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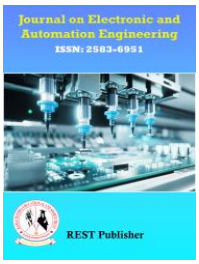

Understanding Bird Migration Pattern: Causes and Mechanisms

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Abstract: *Responding to environmental changes, a variety of bird species have recently been displaced, leading to changed behavior. Migrant and sedentary birds show interpersonal survival differences in rates, population count, and lifetime of 180 individuals radio-tracked throughout, including partially displaced Great Bustards (Otis tarta), with 16 years of data for analysis. We utilized population migration patterns in this study, automating the step of screening ecological phenomena from radar data. This approach will significantly assist in conducting large-scale research. We employed Fisher on SIFT descriptors as the basis of the vector model, comparing it to convolutional neural networks (CNNs). By comparing the performance of these models, we can use various techniques for this new mission. We evaluated the performance of deep and shallow network structures, comparing the conventional CNN model with deep structure models and trained them on radar imagery before fine-tuning using ImageNet. We compared the results obtained. There may be several reasons why many birds migrate. The primary reason is the availability of food during their migration. If they remain in one place, their food supply during the breeding season will eventually run out. Therefore, they move to areas where food is plentiful to reproduce. During this period, a decrease in food does not affect incoming birds, but it does attract predators who view them as an easy meal. Additionally, birds usually migrate to ensure healthy conditions for raising their offspring. Another reason for migration is changes in climate or weather conditions. If there is a change in these conditions, it may trigger their migration. Severe situations such as predators and diseases can drive them to migrate in order to protect themselves and their descendants. Generally, they migrate to places that are safe and inaccessible to predators.*

Keywords: *Migratory Behavior and Climate Changes, Life Cycle of Bird Migration, Timing of Breeding in Bird Migration, Environmental Change in Bird Migration*

1. INTRODUCTION

Many bird species migrate long distances along specific routes. During temperate or arctic summers, they fly north in time for breeding and then migrate south in autumn to winter in warmer areas. Returning to their original lands is also a common pattern. Similarly, human migration involves people moving from one place to another. The ways in which human movement reflects changing conditions and cultural landscapes can affect places where people settle. The migration of species, such as storks, turtle doves, and swallows, has been recorded by ancient Greek writers like Homer, Aristotle, and in the Book of Job, dating back 3,000 years. In reviewing the theories of bird migration, we will focus on discussing different types of questions and approaches used, providing an overview table rather than delving into the theoretical assumptions of each specific model. It is important and fascinating to explore the comprehensive scope and complexity of the development of bird migration theory. In recent decades, the migratory behavior of many bird species has changed. Changes in migration timing and distance traveled are often observed and are usually explained by climate changes (Newton 2008; Møller et al. 2010). However, little is known about other influencing factors on bird migration behavior, especially in humanized landscapes. Infrastructures such as railways, motor tracks, electric power lines, or wind turbines pose significant risks to many animals, including birds. Bird migration is a regular seasonal movement, primarily from north to south, involving reproduction and wintering along the way. A wide variety of bird species engage in migration. Migratory hunting, including human hunting, poses high mortality costs and is primarily driven by food availability. This phenomenon is most common in the Northern Hemisphere,

where natural barriers like the Mediterranean Sea or the Caribbean Sea limit specific migration pathways. Recording the dates of spring migrants' visits began with Johannes Lech in 1749 in Finland. Modern scientific studies employ techniques such as bird ringing and satellite monitoring to track migrating birds. Threats to bird habitats, including nesting and wintering sites, as well as human-made structures like electrical connections and windmills, have become increasingly destructive.

2. BIRD MIGRATION

FIGURE 1. Bird migration

Breeding and wintering periods in bird migration often experience higher mortality compared to migration itself. Thus, bird migration can have a significant impact on the annual survival and population dynamics of migratory species. During migration, birds face various risks such as death, adverse weather conditions, hunting, poor food availability, habitat destruction, overexploitation, climate change, and human-induced barriers. These factors pose major threats to migratory animals. The latest technology has opened new avenues for research in migration discovery. For example, by employing technologies that allow tracking individual migratory animals over extended periods, researchers can gather data on their physiological characteristics. This technology, especially in the field of bird migration, has greatly improved our understanding of bird behavior, demography, ecology, and physiology. We specifically focus on the improvement of knowledge regarding thermal detection and selection tactics, flight speed, direction choice, and site selection during bird migration. However, our current knowledge of bird migration is still fragmented, and there are gaps that need to be filled. To address this, researchers have developed individual-based bird migration models that consider population-level dynamics, variation in migration speed and distance, and other factors. Additionally, significant insights into the internal mechanisms of bird migration have been gained from studies conducted on captive birds. While some factors influencing bird migration, such as food availability, weather, competitors, parasites, and diseases, are known, there is still much we don't understand about external factors and their effects on migration.

