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Flightless Birds: Unglorified Reptiles

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Abstract: Flightless birds are a captivating group of avian species that have lost the ability to fly through evolutionary processes. This study provides a detailed analysis of the current studies on the evolutionary history, ecological adaptations, behaviour, and conservation status of flightless birds that are still in existence. Flightlessness has emerged through separate evolutionary processes on many occasions in birds, typically as a result of the absence of mammalian predators and the presence of plentiful food sources. Flightless birds possess distinct morphological, physiological, and life history characteristics in comparison to birds capable of flight. Several flightless animals face the risk of extinction as a result of human activities such as the destruction of their habitats, the introduction of predators, and hunting. To ensure the preservation of these distinct avian species, it is imperative to conduct scientific investigations, safeguard their natural habitats, and manage the spread of non-native organisms. Additional research is required to investigate the population dynamics, genetic diversity, and ecological functions of birds who are unable to fly. This study provides a comprehensive synthesis of research on the evolutionary, ecological, behavioural, and conservation aspects of flightless birds.

Keywords: Flightless birds, Ecological adaptations, Conservation, Population dynamics, Genetic diversity

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Introduction

Flightless birds are a varied collection of animals that have lost the capacity to fly via the process of evolution. Out of the roughly 10,000 bird species that exist today, the majority are capable of flying. However, there are at least 60 species of birds that are unable to fly, belonging to 12 different families. Famous examples comprise the ostrich, emu, cassowary, kiwi, and penguin, however, there are also less familiar flightless species such as the kakapo parrot, takahe rail, and other flightless cormorants. The occurrence of flightlessness in many bird lineages through independent evolution poses intriguing inquiries into the evolutionary forces and ecological circumstances that precipitated this profound alteration in biology and way of life. What are the benefits and drawbacks of living without the ability to fly? What are the differences between flightless birds and their flying counterparts in terms of their physical characteristics, bodily functions, actions, and life cycle? What ecological functions do flightless birds fulfil in their ecosystems?

The phenomenon of flightlessness in birds serves as a striking illustration of how alterations in selective pressures can result in swift degradation of intricate adaptations. Flight originated in theropod dinosaurs during the Jurassic period, resulting in significant advantages for dispersal, feeding, and evading predators (Gatesy and Baier, 2005). Nevertheless, the capacity for flight comes with substantial expenses, such as the need for extensive pectoral muscles and skeletal modifications, and the use of substantial amounts of energy (Alexander, 1998). Transitioning from a flying to a non-flying way of life is projected to decrease daily energy usage by at least 30% (McNab, 1994). Flightlessness typically arises when the advantages of flying are diminished and the disadvantages outweigh other factors that influence natural selection. These conditions have occurred repeatedly on islands without mammals that hunt and have plenty of food that is either abundant or distinctive and can be obtained without flying. The flightless cormorant (*Phalacrocorax harrisi*) developed on the Galapagos islands, where it may search for fish and octopus in nearby waters without the need to fly due to the absence of predators (Wilson *et al*., 2008). Flightlessness has independently emerged multiple times in the evolutionary history of large, terrestrial bird lineages under situations when the risk of predation is minimal and there is limited necessity for covering lengthy distances. Ratites such as the ostrich, emu, cassowary, rhea, and kiwi have achieved a broad geographical distribution encompassing Africa, Australia, New Zealand, and South America. Their emergence seems to be connected to the demise of large carnivorous dinosaurs and the expansion of grassland ecosystems (Mitchell *et al*., 2014). The dodo and *Rodrigues solitaire*, both flightless birds, developed on islands in the Indian Ocean where there were no predators that were mammals. However, they quickly became extinct after humans arrived.

The occurrence of flight loss in many avian taxa independently highlights the susceptibility of this intricate characteristic to specific ecological circumstances. There are at least twelve bird families that have species that cannot fly, such as waterfowl (Anatidae), rails (Rallidae), parrots (Psittacidae), and cormorants (Phalacrocoracidae) (Roots, 2006). Volant and flightless species often coexist within the same family or genus, offering significant opportunity for comparative study (Livezey, 2003). Advancements in genomics have recently revealed fresh perspectives on the genetic alterations that contribute to the loss of flight in birds (Sackton *et al*., 2019).The study focuses on the morphology, physiology, and life history of birds that are unable to fly.The transition from being able to fly to being unable to fly leads to significant alterations in the physical structure and biological functions of birds. One noticeable change is a decrease in the size of the wings, which can vary from modestly shortened wings to almost non-existent remnants, as observed in kiwis and moas (McNab and Ellis, 2006). Flightless birds generally have diminished pectoral muscles, smaller keels on the sternum, and less pneumatized skeletons due to the absence of the requirement to reduce body bulk for flight (Cubo and Arthur, 2001). Flightless birds typically have larger and modified hind limbs and feet that are adapted for moving on land. Ratites has robust, muscular legs that are specifically designed for running, whereas island rails and waterfowl frequently possess diminished, spread-out feet that are specialised for navigating through dense vegetation (Kirchman, 2009). Flightless birds such as penguins and cormorants have developed webbed feet and modified wing bones as adaptations to facilitate swimming and diving (Raikow *et al*., 1988).

