The Evolution-Defying Species: Tree-Kangaroos

INTRODUCTION

Dollo's law of irreversibility states that organisms that are evolving cannot redevelop an organ or attribute from an ancestor, but apparently he did not take into account tree-kangaroos. This unique genus, *Dendrolagus*, went back up to live in trees after its ancestors descended from arboreal life. There is no explanation for this scientific phenomenon, but there are some hypotheses that have developed by looking at the ancestral history of this genus and the history of the land masses they inhabit.

Tree-kangaroos are tree-dwellers who inhabit lowland and mountainous rainforests in Australia, Indonesia, and Papua New Guinea (Tree Kangaroo). They have shorter legs and strong forelimbs that make climbing easier. Resembling a lemur and a kangaroo, little is known about this species due to their preferred habitat, cryptic nature, and scarcity (Bowyer et al. 2002). These species feed on leaves, ferns, flowers, and tree bark and live in tropical rainforest climates (About Tree Kangaroos).

In this literature review, I will be examining the reasoning behind tree-kangaroos defying the law of irreversibility by returning to arboreal life. This paper will dive deep into the biogeographical history of Australia and New Guinea as well as the evolutionary history of Macropods. I am hypothesizing, with acknowledgements to a similar hypothesis presented, that this organism went back into arboreal life due to human impacts causing botanical changes that happened to New Guinea and Australia in the past. This is important because not much is known about this species or why it went against one of the fundamental principles of evolution, so understanding why this species reverted back to ancestral ways can open doors for future research regarding evolution among other species. It is also important to see how much humans have impacted animals and plants throughout history just like they do today.

HYPOTHESES

Although there is little information regarding tree-kangaroos, there are still hypotheses concerning the origins of these species and why they defied the law of irreversibility. According to Alan Ziegler, a museum curator from Hawaii, the tree-kangaroo genus, *Dendrolagus*, must have originated in Northern New Guinea when a north Australian land mass macropodidae occupied the uplifting area soon after the former insular Northern New Guinea merged with the southern land mass (Roger Martin 2005). This hypothesis relates to the origin of the species, but since this cannot be proven as to how the species came about, it could lead to clues about why this species went back into the trees. This hypothesis is not exactly specific about why the species went back into the trees, but it does lead to speculations as to why they decided to return to the trees due to the nature of their arrival.

Another hypothesis about the origin of this species and why they returned to arboreal life is due to an abundance of food variation in Australia, which is similar to my hypothesis. There were frequent connections between Australia and New Guinea and noticeable changes to vegetation occurred during these times. One plant species in particular, of the Indo-Malayan origin, was pre-adapted to the seasonality of the tropical lowlands in these areas. This botanical element provided an “evolutionary opportunity” for rock-wallabies, who already had climbing ability, to make their way back into the trees to feed on more nutritional foods. This species eventually evolved into what is now known as the tree-kangaroo (Roger Martin 2005).

BIOGEOGRAPHICAL HISTORY OF AUSTRALIA AND NEW GUINEA

During the Miocene, Australia was further south than it is now and was covered in temperate and subtropical rainforests. These rainforests were inhabited by many tree-dwelling species, including the ancestor of the tree-kangaroo. The Australian plate began to move north during the Mid-Miocene, causing it to come into close proximity with the eastward moving plate of Sundaland. The Malesian flora began to inhabit Northern Australia and New Guinea (Roger Martin 2005). During this period, New Guinea and Australia were on the Australian plate and by the late Miocene, this plate had become cooler and drier (Australian Museum). New Guinea did not look like it did today as it was just a series of islands that were in close proximity to where New Guinea is now.

Moving forward to the Pliocene, the continent of Australia was closer to the position it is in today. The Australian plate finally came into contact with the South East Asian plate causing the larger area of New Guinea to rise above sea level. The climate was warm and wet but was starting to recover from the drying out of the late Miocene epoch (Australian Museum). This change in climate allowed for open forests to form grasslands on a large scale which caused the ancestor of the kangaroo and tree kangaroo to come down from arboreal life and inhabit the open plains (Pliocene Australia). The changes in climate happened due to the ice caps expanding and contracting, causing waves of cold-warm and wet-dry phases.

