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Shark and ray faunas in the Middle and Late Eocene of the Fayum Area, Egypt

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ABSTRACT

The Eocene rocks exposed in the Fayum Area, Egypt, are well known for their fossil vertebrates but in recent times the sharks and rays have been largely neglected. Extensive surface collecting, supplemented with bulk samples, has produced large collections from the Midawara, Gehannam, Birket Qarun and Qasr el-Sagha formations, spanning the Bartonian and Priabonian stages and from palaeoenvironments varying from open muddy shelf to very shallow estuarine systems. In total about 90 species of sharks and rays are recorded, many of them previously unrecognised, resulting in some of the most diverse fossil chondrichthyan assemblages known from the Tertiary. Teeth of these species suggest that they occupied a wide range of ecological niches from top predator to tiny benthic invertebrate feeder to planktivore. Many of the species are limited in their stratigraphical range and show potential to be used, at least locally, as biostratigraphical indicators for stratigraphically poorly constrained vertebrate sites elsewhere in North Africa. Distinctly different faunas from different sedimentary environments indicate a strong environmental control on the distribution of many species.

1. Introduction

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 and very strong provincialism. These changes were especially pronounced amongst the larger predatory taxa, with the disappearance of the previously ubiquitous genus *Striatolamia* from tropical Tethyan regions in the Middle Eocene coinciding with the appearance of several, at least initially, endemic Tethyan genera (e.g. Adnet et al., 2010). This was followed in the latter parts of the Eocene by the replacement of lamniform-dominated by carcharhinid-dominated ecosystems (e.g. Adnet et al., 2007).

Tethyan shark faunas from the Late Eocene are known in North Africa (e.g. Case and Cappetta, 1990; Adnet et al., 2010), West Africa (White, 1926), the Arabian Peninsula (e.g. Casier, 1971) and southern Asia (e.g. Adnet et al., 2007). Despite this, no study has addressed stratigraphical variations within the assemblages. Shark and ray fossils are especially widespread and abundant in the Egyptian Western Desert, both in Fayum (e.g. Case and Cappetta, 1990) and Bahariya oases (Strougo et al., 2007). There was intense interest in the vertebrate fossils of this area of Egypt in the late 19th and early 20th centuries, with large collections of marine and terrestrial mammals being made. Many of these older studies mentioned or figured elements of the shark and ray faunas of the region (Andrews, 1906; Dames, 1883, 1888; Leriche, 1922; Priem, 1897a,b, 1905, 1907; Stromer, 1903, 1905a,b) but these invariably concentrated on larger remains that were collected at fossil mammal sites or as part of larger scale mapping, with little subsequent study. Despite the abundance of material present and the extensive study of associated mammalian faunas (e.g. Gingerich, 1992), the main studies of the shark and ray faunas of the region are either biased towards larger specimens and from unlocated sites (Case and Cappetta, 1990), from marginal marine facies (Murray et al., 2010) or from poorly dated localities (Strougo et al., 2007).

2. Geological setting

The Eocene rocks of the region around and to the west of the Fayum Oasis comprise a thick succession of shelf marine rocks representing environments from open shelf to restricted lagoon. The stratigraphy of the area has been documented on a number of occasions (e.g. Beadnell, 1905; Dolson et al., 2002; Gingerich, 1992), but considerable lateral variation within parts of the succession has caused problems with applying a lithostratigraphical scheme (Strougo, 2008).

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The lower units from which shark and ray material was collected are within the Midawara Formation (see Fig. 3A). This is a succession of open marine facies and comprises alternating glauconitic sandstones, mudstones and micitic and bioclastic limestones (e.g. Strougo, 2008). At least one thick and several thin glauconitic units are present and it is these that contain the rich vertebrate faunas containing remains of marine mammals and teleosts in addition to sharks and rays. The base of the formation is not seen, but it is likely that the lowest sample was from a level quite low in the formation.

The succeeding platform carbonates were not seen to contain shark and ray remains and have a wide outcrop area separating the exposures of the Midawara Formation to the south from the other units to the north. The hard, white micritic limestone of the Sath el Hadid Formation is overlain by a thick unit of alternating marls and thin limestones, some rich in large *Nummulites*, of the Gharaq Formation.

The exposures of the higher fossiliferous units are within the Wadi Al-Hitan UNESCO World Heritage Site, made famous by its fossil marine mammals (e.g. Gingerich, 1992) (see Fig. 1). Although the general stratigraphical scheme for the region is relatively well established (Gingerich, 1992 and refs. therein), the contacts between the different formations have not be well defined and the stratigraphy of the region is not easy to interpret due to rapid lateral facies changes. Recent sedimentological studies by Peters et al. (2009) and Abdel-Fattah et al. (2010) have concentrated on only parts of the succession and not addressed the detailed lithostratigraphy of the area. Ongoing study by King (in prep.) has suggested a correlation of rocks within the region that is used here (see Fig. 2).

The Gharaq Formation is overlain by open marine mudstones of the Gehannam Formation (see Fig. 3B). The upper part of this formation is strongly diachronous, and passes laterally into the sandstones of the Birket Qarun Formation. The formation has been provisionally divided into seven units, designated A–G. Small scale cyclicity is present within the variably calcareous mudstones (A and C) and intervening glauconitic interval (B) of the lower part of the formation. These pass upwards into impersistant siltstones (E) or marls and impure limestones (D), the latter often containing glauconitic seams and lenses. The three higher mudstone units of the Gehannam Formation interbed with, and pass laterally into, the Birket Qarun Formation.

