

A RECONSTRUCTION OF THE PALAEOECOLOGY AND ENVIRONMENTAL DYNAMICS OF THE BAHARIYA FORMATION OF EGYPT

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The Bahariya formation is one of the most productive in Africa in terms of fossil material. This paper conducts a comprehensive review of the flora & fauna and creates ecological reconstruction of this assemblage based on modern analogues.

There is no evidence that the major vertebrate components of this biome were mangrove adapted taxa & most were commuters from the surrounding mainland. The high number of theropod species is overstated as niche partitioning between them lowers the predator/prey ratios and is a result of this habitat developing from the broader North African ecosystems with its limited vegetation. While Bahariya had great diversity of predators, the populations of most were limited; further offsetting the predator/prey imbalance; although its currently impossible to differentiate local population patterns from the general population trends in this ecosystem as a whole. The rarity of ornithopods can now be seen as a result of aridity and simplified forest structure. Crustaceans can be confirmed as forming a major trophic base but new emphasis needs to be placed on Bahariyan gastropods as potential ecosystem engineers. Although some questions still remain concerning missing faunal elements; Bahariya's reportedly substantial productivity, and later over-productivity, can now be confirmed.

Key words: Bahariya, Ecology, Cenomanian, Palaeoenvironment, Egypt.

INTRODUCTION

The Bahariya formation has proven to be a boon to researchers, yet despite its potential, this formation remains mostly overlooked (Rauhut & López-Arbarello 2009). The situation is made worse by near total loss of Stromer's collection during world war two and many valuable specimens still remain undescribed (Nothdurft et al. 2002). Despite this, the Bahariyan assemblage is recorded in more detail than is generally credited.

Bahariya records a crucial period in Mesozoic history and with renewed interest in North African palaeofauna (Mannion & Barrett, 2013; Ibrahim et al. 2014b), an understanding of Bahariya's fauna will be essential to help settle issues of taxonomy and ecology. Specimens from Bahariya are also known from partial skeletons as opposed to the Kem Kem beds where most are known from isolated and broken remains from various individuals (E. Läng personal communication, 2014). This is due to the generally more benign depositional environment (Smith et al. 2001B),

making Bahariya the best place in North Africa to find partially complete skeletons.

Yet while the individual aspects of this ecosystem are known in detail, the environmental dynamics of this region as a whole has never been quantified in detail. This paper conducts a comprehensive review of the Bahariyan biota and is the first to unite previous aspects of Bahariyan research on how this ecosystem functioned into a unified whole, resulting in an environmental reconstruction equal to that done for other, better known, formations.

LITHOSTRATIGRAPHY

The Bahariya formation (Fig. 1) is divided into three members: Gebel Ghorabi, Gabel el Dist & El Heiz (Norton, 1967) and is succeeded by the Abu Roash formation (Beadnell, 1902); which is divided into several members, informally known by the initials A to G (Norton, 1967; Robertson Research International et al. 1982). While the Abu Roash formation crosses the Cenomanian/Turonian boundary, the oldest portion of the G member is coeval with the upper part of the Bahariyan formation (Khaled, 1999). The F member, while also of cenomanian age, records an environmental shift from terrestrial coastline to open ocean, and as this paper reviews only the terrestrial ecosystem, will not be discussed here.

Most of the sediments at Bahariya were sourced from the Neoproterozoic rocks to the south (Tanner & Khalifa, 2009). Enhanced continental weathering resulted in Bahariya developing layers of iron ore, ranging from 5 to 7 meters in thickness in some areas (Floegel & Hay, 2004; Meyer & Kump, 2008; Tanner & Khalifa, 2009; Baioumy & Boulis, 2012). Unsurprisingly, ferricretes are also common at Bahariya (Tanner & Khalifa, 2009) and usually form in large numbers in swamps when the soluble iron in groundwater meets salt water (Widdowson, 2007).

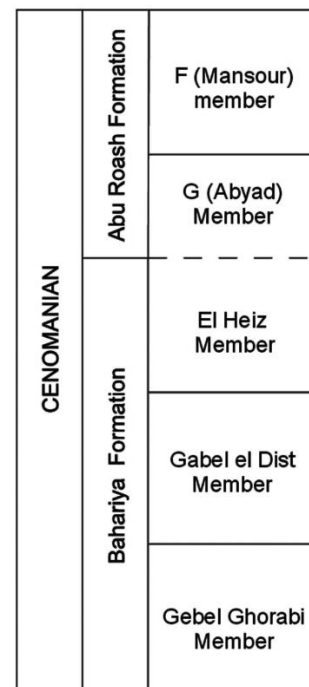


Figure. 1. A stratigraphical chart for the Cenomanian of Egypt. Dotted line indicates the coeval nature of the El Heiz and G member beds.

PALAEOENVIRONMENT

Topography

Bahariya itself (Fig. 2) was a vast mangrove swamp referred to as the "*Bahariya Bight*" by researchers (Lacovara et al. 2003) that extended for an estimated 300 km inland & 300 km along the coastline of Northern Gondwana (Catuneanu et al. 2006; Grandstaff et al. 2012; K. Lacovara, personal communication, 2010).

While known primarily for its mangroves, the Bahariya Formation extends across half of Egypt with the Bahariya Bight being just part of a larger coastal wetland system with great variations in the prevailing palaeoenvironments both along the coastline (north to south) and from the coastline to inland regions (east to west). Stromer (1914), Werner (1989), Lyon et al. (2001), El Sisi et al. (2002) & Grandstaff et al. (2012) found evidence of estuarine deposits and Catuneanu et al. (2006) & Grandstaff et al. (2012) note that that these fluvial areas are more extensive in the in southern region of Bahariya; forming a huge, braided, fresh water river network.

Moustafa & Lashin (2012) have also shown that the Bahariya segment of the El-Waha-1 succession preserves a neighboring upland community while the depositional environment of the Abu Roash formation's G member/Bahariyan El Heiz member, also records the development of a vast lagoon in the south (Said, 1962, 1990). The Bahariyan ecosystem can thus be divided into three basic micro-habitats within the overall ecosystem: upland, coastal freshwater and coastal marine with varying degrees of overlap between them over time.

Sedimentology shows that the Bahariya Bight itself had a fine grained, low energy, meso-tidal regime (Lacovara et al. 2003; Schweitzer et al. 2003); although a few areas of Bahariya show coarser grained, higher energy conditions (Catuneanu et al. 2006; Grandstaff et al. 2012; Baioumy & Boulis, 2012; Tahoun & Mohamed 2013). A result of the generally limited wave action along most of this coastline would be high levels of salinity, although this would be negated to some extent by river inflow (Werner 1989), high water table (Catuneanu et al. 2006), high tidal range (Lacovara et al. 2002) and the actions of the local fauna itself (Micheli et al. 1991; Stieglitz et al. 2000). In the fluvial regions to the north and south, the salinity levels were much lower (Tahoun & Mohamed, 2013).

In the early Cenomanian, the continental shelf saw a gradual base-level rise (Said, 1990), interrupted by three periods of base-level fall (Catuneanu et al. 2006; Tanner & Khalif, 2009) and the movement of the depositional basin inland (El-Sisi et al. 2002; Moustafa & Lashin, 2012, Baioumy & Boulis, 2012; Tahoun et al. 2013; Makled et al. 2013). This led to the development of deep marine basins alongside carbonate platforms in some areas (Moustafa & Lashin, 2012). However the number of marine transgressions and the duration of each varied depending on location; some areas experienced multiple transgressions (Nothdurft et al. 2002; Baioumi et al. 2012) while others only experienced only two transgressions followed by forced regressions (Smith et al. 2001B; Catuneanu et al. 2006; Baioumi et al. 2012).

The waters were predominantly dysoxic/anoxic (El-Soughier et al. 2011; Tahoun et al. 2013; Makled et al. 2013; Zobia et al. 2013), although conditions in some areas were suboxic/anoxic in nature (El-Soughier & et al.011). Despite the water conditions, fish were incredibly diverse and the huge sizes attained by many shows the waterways must have been deep and extensive; estimated depths ranging from 3 to 6 meters (Nothdurft et al. 2002) to 50 to 500 meters (Baioumy & Boulis, .

2012), although channel depth would have varied over time and location.

While there are no extant parallels, as the Bahariyan flora seems to have evolved different methods of surviving in a "mangrove biome" compared to extant mangrove taxa (Lacovara et al. 2003), Bahariya shows characteristics of both tidal and basin mangroves.

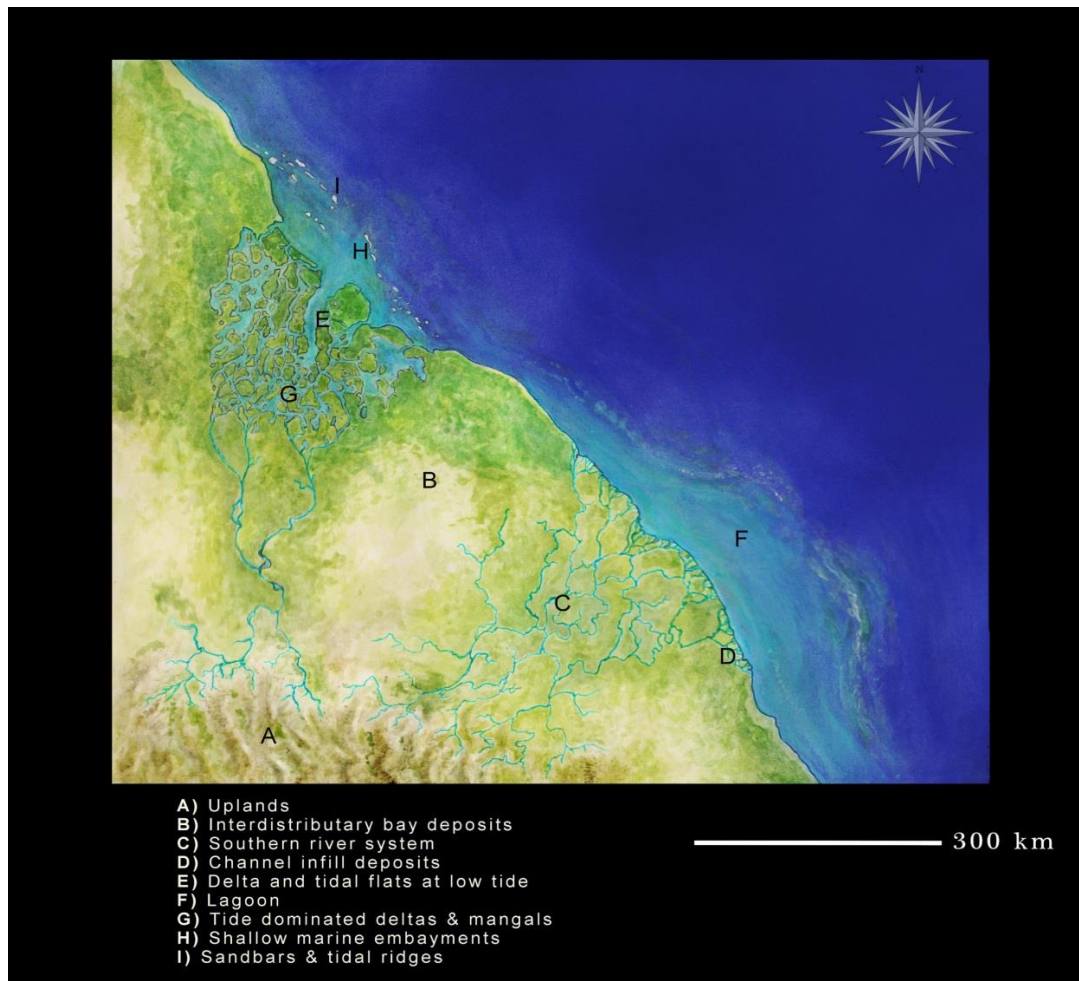


Figure. 2. North-Eastern Africa, circa 93.5 mya. A diagram showing the palaeogeography of the Bahariya Formation. Adapted from El Sisi et al (2002).
 Artwork by Joschua Knüppe.

Climate

During the Cenomanian, 99.0 to 93.5 mya, North Africa generally had a stable climate that lacked defined seasons although it suffered violent monsoons (Russell & Paesler, 2003). However most climatology work focuses on the Kem Kem beds and may not be representative of the Bahariya formation; although the local ammonite fauna (Wiese & Schulze, 2005) supports Russell & Paesler's interpretation and the abundance of glauconite also suggest frequent and violent storms (Baoumy & Boulis, 2012). Traces of charcoal show this region was also subject to periodic forest fires (Nothdurft et al. 2002).

With latitude of roughly 10° N, Bahariya was near the palaeoequator which would have resulted in a tropical climate (Lacovara et al. 2003; Deaf, 2009). The presence of xerophytic plants such as *Weichselia reticulata* (Stokes & Webb, 1824?) and palynomorph studies suggest a dry climate (Bolkhovitina, 1953; Krutzsch, 1961; Trevisan, 1980; Zobaa et al. 2008; Deaf, 2009; Baioumi et al. 2012; Zobaa et al. 2013) as does the leaf morphology (Lyon et al. 2001). However the presence of some palynomorphs suggests humid conditions in some areas (Schrank, 1990; Brenner, 1996; Shehata & Abdou, 2008; Deaf, 2009; Baioumi et al. 2012; Zobaa et al. 2013) and Catuneanu et al. (2006) shows a brief swing towards wetter climatic conditions in the middle Cenomanian.

FLORA & FAUNA

Microfauna & Meiofauna

Dinoflagellates

Bahariya dinoflagellates include *Spiniferites* sp (Mantell, 1850) Sarjeant 1970, *Mudrongia simplex* (Alberti, 1961) Cookson and Eisenack 1958, *Pediastrum* sp & *Scenedesmus* sp (Meyen, 1829), *Cyclonephelium vannophorum* & *Cyclonephelium edwardsii* (Davey, 1969), *Kallosphaeridium* sp (De Coninck, 1969?), *Exochosphaeridium* (Davey et al. 1966) Guler et al. 2012, *Coronifera oceanica* (Cookson & Eisenack, 1958), *Pseudoceratium securigerum* (Davey & Verdier, 1973) & *P. anaphrissum* (Sarjeant?) Bint, 1986, *Botryococcus* sp (Kützing, 1849), *Palaeoperidinium cretaceum* (Pocock, 1962), *Florentinia mantlii* (Davey & Verdier, 1974) Guler et al. 2012, *F. cooksoniae* & *Florentinia* sp (Singh, 1971), *Xiphophoridium alatum* (Sarjeant, 1966) Cookson and Eisenack 1962, *Dinopterygium cladoides* (Deflandre, 1935) Dolding 1992 and *Subtilisphaera perlucida* and *S. senegalensis* (Alberti, 1959) Jain & Millepied 1973.

Foraminifera

Foraminifera are also known from this Formation (Zobaa et al. 2008). Record families include the Cibicididae, Vaginulinidae, Hauerinidae, Nezzazatidae, Mayncinidae, Favusellidae, Hedbergellidae, Rosalinidae, Heterohelicidae, Thomasinellidae, Textulariidae and the Discorbidae (Ismail & Soliman, 1997). Known species include *Favusella washitensis* (Carsey, 1926), *Charentia cuvillieri* & *Mayncina orbigny* (Neumann, 1965), *Whiteinella archaeocretacea* (Pessagno, 1967), *Thomasinella fragmentaria* & *T. aegyptia* (Omara, 1956), *T. punica* (Schlumberger, 1893) Loeblich & Tappan 1983 along with *Rotalipora reicheli* & *R. cushmani* (Morrow, 1934).

FLORA

Miospores

Spore and pollen species are also known (Zobaa et al. 2008). Species include *Appendicisporites* sp (Weyland & Greifeld, 1953) Vallati 2006, *Crybelosporites pannuceus* (Dettmann, 1963) Brenner & Srivastava, *Aequitriradites spinulosus*

(Cookson & Dettmann, 1961) Cookson & Dettmann 1961, *Cicatricosisporites orbiculatus* (Singh, 1964), *Afropollis jardinus*, *A. kahramanensis* & *A. operculatus* (Brenner) Doyle, Jardiné, and Doerenkamp 1982, *Alaticolpites limai* (Regali et al. 1974), *Concavissimisporites variverrucatus* & *C. punctatus* (Brenner, 1963), *Tricolpites* sp (Cookson 1947) Couper 1953, *Retimonocolpites* spp (Pierce, 1961), *Elaterosporites verrucatus* & *E. klaszii* (Jardiné 1967), *Pilosisorites trichopapillosus* (Delcourt & Sprumont, 1955) Vallati 2006, *Cicatricosisporites orbiculatus* (Singh 1964), *Murospora florida* (Somers, 1952?), *Crybelosporites pannuceus* (Brenner 1963), *Scortea hamoza* & *S. tecta* (Chlonova, 1971), *Deltoidospora* sp (Miner, 1935), *Elaterocolpites castelainii* & *Ephedripites* sp (Regali et al. 1974), *Elateroplicites* sp (Herngreen 1973), *Cyathidites* sp (Allam & Cramer, 1973), *Dictyophyllidites harrisii* (Couper, 1958a & b), *Dicheiropollis etruscus* (Trevisan, 1971), *Retitricolpites* sp (Van der Hammen, 1956), *Spheripollenites psilatus* (Couper, 1958a & b), *Impradecispora apiverrucata* (Couper, 1958a & b) Venkatachala et al. 1969a & b, *Classopollis torosus* (Reissinger) Couper 1958a & b, *C. brasiliensis* (Herngreen 1973) & *Classopollis* sp (Doyle 1999), *Matonisporites simplex* (Couper 1958?) Mohr & Seufert. 1987?, *Galeacornea causea* (Stover 1963), *Araucariacites australis* & *Araucaiacites* sp (Cookson 1947), *Cretacaeiporites densimurus*, *C. scabratus* (Herngreen 1973) Vallati 2006 and *Xenascus cerartoides* (Deflandre, 1937) Lentin and Williams, 1973.

