azzam, H., Zalmout, I.S. and Mustafa,H.A. (2003).Middle Eocene selachian fauna from Al-Rijla Al-Bayda, Eastern Desert of Jordan. Abhath Al-Yamouk Basic Science and Engineering, 12: 619-631.

Stromer, E. (1905).Sie Fischreste des mittelren und oberen Eocäns Von Ägypten.I. Teil: Selachii, B. Squaloidei, und II. Teil: Teleostomi, A. Ganoidei. Beitrage zur Palaeontologie und Geologie Ostrerreich-Ungarns und Orients, Universitats-Buchhandler in Wein 18:163−192.

Stromer, E.(1905a). Die Fischreste des Mittleren und Oberen Eocäns von Ägypten. I. Teil: Selachii, B. Squaloidei, und II. Teil: Teleostomi, A. Ganoidei. Beiträge zur Paläontologie und Geologie Österreich-Ungarns, 18: 37-58.

Stromer, E.(1905b). Die Fischreste des Mittleren und Oberen Eocäns von Ägypten. I. Teil: Die Selachier, A. Myliobatiden und Pristiden. Beiträge zur Paläontologie und Geologie Österreich-Ungarns, 18: 163-185.

Strougo, A.(2008). The Mokattamian stage: 125 years later. Middle East Research Center. Earth Science Series, Ain Shams University, vol. 22: 47–108.

Strougo, A., Cappetta, H. and Elnahas, S.(2007). A remarkable Eocene ichthyofauna from the Elgedida glauconitic sandstone, Bahariya oasis, Egypt, and its stratigraphic implications. Earth Science Series, Middle East Research Center, Ain Shams University, vol. 21: 81–98.

Tiwari, R.P., Mishra, V.P. and Lyngdoh, B.C. (1998).Lower Miocene fish teeth from Mizoram, India. Geoscience Journal, 19: 9-17.

Underwood, C.J., Ward, D.J., King, C., Antar, S.M., Zalmout,I.S. and Gingerich,P.D. (2011).Shark and ray faunas in the middle and late Eocene of the Fayum area, Egypt. Proceedings of the Geologists' Association, 122: 47-66.

Vliet, H.J. van and Abu El Khair,G. (2010). A new Eocene marine mammal site in the Qattara depression (Egypt). Cainozoic Research, 7: 73-77.

Wallett, L.A. (2006). Eocene selachian fauna from nearshore marine deposits, Ampazony, northwestern Madagascar. Bsc. Thesis, 59 pp. Department of Biological Sciences, South Hadley.

Weiler, W. (1929).Ergebnisse der Forschungsreisen Prof. E. Stromers in den Wüsten Ägyptens. V. Tertiäre Wirbeltiere. 3. Die Mittel-und obereocäne Fischfauna Ägyptens mit besonderer Berücksichtigung der Teleostomie. Abhandlungen der Bayerischen Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Abteilung, neue Folge, 1: 1–57.

Welton, B.J. (1972). Fossil sharks in Oregon. The Ore Bin, v. 34: 161-170.

Wendorf, F. and Schild, R.(1976).Prehistory of the Nile Valley. Academic Press, New York: 222-226.

White, E.I. (1926). Eocene fishes from Nigeria. Bull. Geol. Surv. Nigeria, v. 10: 1-87.

White, E.I. (1956). The Eocene fishes of Alabama. Bulletins of American Paleontology, 36: 123-151.

Zalat, A.A. (2015). Holocene diatom assemblages and their palaeoenvironmental interpretations in Fayoum depression, Western Desert, Egypt. Quaternary International 369:86-98.

Zalmout, I.S.A., Antar, M.S.M., Abd-El Shafy, E., Metwally, M.H., Hatab, El.E. and Gingerich, P.D. (2012). Priabonian sharks and rays (Late Eocene: Neoselachii) from Minqar Tabaghbagh in the western Qattara depression, Egypt.Museum of Paleontology, University of Michigan.32 (6): 71-90.

