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Effect of climate change on birds in mangrove

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Abstract. In the past 20 years, global climate change has attracted great attention from scholars around the world. The mangrove ecosystem is mainly situated in the inter-tidal zone of the tropical and subtropical coasts. It is a fragile and sensitive ecosystem, as well as one of the typical marine ecosystems which could be first affected by global climate change. Mangrove birds are an indispensable part of the mangrove food chain, and they are also greatly affected by climate change in mangroves. This article will briefly outline the important role of mangroves in ecosystems and reveal the effect of global climate change on mangrove ecosystems from four main aspects: global warming, seawater chemical composition, increase in atmospheric CO2 concentration, and extreme weather, and finally describe responses of mangrove bird to serious climate changes. Global climate change will bring opportunities and challenges to the research and protection of mangrove birds.

Keywords: Climate change, mangroves, birds

1. Introduction

Mangrove forests as environment with high animal diversity provide essential ecosystem services such as erosion prevention, carbon fixation, and shoreline protection [1]. Such ecosystem is built upon the foundation of mangrove trees such as Avicennia marina [2]. Those trees have special adaptations such as secreting salt from their leaf and tolerance to low oxygen due to constantly waterlogged soil [2]. Although mangroves represent less than 1 percent of all tropical forests all around the world [3], they are ecosystems with great value that provide a range of important goods and services. These outputs contribute significantly to the livelihoods, reproduction and security of coastal communities contribute.

Climate change has been causing dramatic effects on ecosystems around the world. The mangrove ecosystem is located in the intertidal zone of the tropical and subtropical coasts. It is a fragile and vulnerable ecosystem, as well as one of the typical marine ecosystems which could be first affected by global climate change. The climate changes which can have impact on the mangroves includes change in seawater chemistry, more frequent extreme weather events, and rising sea level, etc.

Many researchers have studied the specific impact of climate change on mangroves or the impact of climate change on birds. However, bird species in mangroves are different from other ecosystems and may also be affected by climate change differently. By synthesizing recent research and papers, this study will discuss and summarize several impacts of climate on mangrove which can affect mangrove animals significantly, as well as the concrete presentation of climate impact on mangrove birds.

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Figure 1. Avicennia marina.

2. Ecological role of mangroves

Nowadays, there are nearly 17,000,000 hectares of mangroves all over the world, mainly distributed within the 25°C isotherm in both two hemispheres [4]. Mangrove forests as environment with high animal diversity provide essential ecosystem services such as nursery role and shoreline protection.

2.1. Nursery role

Mangrove habitat serves as important nursery place for a variety of species such as crustaceans, fishes, insects and birds. The essential factors include food, shade from the canopy, hiding space.

To crustaceans, the unique advantages of mangroves come from their complex prop and aerial roots, where soft-shelled crustaceans can avoid predation by large fish during ecdysis [5].

In mangroves, littoral macrophytes and seagrass beds are popular spawning sites for adult fish, while numerous microalgae provide high abundant food for both adult and juvenile fish. Particularly, to juvenile fish, mangrove forests provide more substantial and reliable habitats for them to hide [6].

Mangroves is an overlooked hotspot for insect diversity [7]. Insects are one of the biological components that make up the mangrove ecosystem and play an important role in the food chain [8]. Larvae of a large proportion of arthropod develop in sediments. They may live on plants and fungi in forest habitats or mud flats.

As so many crustaceans, fishes and insects species in mangroves, birds have sufficient food to thrive. A total of 42 bird species was found in the Sungei Mandai mangrove forest in Singapore [9]. Kingfishers and Striated Heron were found in large numbers in Australian mangroves[10]. The quality of habitats greatly affects the number of mangrove bird species, which include the plant species richness of mangroves and the distribution of food resources (seaside, streams, shrubs, etc.).

2.2. Shoreline protection & land-building capacity

Shorelines are highly dynamic landforms that change in space and time with fluctuations in related factors such as tidal currents, storm surge events and sea level changes.