Vascular Plants

The dominate plant at Bahariya was the tree fern *Weichselia reticulata* (Lacovara et al. 2003; Silantieva & Krassilov, 2006). Other native water ferns are *Cladophlebis* sp (Brongniart, 1849; Lyon et al. 2001; Barbacka & Bodor 2008) & *Marsilea* sp (Linnaeus, 1753; Lyon et al. 2001). The tree *Agathis* sp (Salisbury, 1807) is also found in Bahariya (Lyon et al. 2001).

Lyon et al. (2001) document the presence *Nelumbites* sp and *Liriodendrites* sp (Johnson, 1996) with other indeterminate species assigned to the Sapindales, Piperaceae, Lauraceae and Platanaceae. Stromer (1936) mentioned evidence of flowering plants belonging to what is now known as the Magnoliopsida and Nymphaeaceae and Lejal-Nicol & Dominik (1990) mention evidence of Cornaceae, Lauraceae, Proteaceae & Vitaceae.

Ultimately thirty different genus of plant are known from Bahariya, some of which fall into the category of mega-flora (Lyon 2001). Sadly much of this material has yet to be described.

FAUNA

Invertebrates

Insects

Insect remains are sparse although Lyon (2001) found leaves with evidence of extensive insect damage.

Gastropods

Nothdurft et al. (2002) mention the remains of predatory snails buried in the act of scavenging a fish carcass. This habitat also had reefs composed of *Exogyra* sp (Say, 1820; Lyons, 1894; Stromer, 1936; Lacovara et al. 2003; Grandstaff et al. 2012), *Nucula* sp (Lamarck, 1799b; Stromer, 1936), *Cardium* sp (Linnaeus, 1758; Stromer, 1936), *Gastrochaena* sp (Spengler, 1783; Stromer, 1936) and *Ostrea flabellata* (Goldfuss, 1833; Stromer, 1914).

The ammonites *Neolobites vibrayeanus* (d'Orbigny, 1841) and *Baculites* sp (Lamarck, 1799a) are also known from Bahariya (Stromer, 1936; Kassab & Obaidalla, 2001; Wiese & Schulze, 2005; Abdel-Gawad et al. 2006; Gertsch et al. 2010; El-Sabbagh et al. 2011).

Crustaceans

Bahariya crabs are referred to the Necrocarcinidae (Schweitzer et al. 2003) and Stromer (1936) also mentioned fragmentary lobster remains. The most diverse crustaceans are the ostracods with the families Cytherellidae, Loxoconchidae, Bythocyprididae, Cytherideidae, Paracyprididae, Xestoleberididae, Trachyteberididae, Bairdiidae, Bythocytheridae, Cytheruridae, Progonocytheridae and Brachyocytheridae present (Ismail & Soliman, 1997; Gebhardt, 1999).

Named ostracod species include *Amphicytherura sexta*, *Anticythereis gaensis*, *Xestoleberis obesa*, *Ovocytheridea caudata*, *Brachycythere ledaforma porosa*, *Cythereis bicornis levis* & *C. canteriolata* & *C. algeriana*, *Loxoconcha clinocosta* (Crane, 1965), *Bythoceratina avnonensis* & *Bythoceratina tamarae*, *Looneyella sohni*, *Paracypris triangularis*, *Pterigocythere raabi*, *Paracypris acutocaudata* (Rosenfeld, 1974), *Bythocypris eskeri* (Bassiouni & Luger, 1990), *Metacytheropteron berbericum*, *Paracypris mdaouerensis* (Bassoullet & Damotte, 1969), *Cytherella ovata* (Roemer, 1841), *C. paenovata* (Alexander, 1932), *C. parallela* (Reuss, 1844) & *C. sulcata* (Rosenfeld & Raab, 1974); *Loxoconcha fletcheri* (Israelski, 1929), *Ovocytheridea producta* (Grekoff, 1962) & *O. reniformis* (Grosdidier, 1979), *Paracypris angusta* (Alexander, 1929), *Veeniacythereis jezzineensis* (Bischoff, 1963) along with *Fabanella* sp. A & sp. B as well as *Bairdia bassiounii*, *B. elongata* (Ismail & Soliman, 1997) and *Bairdia* sp. A & sp. B (van den Bold, 1964).

Vertebrates

Nontetrapods

Fish

Bahariya's signature taxon is *Mawsonia libyca* (Weiler, 1935; Grandstaff, 2006). However the number of *Mawsonia* species in North Africa is debated (Tabaste, 1963; Cavin & Forey, 2004; Carvalho & Maisey, 2008; Gallo et al. 2010) and further complicated by the lack of neotype for *M. libyca*. For that reason all Egyptian *Mawsonia* remains are herein assigned to *M. libyca* pending further revisions of this taxon.

Another predatory fish is *Stromerichthys aethiopicus* (Weiler, 1935; Cavin et al. 2010) and Smith et al. (2006b) mention evidence of *Enchodus* sp (Agassiz, 1843). Known only from a tooth, *Enchodus* sp is accepted herein with caution. Stromer (1936) also notes indeterminate Pachycormidae remains.

Another enigmatic taxon is *Paranogmius doederleini* (Weiler, 1935; Cavin & Forey, 2008). Possibly conspecific with *P. doederleini* is *Concavotectum morroccensis* (Cavin & Forey, 2008) which was also found in Bahariya (Le Loeuff et al. 2012). Stromer (1936) also found remains referred to *Saurodon* sp (Hays, 1830). However this referral is unlikely as *Saurodon* sp postdates the Cenomanian and is known only from Europe and North America, thus these specimens are herein left as Ichthyodectidae *incertae sedis*.

North Africa also had a diverse Elasmobranchii fauna. The best known is *Onchopristis numidus* (Haug, 1905; Stromer, 1927; Dutheil, 1999) which is now known from a complete cranium & associated vertebrae (Dutheil & Brito, 2009). Other Sclerorhynchiformes include *Baharipristis bastetiae* (Werner, 1989, 1990; Suarez & Cappetta, 2004; Vullo et al. 2007), *Marckgrafia lybica* (Weiler, 1935; Werner, 1990; Dutheil, 1999; Wueringer et al. 2009), *Distobatus nutiae* (Werner, 1989; Dutheil, 1999), *Aegyptobatus kuehnei* (Werner, 1989, 1990), *Peyeria libyca* (Weiler 1935), *Rhinoptera* sp (Hasselt, 1824 in Nelson, 2006), *Isidobatus tricarinatus* (Werner, 1989; Murray, 2000), *Schizorhiza stromeri* (Weiler, 1930), *Gymnura laterialata* (Weiler, 1930; Werner, 1989) & *Renpetia labiicarinata* (Werner, 1989, 1990) and *Ptychotrygon henkeli* (Werner, 1989, 1990; Murray, 2000).

Sharks were also abundant. One of the larger species was *Squalicorax baharijensis* (Stromer, 1927; Slaughter & Thurmond, 1974; Vullo et al. 2007). Others include *Cretodus longiplicatus* (Werner, 1989, 1990; Murray, 2000), *Cretolamna appendiculata* (Agassiz, 1843; Smith et al. 2006b) and *Scapanorhynchus subulatus* (Agassiz, 1843; Smith et al. 2006b).

More controversial is *Carcharias amonensis* (Cappetta & Case, 1975; Wellnhofer & Buffetaut, 1999; Dutheil, 1999; Vullo et al. 2007; Cavin et al. 2010). Most agree that *amonensis* requires a new genus and while Bernardez did name a new genus, his work is still unpublished (Guinot personal communication). For this reason the genus is retained as "*Carcharias*" until a new genus is erected.

More controversial is *Carcharias amonensis* (Cappetta & Case, 1975; Wellnhofer & Buffetaut, 1999; Dutheil, 1999; Vullo et al. 2007; Cavin et al. 2010). This species has had a long and complex history and has been attributed to various genera over the years: first *Odontaspis* (Cappetta and Case 1975), then to *Serratolamna* (Landemaine 1991) and finally to *Carcharias* (Vullo et al 2007). Vullo et al. (2016) finely coined the new name, *Haimirichia*, in 2016 after a study of a wonderfully preserved partial specimen from Morocco.

The region was also home to *Tribodus aschersoni* (Stromer, 1927; Werner, 1989; Vullo & Neraudeau 2008; Le Loeuff et al. 2012; Cuny, 2012) and its sister taxon *Asteracanthus aegyptiacus* (Stromer, 1927). While dismissed as a *nomen dubium* by some (Rees & Underwood, 2002), Werner (1990), Dutheil (1999), Lane (2010) & Cavin et al. (2010) consider *A. aegyptiacus* valid and this opinion is accepted herein. *Squatina* sp (Dumeril, 1806; Slaughter & Thurmond, 1974; Underwood & Mitchel, 1999) is also known from Bahariya.

Stromer (1914) and Slaughter & Thurmond (1974) also found specimens of *Neoceratodus africanus*. Churcher & De Iuliis (2003) however, believe that some specimens warrant their own genus, *Retodus tuberculatus* (Churcher et al. 2006). Tooth plates also show that *Ceratodus* sp was also present in Bahariya (Stromer 1936, Nothdurft et al. 2002). Scales assigned to *Lepidotes* sp (Forey et al. 2011) are also known from Bahariya, although this material may be referable to polypterids such as *Bawitius bartheli* (Stromer, 1936; Grandstaff, 2006; Smith et al. 2006A; Grandstaff et al. 2012).

Coelodus sp (Heckel, 1854; Stromer, 1936) is also found in Bahariya along with *Plethodus libycus* (Weiler, 1935) and *P. tibniensis* (Schaal, 1984). However the status of these *Plethodus* species is questioned by the discovery of *Palaeonotopterus greenwoodi* (Forey, 1997; Taverne & Maisey, 1999; Cavin & Forey 2001). The tooth plates are so similar that *P. libycus* and *P. tibniensis* are herein referred to *P. greenwoodi* (following Taverne, 2000). While this creates a nomenclature problem as *P. greenwoodi* is the junior synonym; *P. libycus* and *P. tibniensis* are only known from destroyed holotypes rendering them both *nomen nudum* regardless. Thus it would be best if *P. libycus* and *P. tibniensis* were considered *nomen oblitum* and *P. greenwoodi* erected as a *nomen conservandum*.

Tetrapods

Testudines

Turtles are also known (Lapparent & Werner, 1998); one genus being *Apertotemporalis baharijensis*, although there are clearly other species present (Stromer, 1934).

Squamata

The most common squamate in this region is the sea snake *Simoliophis* sp (Sauvage, 1880; Nessov et al. 1998; Nothdurft et al. 2002). As the Bahariyan *Simoliophis* species is chimaeric (Rage & Escuillie, 2003; Rage & Dutheil, 2008), the Egyptian specimens are left as *Simoliophis* sp with the other vertebra assigned to a new indeterminate snake genus (Rage & Dutheil, 2008).

Crocodylomorpha

The crocodylomorphs are typified by *Stomatosuchus inermis* (Stromer, 1925, 1933) & *Aegyptosuchus peyeri* (Stromer, 1933). A third crocodyliiform is *Libycosuchus brevisrostris* (Stromer, 1914; Buffetaut, 1976). Further *Libycosuchus* material was

found by Nothdurft et al. (2002), Tumarkin-Deratzian et al. (2004) & Buffetaut (1976); although some material may in fact be referable to *Hamadasuchus rebouli* (Larsson & Hans-Dieter, 2007).

Plesiosauria

The Bahariya formation was home to *Leptocleidus capensis* (Stromer, 1933; Stromer, 1935; Cruikshank, 1997). However the remains lack the diagnostic traits seen in *Leptocleidus* (Sachs, 2014). Thus the Bahariyan pliosaur is herein referred to Polycotylide *incertae sedis*.

Dinosauria

The most iconic Bahariyan dinosaur is *Spinosaurus aegyptiacus* (Stromer, 1915, brahim et al. 2014b). While *Sigilmassasaurus braviolis* (Russell, 1996) is usually considered a junior synonym of *Spinosaurus* (Evers et al. 2012; McFeeters et al. 2013; Ibrahim et al. 2014b), it now appears that *S. braviolis* may indeed be a valid taxa (Evers et al. 2015).

While accepting the argument that there are two separate spinosaurids in North Africa, Cau (2015) questions whether this material is truly distinct from *Spinosaurus* (in which case *Sigilmassasaurus braviolis* would become *Spinosaurus braviolis*). While such a discussion is beyond the scope of this paper; all that matters herein is that there were clearly two distinct spinosaurids in this region (Russell 1996, Evers et al. 2015), irrespective of whether they are separate on a species level or genus level.

Another theropod with a complex taxonomic history is *Bahariasaurus ingens* (Stromer, 1934; Huene, 1948). It's been proposed that *B. ingens* is a senior synonym of *Deltadromeus agilis* (Serenio et al. 1996; Nothdurft et al. 2002; Carrano & Sampson, 2008), however a reappraisal suggest that Sereno's transfer of *B. ingens* material to *D. agilis* was unwarranted and the *B. ingens* paratype lacks all the diagnostic features of *D. agilis*; rendering both taxa distinct from each other (Mortimer, 2014). For that reason, *B. ingens* is herein considered a valid taxon and *D. agilis*, which can now only be positively identified from Morocco, will not be considered further.

Also known from Bahariya is *Carcharodontosaurus saharicus* (Depéret & Savornin, 1927; Stromer, 1931; Brusatte & Sereno 2007). There are also potential dromaeosaurid remains in North Africa (Rauhut & Werner, 1995; Smith et al. 2001a). Known only from teeth, it is also possible that these specimens actually represent abelisaurids as there is evidence of at least one species of abelisaurid inhabiting North Africa at this time (Russell, 1996, Mahler, 2005, Carrano & Sampson, 2008; Porchetti et al. 2011; Richter et al. 2012; Evans et al. 2014; Chiarenza & Cau 2016).

Both Stromer (1931) and Lavocat (1954) also noted the presence of *Erectopus* sp (Sauvage, 1882) and elaphrosaurid remains. While its possible these belong to *D.*

agilis (Mortimer, 2014), they are herein both left as theropod *incertae sedis* due to as their fragmentary nature.

The sauropod fauna of this region is comprised of *Aegyptosaurus baharijensis* (Stromer, 1932) and *Paralititan stromeri* (Smith et al. 2001b). Stromer (1932) identified a vertebra alongside an isolated scapula as *Dicaeosaurus hansemanni* (Janensch, 1914). Nothdurft et al. (2002) tentatively reassigned these remains as a rebbachisaurid, but Mannion & Barrett (2013) make a strong case that the material belongs to a third, unnamed species of titanosaur.

ECOLOGICAL RECONSTRUCTION

Primary production

The Bahariya Bight is often claimed to be one of "the most productive non-marine biomes during the Mesozoic" (Lacovara et al. 2002), suggesting greater productivity led to larger fauna. Net primary production can be simplified as tonnes of carbon produced via photosynthesis per hectare per year (Hogarth, 2007). Comparisons with extant mangroves can give a general picture of productivity since Lacovara et al. (2003) have noted that the depositional environment of the Florida mangroves are the closest extant analogue to Bahariyan sedimentation, so Bahariya is not entirely without precedent. The flora was also clearly behaving like an extant mangrove community and would have had to survive under identical conditions as any "true" mangrove swamp.

A habitats net primary production is also dependent on its total area (Pauly & Ingles, 1986) and with the mangrove bight alone, extended for an estimated 300 km in all directions; Bahariya clearly had sufficient landmass for a large trophic base.

Schweitzer et al. (2003) and Tanner & Khalifa (2009) record that the mud and sandstones were rich in organic matter. The abundance of siderite is also evidence of an organic-rich environment (Tanner & Khalifa, 2009). Trees like *Agathis* sp are also productive in terms of biomass (Gee 2011) and studies by Hummel & Clauss (2011) suggest that the energy content of some ferns would have been only slightly lower than modern grasses. Lacovara et al. (2003) also show that the anchor roots of some species of Bahariyan plants accumulated mud and other nutrient rich sediments like modern mangrove taxa.

Nutrients would also be imported into the biome through the extensive rivers (Werner, 1989; Lyon et al. 2001). Models of hydrologic cycles by Floegel & Hay (2004) also show that the tropical climate would also enhance the rates of groundwater flow, increasing the amount of nutrients entering the ecosystem. Changes in water circulation in the Tethys sea also resulted in increased oceanic nutrient flow (Leckie et al. 2002) and the high tidal energy along the coastline would have imported large quantities of these nutrients into Bahariya (Lacovara et al. 2002).

Yet the nutrient content of such tidal influxes can be as much as 10 to 20 times lower than riparian sources (Lugo et al. 1976) and data suggest that terrestrial water runoff is more important than tidal influx in delivering nutrients to modern mangroves (Hogarth, 2007). So while Bahariya would have increasingly stored nutrients rather than exported them due to the low tidal action (Lugo et al. 1976; Hogarth 2007), the mangroves at the mouth of the extensive river networks to the south would have been more productive than those in the bight itself.

