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Out of Africa: The Ecological Context and Constraints on Early Homo Migration

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Abstract

When examining evidence further back in geologic time, it is more challenging to get a clear picture of the climate and ecosystems because it becomes more obscured in the record and this has been the case for the timing of early members of the genus *Homo's* migration of out Africa. This paper attempts to reconstruct the environment of Africa and the Levant region of the Middle East approximately 1.8 million years ago to understand what may have catalyzed early *Homo's* migration out of Africa and allowed them to spread widely through Eurasia soon after. In this paper, I will explore how the environment can encourage or constrain movement through North Africa and explore three proposed migration routes out of Africa. This research synthesizes paleoclimate data; including paleosol, pollen, isotopic studies, eolian dust, and dental microwear, to reconstruct the environment and timings of migrations around 1.8 Ma. At this time, the environment in North Africa underwent intense aridification, which could have limited migration routes out of Northern Africa. However, based on the recent discovery of Oldowan and Early Acheulean tool assemblages found outside of Africa, it is likely that hominins left Africa earlier than 1.8 Ma when there was enough moisture to support a green migratory corridor through North Africa into the Middle East. If this is the case, we must reconsider our understanding of the timeline of human evolution and migration and whether big brains and big bodies are needed to exploit these environments out of equatorial Africa. Based on the known timings Green Sahara Periods and faunal movement between Africa and Eurasia, it is likely hominins left Africa earlier than 1.8 Ma.

Introduction

Out of Africa

The first skeletal evidence of hominins outside of Africa is at the site of Dmanisi in the Republic of Georgia, approximately 1.8 Ma (Lordkipanidze, 2013). It appears that after this time, *H. erectus* spread throughout Eurasia and reached Java 1.4 Ma (Zhu & Dennell, 2018) then reached Europe approximately 1.2 Ma based on a molar at the Atapuerca site in Spain (Carbonell & Bermudez de Castro, 2008). The genus *Homo* was soon able to exploit the non-equatorial environments of Europe and Central and Eastern Asia. It remains unclear which species of early *Homo* successfully left Africa first. At Dmanisi, the post-cranial evidence suggests the individuals that occupied this site were smaller and had a mix of primitive and derived features. It is unclear if they should be classified as *H. erectus, H. habilis*, or something else. For clarity, this paper will not concern itself with which species left Africa first and will refer to all early species by their genus name, *Homo*.

1.8 Ma is at the Plio-Pleistocene boundary and is considered a likely date of speciation and migration because a significant Turnover Pulse is witnessed around this time in African and Eurasian species, and there was a sizeable climatic shift (Arribas & Palmqvist, 1999). The Turnover Pulse Hypothesis, proposed by Elisabeth Vrba (1996), predicts there will be large faunal turnover and adaptive radiations of species during times of intense climate change because these environmental shifts can pressure adaptation and evolution. Pulses have been hypothesized to have occurred around 2.8-2.5 Ma and 1.8 Ma. These climate changes saw an increase in aridity, expansion of the Sahara Desert, and speciation events. According to Vrba, this time also corresponds with species, including *Homo* migrating out of Africa (Vrba E. S., 1996).

Environmental Context

The fossil record indicates that there was an increase in aridity approximately 1.8 Ma, leading to an increase in arid grasslands and desert environments. This aridification was likely caused by an intensification of the Walker Current over the Pacific Ocean at 1.8 Ma. The Walker Current caused a decrease in precipitation and cooler temperatures (Etourneau, 2010), which led to unseasonable and increasingly arid environments with less moisture than earlier in the Pliocene. This increase in seasonality caused changes including an increase in C4 plants from 20% to 60-80% and changes towards more arid paleosol types (Cerling & Quade, 1991) (Bobe & Behrensmeyer, 2004). Another indicator of paleoclimate is the fluctuation of the Sahara Desert in Northern Africa. This desert arose approximately 3 Ma during a global cooling event. At approximately 1.8 Ma, the desert increased again in size (deMenocal, African Climate Change, and Faunal Evolution During the Pliocene-Pleistocene, 2004). These changes are measured by eolian dust deposits, which are wind-borne dust blown into the Atlantic Ocean, which then settles on the seafloor. More dust accumulates during periods of less moisture. These cores indicate long-term seasonality and other patterns during this time (deMenocal, African Climate Change, and Faunal Evolution During the Pliocene-Pleistocene, 2004) (Potts, Environmental Hypotheses of Hominin Evolution, 1998). Through this range of evidence, we observe unseasonable cooling approximately 1.7-1.9 Ma. Regions such as the Turkana and Olduvai basins were once filled with many lakes and fluvial systems. However, over the course of 10,000 years, these water systems became more ephemeral, and a shift of the paleoenvironment towards cooler and dryer caused these lakes to disappear (Potts, Environmental Hypotheses of Hominin Evolution, 1998).