During the Pleistocene, Australia was very close to its global position currently, and the sea levels fell which caused there to be temporary land bridges between Australia and New Guinea. The climate of Australia during this time kept cycling between greenhouse (warm and wet) and icehouse (cold and dry) phases. The first fossils that were attributed to the tree-kangaroo were in New South Wales during the Pleistocene (Figure 1). This fossil was an ankle bone which allowed the animal to rotate its back foot to turn the sole of the foot outwards, something that only tree-kangaroos are capable of within the kangaroo family (Martin, 2005).

During this same period, humans came to the Australian plate. The arrival of humans to New Guinea and Australia caused most of Australia's large mammals, including the majority of its herbivores, to become extinct during the Pleistocene. This extinction event caused a huge shift in the ecosystems of Australia, which in turn caused animals who had a predominantly C_4 photosynthetic plant diet, which includes grasslands, to shift to a predominantly C_3 photosynthetic plant diet, which includes trees and most flowers (Miller et al. 2005). This shift in diet was due to the decrease of C_4 plants. If there was a major shift in the types of plants that were available, then the kangaroos must've had to shift their ways in order to survive. These animals must have gone back up into the trees around this time to keep up with the shift in the available food sources (Figure 1).

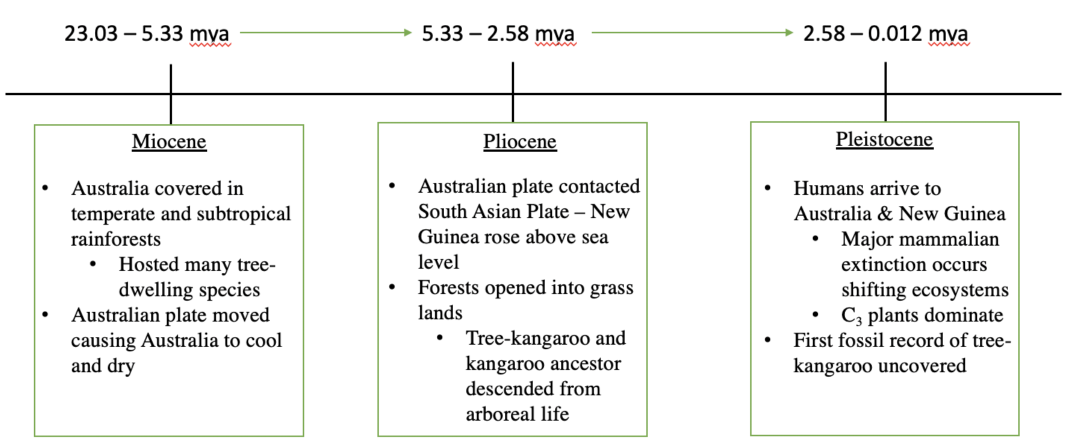

Figure 1. History of Australian Plate. This figure shows the biogeographical history of Australia and New Guinea.

EVOLUTIONARY HISTORY OF TREE-KANGAROO

There is not much information known about the evolutionary history of the tree-kangaroo due to their lack of fossils in the fossil record (Prideaux 2008). The behavior, habitat, and distribution of this genus, *Dendrolagus*, makes the evolutionary history unknown and very controversial among scientists today (Eldrige et al. 2018). The information that is known about tree-kangaroos causes disagreements amongst many different members of the scientific community because there is plenty of room for hypotheses to form and speculations to arise.

The first marsupials are thought to have been small, partly insectivorous descendants of the phalagerids, similar to the present-day contemporary musk rat-kangaroo. The first fossil of the tree-kangaroo, the ankle bone, was identified and described as *Bohra paulae*. This animal's body weight was estimated at 30-40kg, which is a lot bigger than the largest known tree-kangaroo still alive today which weighs in at only 23kg (Prideaux 2008).

