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Diversity in Australia: An Evolutionary Confirmation through Darwin's Explanation

Shivangi Barik [a] and Majesh Tomson [a*]

[a] Department of Life Sciences, School of Sciences, CHRIST University, Bengaluru, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This article aims to study and analyse the factors mentioned by Charles Darwin in his book, *On the Origin of Species* with respect to the unique flora and fauna found in the Australian continent. Natural selection and adaptability of the organisms meet at an inimitable point to develop their progeny. The way of utilization of the process, natural selection to convince the successful formation of new progeny is admirable and it has a factual strength of science.

Keywords: Evolution; biodiversity; Darwin; Australia; species; natural selection.

1. INTRODUCTION

Aboard the HMS Beagle, Charles Darwin visited Australia in 1836 and collected over 110 specimens. He then went on to write his path breaking masterpiece, "On the Origin of Species" in 1859. It is said that this trip is what inspired him. The variety of organisms in Australia, the abundant wildlife with their unique features found almost nowhere else on the planet, and the

**Corresponding author: Email: majesh.tomson@christuniversity.in;*

thriving ecosystem was the final brick in the wall that built the foundation to his revolutionary work. Australia has one of the most diverse ecosystems on the planet today, with species that are endemic as well as those introduced by man.

Charles Darwin is arguably one of the most well-known scientists of the modern age, having established several theories regarding ecology and evolution that are foundations for modern-day studies regarding the same. However, there are ongoing debates regarding how to best interpret his theories of evolutionary biology and speciation [1]. This article aims to study the application of his theories in context of Australian biodiversity and evolution.

2. ARTIFICIALLY INTRODUCED SPECIES

Exotic species, i.e., species introduced artificially by man plays a major role in shaping the ecosystem of the region. It is considered to be the "least reversible" human impact, threatening the endemic species of the region. (Peter S. White, 1998). In addition to this, evolutionary changes in natives in response to invasive species has also been noted. These responses range from altered defensive characteristics, changes in habitats and food habits, and alteration in the spectrum of resources used. These changes depend on a variety of factors such as a history of invasion, genetic variability, and the niche occupied by the invader. Failure to do so may lead to the extinction of the native species [2].

The diversity observed in Australia in the present day has also been aided by the several instances of domestic species that were introduced by colonists being allowed to run wild. As mentioned in the book, the slow-breeding cattle and horses had rapidly increased to such an extent that without proper statistical evidence, it would not have been credible. One such example is the present-day "Brumby" or "Brumbies". Introduced in 1788 by the settlers, these horses were healthy and strong, which helped them flourish, and since the 1800s have proliferated and become wild, feral horses. The numbers grew to 3500 in 1820 and rose sharply to 1,60,000 by 1860. The first record of one such horse escaping was in 1804. The legalization of horse racing, lack of large predators, and virtually no diseases in horses led to such rapid growth and eventually to them becoming feral [3].

Goats first arrived in Australia in 1788 with the First Fleet. The current feral goat populations are descended from animals introduced in 1788 and later years for a variety of causes. In addition to this, goats were herded in the 19th century to ensure supplies of emergency food, cashmere goats imported in 1837 to start a goat fibre industry, and goats were also taken around the island as the settlers shifted. These species have now interbred, become feral and cover over 28% of the landmass, which is a problem [4]. The dangers of introducing foreign species are many, including less survival rates of endemic species due to higher competition and loss of biodiversity. Despite having seen such effects of invading species in the past, the cane toad was introduced in 1935 to control the cane beetle that was native to Australia, and protect sugarcane crops. However, this led to problems in the long run due to the lack of natural predators of the toad, leading to their rapid proliferation. In addition to competition for native species, this is further dangerous as they contain bufotoxins that kill Australia's native animals [5].

It is often seen that artificially introduced species have better adaptability and can adjust well to a wide range of external conditions as compared to indigenous species. This is seen in the instance of the invasive Asian house gecko *Hemidactylus frenatus*, which occupies a broader range of light environments in the field than the native gecko *Gehyra dubia*. Furthermore, in Y-maze experiments, *H. frenatus* was more willing to forage closer to illuminated regions, which gives it an advantage compared to the native species and explains its ability to establish itself in pre-populated regions [6].

