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The Impact Of Climate Change On Fish Physiology And Behaviour: A Review

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ABSTRACT

It is anticipated that ongoing climate change will have an impact on individual organisms at every stage of life, which will have an impact on species populations, communities, and ecosystem function.Because of rising temperatures, ocean acidification, hypoxia, and habitat changes brought on by climate change, fish physiology and behaviour are being profoundly impacted in aquatic ecosystems.Potential changes in biodiversity and the sustainability of fisheries result from these alterations, which also impair metabolic processes, reproductive success, and ecological interactions. Although some species may be able to adapt through behavioural and physiological flexibility, many are in danger because of the quick changes in their surroundings. The effects of these environmental stresses on fish immunological responses, growth, reproduction, and metabolic rates are examined in this review. High temperatures speed up metabolic processes, raising energy needs while perhaps decreasing growth and reproductive success. Ocean acidification impairs feeding and predator avoidance by interfering with sensory processes.Respiratory stress brought on by low oxygen levels modifies habitat choices and movement behaviours. Furthermore, changes in migration and spawning cycles brought on by climate change have an effect on species ranges and population dynamics. Comprehending these physiological and behavioural reactions is essential for forecasting future shifts in biodiversity and putting conservation plans into action. This review highlights knowledge gaps and potential research goals by synthesizing recent studies on fish adaptations and vulnerabilities brought on by climate change.It is essential to comprehend these effects in order to create conservation plans and sustainable management techniques. To protect aquatic ecosystems in a changing climate, future studies should concentrate on species-specific reactions, long-term adaption strategies, and mitigation techniques.

KEYWORDS: Climate change, Aquatic ecosystem, Fish physiology, behaviour, temperature, Ocean acidification, hypoxia, Environmental stress

INTRODUCTION

In the intricate ecosystems of Earth, fish serve two purposes. They are both aquatic area inhabitants and global environmental health indicators. Because of the enormous challenges posed by climate change, there has been a lot of interest in researching the physiological complexity of fish species*(Subhendu Kumar Chatterjee, Priyajit Chatterjee &Chandan Malick, Dec 2024).*Although aquaculture is essential to supplying the world's expanding demand for aquatic products, climate change is posing a significant danger to its viability*(S. I. Action,2020).*

Aquatic ecosystems around the world are facing one of the biggest environmental challenges: climate change. Freshwater and marine environments are changing physically and chemically due to rising global temperatures, ocean acidification, oxygen level fluctuations, and extreme weather events. These modifications impact fish development, reproduction, metabolism, migration patterns, and survival, among other aspects of their physiology and behaviour.Salinity and temperature are two important environmental variables that have a big impact on fish physiology, including their energy balance and metabolism. By controlling food intake, digestion, absorption, and the distribution of energy among vital processes like activity, growth (including larval and juvenile development), and reproduction, temperature controls how much energy is acquired. A particular temperature range is often used by each species to maximize physiological functions. Their susceptibility to temperature fluctuations is shown by the substantial effects that deviations from these ideal temperatures have on fish health and survival*(Agarwal, Deepak et al.,2024*).

The environmental conditions to which fish have adapted over millions of years are changing due to rising temperatures, ocean acidity, and hypoxia. Fish are extremely sensitive to changes in their surroundings because vital physiological functions including breathing, osmoregulation, and enzyme activity depend on steady water conditions. Ocean acidification may affect sensory perception and predator avoidance, while warmer water temperatures may speed up metabolic rates and raise the need for oxygen. Climate-driven habitat changes can also interfere with migratory routes, feeding habits, and spawning seasons, which will ultimately impact fish populations and biodiversity.

Fish physiology and behaviour are significantly impacted by these changes, which have an impact on growth, migration, reproductive, metabolic processes, and survival**.** The ability of a fish to mount a sufficient stress response—which involves the activation of physiological systems, the reallocation of energy towards defensive mechanisms, and a behavioural change to deal with or avoid the environmental threat—is what drives its capacity to adapt to environmental change (*Alfonso Sébastien, et al.,2021).*Fish are essential to aquatic biogeochemical processes, ecosystem architecture, and food web link functioning since they are the most varied vertebrates (with over 35,000 species) and spend their whole lives in water *(De Iuliis and Pulera, 2019, Fricke et al., 2020).* Fish are ectothermic organisms, meaning their body

temperature and physiological functions are directly influenced by external environmental conditions. It is essential to comprehend how fish physiology and behaviour are affected by climate change in order to manage fisheries, forecast ecological changes, and preserve aquatic biodiversity. Highlighting significant scientific discoveries and viable adaptation techniques, this chapter examines the diverse physiological and behavioural reactions of fish to climate change.

EFFECT OF CLIMATE CHANGE ON FISH PHYSIOLOGY

Higher water temperatures cause metabolic rates to rise, which raises energy requirements and may cause physiological stress. (*IPCC.2014*Lastly, persistent or acute exposure to heated temperatures might change how the stress axis work and how an animal reacts to further stresses, perhaps impairing its ability to cope over the long term. This is especially crucial as

other aspects of global change in aquatic environments, like ocean acidification and salinity changes, are occurring concurrently with global warming. The growing amount of carbon dioxide in the atmosphere is also causing ocean acidification, which is a concerning hazard. Smaller bodies, aberrant embryo development, and decreased survival rates among susceptible fish species are the results of this (*Munday et al., 2010*).