Towards the end of the Cenomanian, Bahariya actually became over-productive: the over-abundance of nutrients and the increased amount of iron being delivered into this ecosystem resulting in the eutrophication of the waters triggering algal blooms (Martin & Fitzwater, 1988; Frost, 1996; Boyd et al. 2000; Tanner & Khalifa, 2009; El-Soughier et al. 2011). While the exact effects vary depending on the taxa in question (Lyons et al. 2014); in general such blooms initially boost productivity, but lead to a decline in species richness in the long term (Dolbeth et al. 2003; Worm & Lotze, 2006; Lyons et al. 2014). This suggests that Bahariyan ecological stability would have begun to fail towards the Cenomanian/Turonian boundary as a result of nutrient overloading and the subsequent over-productivity of plankton & aerobic bacteria. This pattern was part of a larger global extinction event at this time (Sinton & Duncan, 1997; Kerr, 1998; Huber et al. 1999, 2002; Leckie et al. 2002; Meyer & Kump, 2008; Yilmaza et al. 2010).

Carbon imports and exports

Coastal region like Bahariya not only import nutrients but also particulate and dissolved organic matter (Hogarth, 2007). Other imports come in the form of crustacean megalopae returning after spending their larval stage at sea and fish using mangroves as nurseries for their young (Morrissey & Gruber, 1993a, 1993b; Cerutti-Pereyra et al. 2014). At least one species of Bahariya fish appears to have done the same (Cavin, 1999).

However mangroves also lose productivity. Lyon (2001) reports extensive insect damage; but extant swarming herbivorous insect's only accounts for an inconsequential 2 to 5% of productivity (Hogarth, 2007). Likewise the microfauna are also a drain on mangrove productivity, despite playing an important role in leaf litter turnover, because the carbon they produce gets recycled within the microbial community alone with little escaping into the wider ecosystem. Roughly 10% of production is lost this way (Ong, 1993).

Lacovara also doubts that the dinosaur population lived permanently in the mangroves (in Nothdurft et al. 2002). This is in accordance with extant mangroves; in Australia, out of the 200 bird genera recorded in this habitat, only 14 are found solely in mangroves; the rest commute daily or annually (Noske, 1996). Even fewer mangrove adapted birds are known from elsewhere in the world and the number of mangrove adapted mammals is smaller still (Hogarth, 2007). It must also be noted that most Egyptian dinosaurs were multi-ton animals yet no mangrove adapted herbivore over a ton in weight ever appears to have evolved, although terrestrial

multi-ton herbivores such as elephant and rhinoceros used to frequent mangroves such as the Sundarbans to feed in the recent past (Hogarth, 2007). Indeed the bulk of the vertebrate fauna from this formation (Fig. 3) is comprised of aquatic or semi-aquatic forms with terrestrial fauna in the minority.

Nagelkerken et al. (2008) suggest that this lack of mangrove adapted taxa is a result of the basic structure of this environment preventing specialization amongst the local fauna. Indeed titanosaurids, the dominant herbivore group in Bahariya, appear to have been increasingly adapted for inland habitats (Brusatte, 2012). Thus Bahariya probably had a generalist population entering the mangroves and river networks from the mainland to take advantage of the abundant food supply, rather than being mangrove adapted taxa. The exception to this rule appears to be the spinosaurids which were adapted for coastal environments (Fanti et al. 2014).

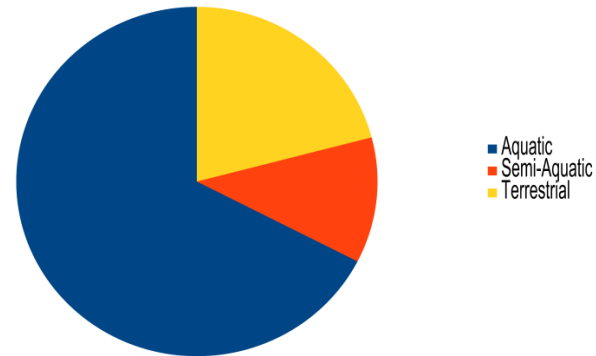


Figure. 3. The fauna of cenomanian Egypt. Vertebrate ecological diversity for the Bahariya formation. Results show genus level diversity.

This means that Bahariya was losing productivity as the fauna fed and then took that carbon outside of the biome. However this loss may be overstated as little carbon is apparently exported to surrounding habitats (Nagelkerken et al. 2008; Bouillon et al. 2008). This would be offset further by the fact that animals also import carbon (FAO, 1994) both in terms of faecal matter - trees used as roosts by bird flocks display greater productivity for instance (Stafford & Deitsch, 1996) - and in carcasses. This would be especial prominent with dinosaurs who would become what Russell (2009) called "cadaver decomposition islands" (American Association For The Advancement Of Science, 2001).

Carrano & Velez-Juarbe (2006) also suggest the relative immunity of adult sauropods to predation would have created a feedback loop where carbon was recycled through one trophic level, resulting in greater productivity and thus a greater diversity of large predators. The presence of such a loop would give increased importance to decomposers.

Nutrient recycling

The chief mangrove detritivores are often crabs (Tang & Ng, 1994; Burnie et al. 1996; Gillikin & Schubart, 2004; Hogarth, 2007). Crab burrows oxygenate the soils and reduce salinity (Micheli et al. 1991; Stieglitz et al. 2000) while their tendency to bury leaves increase nutrient cycling and leaf litter turnover rates 75 times faster

than microbial decay (Robertson & Daniel, 1989). Decopod digestion also enhances the nutritional value of leaves excreted (Lee, 1997; Nerot et al. 2009). Bahariya crabs were undoubtedly scavengers of both vegetation and animal carcasses (Schweitzer et al. 2003; Ibrahim et al. 2014a) and the paleosoils show signs of extensive burrowing (Schweitzer et al. 2003; Tanner & Khalifa, 2009) proving a high population and/or species diversity.

Nothdurft et al. (2002) also recorded high numbers of snails. This is not without precedent as extant species can achieve great population densities, although carnivorous species like the Bahariyan snails are usually rare in extant mangroves (Sasekumar, 1974; Wells, 1984; Nagelkerken, 2008). Indeed snails sometimes replace crabs as the primary ecosystem engineers in some regions: Crab predation on seedlings in Malaysia are responsible for 95 to 100% of losses while in Florida they only accounts for 6% of losses with 73% taken by gastropod molluscs (Hogarth, 2007).

High species diversity and population density of snails is also noted in the coeval Halal Formation; some of which are known from near-monospecific bone-beds (Ayoub-Hannaa & Fürsich, 2011). So gastropods could very well have equalled crabs in their importance in this ecosystem, sadly little has been published on Bahariyan snails so their role cannot be studied in greater detail besides noting the fact that they were clearly abundant.

Floral population dynamics

Such nutrient richness along this coastline may be the source of Bahariya's rich diversity of plant life (Fig. 4); although due to the fact that many floral specimens are unsubscribed, the current count is based solely on Miospore taxa. However, it must also be noted that megaflores can also flourish in nutrient depleted soils (Aragao, 2009). This diversity was maintained, despite the arid climate, as result of North Africa's high water table (Catuneanu et al. 2006) and a low continental gradient which slowed the exit of river water and allowed the Tethys sea to flood the land, creating a water rich environment despite the limited rainfall (Nash, 2012).

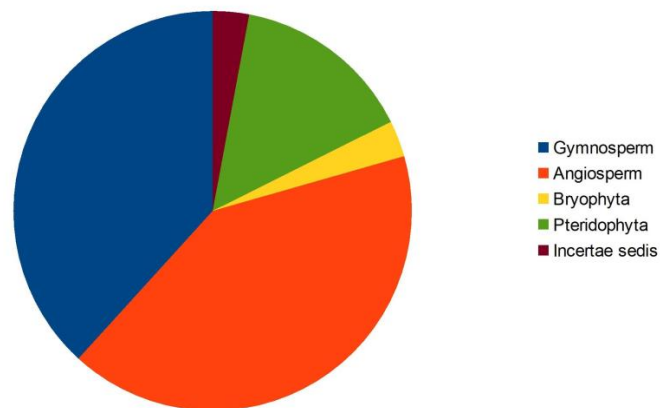


Figure. 4. The plants of Cenomanian Egypt. Floral diversity for the Bahariya Formation. Results show species level diversity.

However it must be noted that Bahariya was a mangrove swamp by definition only: a tidal, saline forest (Hogarth, 2007). None of the taxa that constitute modern mangrove flora existed at that point and Bahariya's flora had different adaptations compared to extant mangrove species (Silantieva & Krassilov, 2006).

Weichselia reticulata is among the most common taxa present, creating gallery forests along Bahariya's waterways (Nothdurft et al. 2002). However the presence of some of the other taxa recorded in Bahariya is strange: *Agathis*, for instance, can only survive short periods of waterlogging and mild salt spray (Tomlinson, 1986; Thomson, 2006). Mahmoud & Moawad (2002) and Moustafa & Lashin (2012) show that such coniferous forests were found only in the upland and river networks, way from the coastline, during the preceding Aptian and this may well have been the case in the Cenomanian as Baioumi et al. (2012) note the decline of araucariacean pollen in this region as marine influences increased during the Cenomanian.

The waterways of Bahariya were also rich in phytoplankton (Stromer, 1936). *Mudrongia*, *Cyclonephelium*, *Xiphophoridium*, *Florentinia*, *Cribroperidinium*, *Dinopterygium*, *Exochosphaeridium*, *Pseudoceratium* & *Subtilisphaera* were the dominant dinoflagellate taxa; composing 40 to 90 percent of the total plankton biomass in some areas (Tahoun et al. 2013). Multiple algal blooms saw *Pediastrum scenedesmus* and *Botryococcus* periodically increase in abundance (El-Soughier et al. 2011).

Miospore taxa also allow us to track changes in plant diversity over time. Bahariya went through 4 biozones (Tahoun et al. 2013) named after the dominate taxa in each: zone 1 (*Afropollis jardinus*), zone 2 (*Elaterosporites klaszii*), zone 3 (*Cretacaeiporites densimurus*) & zone 4 (*Trilobosporites laevigatus*); the changes in flora correlating to changes in sea level and climate. These zones remain consistent across the western desert with some variation due to the localized environmental conditions; supporting the idea of a continual ecological province (Ibrahim et al. 2014b), at least in North Eastern Gondwana.

We can also study floral diversity on a localized level as well as for the overall ecosystem. Baioumi et al. (2012) note that the sediments at the Horous -1 well represent a fresh water river area - as opposed to the brackish marine conditions predominant elsewhere in this ecosystem - and it also demonstrates localized humid conditions in a region that was predominantly arid.

Afropollis jardinus is abundant throughout the cenomanian at this location (20 percent or higher of the sampled sediments). At only three points in time does it become rare (less than 10 percent). *Crybelosporites pannuceus*, *Cyathidites* sp and *Dictyophyllidites harrisii* were also common with brief periods of decline and recovery. The amounts of *Cicatricosisporites minutistriatus*, *Elaterosporites klaszi*, *Classopoll* sp and *Ephedripites* sp. however, remain constantly low except for brief periods where abundances increase (Baioumi et al. 2012).

The section of the formation that outcrops at El- Waha- 1 also has a different palynomorph assemblage from the rest of the formation (Moustafa & Lashin 2012), initially containing *Classopollis brasiliensis*, *Cretaceioporites scabratus*, *Ephedripites* sp, *Araucaiacites* sp. This ecosystem later shifted to an *Afropollis jardinus*, *Classopollis brasilienses*, *Retimonocolpites* sp, *Matonisporites simplex*, *Crybelosporites pannuceus*, *Cretaceioporites scabratus* and *Retitricolpites* sp dominated assemblage in the later Cenomanian. As this represents a dry, highland community; the difference in flora is to be expected.

Niche partitioning amongst Bahariyan herbivores

Large herbivores also contribute to a habitats floral diversity through their feeding; a pattern we see with modern mega-herbivores (Hansson et al. 1995; Nothdurft et al. 2002; Pringle, 2008; Nasser et al. 2011). Titanosaurid sauropods were the dominant herbivores in this region with two named species and a third poorly known taxa (Stromer, 1932; Nothdurft et al. 2002; Mannion & Barrett, 2013). However these mega-herbivores were probably not superabundant: the Morrison ecosystem dynamic with lots of young, but few adults of each species per km, likely applied here (Farlow, 2007).

The shape of the skull and teeth is an indicator of feeding habits in sauropods. One, undescribed, tooth is known for *P. stromeri* (Smith et al. 2001b); but such material is absent for *A. baharijensis* and the third unnamed species making the question of niche partitioning unanswerable beyond the assumption that there must have been some variation, if only due to the considerable size difference between them.

However, work by Tütken (2011) suggests that sauropods did not feed on aquatic plants, which agrees with Carrano & Velez-Juarbe (2006) who note the rarity of large herbivores in similar habitats. Yet it's incredibly unlikely that sauropods would be in Bahariya for any other reason than to feed (a certainty in the unlikely event that they lived there permanently). However Tütken did not specifically analyze mangrove plants in his study and cannot exclude it (Tütken, personal communication, 2013).

Mangroves do appear to have distinct $\delta^{13}C$ values compared to other marine plants (Loneragan et al. 1997) although the question is whether they are isotopically distinguishable from terrestrial plants, if not the consumption of mangrove plants would be impossible to differentiate. A similar study dealing with Bahariyan sauropods and mangrove plants would be needed to settle this issue.

Missing faunal elements

It's also interesting to note that the evidence of rebbachisaurid sauropods from Bahariya is dubious, consistent with the theory that rebbachisaurids were restricted to Northwestern Africa (Mannion & Barrett, 2013). Mannion & Barrett (2013) suggest that the Trans-Saharan seaway blocked their dispersal into the rest of the

continent, but this is unlikely since the Tethys Sea to the north proved no barrier to rebbachisaurid dispersal into Laurasia (Torcida et al. 2011; Fanti et al. 2013).

Ornithopods are also unknown from Bahariya and Läng et al. (2013) & Ibrahim et al. (2014b) have shown that they were genuinely rare in North Africa at this time. It's been suggested that the large number of theropod species acted as a deterrent (Nash, 2012), similar to Shark Bay where large shark populations keep aquatic herbivores away (Wirsing, Heithaus & Dill, 2007; Wirsing & Heithaus, 2011). While this may be true for the Kem Kem formation (although it must be noted that the lack of abundant vegetation - Läng, personal communication, 2014 - would be a more plausible explanation for their rarity), it's doubtful that this applies to Bahariya with its more balanced ecosystem, diverse flora and more commonplace herbivore remains.

A more likely explanation for their rarity would be North Africa's distinct climate. Noto & Grossman (2010) note that mid to low level feeders become rarer as the environment becomes drier. Hogarth (2007) & Nagelkerken et al. (2008) have also noted the simplified ecological structure of mangrove habitats which lack a developed understory and ground level vegetation. This would explain the rarity of ornithopods, and possibly rebbachisaurids, in Bahariya which was an arid habitat despite its diverse flora.

Other missing fauna include Garial-like and herbivorous crocodylomorphs from the Kem Kem beds (Lavocat, 1955; de Broin, 2002; Sereno & Larsson, 2009). Pterosaurs are unknown from Bahariya, but common in Morocco (Mader & Kellner, 1999; Ibrahim et al. 2010) and there are no known thyreophorians despite Lapparent (1960) & Russell (1996) making reference to material from Morocco. Birds & mammals have also proven absent (Cavin et al. 2010) despite being present elsewhere in North Africa (Nessov et al. 1998; Fabio et al. 2003; Riff et al. 2004; Contessi & Fanti 2012; Contessi, 2013). Only the lack of amphibians is expected as, with few exceptions, amphibians cannot tolerate brackish waters (Dicker & Elliott, 1970); suggesting amphibian remains would be most likely found in the southern freshwater regions, if they existed in Bahariya at all.

While simple none recovery is the most likely explanation in most cases given how poorly sampled the formation is (for instance, it took 120 years of searching before ankylosaurid remains were found in the well sampled Morrison formation, Foster, 2007); it's impossible to say with certainty. Especially as some groups may be genuinely absent as marine transgressions would have forced any fresh water dependent communities further inland. There is evidence of this amongst marine invertebrates as the shallow water reefs were drowned by rising sea levels; resulting in previously common genera such as *Exogyra* sp declining rapidly towards the Turonian boundary (Kauffman, 1995; Dhondt et al. 1999).

Such transgressions are also the reason for the rarity of abelisaurids (Fanti et al.

2014; Sales et al. 2016). While Benson et al. (2012) suggest this was a result of Gondwana being divided into ecological bands as a result of climate, recent work shows that the situation is more complicated with ecological factors as well as climatic factors playing a role (Fanti et al. 2014, Chiarenza & Cau 2016).

Predator/prey ratios

The low numbers of abelisaurids helps explain one of the most important issue facing previous ecological reconstructions: the over-abundance of predators (Nothdurft et al. 2002), especially as Läng et al. (2013) have also showed that this unbalance is genuine, contra McGowan & Dyke (2009). It's also important to remember that it's not the number of carnivore species that makes this formation unique, other formations such as the Morrison have even more diverse theropod assemblages, it's the relative absence of herbivores.

Chiarenza & Cau (2016) have suggested that this overabundance of theropods was a result of poor stratigraphic resolution & that there was not really any environmental overlap between the theropod species. While they are right to point out the lack of stratigraphic placement for many of the specimens from the Kem Kem formation; such is not the case for Bahariya where the units of the formation are exceptionally well documented, with clear stratigraphic placements and correlations between the *neighbouring* Maghrabi and Naqb el Sellem formations (Churcher & De Luliis 2001; El Sisi et al. 2002). Clearly *S. aegyptiacus*, *C. saharicus* and *B. ingens* were sympatric, at least in this region.