Over the past few years, the problem of severe erosion along the coastline of the Mekong Delta has become increasingly important. Besset et al. found that one of the issues related to this question is its relationship with mangroves [11]. Mangroves promote coastal growth when fine-grained sediment sup-

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plies are plentiful. Large and healthy fringe mangrove strips can effectively protect shorelines by inducing more efficient dissipation of wave energy than narrower fringes. Nowadays, the worldwide disappearance of mangroves has exacerbated ongoing shoreline erosion.

3. Response of mangrove to climate change

The total area of mangroves in China has decreased slowly in recent years. The mangrove area was 21612.9 hm2 in 2019 [12] and was about 22800 hm2 in 2001[13], which had reduced by over 5%. The decline of mangroves is mainly due to three aspects: excessive salinity, devastation of storms and unsuitable temperature.

There may be different causes of the high salinity in different regions. Higher temperatures and stronger sea breezes than ever before have exacerbated the evaporation of seawater where the mangroves live, leading to higher salinity in the mangrove forests located along the lagoon called Ensenada de La Paz in Baja California Sur, Mexico [14]. Under soil salinity stress, plants will not absorb sufficient water and mineral nutrients, leading to malnutrition, low chlorophyll content and then affecting the effectiveness and efficiency of photosynthesis. At the same time, the general trend of excessive salinity is that the respiration consumes excessive energy, and the net photosynthetic productivity is low, which is not conducive to plant growth. In Brazil, decrease in annual precipitation and damming of rivers aggravated the coastal salinization, causing mangroves, for example, Amazon Macrotidal Mangrove Coast (AMMC), to be eroded and migrate to land [15].

In North America, Africa and Asia, storms uprooted trees and killed large numbers of mangroves [16]. Temperature affects the ability of mangroves to absorb CO2. Currently, the distribution of many mangroves is latitude limited by a minimum temperature of 16°C in the coldest months. Mangroves have expanded into salt marsh areas in high latitudes in both hemispheres due to rising temperatures and fewer frost events. However, plant mortality had been observed during severe winters at extreme latitudes [15].

In addition to the above factors, rising sea levels will also lead to the death of mangroves. Although mangroves are composed of mostly coastal plants near water, due to high erosion rates and sea-level rise, increased submerged periods can lead to leaf stomatal closure with longer time and chloroplast degradation, resulting in reduced photosynthesis rates. Hypoxic conditions and mortality can quickly appear if sea level rise persists [17].

4. Effect on birds in mangroves

Mangrove forests provide shelters for many bird species all over the world. According to statistics, about 130 species of birds (both resident and migratory) are known to be observed in mangroves and mudflats in Singapore [18] and in other parts of Southeast Asia [19, 20]. Birds connect multiple species in the biosphere through foraging behaviors and demands for habitat or resources. However, climate change is not only affecting mangroves, but also taking a huge toll on the birds that live in them. Global warming caused by greenhouse gas emissions has increased Earth's temperature. High temperatures have caused many birds to nest and lay eggs nearly a month earlier than their breed time period 100 years ago.

4.1. Nesting of land birds

Mangroves are used as nesting grounds by herons, storks and owls. The gradual disappearance of mangroves means that these birds will also lose their habitat.

At the same time, extreme weather has a huge impact on bird nesting. Birds sometimes rebuild their nests repeatedly after being destroyed by typhoons, thus affecting their reproductive efficiency. Planting and protecting mangroves can help improve this situation. Hurricanes Opal and Roxanne destroyed about 1,700 hectares of mangrove forest in Mexico in 1995. Since then, Mexico started to pay attention to implementing hydrological restoration measures in order to protect the mangroves and their biodiversity. In 2019, Canales-Delgadillo et al. did an assessment and found higher bird species richness and relative abundance in disturbed and restored sites [21].