Fish are currently facing challenges due to global warming, which is causing seasonal water temperatures to rise and intense heatwave events to occur. The physiology of stress is essential for adapting to environmental changes, such as global warming. The physiology, behaviour, and general survival of fish have all been greatly impacted by the gradual rise in water temperatures caused by global warming in aquatic habitats. Because they are ectothermic, fish are extremely sensitive to temperature changes, which leaves them open to environmental stressors linked to climate change. (*Stiasny et al., 2019;&Cominassi et al., 2020 In* this review, we describe how stress physiology brought on by global warming might cause energy constraint in fishes, which in turn alters their susceptibility to other environmental stressors.

This section examines the different ways that fish populations are stressed by global warming, with an emphasis on temperature stress, metabolic alterations, oxygen shortages, and ecological disturbances.Since aquatic environments are experiencing acidification, hypoxia, chemical pollution, and other issues in addition to global warming, this is of fundamental relevance(*Sih, 2013;& Gordon et al., 2018*).

It is recognized that freshwater and marine aquatic habitats, as well as the creatures that inhabit them, are even more susceptible to climate change than their terrestrial counterparts (*Comte and Olden, 2017, Knouft and Ficklin, 2017).* According to a global quantitative synthesis, ectothermic species' body size decreases brought on by warming were ten times larger in aquatic habitats than in terrestrial ones*(Forster et al., 2012*). In (2010, McCormick et al.) conducted a study that demonstrated the link between rising temperatures and coral reef fish embryo growth acceleration. Consequently, hatching timing is impacted and more conducive circumstances are produced.

EFFECT OF CLIMATE CHANGE ON FISH BEHAVIOUR

Changes in fish growth are probably going to have predictable, long-lasting effects on recruitments, population dynamics (such overwintering mortality), and features (like age-size structure, egg size, and reproductive phenology). (*Murdoch and Power, 2013&, Carozza et al., 2019*) For instance, temperature variations, particularly those brought on by climate change in the air and water, directly increased the somatic growth rate of fish(*Heather et al., 2018,& Gamperl et al., 2019)* This study demonstrated that, on both a global and local level, the overall impacts of climate change—mostly temperature variables—on fish growth, as evidenced by physiology and health, were detrimental. Thus, the findings indicated that in order to have a better knowledge of how climate change affects fish growth, more species (such as chondrichthyan fishes, low-level consumers, and small fishes) and geographical areas This study demonstrated that, on both a global and local level, the overall impacts of climate change—mostly temperature variables—on fish growth, as evidenced by physiology and health, were detrimental. Thus, the findings indicated that in order to have a better knowledge of how climate change affects fish growth, more species (such as chondrichthyan fishes, low-level consumers, and small fishes) and geographical areas; such as high-latitude areas (*Huang, M.,2021).*The basic behaviours that are essential for fish survival are put at danger when high temperatures, shifting pH levels, and other environmental stressors combine to impair the capacity to smell and taste(*Dixson et al., 2010; &Kasumyan 2019*). Recruitment success is mostly dependent on fish growth, which is a comprehensive result of the synergistic interactions between environmental factors and gene-determined growth potential(*Rountrey et al., 2014).* Predicting future ecological effects, directing conservation efforts, and guaranteeing the sustainability of aquatic ecosystems in a world that is changing quickly all depend on an understanding of the intricate relationships between climate change and fish physiology and behaviour.In order to better comprehend and lessen the effects of climate change on aquatic ecosystems, this study attempts to summarize the most recent findings on the physiology and behaviour of fish, emphasizing important issues, adaptive solutions, and future research avenues.

CONCLUSION

Fish physiology and behaviour are changing dramatically due to climate change, which has an impact on their ecological roles, distribution, and survival. While ocean acidification damages sensory perception and predator-prey relationships, rising water temperatures raise metabolic rates, interfere with reproductive cycles, and complicate oxygen management. Aquatic ecosystems undergo changes as a result of fluctuations in environmental factors that also affect social dynamics, eating habits, and migration patterns.Although some fish species may be able to adjust through behavioural changes or physiological plasticity, many are finding it difficult to adapt to the fast-changing climate. Global fisheries, biodiversity, and food security may be impacted in the long run. Therefore, in order to sustain fish populations and preserve ecosystem stability in a changing world, immediate conservation measures, habitat protection, and climate mitigation methods are crucial. To lessen the negative consequences of climate change on aquatic life, future research should concentrate on adaption strategies, species

resilience, and sustainable management techniques.Physically, climate change impacts fish by altering their perceptions of their surroundings, which in turn influences how they mate and locate breeding areas. Due to the fact that fishing is the main source of income for many communities throughout the world, the change affects not just individual fish but also ecosystems overall. In light of this, it is critical to address the issue of how fish physiology is affected by global warming since doing so will protect marine variety and ensure sustainable fisheries for future generations. Thus, we must take early action by implementing preventive measures to ensure that fish stocks and habitats are resilient for future generations. Maintaining equilibrium across various ecosystem types and climatic zones should also be a focus of future research.

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