3. SPECIATION IN ISOLATION

One reason which has been put forth as an explanation for Australia's unique biodiversity is the fact that it is an isolated island continent, and is smaller than every other continent. Small isolated areas favour the production of new species, but the course of modification will be faster in larger areas. Since the new species in larger areas will already have competed with many species, they would be more successful in the long run and spread widely. This explains why Australia has such a unique range of flora and fauna in the first place, and then the fact that they do not migrate or spread over to other continents either. It has also been proved that reproductive isolation and ecological divergence play an important role in speciation [7].

The south-western region of the Australian continent is home to a wide variety of endemic

species despite its low relief and subdued topography, i.e., about 75-80% of its fauna is endemic. However, other regions in the world with high levels of endemic populations have much more extensive mountain systems. Among other factors that contribute to this, one important factor is the presence of marine, climatic, and edaphic barriers on all migration sides of the southwestern region since the Eocene epoch that isolated the population of this region, preventing interbreeding and leading to niche speciation (Stephen D. Hopper, 1979).

However, later findings by J. Ford proved that this is not always what happens, at least in the case of birds. “The total number of differentiated isolates in minor refugees is very much smaller than in major ones.” And “rates of production of differentiate in minor and major refuges are equal.” *(Ford, 1987).* It was observed that only the sedentary birds of the mulga habitat in the arid regions of Australia produced differentiated isolates. This was enabled by the Eyrean barrier that prevented interbreeding [8]. It has also been speculated that some species, such as *Petroica rodinogaster* and *Corvus tasmanicus* had evolved in Tasmania and migrated to the mainland. A much more recent discovery that does support the theory that isolation produces more variation is of the isolated groundwater springs of Australia’s Great Artesian Basin. This ecosystem is unique because it has been isolated for such a long time that it has developed an ecosystem seen nowhere else. Freshwater amphipods of the family Chiltoniidae are seen here that are endemic to this zone and are thought to have evolved during the late Miocene, which is when the aridification of Australia occurred and such springs were isolated [9]. Along with this, recent research in the calcretes of the Yilgarn region of Western Australia has led to the discovery of approximately 25 new species of Collembola from 10 calcrete aquifiers that were studied. Only 5% of the calcretes were sampled, and thus, there could be a larger and more diverse Collembola population in the region. This implies that there could be several undescribed organisms in areas that have been completely isolated, such as the calcretes [10].

4. SUCCESSION OF SAME TYPES WITHIN SAME AREAS

Succession is the phenomenon through which an ecological community evolves over time. For a population to thrive in one particular environment, it must be highly specialized, and so, cannot be adapted to many different sets [11]. One subclass that is a key feature of Australian biodiversity is Marsupials. These pouch-bearing mammals are found majorly in Australia, with some being present in South America and parts of Asia such as Tasmania and New Guinea. It has been found that fossilized mammals found in Australian caves closely resemble the marsupials found there today. It has also been found, however, that although marsupials do not occur in Europe today, numerous marsupials used to populate Europe about 125 million to 14 million years ago.

Once in Australia, they continued to diversify and thus yielded the species that we see today, and are seen nowhere else. The diversity was the highest during the early and middle Miocene, in the Riversleigh World Heritage Area. The late-middle Miocene and late Miocene saw a massive loss in the archaic biodiversity. However, this paved the way for the wider diversity we see today. Australia’s first grasslands and arid habitats started developing, along with a massive population explosion of grazing kangaroos. Furthermore, lowered sea levels also allowed species to travel between the mainland, surrounding islands, and New Guinea [12].

Later findings have shown that the appearance of Marsupials in Europe was in the early Eocene, as a result of a wave of mammalian dispersal into the Old World [13]. Darwin then brings forth the “Law of succession of same types within the same areas.” This means that organisms that used to live in a region in earlier times will have given rise to organisms similar to themselves that we can observe today. He also mentions the “law of long endurance of allied forms on the same continent”, which adds onto the theory mentioned above. Southeast and southwest corners of Australia have nearly the same physical conditions, and are united by continuous land, but have a vast number of distinct mammals, birds, and plants. Here, pre-occupation plays an important part in determining the commingling of species under the same conditions of life.