Fig. 5 shows the current predator/prey ratio for Bahariya. While herbivore diversity is still poor; there are at least three species (two titanosaurs and a third poorly known sauropod), compared to an estimated six theropod species. Poor, but not as unbalanced as originally supposed; the ratio was as bad as seven to two in the earliest studies by Stromer.

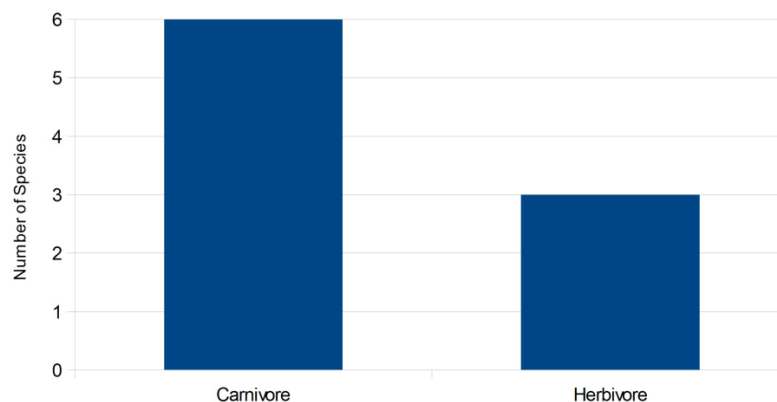


Figure. 5. Predator prey interactions. Dinosaur predator/prey ratios for the Bahariya Formation. Results show genus level diversity.

A specimen count for Bahariya (Fig. 6) shows *C. saharicus* & *B. ingens* from their holotype and paratype specimens respectfully, while *S. aegyptiacus* is known from at least one specimen, two if "*Spinosaurus B*" is referable to that species (Stromer, 1915, 1931, 1934, 1936). The supposed abelisaurids & dromaeosaurids are not

included due to the fragmentary nature of their remains, making it impossible to accurately count the number of species and individuals present.

If we include specimens from North Africa in its entirety, the result stays the same for the abelisaurids, dromaeosaurids & *B. ingens*; while the number of *C. saharicus* specimens increases to seven and *Spinosaurus* sp is now known from an estimated twenty two specimens (Bertin, 2010; Ibrahim et al. 2014b).

Both counts shows that spinosaurids sp was the most common taxa (albeit slightly in the case of Bahariya alone), irrespective of whether or not we are dealing with two separate species or two separate taxa This further validated the argument that the spinosaurids were the only year round occupant of these environment (Fanti et al. 2014, Sales et al. 2016), with the others being commuter predators entering the mangroves and river networks on occasion to hunt.

This would offset the over-abundance of theropods as three of the five taxa are rare, exceptionally so in the

case of the abelisaurids; a pattern seen in the Morrison Formation which also has a large numbers of theropod species, but 75 percent of all theropod remains belong to just one, with the rest in the minority (Foster, 2007).

Sadly the current predator/prey ratio is only provisional. While most researchers considered the caudal vertebrae and scapula as belonging to a third sauropod (Stromer, 1932; Nothdurft et al. 2002; Mannion & Barrett, 2013), a view followed herein; the lack of overlap between them and the holotypes of *A. baharijensis* and *P. stromeri* means that the specimens could possibly be referred to either of those species in the future, altering the ratio.

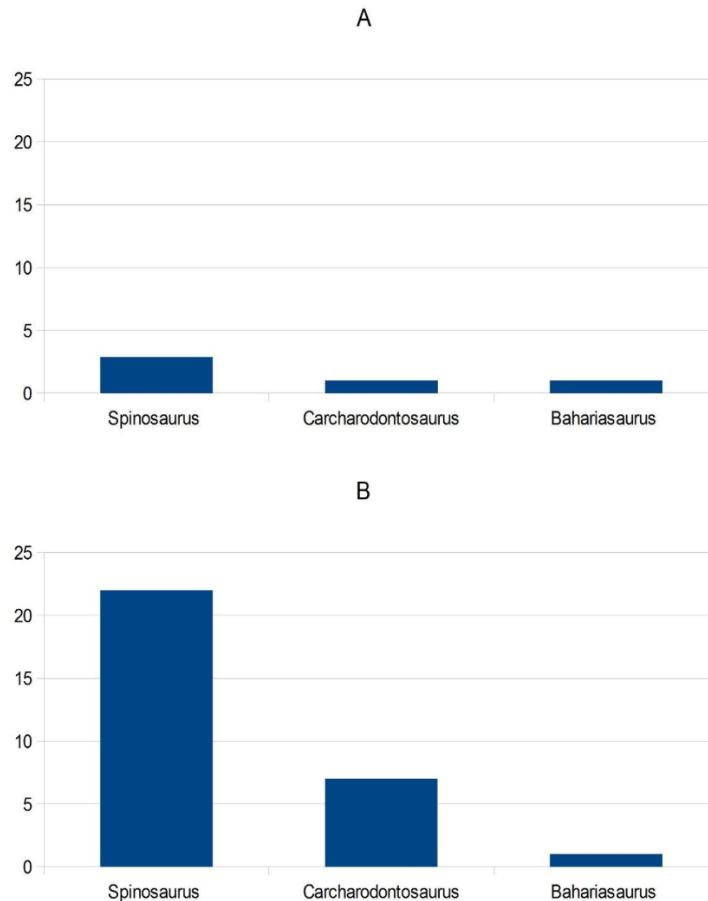


Figure. 6. Theropod population dynamics. A Theropod specimen count for North Africa. Graph A shows the count for Bahariya and graph B shows a specimen count for all of North Africa.

It's also based on the assumption that there was only one species of abelisaurid and dromaeosaurid in Bahariya. While this should be the null hypothesis given the current state of the evidence, both are known almost entirely from isolated teeth; this means that the ratios could alter once we have a greater resolution on abelisaurid and dromaeosaurid taxonomy; assuming that these specimens really are referable to either group (Chiarenza & Cau 2016).

Yet Bahariya was clearly more ecological stable than the Kem Kem beds; Bahariya has a more diverse herbivore fauna and abundant megaf flora whereas in the Kem Kem beds wood and pollen are extraordinarily rare (Läng et al. 2013; E. Läng, personal communications, 2014) - even when accounting for potential preservational bias. The fact that much of the fauna appears uniform across North Africa at this time shows that Bahariya's predator/prey imbalance is a relic from this ecosystems development from the earlier marginal Kem Kem environs (Ibrahim et al. 2014a) as the rarity of mangrove adapted taxa means the faunal composition of a mangrove is just a subset of the regional population (Nisbet, 1968; Wells, 1984; Hogarth, 2007) and North Africa was historically unstable in this regard (Russell, 1996; Läng et al. 2013; Ibrahim et al. 2014a).

Niche partitioning amongst Bahariyan carnivores

While many have noted the abundance of large carnivorous dinosaurs, few have noted the equally large number of large predatory fish (Fig. 7). Elasmobranchs, especially batoids, are incredibly diverse in this ecosystem. Weiler (1935) noted that a large number of Bahariyan fish species possessed dentition for

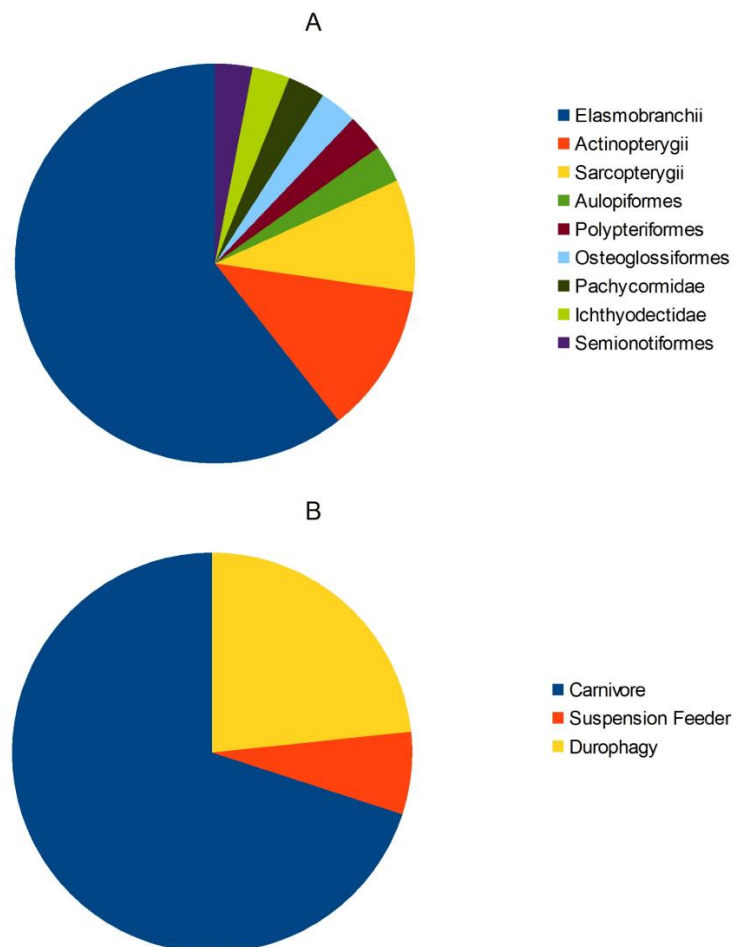


Figure 7. Niche partitioning amongst Bahariya Fish. Graph A shows genus level diversity for the Bahariya formation and graph B shows the same results divided by ecological niche.

grinding shells and this diversity inhabiting a similar niche must have been supported by high crab, bivalve & gastropod mollusk population densities/species diversity. Sheaves (2005) and Lugendo et al. (2007) have also shown that fish populations are larger when the mangroves are always accessible as was the case in Bahariya with its meso-tidal conditions.

This combination of high density invertebrate population and extensive, stable environment provided a broad base for various specialized fish which in turn sustained a diverse population of aquatic predators (Nash, 2012). It must also be noted that such top heavy food chains appear to be the norm for a healthy, tropical oceanic ecosystem (Sandin et al. 2008).

It's no surprise that Bahariya's incredible diversity of large fish coincide with the presence of pliosaurids, crocodyliforms and large piscivorous dinosaurs such as *S. aegyptiacus* (Charig & Milner, 1997; Soares, 2002; Rayfield et al. 2007; Amiot et al. 2010). The spinosaurids, along with the turtles & crocodyliforms, would have facilitated the main connection between the terrestrial and aquatic biomes, similar to prior ecosystems (Carrano & Velez-Juarbe, 2006; Fig. 8).

The large adult sizes attained by many fish would make capture difficult; which concurs with studies suggesting that spinosaurids often preyed on creatures capable of offering sustained resistance before succumbing (Therrien et al. 2005). Russell (1996) suggested that other terrestrial predators may have fed directly on fish. While *C. saharicus* undoubtedly would have fed on fish when the opportunity allowed, the presence of large sauropods shows that the Bahariyan population of *C. saharicus* had greater choice in prey selection, rendering the food chain more intricate than that of the Kem Kem formation (Calvin et al. 2010).

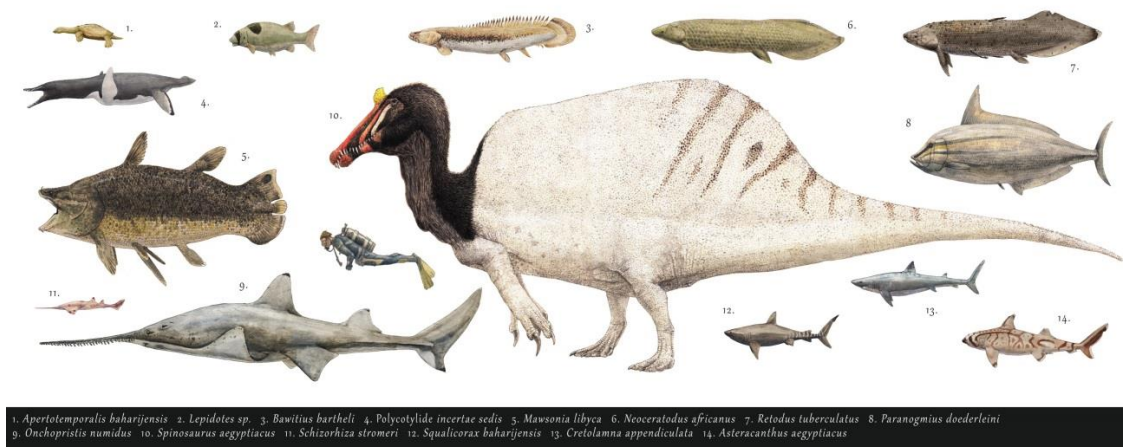


Figure 8. A scale chart comparing *Spinosaurus aegyptiacus* with various contemporaneous taxa. *S. aegyptiacus* formed one of the main connections allowing nutrient flow between the terrestrial & aquatic biomes. Artwork by Joshua Knüppe.

Of the five theropod species only three: *C. saharicus*, *B. ingens* and any abelisaurid, would have been predators of large game (Fig. 9); despite its huge size *S. aegyptiacus* was not a predator of large terrestrial prey and would only have fed on small terrestrial animals (Charig & Milner, 1997; Sue et al. 1999; Buffetaut et

al. 2004; Amiot et al. 2010). The dromaeosaurids (of which there could potentially have been various species & sizes) would have feed on smaller animals and scavenged large game when available (Hone et al. 2011; Carbone et al. 2011).

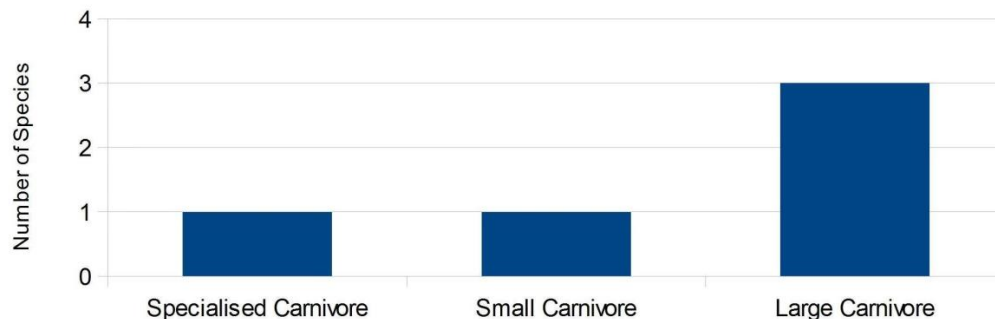


Figure. 9. The ecological roles of the Bahariyan theropods. Niche partitioning amongst Bahariyan Theropods, results show genus level diversity.

The Bahariyan crocodylomorphs also show distinct niche partitioning. *L. brevirostris* was a terrestrial predator (Buffetaut, 1982) while *A. peyeri* fed on large, slow moving fish like its relatives (Holliday & Gardner, 2012). *S. inermis* is often portrayed as a filter feeder (Nopcsa, 1925, 1926) due to the lack of teeth & gular sac. While the evolution of a suspension-feeding reptile is not impossible (Rieppel, 2002), the preservational state of the now destroyed holotype was poor. So while it's likely that Sereno & Larsson's (2009) reconstruction of the stomatosuchidae as specialized ambush predators applied to *S. inermis*, the issue cannot be settled until new material is discovered.

Faunal population dynamics

Sadly we don't have specimen counts for most of the formation to show how rare or common most taxa actually are. Most species are known only from their holotype specimens with only generalised statements that others, *M. libyca* (Grandstaff, 2006) and *Simoliophis* sp (Nothdurft et al. 2002) for instance, were abundant in Bahariya.

However, such information does exist for site BDP 2000-19 (Grandstaff et al. 2012), allowing for a comparison between species diversity and actual specimen counts (Fig. 10). The high diversity of fish and turtles is unsurprising, but plesiosaurids are totally absent in this area and the number of crocodyliform and sea snakes are small. The limited number of elasmobranch and dinosaur specimens is also surprisingly small given that their genus count takes up such a large percentage of the total vertebrate diversity. This is further proof that Bahariya's productivity went into supporting a high diversity of terrestrial & aquatic predators, but small populations of each.

However this data contradicts previous statements about the large numbers of sarcopterygians and sea snakes (Nothdurft et al. 2002; Grandstaff, 2006). It must

also be recorded that the depositional environment of site BDP 2000-19 was a rapidly infilling, freshwater, river channel which would have limited the faunal composition in this area. This could explain the low number of sharks as few can tolerate fresh water and possibly the low numbers of other groups such as sea snakes and sarcopterygians. Many of the dinosaur remains also show signs of being transported and may not have inhabited this area in life (Grandstaff et al. 2012).