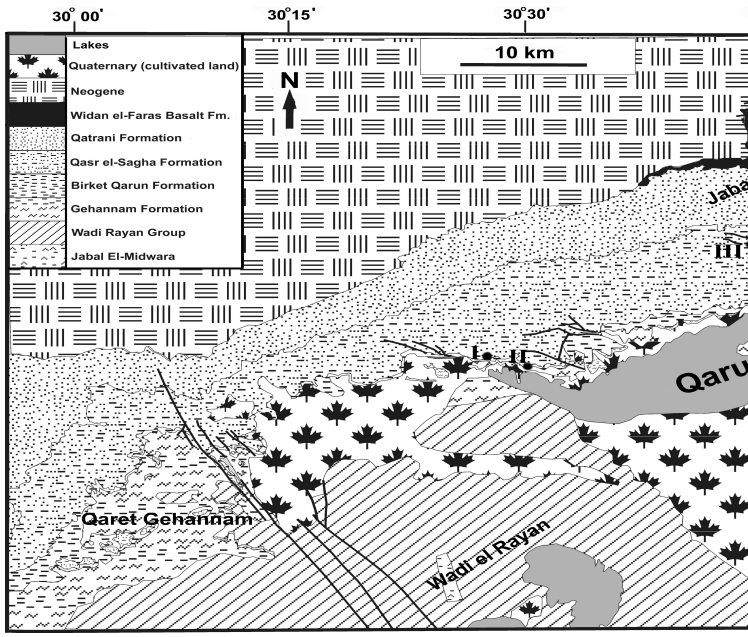

Figure 1. Geological map of Fayoum depression showing position of the studied stratigraphic sections: I. Hussein Wally, II. Birket Qarun, III. Qasr El Sagha area and IV. Wadi El-Afreet.

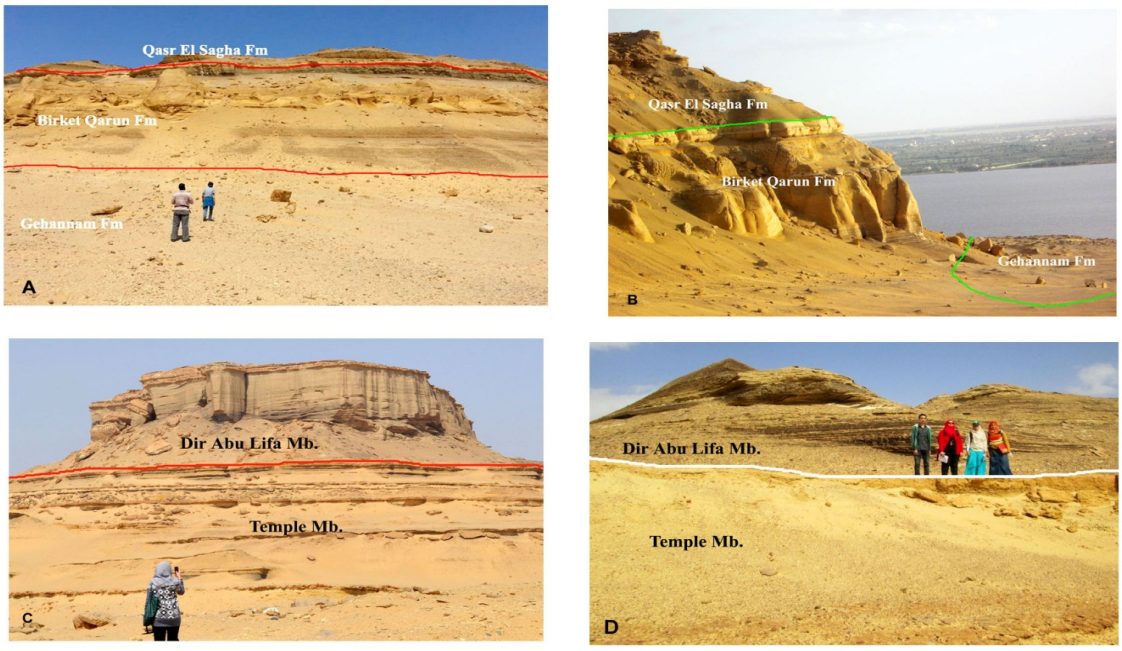

Figure 2. Field photograph of A: Hussein Walley section, B: Birket Qarun section, C: Qasr el Sagha section and D: Wadi El-afreet section.