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4.2. Breeding colonies of seabirds

Another impact is that the breeding colonies of seabirds shrinks, which includes subsidence of coral cays due to the rising sea levels. The species diversity and richness of landbirds in mangroves were significantly higher than those of waterbirds, which may be due to differences in habitat and mangrove vegetation diversity [22]. Landbirds can nest in trees, bushes, herbs and ferns, while seabirds basically rely on marshes and open water. For example, cormorant species tend to choose coastal areas as nesting sites, such as the little cormorant and the little black cormorant [23]. In one of the research projects, most cays are less than three meters above the high-water mark, while low-lying cays could be flooded during storm surges or even at high tide in the future [24]. However, most seabirds prefer low-lying cays which means that young birds and unhatched eggs struggle to survive in flooded nests.

4.3. Feeding

Aquatic plants provide habitat for invertebrates such as oligochaetes, planarians, leeches, arachnids, insects, and crustaceans. These invertebrates are important food resources for water birds [22]. The feeding range of different birds in Mangroves of the Yucatan Peninsula includes 10 to 20 species of fish [25]. Of these birds, egrets and great egrets will also feed on non-fish species (eg, crustaceans, insects, amphibians, etc.). Neotropical cormorants usually feed on fish, mollusks, amphibians, insects, and crustaceans.

Climate changes caused significant impact on the food resources, for example, some species of fish and insects have dwindled sharply because of the increasing temperatures or changes in seawater chemistry, and then birds will also starve to death.Species such as Acartia tonsa, a copepod zooplankton which can be found in mangrove forest near India, have shown a declining trend in population density due to changes in more distinct dry and wet season which led to higher salinity and phosphate concentration[26]. The composition of the crustaceans' population in mangrove forest is also under the influence of climate change. As the precipitation in wet season increases annually due to climate change, crabs as mentioned above may be forced to migrate and abandon their caves which put them under great survival pressure [27].

5. Species interaction

Climate change can cast notable and sophisticated impacts on wild life on Earth. By being involved in intricate interactions within various organismal communities, climatic fluctuations can profoundly influence species interactions, eventually shrinking species' population size. Butterflies are delicate insects which respond sensitively towards climatic changes. Climate change can affect butterfly interaction with their host flora species, causing mismatches and substantially threatening population continuation. Despite direct and immediate effects of climatic fluctuations on butterfly species, indirect impacts via intermediate species also exist, such as in host-plant interconnections. Butterfly and its host vegetation species are sensitive to temperature fluctuations. Meanwhile, the ecosystems in which they habitat are close ones, meaning butterfly and herb species are restricted in migration sites. [28]. The theory such that climatic fluctuations is going to probably confine the habitat shifts of a type of mountain butterfly in the Alps has been confirmed. It is tested that climate change may shrink butterfly population and range shifts via affecting host plant distribution [29]. To test for direct and indirect impacts climate change have towards butterfly species, simulations have been conducted to assess whether the distribution of a butterfly has been altered with or without host plants alterations. Climate change can disrupt species interactions, eventually casting a negative effect on biodiversity.

6. Conclusion

Climate changes, such as rising temperatures, higher sea levels and more frequent extreme weather, have more than one impact on mangrove birds. Birds may forage less food, have less wood or shrubs to build their nests, or their shelters are destroyed by storms more frequently than ever. In addition to advocating for the protection of the environment from more drastic changes in the global climate, we can do something for mangroves and mangrove birds. Breeding and roosting habitats can be provided

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to birds through human intervention. Artificial nests can be deployed in mangroves to serve as a refuge for birds in inclement weather, and modern artificial nests can help protect young birds from extreme weather conditions. As a result, deploying artificial nests will increase the possibility of bird breeding success. On the other hand, where natural coral shoals are degraded, artificial coral shoals can be applied to increase nursery and prey sites for seabirds. Usually, coral reefs form naturally without human intervention and are made of rocks and coral skeletons. Artificial reefs can be made from materials such as rubble. This study summarizes the impact of global climate on mangrove birds in recent years according to previous studies, which tell the impact of climate on mangroves and the impact of various factors on the survival and reproduction of birds. Some conclusions of this study are inferred from the analysis of past research and are lack of some specific data. It is hoped to provide a hypothetical basis for future investigations on the impact of climate change on mangrove birds. We all hope that the birds in the mangroves can be more diverse and prosperous..

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