Effects on birds in natural and man-made climate change scenario:Aneotropical perspective

Abstract

Birds, with their vibrant plumage and melodious songs, serve as nature's living poetry, enriching our world with color and harmony. In the current scenario they are facing both natural and anthropogenic climatic variations. From alterations in migratory patterns and nesting behaviors to habitat degradation and pollution-induced stress, avian species navigate a complex landscape of challenges.According to the study, climate change has resulted in earlier egg-laying times, altered bird habitat, increased risk of disease transmission, reduced food availability, an earlier spring migration, and a decline in bird populations. Integrating findings from diverse ecological studies, this review explains the impacts of natural climate variations and human-driven environmental changes on bird populations. Recognizing the cumulative effects is key for developing adaptive conservation strategies to preserve avian biodiversity.

Keywords: Climate change, Breeding, Temperature variations, Phenology, Migration, Disease

Introduction

Climate change is widely acknowledged as one of the most important and prevalent challenges to biological diversity. Birds are great leading indicators of weather change impacts on biodiversity since they are a well-studied, globally dispersed group (Sekercioglu et.al., 2012). Numerous researchers have investigated the effects of climate change on egg-laying timing, dispersal, abundance, and migration in various bird species and areas.Several experts have said that climate change has the biggest influence on bird species in high latitude regions (Li et al., 2022). Moreover predicting whether fast body size reductions occur in response to rising temperatures is critical for understanding how climate change may affect the phenotypic and ecological dynamics of species in a changing world (Weeks et al., 2020). In addition to natural climatic change, anthropogenic pollutants have a significant impact on avian populations.Various pollutants such as PAH (polycyclic aromatic hydrocarbons), PCB (polychlorinated biphenyls), halogen containing flame retardants, chemicals like benzene and toluene, sulphur dioxide, nitrogen dioxide, brominated diphenyl ethers, pesticides, rodenticides, organic pollutants, fungicides, pharmaceuticals, plastic derived contaminants, heavy metals (cadmium, chromium, lead, and mercury), and radiations that shows a negative impact on bird abundance, species diversity, feeding, structural abnormalities, physiological changes, breeding behaviour, foraging behaviour, fledging, hormonal and immunological toxicity (Richard et al., 2021). Our primary

objectives are to describe the current and possible consequences of both natural and man-made climate change on bird populations.We have covered many consequences has on bird species including, morphological changes ,physiological changes, effects on migration, habitat loss, effects on breeding, population decline and illness risk, along with used recent scenarios to demonstrate how changing climate promotes these changes.

2. Various effects of climate change on birds

2.1. Morphological changes

In a recent study physical changes in birds that live, breed, or migrate through Israel were discovered. Several bird species either decreased in bulk or expanded in body length, but rarely both. Both modifications result in a higher surface area-to-volume ratio and a poorer physiological condition (Dubiner and Meiri, 2022). According to research, higher temperatures during nesting have been proven in experiments to reduce body size of mature bird as a consequence of developmental plasticity during nestling growth (Andrew et al., 2017). Similarly increasing annual summer temperature indicates consistent declines in body size in individuals of 52 North American migratory bird species over a period of 4 decades (Weeks et al., 2020). Morphologic observations on a non-migratory bird group in the Amazonian primary rainforest, which is undergoing more harsh climate, was recorded over four decades. The mean mass of all 77 species was lower and 1/3rd of the species simultaneously grew wing length, resulting in a drop in mass/wing ratio (Jirinec et al., 2021). In a study, the researchers wanted to see how urbanization affected a variety of physical features in great tits from southern France (Montpellier) at different life stages: nestling, yearling breeder, and elder breeder. Results showed that urban birds were smaller than woodland birds. Great tits had shorter tarsi, shorter wing and tail lengths than forest birds at each life stage (Caizergues et al., 2021). Moreover, heavy metals like Pb, Zn, Cu, and Cd and calcium levels negatively impacted morphological factors like wing, tarsus, and toe length, in various tissues and fecal matter of tree sparrows (*Passer montanus*) , that were evaluated in a polluted location and a comparatively non-polluted location (Ding et al.,2022). Radiation has a harmful impact on birds, according to a study at places nearby Chernobyl moderate doses of radiation has a negative impact on brain growth, and as background radiation increases, brain size reduces (Møller et al., 2011).