Analysis of dental microwear of ungulates' molars and the palynological studies were conducted at sites outside of Africa, including Dmanisi, Georgia, and Ubeidiya, Israel. This data indicates a more wooded environment with more rainfall, different from Northern Africa at this time. (Pontzer, 2011) (Belmaker & O'Brien, 2018) (Abbate & Sagri, 2012) (Leroy, 2011). More moisture would provide a more suitable environment for *Homo* and could support more individuals due to increased access to water.

Faunal interchange is recorded in this period, mostly migrating from Africa into Eurasia (Martinez-Navarro B., 2004). Genera leaving Africa between 2.5-1.6 Ma include *Homo*, *Theropithecus*, Panthera, Sabre-toothed cats, *Hippopotamus*, Bovids, and more. Genera leaving Eurasia and entering Africa include Equus and Bovids around 2.3 Ma (Hughes, Elton, & O'Regan, 2008). There is also evidence for a large faunal turnover event of Bovids (1.8 Ma) and Suids (2.0 Ma), which would be indicative of a Turnover Pulse (Bibi & Kiessling, 2015)(Arribas & Palmqvist, 1999). These animals had adaptive changes to fit their environment, which included an increase in body size of Bovids and Equus and other arid adaptive traits for Suids (Bibi & Kiessling, 2015). If the environment is cooling and moving towards more expansive grasslands, it is a reasonable conclusion that these environments would encourage and support a bovid speciation event and migration, because they are grassland adapted species (Bibi & Kiessling, 2015). Another genus that may be important to consider is *Theropithecus,* commonly referred to as the gelada. Both extinct species *T. oswaldi and T. darti* may be good proxies for understanding migration out of Africa because of their similarities to *Homo*. Both are large-bodied, terrestrial primates with larger group sizes. They had a wide range outside of Africa and are often found in the same fossil deposits in Plio-Pleistocene formations. These similarities indicate that they are occupying a similar niche (Hughes, Elton, & O'Regan, 2008). Based on computer simulations of *Theropithecus's* dispersal out of Africa, it appears the late Pliocene, approximately 2.4 Ma, was when they first migrated out of Africa. Environmentally, this time would have been a better time for mammalian dispersal because the environment of North Africa was green and favorable (Hughes, Elton, & O'Regan, 2008). It is not clear what would drive this migration besides a saturated population density.

Possible Routes of Migration

There are three popular routes for hominin dispersal out of Africa. Of these, the most likely is the land crossing of the Levant Corridor, because a land crossing is the most parsimonious solution. However, two other routes should be considered.

One is the Strait of Gibraltar, an 8-mile water crossing from Northwest Africa to Spain. (Bar-Yosef & Belfer-Cohen, 2001) (Abbate & Sagri, 2012) (Martinez-Navarro & Palmqvist, 1995). Hominin occupation of sites around the Mediterranean, as well as the evidence in Atapuerca, Spain, support this route (Carbonell & Bermudez de Castro, 2008). Furthermore, there was reported faunal interchange between Europe and Africa of species, including giraffes and hippos. However, this route seems unlikely for a few key reasons. While the strait may be short enough to swim, a water crossing is difficult to accomplish without material culture such as boats or rafts, which there is no evidence for at this time. The creation of these items needs an amount of social organization to accomplish (Derricourt, 2005). Additionally, Straus argues that even if the sea level were lower in this period, the ocean currents would have been too strong to swim across (Straus L., 2001).

The next is the Bab-el-Mandeb Strait, which is an 18-mile water crossing through the Red Sea and the Gulf of Aden. This route is only possible due to the tectonic movement of the area. At the time, Saudi Arabia and Africa may have been closer together, and the water may have been much shallower (Abbate & Sagri, 2012). However, this is no artifact evidence of occupation of the coast of the Red Sea by humans (Abbate & Sagri, 2012). Similar to the Strait of Gibraltar, water crossings may be too difficult to accomplish at this time.