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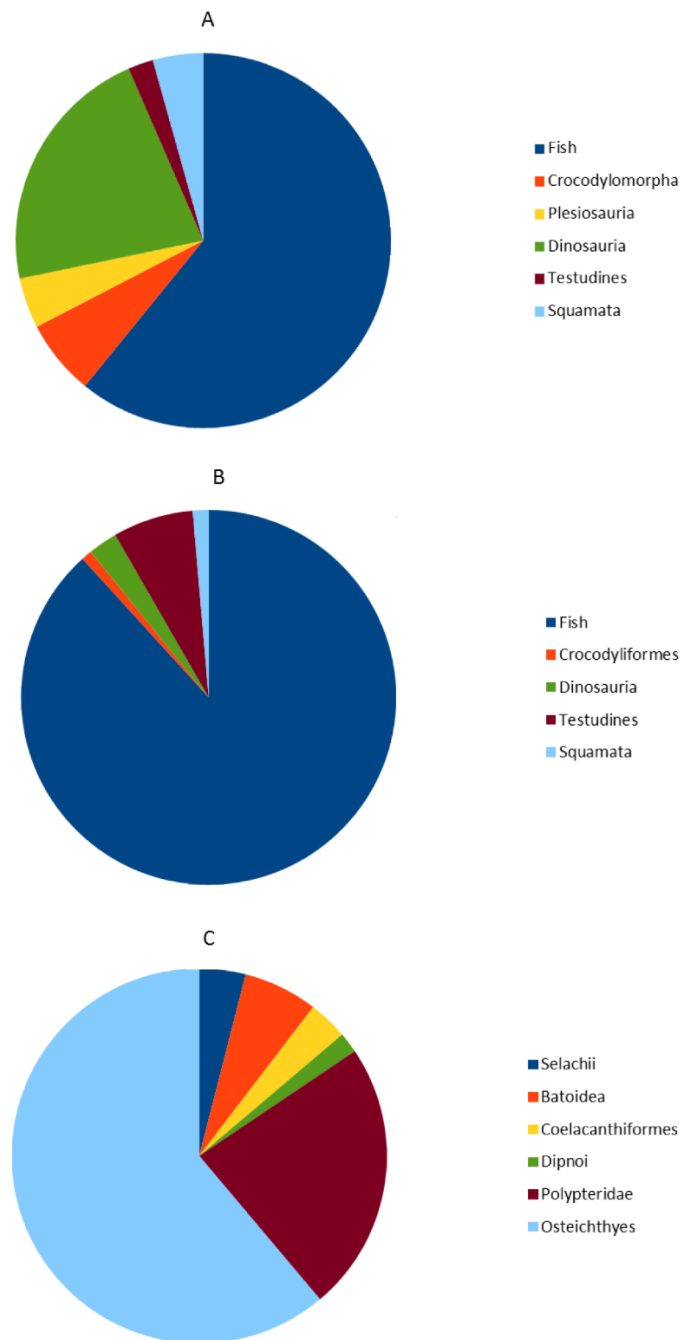


Figure. 10. Vertebrate taxonomic richness for the Bahariya Formation. Graph A shows genus level diversity for the entire formation. Graph B shows genus level diversity from site BDP 2000-19 alone. Graph C shows the taxonomic diversity of fish from BDP 2000-19 alone.

of being transported and may not have inhabited this area in life (Grandstaff et al. 2012).

We will need specimen counts from elsewhere in the formation before we can say with certainty whether the diversity patterns seen here are a result of localised conditions or a genuine population trend across this region. Sadly we only have data from site BDP 2000-19 and further specimen counts from all the sites that compose this formation will be needed to deduce population patterns for both the local environments and the ecosystem as a whole.

CONCLUSIONS

The taxonomic diversity of the Bahariya formation shown by this study rivals the contemporaneous Moroccan and Algerian Kem Kem beds as being among the best known Cenomanian fossil assemblage in the world. This report also provides a reconstruction of a unique palaeoenvironment of unparalleled scale and the first to demonstrate how this wetland would have functioned as an ecosystem; answering previous questions about productivity and faunal compositions.

This overview also demonstrates the further potential of the Bahariya Formation. The mapping of the various micro-habitats within this ecosystem and how the faunal composition varied based on these differing environmental factors is a promising avenue of inquiry. Also the use of new scientific methods for studying fauna and palaeoclimatology, pioneered on other formations, show great promise here where much of the raw data is already known but often unpublished.

Hopefully increased exploration of Egypt's western desert, new techniques and renewed efforts to describe specimens currently languishing in storage will hopefully yield even greater resolution of North African palaeoecology.

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LITERATURE CITED

- Abdel-Gawad GI, El Qot GM, Mekawy MS. 2006. Cenomanian-Turonian macrobiostratigraphy of Abu Darag area, Northern Galala, Eastern Desert, Egypt. Intern. Conf. Geol. Arab World (GAW8), Cairo Univ., Giza, Egypt, 2006, p. 553-568.
- Agassiz L. 1833–1843 [1835, 1839, 1843]. Recherches sur les poissons fossiles [5 volumes]. Imprimerie de Petitpierre, Neuchâtel, 1420 pp.
- Alberti G. 1959. Zur Kenntnis der Gattung Deflandrea Eisenack (Dinoflag.) in der Kreide und im Alttertiär Nord- und Mitteldeutschlands. Mitt. Geol. Staatsinst. Hamburg, 28:93-105.
- Allam B, Cramer F 1973. Note sur la palynologie du Bajocien du Djebel Selfate, Sidi Kacem, Maroc. Pollen et Sporen Vol. 15(3-4) p. 557-562.
- Amiot R, Wang X, Lecuyer C, Buffetaut E, Boudad L, Cavin L, Ding Z, Fluteau F, Kellner AWA, Tong H, Zhang F. 2010. Oxygen and carbon isotope compositions of middle Cretaceous vertebrates from North Africa and Brazil: Ecological and environmental significance. Palaeogeography, Palaeoclimatology, Palaeoecology 297 p439–451.
- Aragao LEOC. 2009. Above- and below-ground net primary productivity across ten Amazonian forests on contrasting soils. Biogeosciences 6 (12): 2759–2778. doi:10.5194/bg-6-2759-2009.
- Ayoub-Hannaa WS, Fürsich FT. 2011. Revision of Cenomanian-Turonian (Upper Cretaceous) gastropods from Egypt – Zitteliana, 51: 115-152.
- Baioumi AAH, Mandur, MM, Moustfa TF. 2012. Aptian-cenomanian palynozonation and paleoecology from horous -1 well, northern western desert, Egypt. Journal of Applied Sciences Research, 8(3): 1490-1501, 2012.
- Bassiouni MAA, Luger P. 1990. Maastrichtian to early Eocene Ostracoda from southern Egypt. Palaeontology, palaeoecology, palaeobiogeography and biostratigraphy. Berliner Geowissenschaftliche Abhandlungen A 120, 755–928.
- Bassoullet JP, Damotte R. 1969. Quelques ostracodes nouveaux du Cénoomanio-Turonien de l'atlas saharien occidental (Algérie). Revue de Micropaléontologie 12, 130–144.
- Benson RBJ, Rich TH, Vickers-Rich P, Hall M. 2012. Theropod Fauna from Southern Australia Indicates High Polar Diversity and Climate-Driven Dinosaur Provinciality. PLoS ONE 7(5): e37122. doi:10.1371/journal.pone.0037122.
- Bint AN. 1986. Fossil Ceratiaceae: a restudy and new taxa from the mid Cretaceous of the Western Interior, U.S.A. Palynology, 10, 135-180.

- Bertin T. 2010. A Catalogue of Material and Review of the Spinosauridae. *Palarch's Journal of Vertebrate Palaeontology* 7(4), 1-39.
- Bolkhovitina NA. 1953. Spores and pollen characteristic of Cretaceous deposits in the central regions of the USSR. *Trudy Geologicheskogo instituta. Akademiya nauk SSSR* 145: 183 pp.
- Bouillon S, Connolly R, Lee SY. 2008. Organic matter exchange and cycling in mangrove ecosystems: recent insights from stable isotope studies. *Journal of Sea Research*, Vol. 59.
- Boyd PW, Watson AJ, Law CS, Abraham ER, Trull T, Murdoch R, Bakker DCE, Bowie AR, Buesseler KO, Chang H & others. 2000. A mesoscale phytoplankton bloom in the polar Southern Ocean stimulated by iron fertilization. *Nature* 407:695–702.
- Brenner GJ. 1963. The spores and pollen of the Potomac Group of Maryland. *Maryland Dept. Geol. Mines and Water. Res. Bull.* 27:215 p.
- Brenner GJ. 1996. Evidence for the earliest stage of angiosperm pollen evolution: a paleoequatorial section from Israel. In: *Flowering Plant Origin, Evolution & Phylogeny* (eds. Taylor, D.W. & Hickey, L.J.). New York, Chapman & Hall.
- Brongniart A. 1849. Tableau des genres de végétaux fossiles considérés sous le point de vue de leur classification botanique et de leur distribution géologique. *Dict. Univers. Hist. Nat., Paris*, 21: 1–35.
- Brusatte SL, Sereno PC. 2007. A new species of *Carcharodontosaurus* (Dinosauria: Theropoda) from the Cenomanian of Niger and a revision of the genus. *Journal of Vertebrate Paleontology*.
- Brusatte SL. 2012. *Dinosaur Paleobiology (TOPA Topics in Paleobiology)*.
- Buffetaut E. 1976. Der Land- Krokodilier *Libycosuchus Stromer* und die Familie *Libycosuchidae* (Crocodylia, Mesosuchia) aus der Kreide Afrikas. *Mitteilungen der Bayerischen Staatssammlung für Paläontologie und Historische Geologie* 16: 17–28.
- Buffetaut E. 1982. Radiation évolutive, paléocécologie et biogéographie des crocodiliens Mésosuchiens, *Mém. Soc. Géol. de France*, N.S. 60 (dated 1981) No. 142, 88 pp. *Libycosuchidae*.
- Buffetaut E, Martill DM, Escuillié F. 2004. Pterosaurs as part of a spinosaur diet. *Nature* 430: 33.
- Carbone C, Turvey S, Bielby J. 2011. Intra- guild competition and its implications for one of the biggest terrestrial predators, *Tyrannosaurus rex*. *Proc. R. Soc. B.* doi: 10.1098/rspb.2010.2497.

- Carrano, M.T, and J. Velez-Juarbe. 2006. Paleocology of the Quarry 9 vertebrate assemblage from Como Bluff, Wyoming (Morrison Formation, Late Jurassic). *Palaeogeography, Palaeoclimatology, Palaeoecology* 237. 147 –159.
- Carrano, M.T, and S.C. Sampson. 2008. The phylogeny of Ceratosauria (Dinosauria: Theropoda). *Journal of Systematic Palaeontology*, 6 : pp 183-236.
- Carsey, D.O. 1926. Foraminifera of the Cretaceous of Central Texas. University of Texas Bulletin Vol. 2612 p. 1-56.
- Carvalho, M.S.S, and J.G. Maisey. 2008. New occurrence of *Mawsonia* (Sarcopterygii: Actinistia) from the Early Cretaceous of the Sanfranciscana Basin, Minas Gerais, southeastern Brazil. Pp. 109-144 in L. Cavin, A. Longbottom and M. Richter. (eds.). *Fishes and the Break-up of Pangaea*. Geological Society Special Publications 295.
- Cappetta, H, and G.R. Case. 1975. Sélaciens nouveaux du Crétacé du Texas. *Géobios*, 8 (4): 303-307.
- Cavin, L. 1999. Occurrence of a juvenile teleost, *Enchodus* sp., in a fish gut content from the Upper Cretaceous of Goulmima, Morocco. *Special Paper in Palaeontology* 60, 57–72.
- Cavin, L, and P.L. Forley. 2001. Osteology and systematic affinities of *Palaeonotopterus greenwoodi* Forey 1997 (Teleostei: Osteoglossomorpha). Volume 133, Issue 1, September 2001, Pages 25–52.
- Cavin, L, and P.L. Forley. 2004. New mawsoniid coelacanth (Sarcopterygii: Actinistia) remains from the Cretaceous of the Kem Kem beds, Southern Morocco. Pp. 493-506. in G. Arratia and A. Tintori (eds.). *Mesozoic Fishes 3 –Systematics, Paleoenvironments and Biodiversity*, Verlag Dr. Friedrich Pfeil, München, Germany.
- Cavin, L, and P.L. Forley. 2008. A new self-tailiform teleost from the mid-Cretaceous (Cenomanian) of the Kem Kem beds, Southern Morocco. Pp. 199 –216. in G. Arratia, H-P. Schultze and M.V.H. Wilson (Eds.). *Mesozoic Fishes IV –Homology and Phylogeny*, Verlag Dr. Friedrich Pfeil, München, Germany.
- Cavin, L, H. L. Tong, C. Boudad, A. Meister, J. Piuze, M. Tabouelle, R. Aarab, R. Amiot, E. Buffetaut, G. Dyke, S. Hua and J. Le Loeuff. 2010. Vertebrate assemblages from the early Late Cretaceous of southeastern Morocco: An overview. *Journal of African Earth Sciences*, 57:391-412.
- Charig, A.J, and A.C. Milner. 1997. *Baryonyx walkeri*, a fish-eating dinosaur from the Wealden of Surrey. *Bulletin of the Natural History Museum of London (Geology)* 53:11-70.
- Cerutti-Pereyra, F, M. Thums, C. M. Austin, C. J. A. Bradshaw, J. D. Stevens, R. C. Babcock, R. D. Pillans, M. G. Meekan. 2014. Restricted movements of juvenile rays

in the lagoon of Ningaloo Reef, Western Australia –evidence for the existence of a nursery. *Environmental Biology of Fishes* 97, 371-383.

Chlonova, A.F. 1971. Palynological characteristics of Cretaceous deposits of Siberia and Far East. Pp. 52-151 in Saks, V.N. (Ed.). *Mesozoic microfossils of Siberia and Far East*. Transactions of the Institute of Geology and Geophysics 138.

Churcher, C.S, and G. De Iuliis. 2003. A new species of *Protopterus* and a revision of *Ceratodus humei* (Dipnoi: Ceratodontiformes) from the late cretaceous Mut Formation of the eastern Dakhleh Oasis, western desert of Egypt. *Palaeontology*, volume 44, Issue 2, pages 305–323.

Churcher C. S, G. De Iuliis and M.R Kleindienst. 2006. A new genus for the Dipnoan species *Ceratodus tuberculatus* Tabaste, 1963. *Geodiversitas* 28 (4) : 635-647.

Cookson, I.C. 1947. Plant microfossils from the Lignites of Kerguelen archipelago. B. A. N. Z. Antarctic Res. Expedition 1929-31, Rept. A2 :127-142.

Cookson, I.C. & Dettmann, M.E., 1961. Reappraisal of the Mesozoic microspore genus 1335 *Aequitriradites*. *Palaeontology* 4, 425–427.

Cookson, I.C. & Eisenack, A. 1958. Microplankton from Australia and New Guinea Upper Mesozoic sediments. *Proc. R. Soc. Victoria*, pp. 205.

Cookson, I.C. & Eisenack, A., 1962. Some Cretaceous and Tertiary microfossils from 1356 Western Australia. *Proceedings of the Royal Society of Victoria* 75, 269–273.

Couper, R.A. 1953. Plant microfossil dating of some New Zealand upper Tertiary volcanic rocks. *New Zealand journal of science and technology* B34: 373-377.

Couper, R.A. 1958a. British Mesozoic microspores and pollen grains. *Palaeontographica* Abt. B 103. 75-179.

Couper, R.A. 1958b. Note sur la palynologie du Bajocien du Djebel Selfate, Sidi Kacem, Maroc. In B. Allam & F. Cramer (ed.). 1973. *Pollen et Spores* Vol. 15(3-4) Pp. 557-562. Cruikshank, A.R.I. 1997. A lower Cretaceous Pliosauroid from South Africa. *Annals of the South African Museum* 105: 206–226.

Catuneanu, O, M.A. Khalifa, and H.A. Wanas. 2006. Sequence stratigraphy of the Lower Cenomanian Bahariya Formation, Bahariya Oasis, Western Desert, Egypt. *Sedimentary Geology* 190, 121–137.

Cuny, G. 2012. Freshwater hybodont sharks in Early Cretaceous ecosystems : A review. Pp. 519-532 in Godefroit, P. (ed.). *Bernissart dinosaurs and Early Cretaceous terrestrial ecosystems*, Indiana University Press, Bloomington.

- Davey, R.J, C. Downie, W.A.S. Sarjeant, and G.L. Williams. 1966. VII. Fossil dinoflagellate cysts attributed to *Baltisphaeridium*. In Davey, R.J., Downie, C., Sarjeant, W.A.S. and Williams, G.L., Studies on Mesozoic and Cainozoic dinoflagellate cysts; British Museum (Natural History) Geology, Bulletin, Supplement 3, p.157-175.
- Davey, R.J. 1969. Non-calcareous microplankton from the Cenomanian of England, northern France, and North America. Bull. Brit. Museum Nat. Hist. 17, 105.
- Davey, R. J. & J.P. Verdier. 1973. An investigation of microplankton assemblages from latest Albian (Vraconian) sediments. Revista Española de Micropaleontología, 5, 173-212.
- Davey, R.J. and J.-P. Verdier. 1974. Dinoflagellate cysts from the Aptian type sections at Gargas and La Bédoule, France. Palaeontology, v.17, p.623-653, pl.91-93.
- Deaf, S. A. 2009. Palynology, palynofacies and hydrocarbon potential of the Cretaceous rocks of northern Egypt. University of Southampton. Faculty of Engineering, Science and Mathematics School of Ocean and Earth Sciences. PhD Thesis ePrintsSoton. 3-335.
- De Coninck, J. 1969. Nouvelles observations sur les kystes de dinoflagellés du genre *Kallosphaeridium*. Editions du Centre national de la recherche scientifique.
- Deflandre, G. 1937. Considerations biologiques sur les microorganismes d'origine planctonique conservés dans les silex de la Craie. Bulletin biologique de la France et de la Belgique, 69, 213-244.
- Dettmann, M. E. 1963. Upper Mesozoic microfloras from south-eastern Australia. Proc R Soc Vic 77:1-148.
- Dhondt, A.V, N. Malchus, L. Boumaz, and Jaillard, E. 1999. Cretaceous oysters from North Africa: origin and distribution. Bulletin de la Société Géologique de France. 170: 67-76.
- Dobeth, M., M.A Pardal, A. I. Lillebø., U. Azeiteiro and J. C. Marques. 2003. Short- and long-term effects of eutrophication on the secondary production of an intertidal macrobenthic community. Marine Biology (2003) 143: 1229-1238.
- Dolding, P.J.D. 1992. Palynology of the Marambio Group (Upper Cretaceous) of northern Humps Island. Antarctic Science 4(3):311-326.
- Doyle, J. A, S. Jardiné and A. Doerenkamp. 1982. *Afropollis*, a new genus of early angiosperm pollen, with notes on the Cretaceous palynostratigraphy and palaeoenvironments of northern Gondwana. Bulletin des Centres de

Recherches Exploration-Production Elf-Aquitaine 6, 39–117.