2.2. Effects on Breeding

Extreme weather may have an effect on the period of egg laying in birds, with preliminary research indicating that certain birds are producing eggs sooner than usual. It can have an impact on where birds reproduce. Scientists studied the breeding regions of British birds during a 20-year period and discovered that 59 species of southern British birds migrated their breeding locations northward over a period of rising temperatures. Warmer temperatures are also causing birds to persist at their nesting locations for somewhat longer than before (Li et al., 2022). Researchers evaluated 25 *Ficedula* flycatcher populations from Europe. Local spring temperature had a substantial influence on laying date in 20 out of the 25 studied groups. In colder places, the laying date was delayed and vice versa (Both et al., 2004). Weather change in California's Central Valley, mainly enhanced nesting season warmth and spring time moisture, that is expected to have a wide-ranging and primarily negative influence on cavity-nesting songbird fertilization rates and offspring mass (Riggio et al., 2023).Temperature and changing climate have the potential to disrupt reproductive success in a wide range of bird species and habitats. Sedentary birds and other bird species that migrate short distances have longer egg laying periods than long-distance migrants. This might be because they are unable to adapt the changed conditions in their breeding grounds. Reproduction in multi-brooded or stationary species will continue to grow with the commensurate increase in warming, however the opposite impact may occur in migrating or single-brooded bird species (Egwumah et al., 2022). In addition radiation (microwaves from mobile tower) exposure lowers the proportion of hatching and egg shell thickness in birds such as quail and crow, according to research (AP, 2022). Moreover, effects of various pollutants were recorded, such as increased levels of perfluorinated sulfonates (PFSAs) and perfluorinated carboxylates (PFCAs) influence eggshell thickness, whereas elevated levels of perfluorodecanoic acids (PFDAs) were linked to lower a sooner egg laying, and a decrease in overall breeding progress (Groffen et al., 2018). Just a few researchers have looked herbicide effects on organisms. Glyphosate is one of the widely utilized herbicides in the world, and residues may get transferred directly from parent to egg, influencing the development of the embryo (Ruuskanen et al., 2020). Furthermore, fungicides have also been reported to negatively impact bird species. Toxicity developed in chickens after they were provided a fungicide containing diet. As a result, eggs with softer shells were laid (Guitart et al., 2010). Also, when a red-legged partridges species were exposed to these fungicides (Tebuconazole, commonly used for seedling management in farming), it negatively affected their

reproductive success (Lopez-Antia et al., 2021). In the island of Tenerife, significant amounts of an insecticide (p,p′-Dichlorodiphenyl dichloroethylene) are frequently observed in eggs of a bird species (common kestrel), and a rise in the concentration of insecticide associated with a drop in eggshell thickness (Buck et al., 2020)

2.3. Habitat destruction

Climate change is usually thought to have pushed the distribution of numerous species towards mountain peaks and the poles. Climate change-induced habitat modification is also seen as a serious hazard to the existence of various bird groups (Li et al., 2022). Moreover, climate variability is raised by greenhouse gases because it increases the quantity of heat and moisture in the environment. This is expected to boost the severity and incidence of severe weather events such as droughts, heat flashes, flooding, tropical cyclones and winter storms (Şekercioğlu et.al 2012).Fire incidence and territory burnt are predicted to rise in many parts of the world as a result of climate change and human habitat modification. One research of tropical Savannah species in Northern Australia found that increasing fire frequency have a negative impact in the expected habitats of nearly all bird species limited to this environment (Reside et al., 2012). In a study it was found that a bird species may be able to adapt to a 2°C increase in average temperature, but if this leads to an increase in severe weather conditions that destroy essential habitat or make foraging difficult, as a result the species may become extinct (Şekercioğlu et.al 2012). Freeman's group also discovered population declines and even disappearance of certain high-altitude bird species in Peruvian highlands, owing to a huge fall in their suitable habitats induced by rising temperatures. They also believe that this shift is the major cause of the extinction of high-altitude species in the tropical Andes, as well as a threat to bird groups in other tropical places (Freeman et al., 2018).

2.4. Increased disease risk

As the changing climate alters the home range of several birds, their chances of catching illnesses are also growing. Temperature variations are highly and positively linked with *Plasmodium* occurrence in birds. A one-degree Celsius rise in worldwide temperatures was associated with a 2 to 3-fold increase in the average incidence of *Plasmodium* in birds. The impact of weather change on the incidence of avian malaria varied by region, with Africa and Europe suffering the greatest consequences (Garamszegi, 2011). Furthermore, rising heat waves caused by variations in the climate allow illness to migrate over higher altitudes and invade birds

that reside there. According to the study, changing weather is raising the temperature in Hawaii, allowing disease to spread to new areas, and thus widening the distribution patterns of avian malaria transmitting. Climate change has resulted in the redistribution of birds, which has contributed in the spread of avian sickness. Mute swan group, having highly infective avian flu H5N1 ,migrated to Western Europe from the Eastern Caspian Sea basin because of an old climate spell (Li et al., 2022). In a study the negative effects of lead contamination on the generation of AIV (Avian Influenza Virus) antibodies were observed in 170 Black-Head Gulls (*Chroicocephalusridibundus*) (Ushine et al., 2023)