A land crossing is the easiest and most parsimonious route available. The only land route open at this time was the Levant Corridor through the Middle East. There is a large amount of faunal exchange through at this time, including Hippopotamus, Suids, Bovids, Sabre-tooth cats, and *Theropithecus*. (Bibi & Kiessling, 2015) (Martinez-Navarro B., 2004). Paleoenvironmental indicators show this would have been a good route because, during the time of migration, there may have been enough moisture, especially around the perimeter, to support migration (Abbate & Sagri, 2012). This route would also explain why hominin occupation is first observed in the Middle East and Asia rather than Europe. European evidence does not occur until much later because large mountainous regions would have blocked westward movement, so hominins expanded east first.

Getting Out of Africa from Green Sahara Corridors

Between 2.1-2.3 MA, there is evidence for more frequent Green Sahara Periods corresponding with the eccentricity maxima (Larrasoana & Roberts, 2013). These more frequent periods would have facilitated movement into Eurasia. A “Green Sahara” is a period, usually corresponding to interglacial cycles, where there is enough moisture to create a suitable environment for fauna to move between Africa and Eurasia (Lahr, 2010). These periods are crucial for the movement of fauna between the continents because the most significant constraint on movement is access to water. Therefore, fauna can only move when water is present. Water was likely not present at 1.8 Ma in Northern Africa, meaning there would have been no corridor present at this time for early *Homo* to move through due to an immense Sahara and ephemeral water sources.

It seems the hardest aspect of migration is not getting out of the continent of Africa but getting out of sub-Saharan Africa and crossing the dry Saharan desert. There were periods of aridity at approximately 1.8 Ma, which caused lakes to dry up, and the landscape to change (Potts, Environmental Hypotheses of Hominin Evolution, 1998). This aridification also affected Northern

Africa, making a green migration corridor disappear. Rivers that would have supported earlier movement through North Africa, such as the Nile River, dried up at this time (Derricourt, 2005). During monsoon periods, ephemeral lakes connected the Rift Valley of Eastern Africa to the Mediterranean through Central Africa. These lakes would have made a humid corridor to pass through, but only during periods of more moisture (Ravelo & Andreasan, 2004) (Derricourt, 2005). Leaving earlier than 1.8 Ma, there would have been sufficient moisture to create a "Green Sahara" corridor through North Africa and into Eurasia. A Green Sahara was present before 1.8 with waterways and river systems. However, it stopped at 1.8 MA. Homo likely moved out of Africa earlier than 1.8 Ma during a greener period, and then the movement was halted between 1.8-1.6 Ma because of the intense aridification of Africa.

This movement between continents likely occurred between 2.4-2.1 Ma, and then this corridor closed around 1.8 when the previously observed drought hit. This evidence challenges the idea of a Turnover Pulse proposed by Vrba, where drastic climate changes caused speciation events (Vrba E. S., 1996). This change towards aridity in Africa may have been the catalyst for the evolution of the bigger bodied, bigger brained *H. erectus* that has been identified approximately 1.6 Ma in East Africa (Brown, Harris, & Leakey, 1985). Additionally, these climate fluctuations during glacial periods may have caused an increase in body size in Africa. Mammals' body sizes are influenced by the seasonality and temperature of their environment. There is a selection for large bodies in more seasonal environments, which may be due to less resource availability and a need for fasting (Reynolds, 2007). This substantial body size increase is seen with *H. erectus,* which may be a result of the change in climate 1.8 Ma. However, *H. erectus* is likely not the species migrating out of Africa 2.4-2.1 Ma, which leads to two conclusions, 1. A smaller early *Homo* left Africa around 2.4-2.1 Ma not due to an environmental change but due to an increased ability to exploit a variety of environments. 2. The more intense climate shift at 1.8 Ma caused the speciation *of H. erectus/ergaster* in Africa.