3. MIGRATORY BEHAVIOR AND CLIMATE CHANGES IN BIRD MIGRATION

Behavioral forms of migration vary widely among bird species. Some species exhibit very predictable and synchronized migrations between the same places each year, often referred to as obligatory or calendar migration. However, the extent to which changes in behavior reflect climate warming due to contemporary climate change is still a controversial topic, although there have been notable studies linking bird migration changes to climate warming. The evolutionary origins of migratory behavior and whether it is a controlled trait remain uncertain. However, given the expected environmental changes resulting from global warming, there is concern about the ability of birds, in general, to cope with these changes. Some species may show limited potential for rapid evolutionary changes in their migration patterns. Understanding the potential for evolutionary responses to climate change is complex and important from an evolutionary perspective. In recent years, there have been observations of shifts in the timing of bird migration associated with climate change. Researchers often use phenological data on bird migration, which involves studying the timing of events over time, to assess changes and understand the complexity of migratory responses to climate change. Many studies have focused on changes in migration timing and how they are influenced by large-scale climate

factors and their interactions. However, our understanding of the specific responses of bird migration to climate change is still limited. The consequences of recent climate change on bird migration include the adjustment of optimal breeding times, increased mortality during displacement, competition for territories and resources, and changes in predator-prey dynamics and phenological factors. Climate change can alter migration timing and lead to shifts in the distribution of migrants, with potential risks of disconnection or increased intensity during spring and autumn migrations. The biological consequences of global climate change on bird migration encompass a wide range of incremental changes.

4. LIFE CYCLE OF BIRD MIGRATION

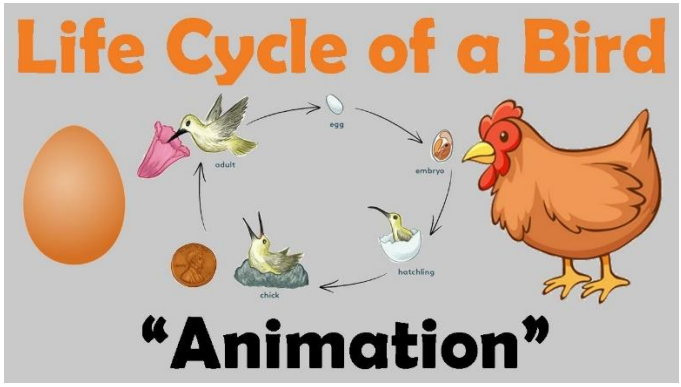

FIGURE 2. Life Cycle of Bird Migration

The findings from comprehensive taxonomic evidence suggest that long-distance migration to temperate and boreal breeding grounds is common among tropical immigrant bird species. This indicates the importance of considering selective factors and evolution in understanding the life cycle of migrants. In studies on speciation among migrant populations, it is crucial to take into account the non-breeding periods, as these studies have mainly focused on breeding grounds as the driver of selection. The unique morphology of tropical immigrant species, which does not occupy breeding spaces, supports the reasoning behind these studies. Considering the life cycle of migrants and their reproductive and non-reproductive areas is essential to understanding the evolution and breeding patterns of migrant species. Recent studies in bird ecology have provided support for the importance of considering both the reproductive and non-reproductive aspects of migrants. Hundreds of species and countless individuals migrate to tropical habitats each year for breeding, which can contribute to competitive aggressiveness. These findings highlight the role of migratory evolution in shaping the characteristics of immigrant species. In summary, the comprehensive taxonomic evidence and findings on migrant species suggest that selective factors and evolution play a critical role in the life cycle of migrants, particularly in tropical immigrant species. Understanding both the reproductive and non-reproductive areas of migrants is important, as it sheds light on their appearance and competitive behavior. The invasion of tropical habitats by numerous species each year for breeding supports the theory of migratory evolution.

5. TIMING OF BREEDING IN BIRD MIGRATION

Individuals of bird species exhibit high phenotypic plasticity, meaning they can modify their phenotype in response to different environmental conditions. This plasticity is often attributed to the capacity of a single modifying gene that allows some populations to quickly adapt to changing conditions, including those caused by climate change. Phenotypic plasticity in birds encompasses various aspects, such as food preferences, habitat selection, migration behavior, phenology (timing of events), and reproduction. During breeding, many bird species show high plasticity in their songs, which can vary among individuals in response to local weather conditions over the years. Breeding dates can also be altered by individuals in response to changes in local environmental conditions. However, the timing of breeding has significant effects on reproductive performance, as there are strong genetic links between breeding time and clutch size. Therefore, advancing or altering the timing of reproduction due to climate change can have profound effects on various aspects of reproduction. For birds living in seasonal environments, timing is crucial for successful breeding. Seasonality in reproductive success has been documented in various bird species and has been shown to be associated with reproductive timing. In the context of long-term warming trends, it is suggested that long-distance