Flightless birds have developed reduced metabolic rates and a tendency to conserve energy as a result of being freed from the need to fly.

These birds have basal metabolic rates that are 20-60% lower than those of flying birds of similar size (McNab, 2009). Flightless birds typically exhibit extended digestive retention periods in order to optimise the assimilation of nutrients from plant material of poor quality (Battley *et al*., 2000).The lack of flying also has ramifications for the life histories and reproductive processes of birds. Flightless avian species typically exhibit reduced clutch sizes, extended incubation and fledging periods, and elevated rates of adult survival in comparison to avian species capable of flight (Roots, 2006). While flightless species such as ostriches and emus often do not engage in long-distance migration, many species of penguins migrate by swimming hundreds of kilometres to reach their overwintering sites. Flightless island birds such as the kakapo and takahe are known for their longevity and delayed development (Clout and Merton, 1998).

The behaviours and ecological functions of flightless birds exhibit a wide range of variation, reflecting the diversity of the species. Ostriches and emus are large, fast-moving birds that eat a variety of plants and have a wide habitat range. They are crucial for spreading seeds in grasslands and savannas (Noble *et al*., 2007). On the other hand, the huge moa of New Zealand were herbivores that significantly influenced the makeup of forest ecosystems (Forsyth *et al*., 2010). Flightless birds on islands frequently display distinctive behaviours and ecological interactions. The kakapo is a parrot that is active throughout the night, feeds on plants, and is known for its unique lek breeding system (Clout and Merton, 1998). The dodo, which is now extinct, occupied the ecological role of a big, land-based seed disperser in Mauritius. This position is currently fulfilled by introduced animals such as monkeys and pigs (Weisskopf *et al*., 2005). Flightless island rails are frequently the dominant indigenous predators in their habitats, feeding on a diverse range of invertebrates, reptiles, and small mammals (Gruber and Behn, 2002). Penguins and cormorants, which are flightless birds that live in the water and on land, have adapted specifically for finding food in the ocean. Penguins are carnivorous marine animals that hunt and eat fish, squid, and krill. They play a crucial role in the food chain of the Southern Ocean ecosystem (Croxall *et al*., 2002). The Galapagos cormorant is a predatory bird that hunts for fish and invertebrates near the coast in shallow waters (Wilson *et al*., 2008). These animals also contribute significant nutrient inputs to terrestrial environments through their guano deposits.

A multitude of flightless bird species are either under the threat of extinction or are already endangered as a result of various human-induced influences. The main dangers to the species are the destruction and division of its natural environment, the hunting of the species by non-native mammals, and the direct exploitation of the species by humans for their meat and feathers (Roots, 2006). More than 60% of existing flightless birds are currently classified as endangered on the IUCN Red List (IUCN, 2020). Island species have suffered greatly, with many extinctions of birds that cannot fly already recorded on islands in the Pacific and Indian Oceans (Duncan *et al*., 2013). Human hunting led to the extinction of the moa and elephant birds shortly after the arrival of Polynesians in New Zealand and Madagascar (Perry *et al*., 2014). The extinction of the dodo, *Rodrigues solitaire*, and many island rails was caused by a combination of habitat destruction and the presence of introduced pigs, cats, and monkeys, which preyed upon them (Cheke and Hume, 2010). Flightless birds in the continental regions have also experienced significant population decreases. The populations of ostriches and cassowaries are at risk due to the loss of their natural habitats, while rheas are extensively hunted for their meat and leather (Roots, 2006). Despite extensive conservation efforts, the kakapo and takahe in New Zealand narrowly avoided extinction and remain in a highly endangered state (Clout, 2001). Recent genomic studies highlight the decrease in genetic diversity in numerous tiny, isolated populations of flightless birds. Effective preservation of flightless avian species necessitates tackling the primary challenges of habitat degradation, proliferation of non-native species, and unsustainable utilisation. Preserving habitats on a large scale is crucial, especially for species that cover a broad area, such as cassowaries and rheas (Seddon and Leech, 2008). The management of invasive predators has played a crucial role in protecting island species such as the kakapo and takahe (Clout, 2001). Programmes that involve raising and releasing captive animals are crucial for the preservation of genetic diversity in remaining wild populations (Howard *et al*., 2017). Customised management measures will be required to safeguard the numerous flightless bird species that are still at risk of becoming extinct.

Conclusion

Flightless birds provide an intriguing perspective on the evolution, ecology, and conservation of species that have seen significant morphological and behavioural transformations. The presence of flightlessness in several bird lineages highlights the significant role of ecological conditions in facilitating this remarkable evolutionary change. Simultaneously, the proneness of numerous flightless avian species to extinction underscores their sensitivity in a swiftly evolving global environment. Further investigation on flightless birds will provide valuable knowledge regarding the mechanisms of adaptive evolution, ecological diversification, and extinction in isolated and dynamic habitats. It is crucial to prioritise further efforts to protect the numerous flightless species that are currently at risk of extinction. These remarkable representatives of bird diversity will only persist to inspire future generations via diligent research, management, and conservation initiatives.

Ethical Statement

This is a review article hence no Ethical Approval needed.

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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