Conclusions and Future Considerations

Between 2.4-2.1 Ma, there was enough moisture in Africa and the Middle East to create a Green Sahara Corridor and promote faunal interchange between the two continents. However, around 1.9-1.7 Ma, there was an intensification of atmospheric currents that caused increased aridity and the deterioration of woodlands throughout Africa. This lack of moisture caused the Sahara Desert to expand and eliminated possible migration routes into and out of Africa. While it is often believed that significant environmental changes affect *Homo's* migration from Africa, without a Green Sahara, there is no easy route out, and migration at this time does not sem likely. However, the environmental changes which occurred 1.8 Ma were likely the catalyst of the speciation of *H. erectus*.

There is disagreement among researchers as to what environment was present and what type of environment would influence migrations. Bar-Yosef argues that during glacial periods the climate was cold and dry, and many lakes dried up. While interglacial periods were characterized by warm and humid periods, Issar et al. (2012) argued for humid glacial and dry interglacial periods, the inverse of Bar-Yosef (Issar A., 2012). For movement to have occurred based on this model, interglacials must be warm and humid to facilitate movement through North Africa. The further in time one goes back, the more difficult it is to determine years of glacial and interglacial periods, and therefore, pinpointing whether they left during an interglacial or glacial period is difficult.

While the Dmanisi site has the oldest skeletal remains of a hominin outside of Africa, there are other sites with stone tool assemblages that are dated much older. The oldest site outside of Africa is Yiron, Israel, dated at 2.4 Ma. It appears they entered and settled in the Middle East during a

Green Sahara Period (Ranov, 2006). Shangchen, a Paleolithic site on the Southern Chinese Loess Plateau, suggest there is evidence of hominin occupation 2.1 Ma (Zhu & Dennell, 2018) Zhu and colleagues used paleomagnetic dating to date the surrounding paleosols and dated stone tool artifacts to 2.1 Ma indicating hominin occupation, however, no associated skeletal remains were recovered. These sites are evidence that North Africa and the Middle East were likely to open during these times. It may be time to push back the date of hominin migration out of Africa. Outside of Africa, dating techniques are more unreliable. Most paleoanthropologists rely on Potassium-Argon dating techniques, which rely on volcanic activity distributing layers of datable ash. With less frequent volcanic activity in places such as Asia, dating techniques are less accurate. While an out of Africa migration likely occurred earlier, the dating techniques may not be accurate, and the number of hominin fossils and artifacts found is few.

Based on our understanding of the need for green migration pathways through North Africa, it was likely early *Homo* would have needed to migrate approximately 2 Ma, which is earlier than previously estimated. The timing of migration corresponds loosely to specific environmental changes. However, it was not the large environmental shift that would have influenced speciation or the need to expand *Homo's* former territories. The changes that allowed *Homo* to expand out of Africa may have been influenced by an unstable and highly variable environment. Pott's Variability Hypothesis states that key hominin traits arose during periods of instability and variability in the environment, rather than during large-scale environmental shifts (Potts, Variability Selection in Hominid Evolution, 1998). During periods of unstable environmental changes, lakes may be ephemeral, or rainfall may have been less than in previous years. Species that can adapt to a wider variety of environments will be better adapted to survive than those that cannot handle the small-scale fluctuations. Starting 2.3 million years ago, East Africa saw a wide range of environmental fluctuations that influenced hominin evolution. Hominins were able to create tools to exploit food sources from environments that were previously unavailable. Advanced tool use gave them the ability to exploit different environments through a range of latitudes and therefore were able to take advantage of the green Sahara and migrate out of Africa and into a variety of environments. (Potts, Environmental Hypotheses of Hominin Evolution, 1998). Their adaptive ability due to small-scale environmental changes allowed hominins to become successful generalizers, exploit a range of resources, and migrate successfully out of Africa. As opposed to an original idea that 1.8 Ma a climate shift towards more arid environments created inhospitable habitats and *Homo* needed to migrate to areas such as Ubediya Israel, which had more moisture at this time.

The Levant corridor is likely the best migratory pathway. However, due to the political conflict in the Middle East, there is not much research occurring in those unstable regions making the data difficult to gather. There may be additional Plio-Pleistocene fossil sites in these areas that would help us better date periods of occupation as well as confirm whether the Levantine Corridor was used as a migration route for early *Homo*.

Based on recent data, it seems that the 1.8 Ma boundary may not be the date that best explains changes in early *Homo's* behavior or physical characteristics. Instead, living in unstable environments led *Homo* to be an excellent generalizer that could take advantage of open migratory routes.