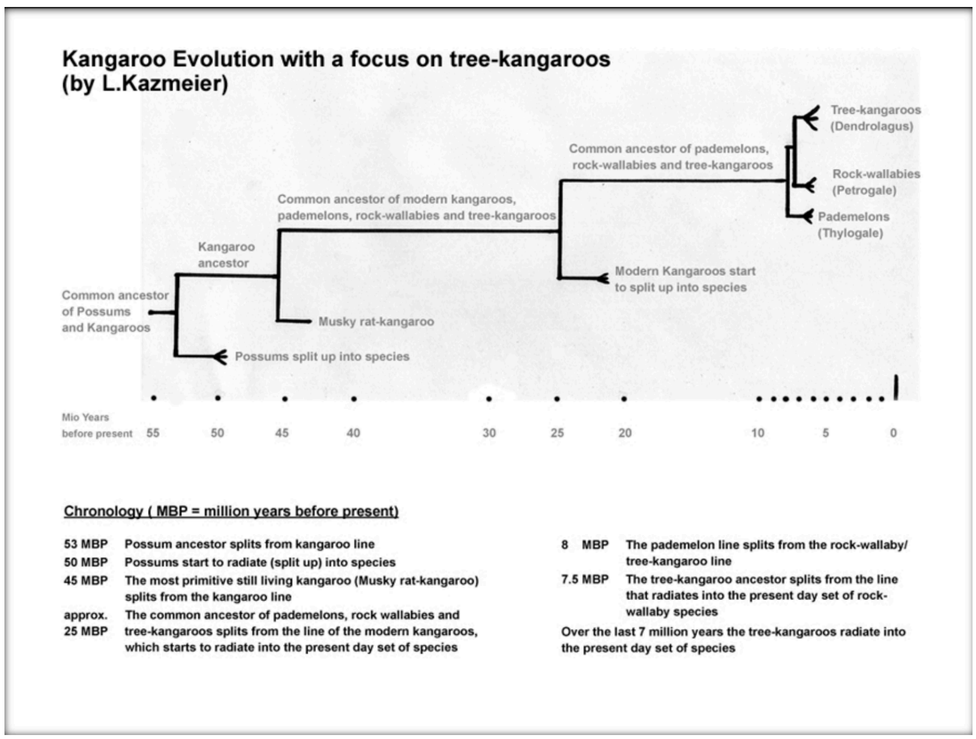

Figure 2. Phylogenetic Tree of Tree-Kangaroo. This figure shows the ancestral history of the tree-kangaroo based off of current knowledge today.

The mid-miocene hosts the one of the first common ancestors of the tree-kangaroo and other macropods, Phalangeridae (Figure 2). The phalangerid was the first marsupial that was discovered by Europeans in the mid-16th century. Although this organism was discovered a long time ago, there are still huge knowledge gaps as to the biology of these organisms and their evolutionary relationships. Many of the groups that fall under the Phalangeridae category do not have much information regarding their evolutionary history (Luis 2005).

FORMAL HYPOTHESIS

Throughout my search to find information regarding tree-kangaroos and why they went back up into the trees, I was able to come up with the hypothesis that this genus went back into the trees due to the lack of available food in Australia and New Guinea due to human activity. Human activity caused the types of photosynthetic plants in Australia and New Guinea to change due to the major extinctions of some of the area's main herbivores and other mammalian species. Once this change occurred, there must have been competition within the species for food, which caused a decline in their population size. Over this period, on an evolutionary time scale, there must have been enough competition for some of the individuals to start incorporating more food from the trees into their diet. Overtime, this led to the individuals evolving to depend more on the food that was found amongst the trees.

There is not much scientific research as to when exactly these species fully returned to arboreal life, probably because this happened over the course of many hundreds of years. Since an animal cannot completely change their diet in a day to adapt to the evolving areas around them, these changes had to have occurred over long time scales. Without knowing exactly when this species went back into the trees does make it more difficult to distinguish their evolutionary paths, but it allows for hypotheses like these to bring the scientific community closer to estimating that time.

CONCLUSION

Throughout all of the research conducted, I was able to form the hypothesis that the ancestors of tree-kangaroos returned to arboreal life due to the lack of food availability in Australia and New Guinea because of ecosystem changes caused by human migration. Although much of the evidence points towards these animals returning to arboreal life due to ecosystem change, there is still no for sure answer as to why they did. Future studies could potentially look at mitochondrial DNA and SNPs to investigate the history of tree-kangaroos and their migratory patterns to have a better understanding of when this shift in their geographic range happened. This opens up so many possibilities for future research regarding the evolutionary backtrack these animals did, as well as learning more about the countries of Australia and New Guinea and their biogeographical histories. This hypothesis alludes to the idea that maybe species, on evolutionary time scales, are able to revert back to certain characteristics their ancestors once had, opening up doors for more investigations on the evolutionary paths of every species around the world.

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