2.5. Effects on migration

According to research, temperature affects the time of migration and the selection of migratory places for migrating birds. It was observed that the first arrival date of various birds is inversely connected to the mean monthly temperature, which means that the greater the temperature, the sooner is the arrival (Li et al., 2022). Climate change, according to Harries et al. (2013), causes a shift in migratory period for several birds in Southeast Asia. The rationale for this delay in long distance migration is that rising temperature allows animals to spend more time in northern breeding grounds. He also observed delay in the arrival of the sandpiper curlew *Calidrisferruginea* and Japanese sparrowhawk*Accipiter gularis*, however no difference in the expected arrival of the other species. Bird migratory trends across countries in Alaska, Maine, and South Carolina were monitored in response to temperature variations from 2010 to 2016. Summer resident birds stayed longer as warmth raised in all states except Alaska, but winter resident birds left sooner and stayed for shorter time as temperature goes up (Zaifman et al., 2017). Differences in migration time for long-distance and short-distance migratory birds has been observed, which arrive 13 and 4 days sooner respectively on an average (Lameris et al., 2017). The pattern of differing reactions by migratory guilds has also been documented in Europe, North America, and India, where climate change is regarded as a key cause of change (Rushing et al., 2020). Light pollution mostly relates to nocturnal visible light which has been demonstrated to effect birds. According to study, migratory birds may fly great distances to arrive a light source in completely dark environments, like the ocean, but when encountered, they have difficulty leaving the sphere of light. Such diversions cost them energy and enhance the risks of arriving delayed for feeding sites, which have a detrimental impact on their fitness (Richard et al., 2021).

2.6. Population decline

Worldwide climate change has caused phenological imbalances, which have led in relative population shifts, population reductions, and even eliminations. Higher temperatures are likely to degrade the bird habitat, resulting in a reduced species number. Higher temperatures are also likely to encourage an upward shift of montane species all across the planet, resulting in disappearance of species that only exist on the highest peaks. Temperature increase has caused an escalation of extinction for birds in Peru's isolated mountain locations, as high-altitude species ranges and populations have dropped, and some common mountainside inhabitants have lost from local communities (Li et al., 2022). Research found that rising temperatures are causing population declines or even loss of species of certain common high altitude bird species in Peruvian hills (Freeman et al., 2018). Moreover, researchers observed a drop in songbird species in Arizona, USA, was connected to climate-related snowfall (Thomas, 2010).Through multilevel population models, researchers investigated the influence of several climatic variables on 47 rainforest birds living in the mountains of the Australian Wet Tropics. Bird populations have shifted in response to a significant increase in temperature, which was accompanied by variations in precipitation trends and an increase in intense heat waves in the plains. On the contrary, cyclones and severe droughts have only a minor impact on community-level distribution and abundance (de la Fuente et al.,2023). Researchers observed breeding birds at 400 sites recording a total of 48 species of birds and 13,081 individual birds at Fukushima, Japan during 2011–2017. They discovered that ionizing radiation was consistently inversely linked with number of species and number of breeding birds (Moller and Mousseau, 2019). Lead pollution occurs as a result of the discharge of gross weights that might be consumed by seabirds. Being the most poisonous metal it is reported to kill millions of birds each year, resulting in population decreases and biodiversity loss (Haig et al., 2014). Although research regarding the effects of electromagnetic radiation in bird communities is yet in its early stages, data shows that the number of species dropped following the construction of mobile towers across India. Moreover, every year, cellphone towers in the United States kill millions of birds species by collisions, majority of which are migratory birds that travels at night (Richard et al., 2021). Even though birds are not the intended target species, pesticides are hazardous to them both directly and indirectly, moreover the toxicity of particular chemicals causes significant deaths in exposed birds (Richard et al., 2021). Birds can be exposed by direct contact with agricultural seeds, infected insects, and

polluted water, as well as through spray events, dermal exposure, and preening activity (Vyas et al., 2007). Also, ethoprop (0-ethyl-S,S-dipropyl phosphorodithioate) which is an organophosphate pesticide is commonly employed in British agriculture as an insecticide and fungicide. In 2016, Ethotrop (pesticide) has the greatest toxic load compared to any herbicide and has significant toxicity in birds. Birds are mostly exposed to ethotrophs via diseased prey as well as pellets (Richard et al., 2021). Many experts believe that the usage of diclofenac, an anti-inflammatory medicine, contributed to the precipitous loss of various vulture species during the study period from 2000 to 2003 (Green et al., 2004).

