Biodiversity of Migratory Species Following Geomagnetic Variations in Strength and Direction

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Introduction (989/1000 character limit)

Earth's magnetic field is an essential barrier that contains the atmosphere and protects the Earth from cosmic rays from the sun. Variations to the geomagnetic field causes phenomena such as solar weather, disruptions to electronic communications, and the polar auroras (Constable and Korte 2006). It is unknown how life on Earth would be affected if the geomagnetic field were to severely weaken or disappear. Migratory genera like birds, deer, sharks, and bees all rely on the geomagnetic field to navigate during migration. These genera contain small amounts of biogenic magnetite in the brainstem that reads the magnetic field similar to a GPS satellite. My objective is to test whether biodiversity in migrating genera changes due to variance in strength and direction in the geomagnetic field. My hypothesis is that the biodiversity of migratory genera would have decreased directly following a geomagnetic reversal, but would have remained fairly constant for non-migratory genera.

Justification (1868/2500)

When Earth's magnetic field begins to reverse, it does not happen all at once; rather, it slowly weakens for hundreds to thousands of years (Gubbins 2008). Rock records provide a detailed account of when these reversals have occurred in time. Disturbances to the geomagnetic field cause phenomena such as space weather and the polar auroras, but little is known about the implications these variations have for life on Earth. Recent research shows that migratory species, such as the European Robin and the honey bee, respond to minute changes in the geomagnetic field and use the field as a means of navigation during migration (Heyers et al. 2010; Kirschvink and Kirschvink 1991). These species contain biogenic magnetite located in the brainstem, which transmits geomagnetic information to the brain, where navigational information from the geomagnetic field is conveyed and interpreted (Heyers et al. 2010). If the geomagnetic field were to show signs of reversing and began to weaken, it is unknown how migratory species that rely on the geomagnetic field would respond. It is possible that with a weakened field, these species will be unable to navigate when migrating. Confusion in the migratory system could lead to disruptions in many different ecosystems around the world. For example, birds migrate to areas with an excess of resources, and if the birds were unable to find their way back to their preferred areas, it is likely that their overall population would decrease (Somveille et al. 2015). This could possibly explain past changes of biodiversity in migratory species that we currently do not have explanations for. This research will allow us to understand the importance of Earth's geomagnetic field in relation to the navigation of migratory species and how variations in strength and direction of the geomagnetic field affect their populations.

Research Plan (1251/2500)

I will use the Paleobiology Database to find the number of occurrences of the class Aves for both migratory and non-migratory genera in the Pliocene and Pleistocene. The non-migratory genera will serve as the control group, in order to measure if the biodiversity of non-migratory genera are also affected by variations of strength and direction in the geomagnetic field. The data will be processed using R software computing, and cleaned to remove any occurrences not properly resolved to the genus level. The data will be analyzed using the diversity function in the vegan package which can be downloaded and installed into R software. In this way, calculations can be made for Shannon's Entropy during periods of a weakened geomagnetic field as well as before and after geomagnetic field reversals. A null hypothesis analysis will then be performed to ascertain if the changes in biodiversity are significant. In this way, we will be able to tell if there is a substantial deviation in the biodiversity of migratory and non-migratory genera during periods of a weakened or reversed geomagnetic field. We will use the paleogeomagnetic reversals listed by Lowrie (1990) in the Pliocene and Pleistocene as the time constraints in our data processing.

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