Impacts of Climate Change on Birds and Measures

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Abstract: The global climate is increasing significantly, and the impact of climate change on biodiversity has become a hot issue. The climatic environment is essential not only for human survival and development but also for the survival and continuation of the entire biological community. As an indicator of the environment, the Birds can reflect ecological changes sensitively, and the merits and demerits of the eco-environment also directly affect the survival of birds. In this article, the major changes in the distribution, migration, breeding, and population size of birds under global warming are summarized. Under the influence of climate change, the distribution of birds shifts to higher latitudes or higher altitudes. The spring migration of birds is earlier than before. Breeding and non-breeding sites are not moving in the same way, and the distribution of birds is gradually decreasing. The spawning period of wild birds is earlier, and bird populations are reduced or even extinct. Finally, this paper proposes some suggestions for coping with climate change by combining domestic and international research experience and practical cases. In the context of global climate change, the international community should attach great importance to climate issues and actively cooperate with each other in compliance with international conventions. Citizens need to increase their awareness of environmental protection. Scientists develop clean energy and pollution control technologies. In the future, we should focus on the impacts of climate change on birds and establish a long-term effective monitoring system.

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1 INTRODUCTION

The global climate is undergoing significant changes. The Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) shows that global temperatures are generally rising, with an average temperature increase of 0.74 °C over the last 100 years; the rate of warming during the past 50 years is almost double that of the previous 100 years (A review of the practical problems resulting from the impact of the climate warming on birds, 2001). Regional changes in rainfall have also occurred, with a 5-10% increase in rainfall in the northern hemisphere mid-and high-latitude regions, as opposed to a 3% decrease in rainfall in the tropics and subtropics (A review of the practical problems resulting from the impact of the climate warming on birds, 2001). In recent years, the impact of climate change on birds has received increasing attention, and a recent report by the World Wide Fund for Nature (WWF) indicates that the survival of most birds is under threat due to global climate change (A. Suman, 2021). Climate is one of the environmental factors affecting the survival of organisms. The increase in temperature will have an impact on species, mainly in terms of changes in species distribution, phenology, and population sizes, such as the distribution of some plants and animals, the germination and flowering periods of plant seeds, and the migration and breeding periods of animals will change to different degrees (Miller-Rushing, 2008). Birds are one of the most active and visible components of the ecosystem. As birds are highly sensitive to climate and weather changes, the particular reason for this circumstance is their high mobility.

Birds have commonly been viewed as pioneer indicator species of the effects of climate change on ecosystems (HITCH, 2007). Birds have historically experienced multiple climate changes and have adapted to their ecological habits. Climate change has been identified as a critical driver in the formation of bird migrations (Beale, 2013). The analysis of more

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than 1,700 species revealed that recent changes in biological distribution are consistent with climate change predictions, with the global range shifting 6.1km poleward every 10 a and spring phenology advancing 2.3 d every 10 a (Visser, 2001). Whether many higher organisms, including birds, will be able to adapt to the rapid climate change is still unknown. Therefore, the survival prospects of birds are not optimistic. Scientists have conducted numerous studies on the impact of climate change on birds. A recent study by the University of York increased the rate of movement by a factor of 2-3, suggesting that species such as birds move 16.9 km to the poles and 11.0 m to higher elevations every ten years (Both, M.E.J.P.o.t.R.S.B.B.S. Visser, 2005). It has been discovered that warming has shifted the distribution of many bird species to polar regions or high altitudes.

This paper investigates the effects of climate warming on bird migration, breeding, population size, population distribution and provides a reference for further understanding of the effects of global climate change on bird ecology. This article also proposes a series of measures to mitigate global warming and provide environmental protection for birds' normal survival and reproduction.