2.7. Physiological changes

Heavy metals including lead (Pb), cadmium (Cd), arsenic (Ar) chromium (Cr), and mercury (Hg) are frequently discharged in the surrounding environment from many man-made sources (Tchounwou et al., 2012).Birds can be injured by pellets from shooting or consuming bullet fragments, which they consume by mistake (Mateo et al., 2007). Birds consume lead beads, which dissolve in their digestive tract as lead salts. When this is swallowed, it binds to subcellular components and impairs the production of hemoglobin's heme group (Espin et al., 2015). The adverse impacts of mercury on avian species have been thoroughly studied. Mercury may create oxidative stress, potentially harming the liver and damaging other body parts (Whitney and Cristol, 2017). Pharmaceutical-induced bird poisoning became a major issue in the beginning of the twenty-first century. Researchers have connected the fall in sub-Indian vulture species to the consumption of Diclofenac, a type of anti-inflammatory drug (Green et al., 2004). This drug was utilized to cure cattle in the Indian sub-continent; however it can induce serious kidney damage in several scavenging species. Although Diclofenac was declared illegal by the governments after the die-off event, it is still widely used illegally, resulting in vulture fatalities (Cuthbert et al. 2016). Moreover, oil contamination can impact both marine and terrestrial birds. The consumption of oil can also harm various internal systems, including the immune system, endocrine system, growth and development, weight, and osmoregulation (Kopf and Walker, 2009). In addition to this plastic is regarded as one of the most widespread hazards to animals. One of the most common ways that plastic endangers bird health is through its ingestion (Moore, 2008). A study showed that Procellariiformes, a group of seabirds seems to be more sensitive towards plastic ingestion as they have tiny gizzards and are unable to vomit absorbed plastic particles (Azzarello and Van Vleet, 1987). In general, radiations have a deleterious impact on

birds. During initial phase of life, avian species are more vulnerable to ionizing rays than adults, causing alterations at cellular and biochemical scale (Harrison and Anderson, 1996). Furthermore, increased radioactivity lowers concentrations of antibody and reduces the amount of WBCs (Bonisoli-Alquati et al., 2009). Additionally, only certain studies have assessed herbicide effects at the organism level. American goldfinches (*Carduelis tristis*) showed changes in metabolism, including changed thyroid hormones related to linuron exposure (Sughrue et al., 2008). Fungicides are another category of disinfectant that is commonly used on plants to combat fungal illnesses. Fungicides can harm non-target organisms and induce acute and chronic impacts on avian species (Aubee and Lieu, 2010). Tebuconazole and Flutriafol, two fungicides, that is common among farmers for treating seeds. Exposure to red-legged partridges (*Alectorisrufa*) resulted in poor physiology (Lopez-Antia et al., 2021). Moreover, Insecticides are most commonly associated with adverse effects on birds (Fry, 1995). The most harmful pesticides for birds include organophosphates, organochlorines, neonicotinoids and carbamates (Mitra et al., 2011). Most common insecticide DDT, which was widely used, has been banned in most industrialized nations. However, certain of its metabolites, such as p,p′-DDE, might remain over time and can alter thyroid histology (Mayne et al., 2005). Pollutants can accumulate in the trophic network, posing a risk to top consumers like aquatic birds. The contaminants addressed above have diverse impacts on avian physiology and behavior, with different responses depending on species.

2.8 Climate change and food availability

Birds rely heavily on insects and invertebrates for their nutrition. Invertebrates, especially insects, are ectothermic creatures that adapt their activity and reproduction according to fluctuating temperatures and rainfall. These species experience changes in their activity and reproduction as a result of climate change. Climate changes are predicted to affect the relative abundance and variety of invertebrates.Bird species will be impacted by shifting invertebrate prey availability (Pierce-Higgins, 2010).Climate change is currently impacting butterfly populations at higher elevations in Northern California (Halsch et al., 2021)."For birds, butterflies are a valuable prey item. Birds will have fewer food sources if there are fewer butterflies. Most likely, the same pattern will arise in relation to other insect species based on their geographic distribution and ecological and physiological tolerances. The success of avian

reproduction is expected to decline in the absence of a consistent, high-quality food source (Osborn, 2023)

3. Conclusion

This review suggests that birds have been discovered to have a significant role in preserving nature's beauty and sustaining ecological equilibrium. Birds are getting more subjected to toxins from our actions, growing urbanization, and habitat degradation. We have discussed rising heat and other pollutants can cause early spring migration, in addition to disrupt bird habitats, morphological changes, raise the possibility of virus infection and various physiological defects. Climate change can also cause decrease in population, habitat loss, sooner egg-laying dates, and reduction in egg shell thickness of certain birds. Conservation scientists should conduct more research and employ control strategy to reduce the consequences of climate change on bird species. Only through collective and decisive action we can hope to mitigate the adverse effects of climate change on birds, ensuring a harmonious coexistence between these feathered inhabitants and our rapidly changing world.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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