Past climate linked to mammal communities in Africa today

October 5 2016, by Jim Erickson

Impala (Aepyceros melampus) in Kruger National Park, South Africa. Credit: John Rowan

Scientists are increasingly concerned about the impact of climate change on the world's biodiversity, and much effort has been placed into forecasting the response of species to these changes over the next century. Research aiming to forecast species' responses often assumes that species are adapted to current climate conditions and will follow their preferred climates during future climate change.

However, the distribution of species today may largely be a product of the climate of the deep past, or paleoclimate. The legacy of paleoclimate on modern biodiversity patterns is the subject of a new study in *Proceedings of the Royal Society B*. The study was led by researchers at Arizona State University, with colleagues from the University of Massachusetts, Amherst, and the University of Michigan.

The researchers statistically analyzed the relative influence of modern, mid-Holocene (~ 6,000 years ago) and Last Glacial Maximum (~ 22,000 years ago) climate on African mammal communities today. Their analysis shows that the structure of mammal communities across Africa today is actually more tightly linked to the climate of the mid-Holocene and Last Glacial Maximum than to modern climate.

"It was quite surprising to us to find that past climate was more important than current climate for these animal communities," said U-M co-author Lydia Beaudrot, assistant professor in the Department of Ecology and Evolutionary Biology and a fellow in the Michigan Society of Fellows.

"Most efforts to predict how climate change will affect species in the future only include current and future climate conditions. Our results suggest that a focus on current climate isn't enough for understanding why these species are where they are today—past climate is equally if not more important."

Including paleoclimate may also improve models for conservation planning that aim to predict how climate change will affect African mammals, she said.

Vervet (Chlorocebus aethiops) in Awash National Park, Ethiopia. Credit: John Rowan

"Our results suggest that African primates are likely to be particularly affected by any reduction in the extent of tropical forest, similar to how they have been affected in the past," Beaudrot said.

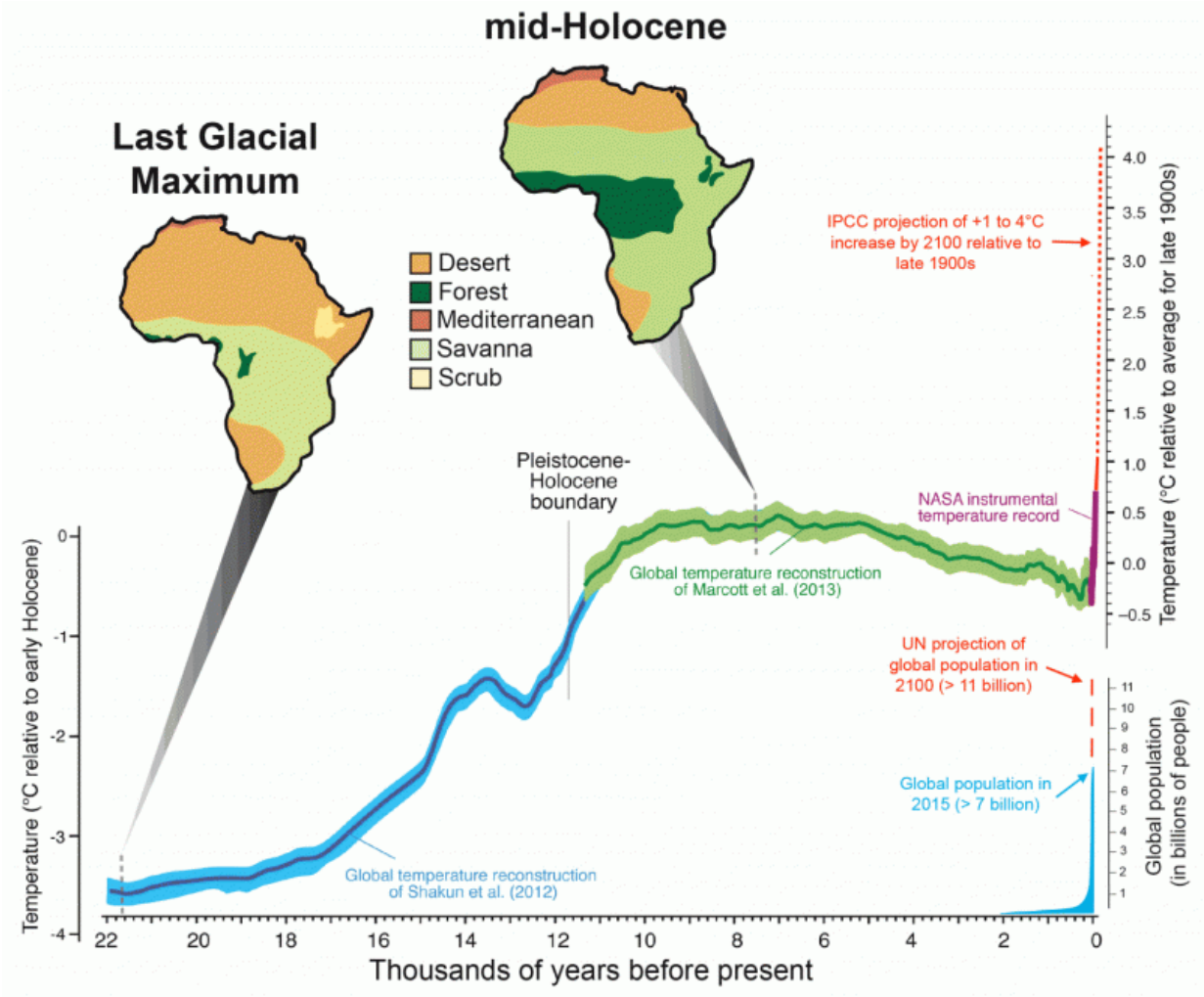
The mid-Holocene and Last Glacial Maximum are periods of climate extremes during the late Quaternary, with the mid-Holocene being warm and wet and the Last Glacial Maximum being cool and arid. These past climate changes drastically altered the distribution of vegetation in Africa (e.g., savannas, forests) and the mammal species that rely upon them.

