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Original Article

Climate Change and Its Impact on Animal Behavior

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Abstract

Climate change, an urgent worldwide phenomenon, is changing the natural behaviour of animal species across terrestrial, freshwater, and marine habitats, and the atmosphere. The warming climate, along with erratic weather patterns, corresponding changes to precipitation, and alteration of seasonal cues from the environment, disrupt the environmental mechanisms animals historically rely on to determine life history activities, such as migration, hibernation, reproduction, and foraging. Alterations in behaviour, while often adaptive, can lead to ecological mismatches, which may compromise biodiversity and/or ecosystem stability. This paper is a thorough review of the ways in which climate change is changing across a variety of taxa. Individual cases such as the Arctic Tern, affected migratory routes and timing, awakening too early from hibernation by mammals, and mismatched phenology in captive and wild-living European pied flycatchers illustrate the diversity and complexity of impacts. The paper also identifies further emerging risks, such as interference with navigation, changes in interactions with species, and changes in aggression mediated by environmental stressors. This qualitative review summarizes the implications of evidence from peer-reviewed articles and reports published by the global community, indicating that changes in behaviour can indicate early ecological stress. It recommends the inclusion of behavioural observations in conservation strategies to improve our understanding of species vulnerabilities and changes in ecosystems. The review argues that although behavioural plasticity provides populations with short-term resilience, species' long-term survival will still rely on their ability to utilize genetic adaptation. It follows, therefore, that conservation policies should include promoting habitat connectivity, protecting climate refugia, and behavioural ecology as considerations to better conserve biodiversity in a changing (i.e., warming) world.

Keywords: *Climate change, animal behaviour, migration shifts, breeding disruption, hibernation, phenology, species adaptation, ecological imbalance, biodiversity loss, environmental stress.*

Introduction

Climate change, driven by increased greenhouse gas emissions, is currently one of the most significant environmental challenges. Although much focus has been placed on the physical effects of climate change, such as melting ice caps, rising sea levels, and extreme weather events, its impact on wildlife behavior is equally critical. Animals rely heavily on environmental cues for vital activities such as migration, reproduction, and foraging. As these cues become increasingly unreliable or altered, animals are forced to adapt their behaviours in ways that can affect individual survival and ecosystem stability. The animals' attempts to keep fit in changing surroundings are shown by these behavioural adaptations, which ask for difficult answers to environmental problems. However, species experience behavioural and environmental problems because of their slow rate of climate change. In addition to genetic adaptation, which takes decades to evolve, many animals accept emotional versatility or rapid behavioural changes in response to environmental changes. Estimating the future of ecological health and biodiversity requires an understanding of personality changes. Action changes are beneficial monitoring tools for conservation efforts, as they can act as early alerts of climate stress before the effects on populations become visible.

An in-depth explanation:
Migration Routes and Timing

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Birds, whales, and caribou are migratory animals that depend on seasonal signals, such as temperature and food availability, to plan their travel. Warming temperatures restored by climate change cause the following:

How Migration is Being Affected by Climate Change:

Early Departures and Arrivals

Increased temperatures result in migratory species experiencing early phenological phases in a wide range of environments. Plants and insects bloom sooner than in past years, especially at northern latitudes, where spring comes early for migratory birds. This has led to significant challenges for the migration of animals.

- **Phenological Mismatches:** When birds arrive at their breeding ground, their key food source may have already "peaked." For example, studies on European pied flycatchers have shown that these birds arrive later with regard to the peak abundance of caterpillars. In some populations, this can diminish the breeding success of European pied flycatchers by up to 90%.
- **Reproductive Consequences:** Although arriving late may lead to competition for less-than-ideal territorial and nesting spaces, the environment may not offer enough resources for early migrators to successfully breed.
- **Physiological Strain:** Not only may animals be under increased metabolic demands (and poorer physical condition) when migrating under less-than-ideal conditions, evidence shows that spring migration is advancing by an average of approximately 2.1 days ser decade in most taxa - with substantial variation among species.

Changed Pathways

Beginning migrations

- Differences between food sources and migration timing (e.g., insect hatching before birds arrive).
- Changed routes to stay out of fire or drought-affected areas.

The traditional migratory pathways of these species are increasingly affected by multiple environmental changes.

- **Habitat Fragmentation:** The expansion of agriculture, urbanization, and deforestation has eliminated pivotal stopover sites that provide critical refueling needs.
- **Resource Availability Change:** Changes in precipitation dynamics can alter the availability of water bodies and food resources along migratory pathways.
- **Geographic Barriers:** As regions suitable for these species shifted northward or upwards in elevation, migratory pathways often crossed additional geographic barriers or maximum distances.
- **Human Infrastructure:** Windfarms and powerlines are now new threats along migratory pathways, with urban light pollution providing additional challenges.
- These changes often push species to take longer or energy-costly routes or unfamiliar locations with uncertain resource availability.