5. GEOGRAPHICAL BARRIERS AS AN ESSENTIAL FACTOR

One would think that landmasses under the same climatic conditions would have the same species populating them. However, this is not true. Climate is not the sole determining factor of the diversity of species found in a region or the similarities between the species living in different

regions. Even though Australia, South Africa, and western South America lie between 25^{o} and 35^{o}, their floras and faunas are entirely dissimilar. The climate is the same, but the species are vastly different. This shows that climate is not the sole determining factor. Geographical barriers play an extremely important role. Even though these continents lie at the same latitude, they are isolated from each other to a great extent by vast oceans. This leads to different species evolving. “Geographical isolation is necessary for species to break up into daughter species” [14].

They are, however, inhabited by species that appear similar to each other, or have similar adaptations to deal with the same climatic conditions. This can be seen as the Straits of Magellan in South America are inhabited by a species of Rhea, and northward, the plains of La Plata by another species of the same genus. However, Rhea isn’t found in Australia and Africa, that lie in the same latitude, instead, other types of flightless birds such as Emu and True Ostrich are seen there respectively. “In allopatric speciation, long-term geographical isolation generates reproductively isolated and spatially segregated descendant species” [15]. Species that inhabit oceanic islands are lesser in number than those in an equal continental area. However, the proportion of endemic species in such oceanic islands is extremely large (e.g. - endemic land-shells in Madeira and endemic birds in Galapagos Archipelago) when compared to any continent.

Recent fossil evidences of the Mesozoic fern, *Osmundaculis* show that it originated from a common ancestor which originated in the Australian region of Pangea, and then spread to North American and East Asian regions. The subsequent development into individual species with characteristic and region-specific features is due to long-term geographical isolation [16].

It is also seen that there is a relation (independent of the distance) between the depth of the water body separating an island from the mainland and the presence of the same mammiferous species or allied species that are very similar. We see this in many islands separated by similar channels from Australia. This is because the shallower the water body is, the easier it is for species to cross over it and migrates to neighbouring regions, and vice versa.

6. GLACIAL PERIOD AND ITS EFFECT

The Glacial Period is an interval of time that is characterized by drastically cold temperatures and glacial advances. They last for about 1000 years and lead to enormous changes in the planet’s flora and fauna. The last glacial period was during the Pliestocene epoch, i.e., about 100,000 to 15,000 years ago. In Australia, it was restricted to the Snowy Mountains and Tasmanian Highlands. This had an acute effect on the surface geology of Australia [17]. When the glacial period arrived, tropical species were the worst affected. These were the ones that became extinct to a large extent. Some could have escaped into the warmest spots, but most became extinct.

During the Last Glacial Maximum (LGM), the Bassian Land Bridge existed, which joined Tasmania with Mainland Australia during periods of low tide. This facilitated biotic movement in between these regions. Dry-grassland fauna characteristic to southeast Australia dispersed between mainland and Tasmania across the land bridge. This dry grassland extended to the Bassian Land Bridge, whose environment also influenced the dispersal of biotic material [18].

The effects of the LGM are also observed on the temperate-adapted bees belonging to the clade Exoneurine, which were key native pollinators of the region. The population of the bees did not decline during the LGM due to their widespread distribution all over Australia and development of genetic and physiological adaptations helped them maintain their population size [19]. Thus, the glacial period, in addition to causing the extinction of several species, also had a role in the increased adaptive ability of certain species.

According to Alph. De Candolle, many identical plants and allied species have migrated from the north to the south. Darwin speculates that this is because land in the north was vaster, with a large number of each species. This led to competition and natural selection, which led to them being more adapted than the southern forms, and so, during the glacial period, they were able to overpower the southern forms which were not as well developed. In the southern mountains of Australia, Dr. E. Muller discovered several European species which were never introduced by human beings occurring in the lowlands. Dr. Hooker agrees, several European genera can be found in Australia, but not in the immediate torrid region. It is then seen that

plants growing on lofty mountains and temperate lowlands of northern and southern hemispheres appear to be the same, but are distinct. They are often related to each other.

The glacial period led to the death of a lot of mammalian megafauna in the region [20-23].

7. CONCLUSION

This article comes to the conclusion that the principles mentioned by Charles Darwin in his book “On the Origin of Species” including artificially introduced species, speciation in isolation, succession of same types within same areas, geographical factors in speciation, and the effects of the glacial periods hold true in the context of speciation in Australia.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable as no new data were generated or analysed during this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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