migratory birds can respond rapidly to these changes. However, studies on the pied flycatcher in the Netherlands have shown that individual reproductive success does not align with optimal timing for breeding, contrasting with previous studies. In the Netherlands, pied flycatchers that migrate from their study area to Russia have been observed to arrive early in some years, contrary to optimal timing for reproduction. This suggests that factors other than constraints related to migration may influence their timing of breeding. Overall, the phenotypic plasticity of birds allows them to adapt and modify their behavior and reproductive timing in response to changing environmental conditions, including climate change. However, the specific mechanisms and constraints involved in these adaptations can vary among species and populations

6. ENVIRONMENTAL CHANGE IN BIRD MIGRATION

Dynamic models that incorporate habitat loss and migration patterns, along with temporal and spatial environmental changes, can provide valuable insights into the fitness outcomes of migratory birds. In urban areas, for example, bird arrival dates may closely match or even exceed those in rural areas due to recent environmental changes. These findings suggest that migration habits of birds may have changed more rapidly in response to urbanization. Urban areas experience environmental changes, such as earlier and faster plant phenology and increased abundance of invertebrates, which can positively influence the timing of bird migration. Consequently, urban areas may attract migrants earlier than rural habitats. However, it is important to note that most studies and reviews examining these patterns are based on correlations, and alternative explanations should be considered. Clear evidence for genetic modification as a causative factor is often lacking. Phenotypic plasticity, as a covariate in analyses, can weaken the relationship between the actual causative environmental factor and bird responses. Additionally, the ability of birds to hide in large geographical areas during migration poses challenges in studying migration timing. This makes it difficult to identify the specific environmental variables that drive migration patterns. Bird migration modeling, coupled with geographic information analysis and technology-based approaches, offers new opportunities to study the diffusion and movement of birds in relation to their environment. Understanding their sensitivity to environmental changes, as well as the potential interactions with other organisms like ticks and tick-borne pathogens, can provide insights into the spread of diseases and the monitoring of changes in climate and weather conditions. While birds have the ability to adapt their behavior to selective climate and environmental changes, the rate and extent of adaptation depend on factors such as population size, genetic variability, intensity of selection pressures, and the rate at which environmental changes occur. Factors like habitat destruction, land use change, and climate change pose significant challenges and can lead to losses in migratory bird populations. In summary, modeling bird migration, employing geographic information analysis and technological tools, and monitoring environmental changes and their impacts on migratory behavior and associated pathogens can provide valuable insights and help address the challenges faced by migratory birds in the face of anthropogenic and environmental changes.

7. CONCLUSION

Your results indicate that seasonality is the primary driving force behind bird migration worldwide. Migration is seen as a behavioral response to seasonal changes, allowing migratory species to maintain a more favorable energy balance throughout the year. This behavior is observed consistently each year, occurring between the same places. Birds exhibit high mobility and their migrations are often predictable. Numerous studies have shown that migration is influenced by large-scale climatic factors and variations. Birds display high levels of phenotypic plasticity, meaning they can alter their phenotype in response to different environmental conditions. This plasticity allows populations to adapt quickly to changing circumstances. Several factors contribute to the motivation for migration. As winter approaches and temperatures drop in breeding areas, food resources become scarce, prompting birds to migrate in search of more favorable conditions and abundant food resources. Availability of food plays a crucial role, especially for insectivorous species that follow seasonal patterns of preferred food sources. Breeding requirements also influence migration. Many bird species have specific nesting requirements and seek out areas with suitable nesting sites, abundant food resources, and appropriate environmental conditions for successful reproduction. They migrate to areas that provide optimal breeding conditions and access to necessary resources. Birds rely on various environmental cues to navigate during migration. They utilize celestial cues such as the position of the sun, stars, and Earth's magnetic field to maintain a consistent heading and navigate accurately over long distances. Hormonal changes control the timing of migration in birds. Changes in hormone levels, such as melatonin and gonadal hormones like steroids, play a key role in regulating migratory behavior. These hormonal signals induce physiological changes in birds, preparing them for migration or prompting their return to breeding grounds. Migration behavior also has a genetic component.

Some bird species inherit migratory behaviors from their ancestors, and these behaviors are passed down through generations. Genetic factors can influence migration timing, duration, and direction among different bird populations. Overall, your findings highlight the importance of seasonality, food availability, breeding requirements, environmental cues, hormonal changes, and genetic predisposition in driving and shaping bird migration patterns.

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