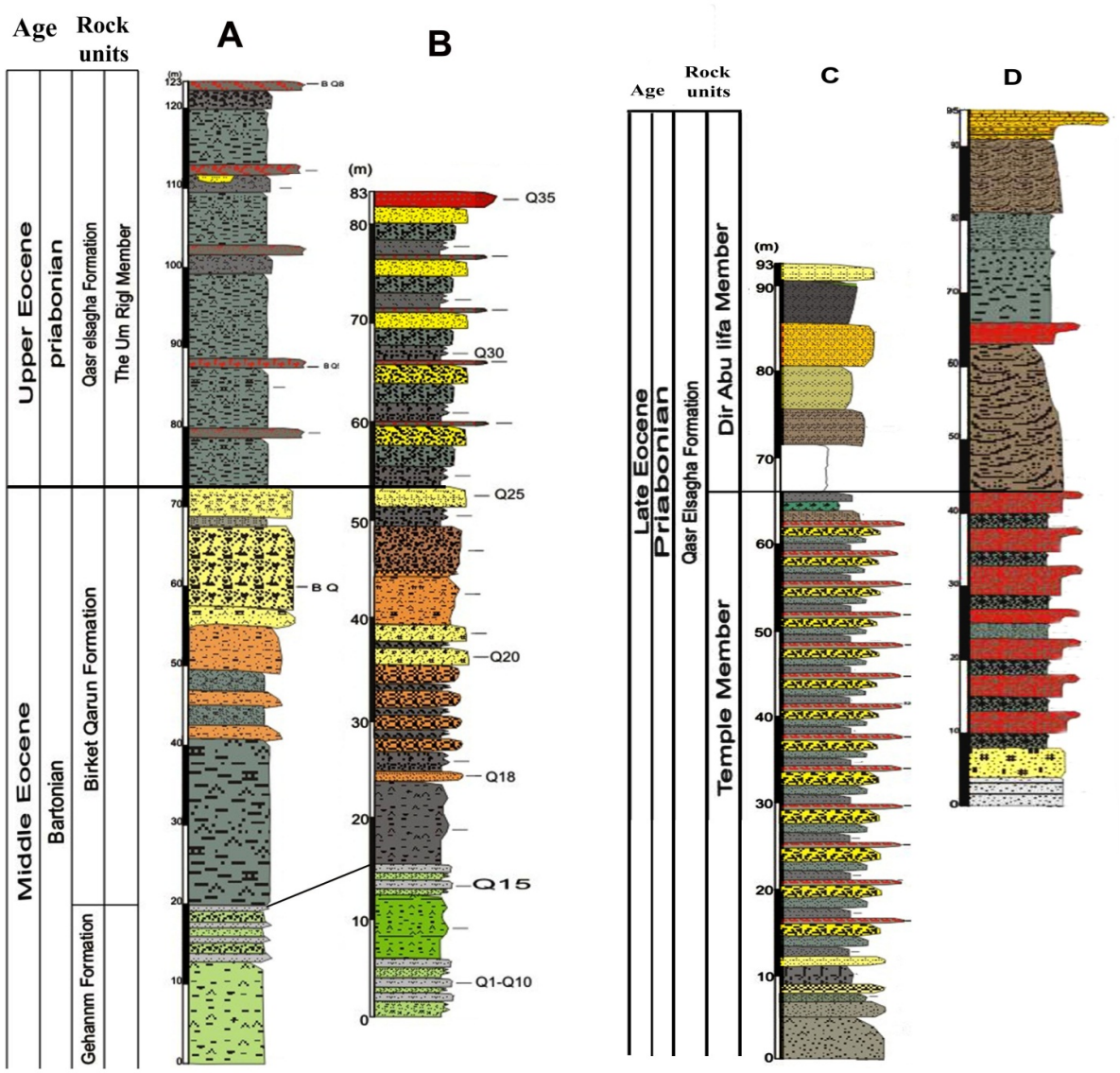

Figure 3. Middle to Late Eocene studied successions A) Hussein Walley village, B) Birket Qarun, C) Qasr El Sagha, D) Wadi El-afreet.