Shortened or Abandoned Migrations:

- **Partial Migration:** The proportion of residential individuals (non-migratory) is on the rise; thus, the populations that historically migrated uniformly are now experiencing increasingly larger proportions of resident individuals,

especially in temperate areas that have experienced milder winters.

- **Reduced Migration Distance:** Many species of birds have been shortening the migration distance by hundreds of kilometres in recent decades, in both Europe and North America.
- **Complete Decentralization:** Some species, such as the European blackcap, are establishing entirely new populations that previously never existed as wintering populations in areas that were unsuited, that is, they simply abandoned long-distance migration and catching the energy lost by migratory travel.
- These changes can radically alter a species' ecological functions and the ecology of their effective relationships in both their breeding and wintering habitats.

Navigation Disturbance

Migratory animals depend on many cues that climate disturbance may be modifying.

- **Magnetic Field Detection:** Early studies indicated that changes in ocean currents caused by climate warming may result in changes in the local magnetic fields that some sea turtles and fishes may use for navigational purposes.
- **Celestial Navigation:** Increased cloud cover in some regions may reduce the visibility of stars or the sun, which also complicates celestial navigation.
- **Olfactory Landmarks:** Chemistry of the ocean is changing and marine chemical gradients used by all salmon and other species as olfactory landmarks can be altered by changing the chemistry of the ocean and ocean acidification.
- **Weather Pattern Disturbance:** Many birds use the prevailing winds and atmospheric pressure systems, which can allow birds to use these components, as clues to facilitate their migratory movements; climate disturbance and the new climate patterns are making these indicators less reliable.

Significant Examples

1. **Arctic Tern:** has relied on ice patterns during polar migrations. Melting to sea ice has caused disturbances to feeding zones.
2. **Caribou:** Calving has not kept pace with the optimal timing for plant growth, resulting in lower calf survival.
3. **Monarch Butterflies:** Deforestation and warming are threatening the critical overwintering forests in Mexico**.**
4. **Barn Swallows and Warblers:** Are now arriving earlier in Europe and North America, when their food source is not at peak abundance.
5. **Salmon:** Warmer Rivers' post-spewing migratory movements cause increased mortality and reduced reproduction success.

Impacts on Ecosystems

1. **Phenological Mismatches:** If animals leave their winter ranges before the food sources are at a peak, the probability of reproductive success will be lower.
2. **Increased Mortality:** Longer or riskier routes expose animals to more predators, human–animal conflicts, or inclement weather.
3. **Ecosystem shifts:** Altered migration patterns also affect food webs and the seasonal timing of ecosystems (e.g., pollination and seed dispersal).

Shifts in Breeding and Reproduction

1. Many species have their reproductive timing correlated with the best environmental conditions and climate change alters:
2. Earlier breeding season (amphibians, birds, insects).
3. Reduced reproductive success if environmental conditions are too warm or food is limited**.**
4. Habitat loss will change mating behaviour and nesting.

Foraging and feeding behaviour.

Climate can limit food availability and increase the need for animals to change when and how they forage.

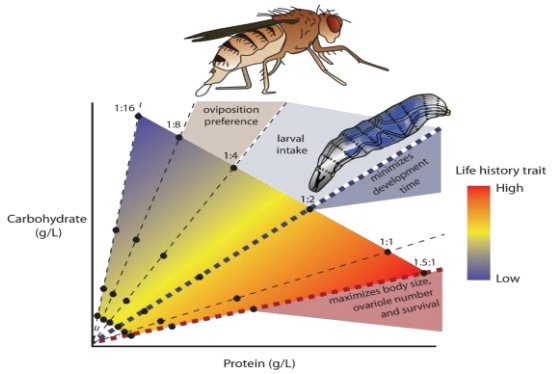
Marine animals are shifting ranges in concert with warming ocean surfaces and cascading predator–prey relationships**.**

Hibernation Disruption

Species that hibernate, such as bears and bats, rely on stable, cold periods.

Shorter or delayed hibernation periods can lead to increased energy expenditures.

Premature waking owing to warm spells can leave animals without sufficient food.



Aggression and Social Behaviour

- Also increased aggression in territorial species.
- Also, breakdown of social organization above for group living species (elephants, primates).

Species Interactions and Competition

As species move to new areas and change behaviours;

1. Invasive species may outcompete native species.
2. New prey-predator dynamics may evolve out of this, creating an ecological imbalance.

Research Methodology:

This research followed a qualitative review methodology to synthesize and analyse results from a large number of peer-reviewed articles and global reports regarding the behavioural impact of climate change on animal species. The following considerations were established to complete a rigorous scientific review with a sufficient scope:

1. **Collecting Literature:**

a. We found primary sources using the following keywords: "climate change," "animal behaviour," "animal phenology," "animal migration," "hibernation," "animal adaptation," and "biodiversity shifts," from the following database, JSTOR, ScienceDirect, PubMed, Google Scholar, and others.

b. We also sought reports prepared by authoritative organizations such as the Intergovernmental Panel on Climate Change (IPCC) to obtain climate trend data.