2 IMPACT OF CLIMATE CHANGE ON BIRDS

2.1 Changes in the Migration Period

The impact of climate change on the living environment of birds is multifaceted. The influence of climate warming on the choice of spring migration time of birds is closely related. Under the influence of climate warming, the spring migration period of birds has changed significantly. In general, climate change has different effects on the migration timing of short- and long-distance migratory birds, e.g., species wintering south of the Sahara (after long-distance migration) have been migrating earlier in recent years. Compared to species wintering north of the Sahara (after short-distance migration), which have delayed their fall migration (Both, Bouwhuis, 2006). The migration time of birds that fly to southern Lithuania for wintering is earlier for short- and long-distance migratory birds. In contrast, short-distance migratory birds leave their breeding grounds at a more variable time than long-distance migratory birds (Field, 2007). For example, the migration period of the field sparrow bunting is about 17 days earlier per decade (Parmesan, 2003). This remarkably important trend was also found by Takuji Usui et al. that the migration time advances with time. Takuji Usui et al. also found this very substantial trend of earlier migration over time. The tendency for early spring migration was significant at higher temperatures (Thomas, 1999).

Miller-Rushing et al. studied the interaction term between U.S. temperature and mean arrival date and overwintering area, showing that migration times of species overwintering in the United States, Central America, and the Caribbean tended to arrive earlier in warmer years (Butler, 2010). In contrast, migration times of late-arriving species in the United States continued to change more rapidly with each unit change in temperature. In each decade, the earliest recorded spring arrival date was 0.20 days later for each species. In contrast, the mean arrival date for birds of each species was 0.78 days earlier per decade (Butler, 2010). The autumn departure period of birds has also changed, but changes in the autumn migration period are more difficult to monitor and more complex, occurring both earlier and later (Miller-Rushing, 2008); (CHINESE JOURNAL OF PUPULATION, RESOURCES AND ENVIRONMENT, 2006). In contrast, Gordo et al. found that the migration of birds from the Southern Sahara to their breeding grounds in Spain was delayed due to the warming of the wintering grounds (Consistent response of bird populations to climate change on two continents, 2016).

2.2 Breeding Changes

The spawning period of some birds has advanced compared to the past. After studying 23 populations of spotted grouse in Europe, Both et al. found that nine species had an earlier egg-laying period, which was associated with warmer spring temperatures (CHINESE JOURNAL OF PUPULATION, RESOURCES AND ENVIRONMENT, 2006). Changes in the spawning period of the birds were mainly related to changes in peak food abundance. Due to climate change, the flowering period of some plants and the breeding period of insects may advance. Such changes are inconsistent with physical changes in birds, altering the original normal food chain relationships (Walther, 2002); (Crick, 1997), resulting in the synchronization of adult or juvenile birds with food availability and affecting their survival (Crick, 2004). Food factors are an influential cause of bird reproduction. Visser et al. found that climate change altered the peak abundance of food caterpillars in greater parus, ultimately leading to

changes in the breeding season of greater parus (Chen, 2011). Second, short-distance migratory birds are vulnerable to temperature changes. Thus, in general, the spawning period of short-distance migratory birds is significantly more variable than that of long-distance migratory birds (Influence of climate change on the abundance, distribution and phenology of woodland bird species in temperate regions, 2010). Even though long-distance migratory birds adapt to the effects of climate change, they also change their migration period (Luhas, 2021). If spring temperatures continue to rise, this shallow response of migration timing to spring temperatures may act as a hard constraint on the response of spawning dates to breeding site temperatures, thus placing migratory species at a disadvantage relative to resident species (Thomas, 1999).

2.3 Population Size

Climate change not only changes the distribution and phenology of species but also affects their population changes, making populations smaller or even extinct. Møller et al. found that birds that migrate long distances do not adjust their migration period in time to adapt to the new environment (Thomas, 1999). Gasner et al. used models to predict population changes of Mesoamerican birds under future climate scenarios showing that almost half of the species' populations will decline over the next century, with a few species trending towards extinction (Wormworth, 2006). The frequent occurrence of extreme weather events, the spread of diseases, and the invasion of exotic species due to climate change also contributed to the changes in bird populations. Extreme weather events affect the migration and breeding success of birds (Sanz 2010). McKechnie and Wolf predicted that warming-induced heat waves would increase bird mortality in desert areas by 2080 (Sanz 2010). According to Garamszegi's study, climate change has increased malaria incidence in birds, leading to population declines (Jenni, 2003). Some competitive exotic species also take the opportunity to invade, leading to bird diseases, reduced food availability, and population declines (Influence of climate change on the abundance, distribution and phenology of woodland bird species in temperate regions, 2010).

