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Paleoclimates of the Cenozoic of Egypt: Evidence from Fossil Plants

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Abstract

Paleoclimatology is the study and reconstruction of past climates for which direct measurements were not taken. Paleoclimatologists, paleobotanists and geologists use a number of proxies to study the past climatic changes and to understand the natural variation and evolution of the current situation; as climate change in the 21st century has been regarded as a threatening issue. Paleoclimate interpretation using fossil plants is one of the most important contributions of paleobotany to earth sciences, as they are considered as reliable indicators of long-term climatic changes, especially during the Cenozoic era; which encompassed a wide range of climates. Research work on the fossil flora of Egypt has started 150 years ago; with paleoclimate inferences being displayed in the different references. Thus, this review collates all the Egyptian paleobotanical and paleopalynological data to reconstruct the Cenozoic climate in Egypt. Spanning through the epochs of the Cenozoic era; woods, leaves, fruits, seeds, pollen and spores have been recorded from different sites. Apparently, the paleoenvironments differed but a tropical to subtropical climate was prevalent during the Cenozoic in Egypt. However, the usage of different proxies, other than fossil plants will reveal a better picture of the past climate.

Keywords: Paleoclimate, Fossil plants, Cenozoic era, Egypt

Introduction

Paleoclimatology is the study of ancient climates taken on the scale of the entire history of Earth. Understanding the possible impacts of global change is not possible without studying the past climates (Uhl et al. 2006). Paleoclimate reconstruction, therefore, can provide a long-term baseline for understanding modern and future conditions.

Prior to the widespread availability of instrumental records, paleoclimatology uses a variety of proxy methods from Earth and life sciences to obtain data previously preserved in tree rings, locked in the skeletons of tropical coral reefs, sealed in glaciers, boreholes, shells and fossils. The past climate interpretations range from simple qualitative assumptions to quantitative assessments; including computer-based process simulations. All approaches to paleoclimatic reconstruction rely on understanding the relationship between climate and the source of evidence (Shuman 2007). Paleoclimatic data is therefore useful to help assess the dangerous level of human interference with the atmosphere and the climate; especially that climate change is the predominant scientific, economic and political issue of the 21st century (Hansen 2009).

Paleoclimate estimates derived from the fossil record are important to give the current climate a historical perspective and serve as a test for global circulation models which are used to estimate future climate (Pan 2007). All types of fossils are useful in "reading the rock record", elucidating the Earth's history. Thus, they are among the most important proxies for scientists attempting to learn about past climates and environments, a major focus of research in Earth and environmental sciences, motivated in part by concerns over future climate change (Seyfullah 2012).

Fossil plants in particular can be useful for archiving past climate signals. Terrestrial plants have a unique degree of dependence on the environment to which they are committed by their sedentary habit, thus plants have a direct relationship with their environment and climate change is encoded in physiognomic change. These changes have been decoded by various workers (such as Wheeler & Baas 1991, 1993; Wiemann et

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al. 1998, 2001; Poole 2000) to reconstruct past climates and climatic changes. Detailed information on environmental and climatic conditions in the past can be provided by all types of fossil plant remains i.e. wood, leaves, fruits, seeds and propagules (Bergen & Poole 2002).

There are two main methods in which fossil plants can contribute evidence that will help to reconstruct past climates: The first method is based on finding the systematic affinities of the fossil taxa to reconstruct the paleoclimate using climatic requirements of the presumed living analogue or Nearest Living Relative (NLR). This method assumes that the fossil taxon had a similar climatic tolerance and habitat to its nearest living relatives (Bamford 2011). The second method does not require a precise identification of fossil specimens (Sakala 2007). This method takes into account the correlation between climate and selected features of the plant structure such as; leaf and wood physiognomy, paleodendrology and stomatal index.

Global climate during the beginning of the Cenozoic era (65 million years ago) (Table 1) continued in the warm mode that persisted before, in the Cretaceous period. The early Cenozoic was symbolized by an almost complete absence of continental ice, in addition to small temperature gradients between low and high latitudes. The global temperatures were also higher than today (Mudelsee et al. 2014). By the end of the Eocene, temperatures had dropped drastically and seasonality had returned. The climate became cool, dry and seasonal in the Oligocene and Antarctica, for the first time in the Cenozoic, was covered extensively with glaciers. Warmer conditions prevailed in the first half of the Miocene. However, in the latter half; cooler temperatures, decreased rainfall and increased seasonality overruled (Zachos et al. 2008). Following the late Miocene; the first half of the Pliocene was warmer than today and during the last half, temperatures dropped again. Finally, the Pleistocene was a time of global cooling and warming with ice ages and interglacial periods occurring every 100,000 years. During the course of the Cenozoic era, significant changes in Africa's physical setting contributed to ecosystem evolution, as did the local and regional effects of global climate change and biotic interactions (Jacobs et al. 2010).

The aim of this paper is to use the paleobotanical and paleopalynological evidences compiled in El-Saadawi et al. (2020) to gain insight into the prehistoric past and to reconstruct the Cenozoic climates in Egypt.

Table (1). Simplified geological timescale.

Eon	Era	Period	Epoch	Millions of Years	Taxa recorded
Phanerozoic	Cenozoic	Quaternary	Holocene	0.0117	
			Pleistocene	2	*Phragmites australis*
		Neogene	Pliocene	5	
			Miocene	23	*Bombacoxylon owenii*
		Paleogene	Oligocene	34	Leaf impressions of Dipterocarpaceae,Cyperaceae and Poaceae
			Eocene	56	Leaves of *Ficus stromeri*, *Litsea engelhardti*,*Maesa zitteli*
			Paleocene	65	*Palaeowetherellia schweinfurthii*, *Nypa*
	Mesozoic	Cretaceous		145	
		Jurrasic		201	
		Triassic		252	
	Paleozoic	Permian		298	
		Carboniferous		358	
		Devonian		419	
		Silurian		443	
		Ordovician		485	
		Cambrian		541	