2. **Selection Criteria:**

a. We focused on relevant articles published between the years of 2000-2023.

b. We reviewed only approved peer-reviewed articles, systematic reviews, and large-scale ecological assessments.

Thematic Analysis:

- We arranged the extracted data from the peer-reviewed articles on an animal's behaviour with respect to climate into six behavioural domains: migration, breeding, feeding, hibernation, social behaviour, and interactions between species.
- Analysis of each of the domains considered both active climate drivers of behaviour, behavioural change in response to climate drivers, and the

subsequent ecological effect of behavioural changes.

Case Studies:

- We selected specific case studies (e.g., Arctic Tern, Monarch Butterflies, Caribou) as concrete illustrations of the breadth and specificity of behavioural changes across taxa..

Data Synthesis:

- We considered cross-species synthesis to be able to look for emergent themes, different context-dependent responses, and overarching ecological effects.

This allows us to consolidate and better understand how behavioural plasticity, maladaptive behaviours, and ecological mismatches play out under persistent climate disruption..

Literature Review

There is considerable literature examining the behavioural impacts of climate change accumulating over the past 20 years. Some of the key early works (Root et al. 2003; Walther et al. 2002) examined the broad ecological impacts of warmer global temperatures, with interrelated shifts in space, time, and life cycle timing.

Phenological Shifts:

Parmesan (2006) and Visser and Gienapp (2019), as a consequence of changing seasonal cues, resulted in poor phenological timing for many species. Many species of birds, amphibians, and insects are the most impactful, including documented mismatches in breeding and food availability.

Migration Patterns:

Research by both et al. (2006) and Brandmark et al. (2014) has indicated that changes in the timing of migration and altered migration routes have resulted in reproductive failures and increased mortality in birds and fish. Changes in migration are often tied to phenological mismatches and habitat fragmentation in migratory corridors.

Hibernation and Dormancy:

Inouye et al. (2000) and Lane et al. (2012) offered data on changes in the timing of hibernation, examples where early emergence forces animals to face inadequate food resources in the spring. Disruptions in hibernation timing have been documented in several mammals, including ground squirrels and bears.

Foraging and Feeding Behaviour:

Polychasia et al. (2013) underscored how marine species shift their ranges because of warming waters, which in turn affects predator-prey relationships and possible ecological imbalance.

Behavioural Plasticity vs. Adaptation:

Seebacher et al. (2015) further indicated that while behavioural plasticity provides short-term resilience, it may not be a sufficient trait for long-term survival if it (behavioural plasticity) is not coupled with genetic adaptation, a process that takes longer in terms of generational time scales.

Interactions with Other Stressors:

Mantica-Pringle et al. (2012) present evidence that climate change often occurs in combination with other stressors caused by anthropogenic activities, such as habitat loss and pollution, which may cause compounded effects on behaviour and ecology.

Overall, these studies highlight the importance of including behavioural observations in conservation plans. They revealed that behavioural changes are not only climate change-related shifts, but they can also act as early signals of ecosystem and population health.

Conclusion:

Climate change not only alters the environment, but also alters the behaviour that animals rely on to survive. The behavioural changes we observed in multiple taxonomic groups were both signalling adaptive responses, as well as maladaptive responses to rapidly changing environmental conditions. Some behaviours may be constructs of species persisting through climate change; changing hibernation patterns may be adaptive if food becomes available earlier. However, as long as mismatched phonologies occur, species can be at risk of wasting additional energy, poorly reproducing, and breaking normal social systems.The interconnections of ecological communities indicate that behavioural changes in one species could reverberate through food webs and ecosystems. When predators hunt their prey differently, their prey species must adjust their anti-predator behaviours; plant reproductive outcomes may be affected when their pollinators have adjusted their timing of emergence.

The rise in global temperatures leads to increased extremities and expected behaviour. Some species are likely to exhibit considerable behavioural plasticity, whereas others are limited in their adaptive capacity. The most likely to be adversely affected will be the species that are behaviourally specialized, do not disperse well and are dependent one cues that climate change has permanently changed.Conservation strategies need to include consideration of behavioural responses to climate change, along with a more established focus on habitat protection. Preserving movement corridors, maintaining habitat heterogeneity, reducing non-climatic impacts, and protecting climate refugia will all be extremely valuable in facilitating behavioural

adaptation. Long-term monitoring of wildlife behaviour helps us build a more critically normal understanding of how wildlife responds to a changing planet. Taking long-term animal behaviour and considering its importance as an early warning indicator of climate change that can structure timely and efficient conservation, they can prevent these behavioural issues from manifesting into population processes in the future.The narrative of animal behaviours from climate change is still developing; however, it unmistakably indicates ecological disturbance from human-caused climate change in natural systems. We need to pay attention to behavioural disturbances, as the consequences of climate change will continue to threaten biodiversity in a rapidly changing world.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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