Doyle, J.A. 1999. The rise of Angiosperms as seen in the African Cretaceous pollen record. Proceedings of the Third Conference on African Palynology, Johannesburg 14-19 September 1997. *Palaeoecology of Africa and the surrounding Island*, 26, 3–29.

Dumeril, A.M.C. 1806. *Zoologieanalytique, ou methodenaturelle de classification des animaux*. Paris, 344 p.

Dutheil, D. B. 1999. An overview of the freshwater fish fauna from the KemKem beds (Late Cretaceous: Cenomanian) of southeastern Morocco. Pp. 553-563 in G. Arratia and H-P. Schultze (eds.). *Mesozoic Fishes 2 –Systematics and Fossil Record*, Verlag Dr.Friedrich Pfeil, München, Germany.

Dutheil, D. B, and P.M. Brito. 2009. Articulated cranium of *Onchopristis numidus* (Sclerorhynchidae, Elasmobranchii) from the kemKembeds, Morocco. Jalil, N. -E. (Ed.). 1st International Congress on North African Vertebrate Palaeontology, Program & Abstracts, Marrakech, 25 –27, p. 66.

El-Sabbagh, A.M, A.A.A. Tantawy, G. Keller, H. Khozyem, J. Spangenberg, T. Adatte, and B. Gertsch. 2011. Stratigraphy of the Cenomanian-Turonian Oceanic Anoxic Event OAE2 in shallow shelf sequences of NE Egypt. *Cretaceous Research* 30:1-18.

El-Sisi, Z, M. Hassouba, M. J. Oldani and J. C. Dolson. 2002. Field Trip No. 8. The Geology of the Bahariya Oasis in the Western desert of Egypt and its Archeological heritage.

Evans, D.C, Barrett, P.M. Brink, K.S. And Carrano, M.T. 2014. Osteology and bone microstructure of new small theropod dinosaur material from the early Late Cretaceous of Morocco. *Gondwana Research* doi: 10.1016/j.gr.2014.03.016.

Evers, S, O. Rauhut, and A. Milner. 2012. Was Stromer right? The affinities of *Sigilmassaurus brevicollis* (theropoda, Tetanurae). 72nd Annual Meeting Society of Vertebrate Paleontology.

FAO. 1994. mangrove forest management guidelines. Food and agricultural organisation, Rome.

Fanti, F, A. Cau, M. Hassine and M. Contessi. 2013. A new sauropod dinosaur from the Early Cretaceous of Tunisia with extreme avian-like pneumatization. *Nature Communications* 4:2080. doi:10.1038/ncomms3080.

Fanti, F, A. Cau and M. Martinelli. 2014. Integrating palaeoecology and morphology in theropod diversity estimation: a case from the Aptian-Albian of Tunisia. *Palaeogeography, palaeoclimatology, Palaeoecology* doi: 10.1016 /

j.palaeo.2014.05.033.

Farlow, J.O. 2007. A speculative look at the paleoecology of large dinosaurs of the Morrison Formation, or, life with *Camarasaurus* and *Allosaurus*. Pp. 98–151 in E. P. Kvale, M.K. Brett-Surman and J. Farlow (ed.). *Dinosaur paleoecology and geology: the life and times of Wyoming Jurassic dinosaurs and marine reptiles*, Shell (WY): GeoScienceAdventures.

Floegel, S. and W.W. Hay. 2004. The hydrological cycle on a greenhouse Earth and its implications; different from today. *Geological Society of America Abstracts with Programs* 36, 196–197.

Forey, P.L. 1997. A Cretaceous notopterid (Pisces: Osteocertain Cretaceous and Eocene teleostean fishes. American glossomorpha) from Morocco. *South African Journal of Museum Novitates* 2524: 1–31. *Science* 93: 564–569.

Forey, P. L., A. López-Arbarello and N. MacLeod. 2011. A New Species of *Lepidotes* (Actinopterygii: Semiontiformes) from the Cenomanian (Upper Cretaceous) of Morocco. *Palaeontologia Electronica* Vol. 14, Issue 1; 7A:12p.

Forster, A, S. Schouten, K. Moriya, P.A. Wilson, and J.S. Sinningh-Damsté. 2007. Tropical warming and intermittent cooling during the Cenomanian/Turonian oceanic anoxic event 2: Sea surface temperature records from the equatorial Atlantic. *Paleoceanography*, 22, PA1219, doi:10.1029/2006PA001349.

Foster, J. 2007. *Jurassic West: The Dinosaurs of the Morrison Formation and Their World*. The University of Chicago Press. Frost, B.W. 1996. Phytoplankton bloom on iron rations. *Nature* 383:474–476.

Gallo, V, M.S.S. de Carvalho, and H.R.S. Santos. 2010. New occurrence of Mawsoniidae (Sarcopterygii, Actinistia) in the Morro do Chaves Formation, Lower Cretaceous of the Sergipe Alagoas Basin, Northeastern Brazil. *Bol. Mus. Para. Emílio Goeldi. Cienc. Nat.*, Belém, v. 5, n. 2, p. 195-205, maioago.

Gebhardt, H. 1999. Cenomanian to Coniacian biogeography and migration of North and West African ostracods. *Cretaceous Research* (1999) 20, 215–229.

Gee, C. T. 2011. Dietary options for the sauropod dinosaurs from an integrated botanical and paleobotanical perspective. Pp. 34-56. in N. Klein, K. Remes, C. T. Gee, and P. M. Sander (eds.). *Biology of the Sauropod Dinosaurs: Understanding the Life of Giants*. Indiana University Press, Bloomington and Indianapolis.

Gertsch, B, G. Keller, T. Adatte-Berner, A.S. Kassab, A.A.A. Tantawy, A.M. El-Sabbagh, and Stueben, D. 2010. Cenomanian–Turonian transition in a shallow water sequence of the Sinai, Egypt. *International Journal of Earth Sciences (Geologische Rundschau)* 99:165-182.

- Gillikin, D.P, and C.D. Schubart. 2004. Ecology and systematics of mangrove crabs of the genus *Perisesarma* (Crustacea: Brachyura: Sesarmidae) from East Africa. *Zoological Journal of the Linnean Society*, 141(3), 435-445.
- Goldfuss, G. A. 1833. *Divisio secunda. Radiariorum reliquiae. Petrefacta Germaniae et ea, quae in Museo Universitatis Regiae, Borussiae Frederischieae Wilhelmae Rhenanae servantur et alia quae in Museo Hueninghausiano, Muensteriano aliisque exstant, iconibus et descriptionibus illustrata* 1(2):115-252.
- Grandstaff, S.B. 2006. Giant fishes from the Bahariya Formation, Bahariya Oasis, Western Desert, Egypt. Dissertations available from ProQuest. Paper AAI3225464.
- Grandstaff, B.S, J.B. Smith, M.C. Lamanna, K.J. Lacovara, and M.S. Abdel-Ghani. 2012. *Bawitius*, gen. nov., a giant polypterid (Osteichthyes, Actinopterygii) from the Upper Cretaceous Bahariya Formation of Egypt. *Journal of Vertebrate Paleontology* 32(1):17-26.
- Grosdidier, E. 1979. Principeaux ostracodes marins de l'intervalle Aptien-Turonien du Gabon (Afrique occidentale). *Bulletin des Centres de Recherches Exploration-Production Elf-Aquitaine* 3, 1-35.
- Guler, M.V., D.G. Lazo, P.J. Pazos, C.M. Borel, E.G. Ottone, R.V. Tyson, N. Cesaretti, and M. B. Aguirre-Urreta. 2012. Palynofacies analysis and palynology of the Agua de la Mula Member (Aguero Formation) in a sequence stratigraphy framework, Lower Cretaceous, Neuquén Basin, Argentina. *Cretaceous Research* 41:65-81.
- Hansson, L, L. Fahrig and G. Merriam. 1995. *Mosaic Landscapes and Ecological Processes*. Springer.
- Haug, E. 1905. *Paléontologie. Documents Scientifiques de la Mission Saharienne Mission Foureau* 2:751-832.
- Hays, I. 1830. Description of a fragment of the head of a new fossil animal, discovered in a marl pit, near Moorestown, New Jersey. *Transactions of the American Philosophical Society, Series 2*, 3(18):471-477, pl. 16.
- Heckel, J.J. 1854. Über den Bau und die Eintheilung der Pycnodonten nebst kurzer Beschreibung einiger neuen Arten derselben. *Sitz.-Ber. Akad. Wiss., Math.-naturw. Cl.*, 12: 433-464.-Wien.
- Herngreen, G.F.W. 1973. Palynology of Albian -Cenomanian strata of bore-hole 1-QS-1 -MA, State of Maranhão, Brazil. *Pollen et Spores*, 15:515-555.
- Hone, D.W.E, T. Tsuchiji, M. Watabe, and K. Tsogbataar. 2011. Pterosaurs as a food source for small dromaeosaurs. *Palaeogeography, Palaeoclimatology, Palaeoecology*, Volumes 331-332, Pages 27-30.
- Hogarth, P. 2007. *The Biology of Mangroves and Seagrasses*, Biology of Habitats series. Oxford University Press.

Holliday, C.M, N.M. Gardner. 2012. A New Eusuchian Crocodyliform with Novel Cranial Integument and its significance for the Origin and Evolution of Crocodylia. PLoS ONE 7(1): e30471.

Huber, B.T., R.M. Leckie, R.D. Norris, T.J. Bralower and E. CoBabe. 1999. Foraminiferal assemblage and stable isotopic change across the Cenomanian-Turonian boundary in the subtropical North Atlantic, J. Foraminiferal Res., 29, 392-417.

Huber, B.T., R.D. Norris and K.G. MacLeod. 2002. Deep-sea paleotemperature record of extreme warmth during the Cretaceous, Geology, 30, 123-126.

Huene, F.V. 1948. Short review of the lower tetrapods. In A.L. Du Toit (ed.). Robert Broom Commemorative Volume. Royal Society of South Africa Special Publication 65-106.

Hummel, J. and M. Clauss. 2011. Sauropod feeding and digestive physiology. Pp. 11-33. in N. Klein, K. Remes, C. T. Gee, and P. M. Sander (eds.). Biology of the Sauropod Dinosaurs: Understanding the Life of Giants. Indiana University Press, Bloomington and Indianapolis.

Ibrahim, N, D.J. Varricchio, P.C. Sereno, J.A. Wilson, and D.B. Dutheil, et al. 2014a. Dinosaur Footprints and other Ichnofauna from the Cretaceous Kem Kem Beds of Morocco. PLoS ONE 9(3): e90751. doi:10.1371/journal.pone.0090751.

Ibrahim, N., P. C. Sereno, C. Dal Sasso, S. Maganuco, M. Fabbri, D. M. Martill, S. Zouhri, N. Myhrvold and D. A. Iurino. 2014b. Semiaquatic adaptations in a giant predatory dinosaur. *Science*. 014 Sep 26;345(6204):1613-6. doi.

Ismail, A. A. & Soliman, S. I. 1997. Cenomanian–Santonian foraminifera and ostracodes from Horus Well—1, North Western Desert, Egypt. *Micropaleontology* 43, 165–183.

Jain, K.P. and P. Millepieid. 1973. Cretaceous microplankton from Senegal Basin, N.W. Africa I. Some new genera, species and combinations of dinoflaellates: *The Palaeobotanist*, v. 20, p.22-32.

Jardiné, S. 1967. Spores a expansion enformed'élateresdu Crétacémoyend'Afrique Occidentale. *Review of Palaeobotany and Palynology* 1:235-258.

Janensch, W. 1914. Übersicht über der Wirbeltierfauna der Tendaguru-Schichten nebst einer kurzen Charakterisierung der neu aufgeführten Arten von Sauropoden. *Archiv für Biontologie*, Berlin, III, 1 (1), pp. 81-110.

Johnson, K.R. 1996. Description of seven common fossil leaf species from the Hell creek formation (Upper Cretaceous: upper Maastrichtian), North Dakota, South Dakota, and Montana. *Proceeding of the Denver Museum of Natural History*. Series 3, Number 12.

- Kassab, A.S. and N. A. Obaidalla, N.A. 2001. Integrated biostratigraphy and inter-regional correlation of the Cenomanian–Turonian deposits of Wadi Feiran, Sinai, Egypt. *Cretaceous Research* 22:105-114.
- Kauffman, E.G. 1995. Global change leading to biodiversity crisis in a greenhouse world: the Cenomanian–Turonian (Cretaceous) mass extinction. In S.M. Stanley & T. Usselman(Eds.). *The Effects of Past Global Change on Life Studies in Geophysics*. National Academy Press, Washington, 47–71.
- Kerr, A.C. 1998. Oceanic plateau formation: A cause of mass extinction and black shale deposition around the Cenomanian-Turonian boundary. *J. Geol. Soc. London*, 155, 619-626.
- Krutzsch, W. 1961. Über fundevon "*ephedroidem*" Pollen imdeutschenTertiar. BeiheftzurzeitschriftGeologie, Nr. 32, s. 15_53.
- Kützing, F.T. 1849. *Species algarum*. pp. [i]-vi, [1]-922. Lipsiae[Leipzig]: F.A. Brockhaus.
- Lacovara, K.J, J.R. Smith, J.B. Smith, and M.C. Lamanna. 2002. Evidence of semidiurnal tides along the African coast of the Cretaceous Tethys Seaway: Bahariya Oasis, Egypt. *Abstracts with Programs -Geological Society of America* 34(6):32.
- Lacovara, K.J, J.R. Smith, J.B. Smith, and M.C. Lamanna. 2003. The Ten Thousand Islands Coast of Florida: a modern analogto low-energy mangrove coasts of Cretaceous epeiricseas, in R.A. Davis Jr. (ed). *Proceedings of the 5th International Conference on Coastal Sediments, Clearwater Beach, Florida*, p. 1773-1784.
- Lamarck, J. B. P. A. de Monet de. 1799a. Prodromed'unenouvelle classification des coquilles. *Mem. Soc. Hist. Nat.Paris*, (1799), 63-90.
- Lamarck, J. B. P. A. de Monet de. 1799b. Prodromed'unenouvelle classification des coquilles, comprenantunerédactionappropriéedes caractèresgénériques, et l'établissementd'un grand nombrede genres nouveaux. -Mémoiresde la Sociétéd'HistoireNaturelledede Paris 1 [an VII]: 63-91, 1 tableau. Paris.
- Lane, J.A. 2010. Morphology of the Braincase in the Cretaceous HybodontShark *Triboduslimae*(Chondrichthyes: Elasmobranchii), Based on CT Scanning.
- Larsson, H.C.E, and S. Hans-Dieter. 2007. Cranial osteology and phylogenetic relationships of *Hamadasuchusrebouli*(Crocodyliformes: Mesoeucrocodylia) from the Cretaceous of Morocco. *Zoological Journal of the LinneanSociety* 149: 533.
- Lapparent, A.F. 1960. The Dinosaurs of the "continental intercalaire" of the central sahara. 1 *Mémoires de la SociétéGéologique de France* 88A, 1 -57.
- Lapparentde Broin, F. de, and C. Werner. 1998. New late cretaceous turtles from the Western Desert, Egypt. -*Annalesde Paléontologie*: Vol 84, # 2, pp. 131-214.

- Lavocat, R. 1954. Sur les dinosauriens du Continental Intercalaire des Kem-Kem de la Daoura. Comptes Rendus, 19th International Geological Congress 1, 65–68.
- Lee, S.Y. 1997. Potential trophic importance of the faecal material of the mangrove sesarminid crab *Sesarmamessa*. Marine ecology progress series, Vol. 159: 275–284.
- Lejal-Nicol, A, and W. Dominik. 1990. Sur la paleoflore Weichseliense et a angiospermes du Cenomanien de la region de Bahariya (Egypte du Sud-Ouest). Berliner Geowiss. Abh. (A), 120 (2): 957–992.
- Le Loeuff, J, E. Läng, L. Cavin and E. Buffetaut. 2012. Between Tendaguru and Bahariya: On the age of the early cretaceous Dinosaur sites from the continental intercalaire and other african formation. Journal of stratigraphy Vol. 36 No. 2.
- Lentin, J.K. & Williams, G.L. 1973. Fossil dinoflagellates: index to genera and species. Geological survey of Canada, Paper 73 –42.
- Leckie, R.M., T.J. Bralower and R. Cashman. 2002. Oceanic anoxic events and plankton evolution: Biotic response to tectonic forcing during the mid-Cretaceous. PALEOCEANOGRAPHY, VOL. 17, NO. 3.
- Linnaeus, C. 1753. Tomus II. Sp. pl.: 561-1200, plus indexes and addenda, 1201-1231.
- Linnaeus, C. 1758. Systema Naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Editio decima, reformata. Laurentius Salvius: Holmiae. ii, 824 pp.
- Loeblich, A. R. Jr and H. Tappan. 1983. Treatise On Invertebrate Paleontology. c219, f.130 (2).
- Loneragan, N. R, S. E. Bunn, and D. M. Kellaway. 1997. Are mangroves and seagrasses sources of organic carbon for penaeid prawns in a tropical Australian estuary? A multiple stable-isotope study. Marine Biology December 1997, Volume 130, Issue 2, pp 289-300.
- Lugendo, B.R, I. Nagelkerken, G. Kruitwagen, G. van der Velde, Y.D. Mgaya. 2007. Relative importance of mangroves as feeding habitat for fish: a comparison between mangrove habitats with different settings. Bull. Mar. Sci. 80, 595–607.
- Lugo, A, E. M. Sell, and C. Snedaker. 1976. Mangrove Ecosystem Analysis. Pp. 113-146 in B. Patten (Ed.). System Analysis and Simulation in Ecology, Vol. 4 Academic Press, Inc. NY.
- Lyons, A.G. 1894. On the stratigraphy and physiography of the Libyan Desert of Egypt. Q. J. Geol. Soc. London. 501894531546.
- Lyons, D.A., C. Arvanitidis, A.J. Blight, E. Chatzinikolaou, T. Guy-Haim, J. Kotta, H. Orav-Kotta, A. M. Queirós, G. Rilov, P.J. Somerfield and T.P. Crowe. 2014.