2.4 Distribution Effects

In a natural state, the distribution areas of birds are dynamic and flexible, even in the absence of climate change. Many factors affect the spread and distribution of birds. When climate change makes the original habitat no longer suitable for survival, it will force many species to shift and open up new territories. For birds, climate warming is the dominant influence in changing their range. Theoretically, such dispersal and distribution should be random. However, an obvious rule can be found from the reports of new records of bird distribution in recent years. The range of many bird species is expanding northward, and this trend has increased in recent years. A plausible explanation for the above is that climate warming is causing birds to move northward in their range. In Europe, Thomas and Lennon studied changes in the distribution of bird breeding sites in Britain. They found that species in the northern region had moved an average of 18.9 km northward by analyzing distribution data over the last 20 years (Joshi, 1992). For North America, Hitch and Leberg studied changes in the distribution of 56 bird species and found that birds in the northern range did not expand southward, while birds in the southern region moved northward by 2.35 km per year (Garamszegi, 2011). Global warming will lead to a significant reduction in the range of bird populations, which may lose their entire range in the future (La, Sorte, 2017). Steen et al. analyzed data from breeding bird surveys. The distribution of five common waterfowl species in the Prairie Pothole Region (PPR) of the United States was predicted to decrease by 64% for these five species. However, 100% of the habitat would be lost for the black-faced vireo (Porzana Carolina) 100% of the habitat would be lost for the American bittern (Botaurus lentiginosus) (Gasner, 2010). Jie Liang et al. evaluated the habitat changes and populations of seven orders and 23 different species of the IUCN Red List of migratory birds from 2014 to 2017 (2014-2017) based on the maximum entropy approach (MaxEnt) model. Habitat changes and population center shifts. Most of the individual species in the study will move more than 50 km, and all species will move to more suitable sites (Gasner, 2010).

Table 1: Migration of Migratory Birds (M.R. Gasner, 2010).

Orders	Shift direction	Shift distance (km)
Total migratory birds	Northeast	51. 01
PODICIPEDIFORMES	Northeast	49. 00
CICONIIFORMES	Northeast	24. 88
GRUIFORMES	Northeast	66. 17
CHARADRIIFORMES	Northeast	52. 74
LARIFORMES	Northeast	73. 63
PELECANIFORMES	Northeast	43. 55

3 MEASURES AGAINST GLOBAL WARMING

3.1 International Community and Government Policies

Currently, global climate change is receiving widespread attention from the international community. Globally, 192 countries have joined the UN Framework Convention on Climate Change (Jonzen, 2006), a global climate protection agreement, and signed the Kyoto Protocol in 1997, pledging to jointly reduce greenhouse gas emissions and help vulnerable regions cope with the disasters caused by warming by 2012 (Gordo, 2010). Formulate supporting laws, regulations, and standards, and improve fiscal, tax, price, financial, and other policy measures. Improve the management system and monitoring and implementation mechanism. In particular, increase the support and backing in finance and science and technology. The EU updated its bioeconomy strategy in 2018 to accelerate development at the national level and keep the economy in balance with the living world. Greater emphasis has also been placed on increasing the resilience of ecosystems and ensuring their contribution to climate change mitigation and biodiversity conservation. However, the responsibility for mapping the interactions between priority setting and goal setting rests with national governments. More than 40 governments worldwide have adopted explicit national strategies to advance their bioeconomy sectors (Udomsri, 2011).

