EARTH ORBITAL VARIATIONS AND VERTEBRATE BIOEVOLUTION; Dewey M. McLean, Department of Geological Sciences, Virginia Polytechnic Institute, Blacksburg, VA 24061.

Cause of the Pleistocene-Holocene transition mammalian extinctions at the end of the last age is the subject of debate between those advocating human predation and climate change. Occurring after the Wisconsinan-Weichselian ice age maximum (20,000-18,000 yr B. P.), during a time of rapid climatic warming, northward retreat of ice sheets and boreal forests, and expanding living space, deciduous forests, and grasslands, those extinctions wiped out nearly 70 percent of North America's megafauna between 15,000-8000 yr B. P. (1), with more than half between 12,000-9,000 yr B. P. Affecting terrestrial mammals large and small, birds, and reptiles, the extinctions impacted most heavily upon terrestrial mammals larger than 44 kg. Identification of an ambient air temperature (AAT)-uterine blood flow (UBF) coupling phenomenon supports climate change as a factor in the extinctions (2, 3), and couples the extinctions to earth orbital variations that drive ice age climatology.

The AAT-UBF phenomenon couples mammalian bioevolution directly to climate change via effects of environmental heat upon blood flow to the female uterus and damage to developing embryos. An embryo's source of food, oxygen, and water, UBF also removes heat from the uterine area, maintaining optimum uterine temperature necessary for embryo development. Among modern mammals, high temperatures elevate core temperature and reduce UBF, producing fetal malformations, dwarfing, and/or embryo death; a 1.5 C rise in uterine temperature kills most embryos. Pleistocene mammals adapted to extreme cold would have experienced thermoregulatory problems during rapid climatic warming, and reduction of UBF, with its effects upon developing embryos. Large mammals, because of small S/V ratios would have experienced maximum elevation of core temperatures, and reduced UBF. The extinctions, and dwarfing and skeletal abnormalities that were coeval with the extinctions on a global scale, are accounted for by the AAT-UBF connection. Birds and reptiles are also affected by the AAT-UBF phenomenon. Regions not experiencing dramatic warming would have served as refugia.

Abrupt cooling equivalent to Younger Dryas event in the North Atlantic about 11,000 yr B. P. may have been global in extent (4); however, its impact in the North American interior is unclear. In any case, extinctions were in progress during climatic warming before the Younger Dryas event, and after, at times when the AAT-UBF couple would have been operative; however, impact of a sudden short-term cooling on mammals in the process of adapting to smaller size and relatively larger S/V would have been severe.

Variations in earth's orbit, and orbital forcing of atmospheric CO2 concentrations, were causes of the succession of Pleistocene ice ages. Coincidence of mammalian extinctions with terminations of the more intense cold stages links mammalian bioevolution to variations in earth's orbit. Cold stages 2, 6, 12, 16, and 22 are marked by deeper and/or longer lasting oxygen isotopic highs than are others (5). Terminations of cold stages 2 and 12 were coeval with Rancholabrean and Irvingtonian extinctions, stage 16 with European Biharian extinctions, and stage 22 with major European Villafranchian extinctions; late Blancan and late Hemphillian extinctions were also coeval with glacial terminations (6). Earth orbital variations are a driving source of vertebrate bioevolution.

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