Macro algal blooms alter community structure and primary productivity in marine ecosystems. *Global Change Biology* Volume 20, Issue 9, pages 2712–2724.

Lyon, M.A, K.R. Johnson, S.L. Wing, D.J. Nichols, K.J. Lacovara, and J.B. Smith. 2001. Late Cretaceous equatorial coastal vegetation: new megaf flora associated with dinosaur finds in the Bahariya Oasis, Egypt. Abstracts with programs Geological Society of America 33, A-198.

Lyon, M.A. 2001. Research Interests. 2001. URL: [http://www.sas.upenn.edu/~mlyon/research.html].

Mannion, P.D, and P.M. Barrett. 2013. Additions to the sauropod dinosaur fauna of the Cenomanian (early Late Cretaceous) KemKembeds of Morocco: palaeobiogeographical implications of the mid-Cretaceous African sauropod fossil record. *Cretaceous Research* 45 (2013) 49e59.

Mantell, G.A. 1850. A pictorial atlas of fossil remains, consisting of coloured illustrations selected from Parkinson's "Organic remains of a former world," and Artis's "Antediluvian phytology." London: Henry G Bohn.191.

Mahler, L. 2005. Record of Abelisauridae(Dinosauria: Theropoda) from the Cenomanian of Morocco. *Journal of Vertebrate Paleontology*, Vol. 25, No. 1.

Mahmoud, M.S. and A.M.M. Moawad. 2002. Cretaceous palynology of the Sanhur-1X borehole, north western Egypt. *RevistaEspañolade Micropaleontologia*, 34(2): 129-144.

Makled, W.A., A.H.A. Baioumi, and R.A. Saleh. 2013. Palynostratigraphicaland paleoenvironmentalsignificance of a palynomorph assemblage from the Late Albian –Cenomanian of BED 14-1 Well, North Western Desert, Egypt. *Egyptian Journal of Petroleum*. Volume 22, Issue 4. 501-515.

Martin, J.H., and S.E. Fitzwater. 1988. Iron deficiency limits phytoplankton growth in the northeast Pacific subarctic. *Nature* 331:341–343.

McFeeters, B., Ryan, M.J., Hinic-Frlog, S, and Schröder-Adams, C.J. 2013. A reevaluationof *Sigilmassasauru sbrevicollis* (Dinosauria) from the Cretaceous of Morocco. *Canadian Journal of Earth Sciences*.

McGowan, A.J, and G.J. Dyke. 2009. A surfeit of theropods in the Moroccan Late Cretaceous? Comparing diversity estimates from field data and fossil shops. *Geology*, v. 37 no. 9 p. 843-846.

Meyen, F.J.F. 1829. Beobachtungenübereinigeneiedere Algenformen. *Nova ActaPhysico-Medica Academiae CaesareaeL eopoldino-Carolinae Naturae*14: 768-778, pl. XLIII.

- Meyer, K.M., and L.R. Kump. 2008. Oceanic euxinia in Earth history: Causes and consequences. *Annual Review of Earth and Planetary Sciences* 36: 251–288.
- Micheli, F, F. Gherardi, and M. Vannini. 1991. Feeding and burrowing ecology of two East African mangrove crabs. *Mar. Biol.* 111, 247 –254.
- Miner, E.L. 1935, Paleobotanical examinations of the Cretaceous and tertiary coals. *Amer. Midland Naturalist*, Vol 16, P. 585-625.
- Mohr, B. and G. Seufert. 1987. Middle Jurassic red beds in the central High Atlas, southern Morocco; Geological and palynological studies. *News Yearbook of geology and palaeontology* Vol. 173 (3) p. 303-319.
- Mortimer, M. 2014. No giant Egyptian Deltadromeus.
URL:[<http://theropoddatabase.blogspot.co.uk/2014/09/no-giant-egyptian-deltadromeus.html>].
- Morrissey, J.F and S.H. Gruber. 1993a. Habitat Selection by Juvenile Lemon Sharks, *Negaprion brevirostris*. *Envir. Biol. Fishes*, 38: 311-319.
- Morrissey, J.F and S.H. Gruber. 1993b. Home Range of Juvenile Lemon Sharks, *Negaprion brevirostris*. *Copeia*, 1993(2): 425-434.
- Murray, A. M. 2000. The Palaeozoic, Mesozoic and Early Cenozoic fishes of Africa. *Fish and Fisheries*, 1 (2): 111-145. Morrow, A.L. 1934. Foraminifera and Ostracoda from the Upper Cretaceous of Kansas. *Journal of Paleontology* Vol. 8 p.
- Moustafa, T.F. and G.A. Lashin. 2012. Aptian –Turonian Palynomorphs from El – Waha–1 Well, Southwestern Part Of The Western Desert, Egypt. *Journal of Applied Sciences Research*, 8(4): 1870-1877.
- Nagelkerken, I, S.J.M. Blaber, S. Bouillon, P. Green, M. Haywood, L.G. Kirton, J.O. Meynecke, J. Pawlik, H.M. Penrose, A. Sasekumar, P.J. Somerfield. 2008. The habitat function of mangroves for terrestrial and marine fauna: A review. 2008. *Aquatic Botany* 89, 155–185.
- Nash, D. 2012. Planet Predator. URL:
[<http://antediluviansalad.blogspot.co.uk/2012/09/planet-predator-ii-kemkem.html>].
- Nerot, C.T. Meziane, A. Provost-Govrich, H. Rybarczyk, and S.Y. Lee. 2009. Role of grapsid crabs in entry of mangrove leaves into an estuarine food web: a mesocosm study. Vol.156 p.2343-352.
- Nessov, L.A, V.I. Zhegallo, and A.O. Averianov. 1998. A new locality of Late Cretaceous snakes, mammals and other vertebrates in Africa (western Libya). *Annales de Paléontologie*, Paris, vol. 84, pp. 265-274.

Neumann, M. 1965. Contribution a l'étude de quelques Lituolidés du Cénomaniende l'île Madame (Charente -Maritime). Revue de Micropaléontologie, 8 (2): 90-95.

Nasseri, N. A., L. D., McBrayer, and B.A. Schulte. 2011. The impact of tree modification by African elephant (*Loxodonta africana*) on herpeto-faunal species richness in northern Tanzania. African Journal of Ecology, 49: 133–140. doi: 10.1111/j.1365-2028.2010.01238.x.

Nelson, J.S. 2006. Fishes of the World, 4th Edition. John Wiley & Sons, Inc. Nisbet, I.C.T. 1968. The utilization of mangroves by Malayan birds. Ibis 110, 348–352.

Noske, R.A. 1996. Abundance, zonation and foraging ecology of birds in mangrove of Darwin Harbour, Northern Territory. Wildlife Research 23:443 -474.

Noto, C.R, and A. Grossman. 2010. Broad-Scale Patterns of Late Jurassic Dinosaur Paleocology. PLoSONE 5(9): e12553. doi:10.1371/journal.pone.0012553.

Nothdurft, W.E. J.B. Smith, M.C. Lamanna, K.J. Lacovara, J.C. Poole, and J.R. Smith. 2002. The Lost Dinosaurs of Egypt. Random House, New York.

Nopcsa, F. 1925. Die Sympliophis-Reste.-In: Ergebnisse der Forschungsreisen Prof. E. Stromers in den Wüsten Ägyptens, II.-Abhandlung der Bayerischen Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Abteilung, München, vol. 30, pp. 1-27.

Norton, P. 1967. Rock-Stratigraphic Nomenclatures of the Western Desert. Egypt Petroleum Corporation, Egypt, 1967.

Omara, S. 1956. Journal of Paleontology. Vol. 30, No. 4, pp. 883-890.

Ong, J.E. Mangroves-a carbon source & sink. Chemosphere 27: 1097 –1107.

d'Orbigny, A., 1840-1842. Paleontologie française: Terrains crétacés. 1. Céphalopodes. Masson, Paris, pp. 1e120 (1840), 121e430 (1841), 431e 662 (1842).

Pauly, D, and J. Ingles. 1986. The relationship between shrimp yields and intertidal (mangrove) areas: a reassessment. In: IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities. IOC, UNESCO, Paris, pp. 227–284.

Pessagno, E.A. 1967. Upper Cretaceous planktonic foraminifera from the West Coastal Plain. Palaeontographia Americana Vol. 5 p. 259-441.

Pierce, R.L. 1961. Lower Upper Cretaceous plant microfossils from Minnesota. Minnesota Geological Survey bulletin 42: 86 pp.

Pringle, R.M. 2008. Elephants as agents of habitat creation for small vertebrates at the patch scale. *Ecology*. 2008 Jan; 89(1):26 -33.

Pocock, S.A.J. 1962. Micro floral analysis and age determination of the strata at the Jurassic Cretaceous boundary in the western Canada Plains. *Palaeontographica B*, 111:1-95.

Porchetti, S.D, U. Nicosia, A. Biava, and S. Maganuco. S. 2011. New abelisaurid material from the upper Cretaceous (Cenomanian) of Morocco. *Rivista Italiana di Paleontologiae Stratigrafia* 117 n.3.

Rage, J.C, and F. Escuillie. 2003. The Cenomanian: stage of hindlimbed snakes. *Carnets de Géologie/ Notebooks on Geology -Article 2003/01 (CG2003_A01_JCR-FE)*.

Rage, J.C, and D. Dutheil. 2008. Amphibians and squamates from the Cretaceous (Cenomanian) of Morocco. *Palaeontographica Abteilung A* 285:1 -22.

Rauhut, O.W.M, and C. Werner. 1995. First record of the family Dromaeosauridae (Dinosauria: theropoda) in the Cretaceous of Gondwana (Wadi Milk Formation, northern Sudan). *Paläontologische Zeitschrift* Volume 69, Numbers 3 -4, p 475-489.

Rees, J, and C.J. Underwood. 2002. The status of the shark genus *Lissodus* Brough, 1935, and the position of nominal *Lissodus* species within the Hybodontoidae (slachii). *Journal of Vertebrate Paleontology* 22: 471-479.

Regali, M.S.P, N. Uesugi and A.S. Santos. 1974. Palinologia dos sedimentos Mesozoicos do Brasil 2. *Bol. Tec. Petrobras, Rio de Janeiro*, 17(4): 263-301.

Richter, U, A. Mudroch, and G.L. Buckley. 2012. Isolated theropod teeth from the Kem Kem Beds (Early Cenomanian) near Taouz, Morocco. *Paläontologische Zeitschrift, Online First*™.

Robertson, A.I, and P.A. Daniel. 1989. The Influence of Crabs on Litter Processing in High Intertidal Mangrove Forests in Tropical Australia. Vol. 78, No. 2 (1989), pp. 191-198.

Russell, D.A 1996 Isolated dinosaur bones from the middle Cretaceous of the Tafilalet, Morocco. *Bulletin du Muséum National d'Histoire Naturelle, Paris, Serie 4*. 18: 349-402.

Russell, D.A, and M.A. Paesler. 2003. Environments of Mid-Cretaceous Saharan dinosaurs. *Cretaceous Research, Volume 24, Issue 5, October 2003, Pages 569 – 588*.

Russell, D.A. 2009. *Islands in the cosmos: the evolution of life on land*. Bloomington, Indiana University Press.

- Sachs, S. 2014. Research Interests. 2001. URL: [https://www.facebook.com/pages/Art-by-JoschuaKn%C3%BCppe/732426953481529?ref_type=bookmark].
- Salisbury, R.A. 1807. Characters of several Genera in the Natural Order of Coniferae. Transactions of the Linnean Society. 8:308-317.
- Sandin, S.A, J.E. Smith, E.E. DeMartini, E.A. Dinsdale, S.D. Donner, et al .2008. Baselines and Degradation of Coral Reefs in the Northern Line Islands. PLoS ONE 3(2): e1548. doi:10.1371/journal.pone.0001548.
- Sarjeant, W.A.S. 1970. The genus *Spiniferites* Mantell, 1850 (Dinophyceae). Grana 10:74–78.
- Sasekumar, A. 1974. Distribution of macrofauna on a Malayan mangrove shore. J. Anim. Ecol. 43, 51–69.
- Sauvage, H.E. 1880. Sur l'existence d'un reptile du type ophidiens dans les couches à Ostreacolumbades Charentes.-Comptes rendus hebdomadaires des séances de l'Académie des Sciences, Paris, t. 91, pp. 671 –672.
- Sauvage, H.É. 1882. Recherches sur les reptiles trouvés dans le Gault de l'est de Paris. Mémoires de la Société Géologique de France, série 3 2(4): 1-42.
- Say, T. 1820. Observations on some species of zoophytes, shells, etc. principally fossil. American Journal of Science, 1st series, 2, 34 -45.
- Schaal, S. 1984. Oberkretazische Osteichthyes (Knochenfische) aus dem Bereich von Bahariya und Kharga, Aegypten, und ihre Aussagen zur Palaekologie und Stratigraphie. Berlin geowissenschaftliche Abhandlungen. Reihe A. Berlin/West 1984; 53: 1-79.
- Schlumberger, C.H. 1893. Description de quelques fossils nouveaux critiques des terrains tertiaires et secondaires de la Tunisie recueillis en 1885 et 1886 par M. Ph. Thomas. -In: Thomas, Ph.: Exploration scientifique de la Tunisie, 5-6: Imprimerie nationale, Paris.
- Schrank, E. 1990. Palynology of the clastic Cretaceous sediments between Dongola and Wadi Muqaddam, northern Sudan. Berliner Geowissenschaftliche Abhandlungen-Reihe A, 120, 149-168.
- Schweitzer, C. E, K. J. Lacovara, J. B. Smith, M. C. Lamanna, M. A. Lyon, and Attia, Y. 2003, Mangrove-dwelling crabs (Decapoda: Brachyura: Necrocarcinidae) associated with dinosaurs from the Upper Cretaceous (Cenomanian) of Egypt, Journal of Paleontology, v. 77, p. 888-894.
- Sereno, P.C, D.B. Dutheil, M. Iarochene, H.C.E. Larsson, G.H. Lyon, P.M. Magwene, C.A. Sidor, D.J. Varricchio, and J.A. Wilson. 1996. Predatory dinosaurs from the Sahara and Late Cretaceous faunal differentiation. Science 272, 986 -991.

Sereno, P.C, A.L. Beck, D.B. Dutheil, B. Gado, H.C.E. Larsson, G.H. Lyon, J.D. Marcot, O.W.M. Rauhut, R.W. Sadleir, C.A. Sidor, D.D. Varricchio, G.P. Wilson, and J.A. Wilson 1998. A Long -Snouted Predatory Dinosaur from Africa and the Evolution of Spinosaurids. *Science*, 282(5392): 1298–1302.

Sereno, P.C, J.A. Wilson, L.M. Witmer, J.A. Whitlock, A. Maga, O. Ide, and T.A. Rowe. 2007. Structural Extremes in a Cretaceous Dinosaur. *PLoS ONE* 2(11): e1230. doi:10.1371/journal.pone.0001230.

Sereno, P.C, and Brusatte, S.L. 2008. Basal abelisaurid and carcharodontosaurid theropods from the Lower Cretaceous Elrhaz Formation of Niger. *ActaPalaeontologicaPolonica*53 (1): 15–46.

Sereno, P.C, J. A. Wilson, and J. L. Conrad. 2004. New dinosaurs link southern landmasses in the mid-Cretaceous. *Proceedings of the Royal Society of London B* 271(1546):1325-1330.

Sereno, P.C, H.C.E. Larsson. 2009. Cretaceous Crocodyliforms from the Sahara. *ZooKeys*28: 144 pp.

Sheaves, M. 2005. Nature and consequences of biological connectivity in mangrove systems. *Mar. Ecol. Prog. Ser.* 302, 293–305.

Shehata, M.G, and A.A. Abdou. 2008. Geochemical Study of the Shales of Gebel El-dist Member, Bahariya Oasis, Western Deser, Egypt. *Australian Journal of Basic and Applied Sciences*, 2(2): 243-251, 2008.

Silantieva, N, and V.A. Krassilov. 2006. *Weichselia* from Lower Cretaceous of Makhtesh Ramon, Israel: new morphological interpretation and taxonomical affinities. *ActaPalaeobotanica*46(2): 119-136.

Singh, C. 1964. Micro flora of the Lower Cretaceous Mannville Group, east-central Alberta: Alberta Research Council, Bulletin 15, p.1–239.

Singh, C. 1971, Lower Cretaceous microfloras of the Peace River area, northwestern Alberta: Research Council of Alberta Bulletin 28, p. 301-542, plates 39-80.

Sinton, C.W, and R.A. Duncan. 1997. Potential links between ocean plateau volcanism and global ocean anoxia at the Cenomanian-Turonian boundary, *Econ. Geol.*, 92, 836-842.