3.2 Responsibility of Citizens

Energy-saving, emission reduction, and combating climate change also require the participation of all human beings. Coping with climate change is the shared responsibility of all human beings, and each of us should participate in it. The theoretical framework in Figure 1 presents the relationship between urban residents' behavioral responses to climate change and their influencing factors. It introduces the concept of the mechanism of the relationship between the influencing factors and the behavioral responses of urban residents. Thus, the reactivity and behavior of citizens in response to climate warming are also crucial. As individuals, we must change our consumption and lifestyle to a low-carbon lifestyle to solve the climate change crisis. We can incorporate relevant content into textbooks and disseminate relevant knowledge. Introduce the relationship between energy conservation and climate change and people's daily lives through various media and introduce climate change's immediate and long-term effects. Call on the public to reduce greenhouse gas emissions through energy conservation and emission reduction in all aspects of life. Encourage the public to monitor wasteful behavior and illegal emissions (Usui, 2017). Through the participation of all people, national policies should be transformed into voluntary actions of each citizen.

3.3 Scientific and Technological Means

Adaptation to climate change is one of the components of the response to climate change, and scientific and technological progress and innovation are important to support adaptation to climate change. Environmental technologies are divided into two basic categories: pollution prevention technologies and pollution control technologies used after pollution has occurred. Clean technologies are technologies that ensure the prevention of pollution before it occurs through organizational and technological changes. Burning fossil fuels, such as oil, coal, etc., or cutting down forests and burning

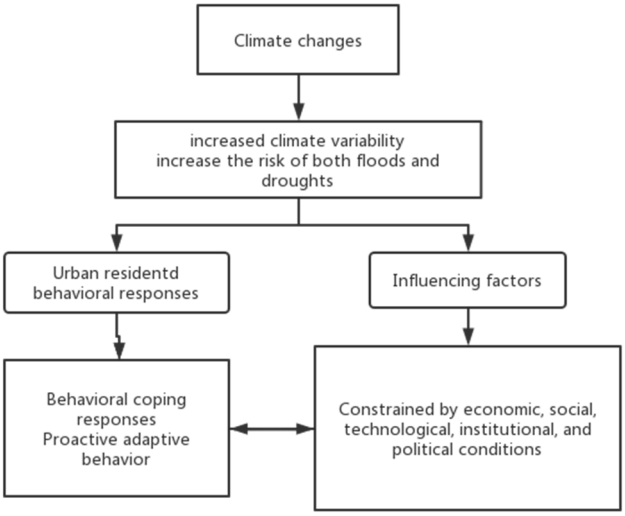

Figure 1: Garbage Floating on the Ocean Surface (T. Usui, 2017).

them produces large amounts of carbon dioxide, contributing to climate warming. Clean energy is an environmentally friendly source of energy that is more environmentally friendly, emits less, and pollutes less than traditional fuels. Biomass and municipal solid waste (MSW) is widely accepted as an important local renewable energy source and is one of the largest renewable energy sources in the world. MSW incineration in Thailand has a sustainable potential and direction in mitigating climate change and promoting biomass-based electricity production (U.N.F.C.o.C.C.J.R.o.E, 2010). Renewable energy plays a critical role in climate change mitigation and adaptation in highly climate-sensitive countries such as Nepal. Nepal has installed micro-hydropower projects, solar energy, improved cookstoves, biogas technology, improved water plants, and wind energy to mitigate and adapt to climate change. The adoption of renewable energy technologies in Nepal has reduced greenhouse gas emissions and enhanced carbon sequestration (Steen, 2012).

4 CONCLUSIONS

Climate change in this century is a long-term and gradual process, and its impact on human and global ecology is undoubtedly enormous. Since the impact of climate warming on the world's economic life, agricultural production, and ecological environment is still expanding, it is of great importance to use birds as indicator species to monitor the evolution of the Earth's environment. In the context of climate change, the geographic range of birds is shifting to higher latitudes. The spawning period of birds has been advanced during the breeding period, and the population size has been gradually reduced. In the face of the increasingly severe ecological hazards caused by climate change, it is possible to mitigate the warming problem from the government, people, and technology. In the future, a complete bird data monitoring system can be established, integrating data collection, uploading, sharing, and research. Scholars conduct long-term monitoring and investigation on a particular object and carry out several large-scale land bird monitoring studies. New prediction and assessment methods are studied and researched to accurately predict trends in the world's birds under future climate scenarios. In the future, we should combine modern research techniques to improve management methods, strengthen education and awareness, and better respond to climate change's harm.

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