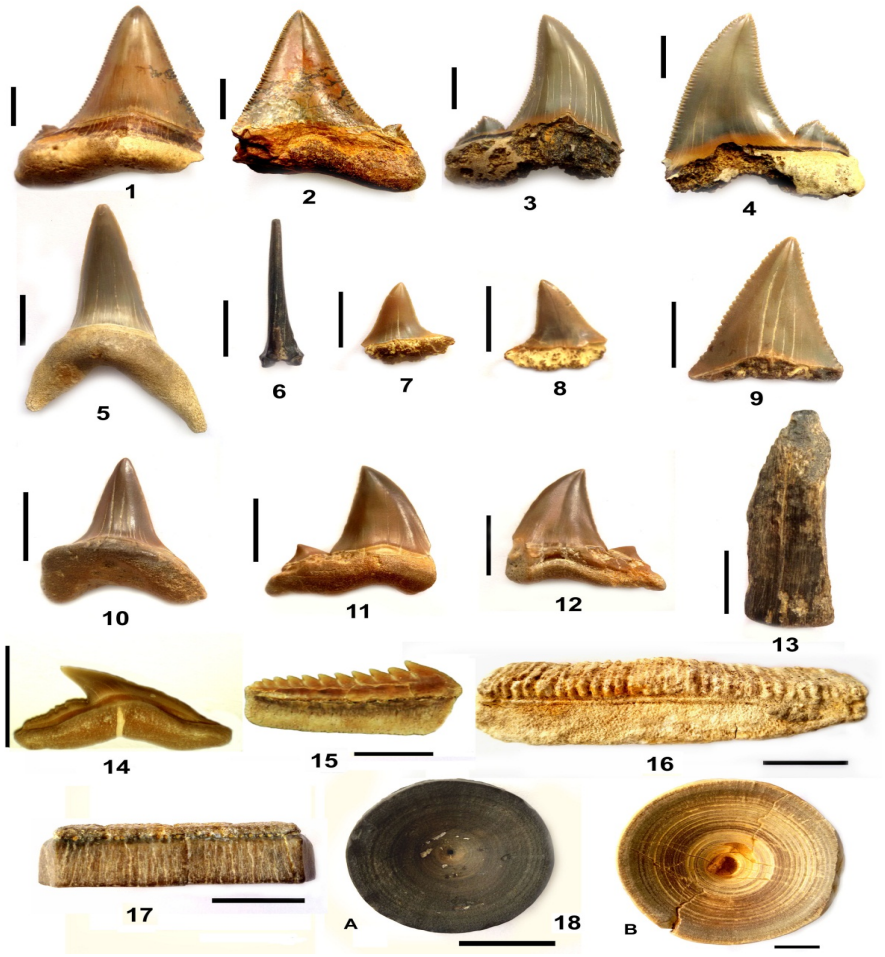

Plate 1: 1-4. *Otodus sokolovi* (Jaekel) 1. lingual view, 3-4. labial views; 5. *Macrorhizodus praecursor* Leriche, lingual view, 6.Fish-fin spine (labial view); 7-8. *Rhizoprionodon* sp., lingual view; 9. *Carcharodon carcharias* Linnaeus, lingual view; 10. *Negaprion frequens* Dames, lingual view; 11,12. *Cretolamna twiggsensis* Case, 11. lingual view, 12. labial view; 13. *Eutrichiurides* sp., labial view; 14. *Galeocerdo cuvieri* Péron & Lesueur, lingual view; 15. *Hexanchus agassizi* Cappetta, labial view of lower lateral tooth; 16. *Rhinoptera sherburni* Arambourg; 17. *Leidybatis* sp.; 18. *Pristis lathami* Galeotti.(scale bar= 10 mm).

دراسة تصنيفية وتشكلية لبقايا الفقاريات من القروش والاسماك من تتابع عصرالأيوسين الاوسط والعلوى فى منخفض الفيوم , مصر

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يتناول هذا البحث دراسه الوضع التصنيفى و الشكل الوصفى لبقايا الفقاريات كالقروش والاسماك التى تم تجميعها من تتابع عصر الايوسين الاوسط والعلوى من منخفض الفيوم بالصحراء الغربية مصر من خلال اربعة قطاعات رسوبية تمت دراستها ووصفها وهم على النحو التالى : قطاع قريه حسين والى , قطاع بركه قارون , قطاع قصر الصاغه وقطاع وادى العفريت وبناءا على الدراسات الطباقية الصخرية لهذه القطاعات فانها تتكون من ثلاث تكوينات مرتبه من الاقدم الى الاحدث كالاتى : متكون جهنم ومتكون بركه قارون ومتكون فصر الصاغه حيث تم التعرف على 3 فصائل و7 رتب و12 عائلة و 18 جنس و 21 نوع من أسماك القرش فى منطقه الدراسه وتم وصف الوضع التصنيفى والشكلى لكل نوع والتعرف على البيئات الترسيبية فى عصر الايوسين الاوسط والعلوى فى منطقه الدراسه من خلال بقايا الفقاريات التى تم تجميعها والتى اوضحت ان البيئة الترسيبية تتنوع بين البيئة البحرية العميقة الى البيئه البحرية الضحله وبالرغم من ذلك فان وجود تنوع من الاحافير الكبيرة واثارها فى الحجر الرملى لمتكون بركة قارون فهذا دليل جيد على البيئه البحريه الضحله.