Slaughter, B.H, and J.T. Thurmond. 1974. A lower Cenomanian (Cretaceous) ichthyofauna from the Bahariya Formation of Egypt. *Anna Is of the Geological Survey of Egypt* 4:25-40.

Smith, J. B, M.C. Lamanna, Y. Attiya and K.J. Lacovara. 2001a: On a small predatory dinosaur from the Late Cretaceous of Egypt. *Abstracts with Programs -Geological Society of America* 33(6): 389.

- Smith, J.B, M.C. Lamanna, K.J. Lacovara, P. Dodson, J.R. Smith, J.C. Poole, R. Giegengack, and Y. Attia. 2001b. A Giant Sauropod Dinosaur from an Upper Cretaceous Mangrove Deposit in Egypt. *Science* 292, 1704-1706.
- Smith, J.B, B.S. Grandstaff, and M.S. Abdel Ghani. 2006a. Microstructure of polypteridscales (Osteichthyes: Actinopterygii : Polypteridae) from the Upper Cretaceous Bahariya Formation, Bahariya oasis, Egypt. *Journal of Paleontology*80(6):1179-1185.
- Smith, J.B, M.C. Lamanna, H. Mayr, and K.J. Lacovara. 2006b. New information regarding the holotype of *Spinosaurus aegyptiacus* Stromer, 1915, *Journal of Vertebrate Paleontology*, v. 80, p. 400-406. DOI: 10.1666/0022-3360.
- Smith, J.B, M.C. Lamanna, A.S. Askar, K.A. Bergig, S.O. Tshakreen, M.M. Abugaresand D.T. Rasmussen. 2010. A Large Abelisauroid Theropod Dinosaur from the Early Cretaceous of Libya. *Journal of Paleontology*, 84 (5). 927-934. ISSN 0022-3360.
- Soares, D. 2002. An ancient sensory organ in crocodilians. *Nature* 417: 241 -242.
- Stafford-Deitsch, J. 1996. Mangrove. The forgotten habitat. Immel, London.
- Somers, E. 1952. A preliminary study of the fossil spore content of the lower Jubilee seam of the Sydney coalfield, Nova Scotia. *Publ. Nova Scotia Found., Halifax*, 1-30.
- Spengler, L. 1783. Lorentz SpenglersBeskrivelseover
en nye Slægttaf skallede Muskeler, som kaldes *Gastrochaena*,
itreforanderlige Arter, hvoraf hver boer i et forskielligt Ormehus. *Nye Samling af det Kongelige Danske Videnskabers Selskabs Skrifter* 2:174-183.
- Stieglitz, T, P. Ridd, and P. Muller. 2000. Passive irrigation and functional morphology of crustacean burrows in a tropical mangrove swamp. *Hydrobiologia* 421, 69-76.
- Stokes & Webb. 1824. Description of some fossil vegetables of the Tilgate Forest in Sussex. *Transactions of the Geological Society of London*, 2:423. Stover, L.E. 1963. Some Middle Cretaceous Palynomorphs from West Africa. *Micropaleontology* 9(1):85-94.
- Stromer E. 1914. Ergebnisseder Forschungsreisen Prof.E. Stromers in den Wüsten Ägyptens. II. Wirbeltier-Resteder Baharije-Stufe (unterstes Cenoman). 1. Einleitung und 2. *Libycosuchus*. *Abhandlungender Königlich Bayerischen Akademieinder Wissenschaften, MathematischPhysikalische Klasse* 27: 1-16.
- Stromer, E. 1915. Ergebnisseder Forschungsreisen Prof.E. Stromer in den Wüsten Ägyptens. II. Wirbeltier-Resteder Baharije-Stufe (unterstes Cenoman). 3. Das

- original des Theropoden *Spinosaurus aegyptiacus* nov. gen., nov. spec. Abhandlungender Königlich Bayerischen Akademieder Wissenschaften, Mathematisch-Physikalische28(3): 1–32.
- Stromer, E. 1925. Ergebnisseder Forschungsreisen Prof. E. Stromersin den Wüsten Ägyptens. II. Wirbeltier-Resteder Baharije-Stufe (unterstes Cenoman). 7. *Stomatosuchus inermis* Stromer, einschwachbezahnter Krokodilierund 8. EinSkelettrestdes Pristiden *Onchopristis numidus* Huagsp. Abhandlungender königlichen Bayerischen Akademieder Wissenschaften, MathematischPhysikalischeKlasse30: 1–22.
- Stromer, E. 1927. Ergebnisseder Forschungsreisen Prof. E. Stromers in den Wüsten Ägypten. II. Wirbeltier-Resteder Baharije-Stufe(UnterstesCenoman). 9. Die PlagiostomenmiteinemAnhangüberKäno-undmesozoische Rückenflossenstache Invon Elasmobranchiern. Abhandlungender Bayerischen Akademieder Wissenschaften. Mathematisch-naturwissenschaftliche Abteilung, NeueFunde31: 1–64.
- Stromer, E. 1931. Ergebnisseder Forschungsreisen Prof. E. Stromers in den Wüsten Ägyptens. II. Wirbeltierresteder Baharije-Stufe(unterstesCenoman). 10. EinSkelett-Rest von *Carcharodontosaurus* nov.gen. Abhandlungender Bayerischen Akademieder Wissenschaften, athematisch-Naturwissenschaftliche Abteilung, NeueFolge9: 1–23.
- Stromer, E. 1933. Ergebnisseder Forschungsreisen Prof.E. Stromers in den Wüsten Ägyptens. II. Wirbeltierresteder Baharije-Stufe (unterstes Cenoman). 12. Die procölen Crocodilia. Abhandlungender Bayerischen Akademieder Wissenschaften Mathematischnaturwissenschaftliche Abteilung, NeueFolge15:1-31 [M. Carrano/M. Carrano].
- Stromer, E. 1934. Ergebnisseder Forschungsreisen Prof. E. Stromers in den WüstenÄgyptens. II. Wirbeltier-Resteder Baharije-Stufe(unterstesCenoman). 13. Dinosauria. Abhandlungender Bayerischen Akademie der Wissenschaften Mathematisch-Naturwissenschaftliche Abteilung, NeueFolge22: 1–79.
- Stromer, E. 1934b.Ergebnisse der ForschungsreisenProf.E. Stromersin den WustenAgyptens. II.Wirbeltierresteder Baharije-Stufe, Unterestes Cenoman (14:Testudinata.): Abhandlungender Bayerischen Akademieder Wissenschaften Mathematisch-n aturwissenschaftliche Abtelunge Neue Folge, heft 25, p. 4 -26. (Apertotemporalisbaharijensis).
- Stromer, E. 1935. Ergebnisseder ForschungsreisenProf.E. Stromersin den WustenAgyptens: II. Wirbeltierresteder Baharije-Stufe(unterstesCenoman), 15. Plesiosauria: Abhandlungender BayerischenAkademiederWissenschaftenMathematisch-naturwissenschaftliche, Heft. 26, p. 1-55. (Peyereuscapensis= Plesiosaurus capensis).
- Stromer, E. .1936. Ergebnisseder Forschungsreisen Prof. E. Stromers in den Wüsten

Ägyptens. VII. Baharije-Kessel und -Stufemit deren Fauna und Flora. Eine ergänzende Zusammenfassung. Abhandlung der Bayerischen Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Abteilung, Neue Folge 33, 1–102.

Suarez, M. E., and H. Cappetta. 2004. Sclerorhynchid teeth (Neoselachii, Sclerorhynchidae) from the Late Cretaceous of the Quiriquina Formation, central Chile. *Revista Geológica de Chile* 31(1):89-103.

Tabaste, N. 1963. Étude de restes de poissons du Crétacé Saharien. *Mélanges Ichthyologiques à la mémoire d'Achille Valenciennes. Mémoires de l'Institut Fondamental d'Afrique Noire, Mélanges Ichthyologiques*, 68, 437–485.

Tahoun, S. S., W. A. Makled and T. F. Mostafa. 2013. Stratigraphic distribution of the palynomorphs and the particulate organic matter in subsurface Lower/Middle Cretaceous deposits, Western Desert of Egypt: Palynological and geochemical approach. *Egypt. J. Petrol.* (2013), <http://dx.doi.org/10.1016/j.ejpe.2013.11.001>.

Tahouna, S.S., and O. Mohamed. 2013. Palynology and genetic sequence stratigraphy of the reservoir rocks (Cenomanian, Bahariya formation) in the Salmoil field, north western desert, Egypt. *Cretaceous Research*. Volume 45, 342–351.

Tan, C.G.S., and P.K.L. Ng. 1994. An annotated checklist of mangrove brachyuran crabs from Malaysia and Singapore. *Hydrobiologia*, 285: 75–84.

Tanner, L.H. and M.A.. Khalifa. 2009. Origin of ferricretes in fluvial-marine deposits of the Lower Cenomanian Bahariya Formation, Bahariya Oasis, Western Desert, Egypt. *J. Afr. Earth Sci.* (2009), doi:10.1016/j.jafrearsci.2009.07.004.

Taverne, L., and J.G. Maisey. 1999. A notopterid skull (Teleostei, Osteoglossomorpha) from the continental early Cretaceous of southern Morocco. *Revue Zoologique Africaine* 90: 463–469. *American Museum Novitates* 3260: 1-12.

Taverne, L. 2000. *Tselfatia formosa*, téléostéen marin du Crétacé (Pisces, Actinopterygii), et la position systématique des Tselfatiiformes ou Bananogmiiformes. *Geodiversitas* 22 (1) : 5-22.

Thomson, L.A.J. 2006. Species Profiles for Pacific Island Agroforestry, ver. 1.2. *Agathismacrophylla* (Pacific kauri). URL: [<http://www.traditionaltree.org>].

Tomlinson, P.B.P. 1986. *The Botany of Mangroves*. Cambridge Tropical Biology Series 17, 413. Cambridge University Press.

Therrien, F., Henderson, D.M., and C.B. Ruff. 2005. Bite me: Biomechanical models of theropod mandibles and implications for feeding behaviour. Pp. 179–237. in K. Carpenter (ed.), *The Carnivorous Dinosaurs*. Indiana University Press, Bloomington.

Torcida, Fernandez-Baldor, F, J.I. Canudo, P. Huerta, D. Montero, X.P. Suberbiola, et al. 2011. *Demandasaurus darwini*, a new rebbachisaurid sauropod from the Early Cretaceous of the Iberian Peninsula. *Acta Palaeontologica Polonica* 56(3): 535–552.

Trevisan L. 1971. *Dicheiropollis*, a pollen type from Lower Cretaceous sediments of southern Tuscany (Italy). *Pollen et Spores* 13, 561–96.

Trevisan, L. 1980. Ultrastructure notes and considerations on *Ephedripites*, *Eucommiidites* and *Monosulcites* pollen grains from Lower Cretaceous sediments of southern Tuscany (Italy). *Pollen et Spores*, 22, 85-132. Tumarkin-Deratzian, A, B.

Grandstaff, M.C. Lamanna, and J. Smith. 2004. New material of *Libycosuchus brevirostris* from the Cenomanian Bahariya Formation of Egypt. *Journal of Vertebrate Paleontology* 24(3):123A.

Tütken, T. 2011. The Diet of Sauropod Dinosaurs: Implications of Carbon Isotope Analysis on Teeth, Bones, and Plants. Pp. 57-79 in N. Klein, K. Re mes, C.T. Gee and M. P. Sander (eds.). *Biology of the Sauropod Dinosaurs, Understanding the Life of Giants*, Indiana University Press.

Underwood, C. J, and S.F. Mitchel. 1999. Albian and Cenomanian sleachian assemblages from fro north-east England. Pp. 28-29 in D. M. Unwin (ed.). *Cretaceous fossil vertebrates, Special papers in palaeontology* 60.

van den Bold, W. A. 1964. Ostracodenaus der Oberkreidevon Abu Rawash, Agypten. *Palaeontographica* A 123, 111–136.

van der Hammen, T. 1956. A palynologicalsystematic nomenclature. *Boletin Geológico (Bogotá)*, 4(2-3), 63-101.

van der Hammen, T. 1956. A palynologicalsystematic nomenclature. *Boletin Geológico (Bogotá)*, 4(2-3), 63-101.

Vallati, P. 2006. Las primerasangiospermasenel Cretácicode la Cuenca Neuquina(Centro Oestede Argentina): Aspectosgeológicosrelacionados. *RevistaBrasileirade Paleontologia* 9(1):83-92.

Venkatachala, B.S. 1969a. Palynology of the Umiaplant beds of Kutch, Western India -2. Bhujexposures near Walkamata, Kutch District, Gujarat State -systematic palynology. *The palaeobotanist* 17: 1-8.

Venkatachala, B.S. 1969b. Palynology of the Mesozoic sediments of Kutch -4. Spores and pollen from the Bhujexposures near Bhuj, Gujarat District. *The palaeobotanist* 17: 208-219.

Vullo, R, H. Cappetta, and D. Néraudeau. 2007. New sharks and rays from the Cenomanian and Turonian of Charentes, France. *Acta Palaeontologica Polonica* 52 (1): 99–116.

Vullo, R, and D. Neraudeau. 2008. When the “primitive” shark *Tribodus* (Hybodontiformes) meets the “modern” ray *Pseudohypolophus* (Rajiformes): the unique co-occurrence of these two durophagous Cretaceous selachians in Charentes (SW France). *Acta Geologica Polonica*, Vol. 58, No. 2, pp. 249 -255.

Vullo, R., Guinot, G. and Barbe, G. 2016. The first articulated specimen of the Cretaceous mackerel shark *Haimirichia amonensis* gen. nov. (Haimirichiidae fam. nov.) reveals a novel ecomorphological adaptation within the Lamniformes (Elasmobranchii). *Journal of Systematic Palaeontology*.

Weiler, W. 1930. Fischreste aus dem nubischen Sandstein von Mohamid und Edfu und aus den Phosphaten Oberägyptens und der Oase Bahariya, Ägypten, in Ergebnissen der Forschungsreisen Prof. E. Stromer's in den Wüsten Ägyptens: Abhandlungen Bayer Akademie der Wissenschaft, Math.-naturk. Abteilung N. F., 7, 12-42. Gymnuralaterialata.

Weiler, W. 1935. Ergebnissen der Forschungsreisen Prof. E. Stromer's in den Wüsten Ägyptens. II. Wirbellierreste der Bahariya-Stufe (unterstes Cenoman). 16. Neue Untersuchungen an den Fischresten. Abhandlungen der Bayerischen Akademie der Wissenschaften, thematischen naturwissenschaftlichen Abteilung. Neue Folge Heft. 32:1-57.

Wellnhofer, P and E. Buffetaut. 1999. Pterosaur remains from the Cretaceous of Morocco. *Paläontologische Zeitschrift*, Volume 73, Numbers 1-2.

Wells, F.E. 1984. Comparative distribution of macromolluscs and macrocrustaceans in a North western Australian mangrove system. *Aust. J. Mar. Freshw. Res.* 35, 591–596.

Werner, C. 1989. Die Elasmobranchier-Fauna des Gebel Dist Member der Bahariya Formation (Obercenoman) der Oase Bahariya, Ägypten. *Palaeoichthyologica*, 5: 1-112.

Werner, C. 1990. Biostratigraphical results of investigations on the Cenomanian elasmobranchian fauna of Bahariya Oasis, Egypt. -*Berliner geowiss. Abh.*, (A) 120.2: 943 -956.

Widdowson, M. 2007. Laterite and ferricrete. Pp. 46–94. in D.J. Nash, and S.J. McLaren, S.J. (eds.). *Geochemical Sediments and Landscapes*. Blackwell, Malden, Massachusetts.

Wiese, F, and F. Schulze. 2005. The upper Cenomanian (Cretaceous) ammonite *Neolobites vibrayanus* (d'Orbigny, 1841) in the Middle East: taxonomic and palaeoecologic remarks. *Cretaceous Research*, 2005, 26(6) : 930-946.

Wirsing, A. J, M. R. Heithaus and L. M. Dill. 2007. Fear factor: Do dugongs (*Dugong dugon*) trade food for safety from tiger sharks (*Galeocerdocuvier*)? *Oecologia* 153: 1031-1040.

- Wirsing, A. J. and W. J. Ripple. 2011. A comparison of shark and wolf research reveals similar behavioral responses by prey. *Frontiers in Ecology and the Environment* 9: 335-341.
- Worm, B. and K. Lotze. 2006. Effects of eutrophication, grazing, and algal blooms on rocky shores. *Limnol. Oceanogr.*, 51(1, part 2), 2006, 569–579.
- Wueringer, B. E, L. Squire, and S.P. Collin. 2009. The biology of extinct and extant sawfish (Batoidea: Sclerorhynchidae and Pristidae). *Reviews in Fish Biology and Fisheries* Volume 19, Number 4.
- Yilmaza, I.O., D.Altinera, U.K.Tekinb, O.Tuysuzc, F. Ocakoglu and S. Acikalind. 2010. Cenomanian -Turonian Oceanic Anoxic Event (OAE2) in the Sakarya Zone, northwestern Turkey: Sedimentological, cyclostratigraphic, and geochemical records. *Cretaceous Research*. Volume 31, Issue 2, 207–226.
- Zobaa, M, C. Sanchez Botero, C. Browne, F.E. Oboh-Ikuenobe and M.I. Ibrahim. 2008. Kerogen and palynomorph analyses of the mid-Cretaceous Bahariya Formation and Abu Roash “G” Member, north Western Desert, Egypt. *Gulf Coast Association of Geological Societies (GCAGS) Transact.*