The study examined how the community structure of three different mammal groups—carnivorans like lions and hyenas, primates like gorillas and baboons, and ungulates like wildebeest and zebra—was influenced by modern and past climates.

They found that, unlike all other groups, primates have closely followed their preferred climates through time. This is because primates are highly dependent on forests for their survival and have shifted their distributions in response to the changing distribution of forests through wet and dry periods over the last 22,000 years.

Carnivoran and ungulate communities, like mammals overall, are more closely linked with past climate.

Their startling finding, that past climates are more important to the structure of mammal communities than modern climate, implies that African mammal species have either failed to move with their preferred environments over the last several thousand years of climate change or that these species are ecologically flexible and can persist in wide range of climatic conditions.



Temperature, vegetation, and human population growth changes over the last 22,000 years. The cool and arid Last Glacial Maximum saw the expansion of desert environments at the expense of forests, whereas the warm and wet mid-Holocene was characterized by an expansion of savannas and forests. These environmental changes greatly influenced the distribution of African mammal communities. The Intergovernmental Panel on Climate Change (IPCC) projects up to 4°C increase by 2100 and the United Nations (UN) projects human population growth to exceed 11 million people by then. Credit: Modified with permission from Railsbeck's “Fundamentals of Quaternary Science” http://www.gly.uga.edu/railsback/FQS/FQS.html

If species have failed to move with their preferred environment through time to the present, then there is a significant time lag between climate change and species' response. Even worse, this time lag occurs under natural rates of climate change—much slower than rates of anthropogenic climate change.

"The 3-to-4-degree increase from the Last Glacial Maximum to the present occurred over several thousand years and was a shift from an 'Ice Age' world to a warmer one," said Arizona State University graduate student John Rowan, first author of the paper. The other Arizona State author is Kaye Reed, a research associate with the Institute of Human Origins and a president's professor with the School of Human Evolution and Social Change.

"Now, we're looking at up to a 4-degree shift in less than a century, and one in which we go from a warm world to an even warmer one," Rowan said. "The magnitude and rate of climate change we see over the next century may be unprecedented in Earth's history. Species are, in a very real sense, going to have to cope with something they've never experienced before. It's a whole new world."

On the other hand, the second possibility offers a more optimistic point of view. If African mammal species are ecologically flexible and can persist in a wide range of climate conditions, then they may be able to cope with future changes. However, the vastly faster rates of anthropogenic climate change casts doubt on this hopeful view.

"Even if species are flexible enough to have coped with gradual climate changes over the last several thousand years, we still don't know how they will respond to rapid changes," Rowan said. "This uncertainty makes devising robust conservation actions one of the most daunting challenges of the 21st century."

Arizona State's Reed said: "The results of this study on past climate influence can be used to compare the effects of other possible drivers of species distributions and community structure, such as human disruptions of the environment. This will enable forecasting in the future that will be able to analyze the effects of multiple causational factors and lead to better conservation plans for mammal species."

More information: Strong influence of paleoclimate on the structure of modern African mammal communities, rspb.royalsocietypublishing.or….1098/rspb.2016.1207

Provided by University of Michigan