PALAEOCLIMATE

End of the African Humid Period

The Sahara was more humid and habitable thousands of years ago. Reconstructions of North African hydroclimate show that the onset of aridity started in the north, with the monsoon rains weakening progressively later at lower latitudes.

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Roughly ten thousand years ago, the now barren Sahara Desert was a verdant landscape covered with grasslands and trees[1], dotted with numerous lakes[2,3], and incised by large river networks[4]. Petroglyph art and engravings on rocky outcrops capture a rich and diverse mammalian fauna including hippos, crocodiles, giraffes, elephants and antelopes, the latter often pursued by bands of hunters. But by about five thousand years ago, this North African paradise was lost as dry, shifting sands spread across the subcontinent[2,4–6]. There has been considerable debate about whether this termination occurred gradually as a linear response to orbital changes or whether nonlinear climate feedback processes acted to accelerate this change in climate. Writing in *Nature Geoscience*, Shanahan and co-authors[7] show that both processes occurred, with the end of the African Humid Period occurring progressively later at lower latitudes across North Africa, as expected from orbital climate theory[8].

The wet and verdant early Holocene conditions in North Africa — and elsewhere across the northern subtropics — were a consequence of slow changes in the precession of the Earth's orbit. Incoming solar radiation (insolation) during summer peaked about 10,000 years ago in the tropics, strengthening the intensity and northward penetration of the African monsoonal rains during the peak of the African Humid Period. The basic mechanism linking orbital forcing and monsoonal climate response is robust and well-documented, but considerable debate has developed around the details of this linkage. Conflicting records suggest that termination of the humid period either occurred quickly, within a matter of centuries[9,10], or occurred over the course of millennia[5,11,12]. It is similarly unclear whether the termination was uniform or varied spatially and temporally. At the heart of this debate is whether non-linear climate feedback processes act to accelerate climate change, or whether a more simple linear theory linking climate and the Earth's orbit is sufficient.

Shanahan and co-authors[7] generated a record of palaeo-precipitation during the African Humid Period from Lake Bosumtwi, located at about 6° N. They measured the hydrogen isotope composition of leaf waxes preserved in the lake sediments over the past 20,000 years, which reflects the overall amount of precipitation in the lake's catchment region, and compared these data with the dating of the ancient shorelines that record the expansion and contraction of this lake.

In this area, the onset of humid conditions occurred just under 15,000 years ago, as seen elsewhere in Africa[6,9,10,13]. By 10,000 years ago the lake level had risen by nearly 100 metres. Lake levels and the leaf-wax isotopes indicate that humid conditions persisted until about 3,000 years ago. After that, both proxies gradually fell to modern values. In this tropical region, the termination occurred much later than in sites located further to the north, where the humid conditions generally ended 5,000 to 6,000 years ago[6].

Suspecting a latitudinal trend, Shanahan and co-authors then compiled available North African palaeoclimate records from 9° S to 32° N to constrain the timing of the end of the humid phase (Fig. 1a). The conclusion from this analysis is clear: the end of the African Humid Period progressed from north to south, and closely matches what would be expected from orbital forcing[8]. Specifically, the monsoon rains were reduced first in the north, and then progressively later with decreasing latitude.

However, the end of the African Humid Period was locally abrupt at many sites, transitioning from wet to dry conditions much faster than expected from this simple linear theory. Hence some additional, nonlinear mechanism must have been active at these specific sites. Shanahan *et al.* propose that these locally abrupt transitions were the result of soil moisture and vegetation responses to the gradually retreating monsoon: with diminishing rain, soils rapidly become desiccated and barren,

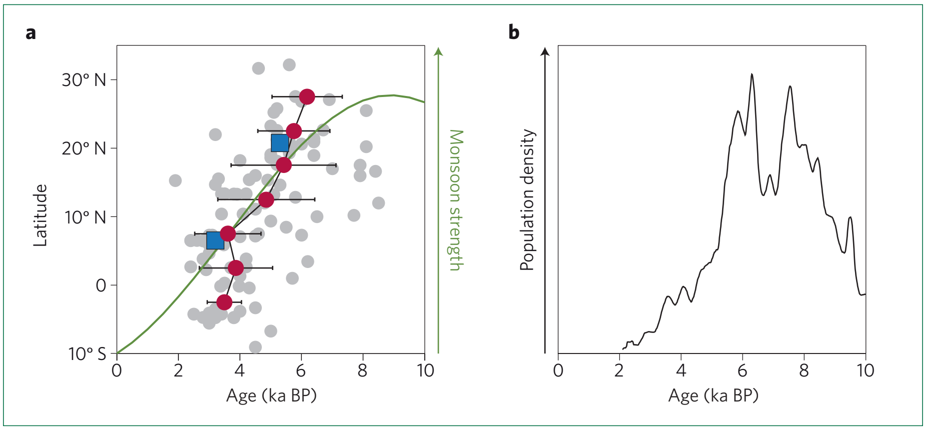

Figure 1 | The time-transgressive end of the African Humid Period. **a**, Shanahan and co-authors[7] generated and compiled proxy records (grey circles) to show that the African Humid Period ended progressively later with decreasing latitude. This progressive termination (better seen in the zonally binned records shown in red) matches what would be expected from the orbital forcing of the African monsoon circulation (green line). The end of the humid period at Lake Bosumtwi (6.5° N) occurred near 3 ka BP, significantly later than observed in sediment cores off Mauritania (5 ka BP at 20° N; blue squares). **b**, Despite the gradual decline in humidity, North Africa was rapidly depopulated between 6,300 and 5,200 years ago based on a recent compilation of radiocarbon dates from North African human settlements[14].

and the loose, sandy soils are subject to rapid wind deflation and transport.

Radiocarbon dating of over 1,000 archaeological sites across North Africa reveals how profoundly the end of the humid phase affected human populations[14]. These dates, which record human occupation at these sites, indicate that North Africa was rapidly depopulated between 6,300 and 5,200 years ago as dry conditions set in (Fig. 1b). Within centuries, sedentary populations appeared along the Nile, marking the emergence of urban and socially stratified Pharaonic culture and construction of the first pyramids[12,14].

Shanahan and co-authors[7] show that the end of the African Humid Period occurred gradually with latitude but changes were quite abrupt locally in many places. It is noteworthy that most of the North African population decline occurred in less than a millennium, suggesting that people, like local climate, can respond nonlinearly to climate change. ❐

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