The overlying Birket Qarun Formation comprises clean sandstones that pass laterally into mudstones of the Gehannam Formation in the north (compare Fig. 3B and C). The sandstones form escarpments that largely enclose the valley. These amalgamate to form a single sandstone unit in the southern edge of the exposure, but elsewhere can be seen to comprise four sand bodies, labelled A–D. Unit A, referred to as the *vicinalis* Sandstone of the Gehannam Formation by Strougo (2008), was only recognised in the southeastern part of the area and appears to thin rapidly to the northwest. Unit B (included into the Gehannam Formation in Fig. 4.2 of Abdel-Fattah et al., 2010), is also well developed to the south and east, but can be mapped as thinning rapidly, and probably passing laterally into mudstones, to the north. Over much of the western part of the outcrop, this unit is capped by one or more pale bands referred to as the Camp White Layer by Gingerich (1992). Well developed burrows were attributed to mangroves (e.g. Dolson et al., 2002), but these are associated with open marine trace fossils (Abdel-Fattah et al., 2010) and *Nummulites*, suggesting

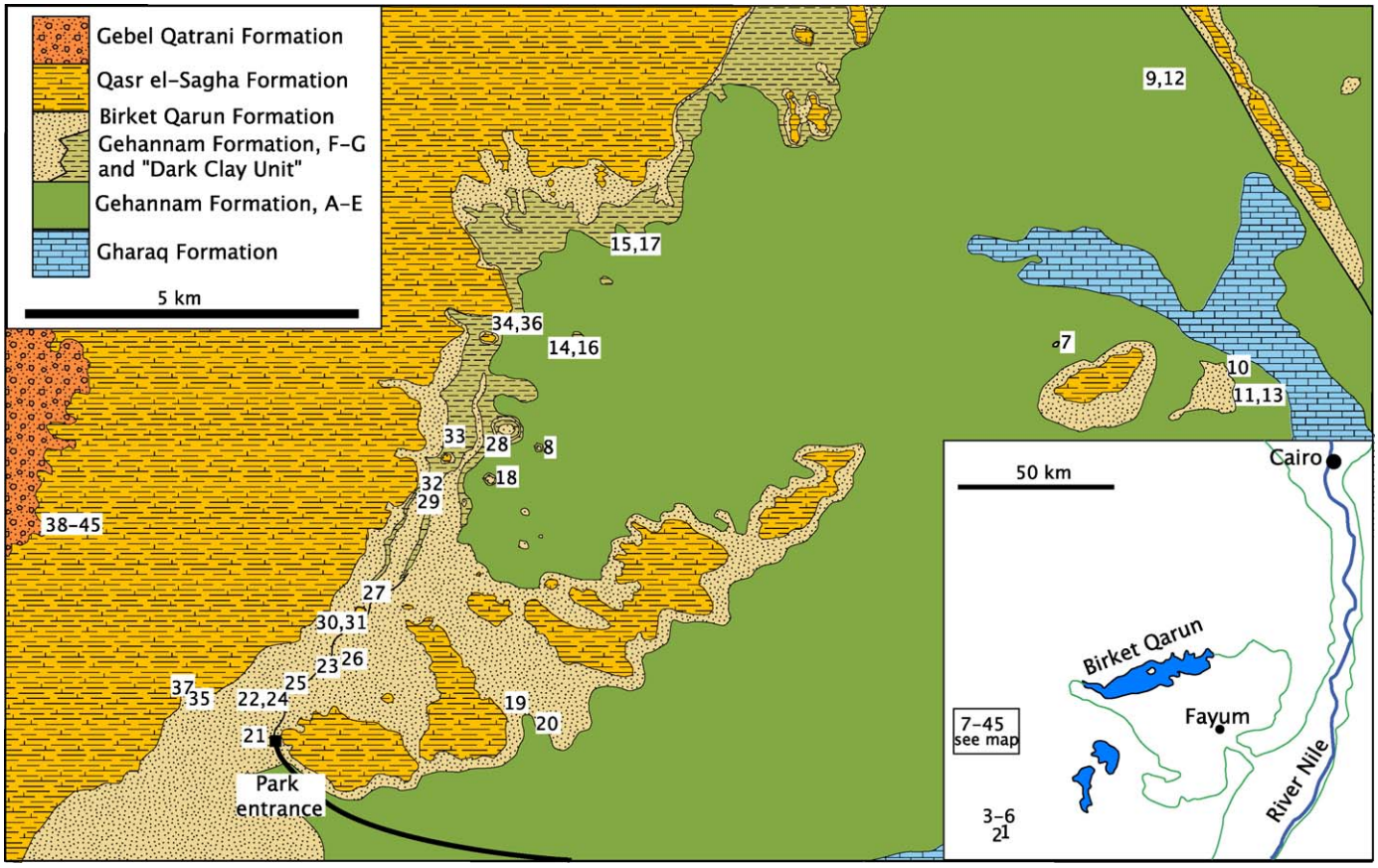

Fig. 1. Map showing the distribution of the samples used in this study, showing the general locality (inset) and a more detailed geological map of Wadi Al-Hitan. Geological map derived from mapping by the authors.