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Original article**The Impact Of Climate Change On Animal Genetics And Breeding**Shivani Das¹ and Rebati Raman Mohanty²¹Division of Animal Genetics, Indian Veterinary Research Institute, Izatnagar, Bareilly 243122, UP²Veterinari Assistant Surgeon, Mobile Veterinary Unit, F&ARD Dept., Odisha**Corresponding author: shivanidas093120@gmail.com*

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ABSTRACT

Animal populations around the world are being significantly impacted by climate change, which calls for adaptive breeding and genetic techniques to guarantee food security and species survival. Animal populations are facing previously unheard-of strains due to rising temperatures, altered disease patterns, and shifting resource availability, endangering resilience and genetic diversity. Animal breeding programs are responding by giving priority to climate-resilient traits and using gene editing and genomics advancements to increase productivity and adaptability. The effects of climate change on animal breeding and genetics are examined in this article, along with the opportunities, problems, and future paths for creating animal populations that are resilient to the changing climate.

INTRODUCTION

Climate change is one of the most pressing global issues of our time, with far-reaching consequences for ecosystems, economies, and human societies. Rising temperatures, melting ice caps, and altered precipitation patterns are disrupting natural habitats, influencing weather extremes, and impacting biodiversity. The consequences of climate change are widespread, from more frequent and intense natural disasters to changes in agricultural productivity, water scarcity, and human migration patterns. As the planet continues to warm, the need for adaptive strategies to mitigate and respond to these changes has become increasingly urgent, affecting not only human societies but also the animals that share our planet.

Animal genetics and breeding play a vital role in agriculture and conservation by enhancing productivity, sustainability, and resilience in livestock populations. Through selective breeding and genetic technologies, farmers can improve desirable traits such as disease resistance, fertility, and growth rate, leading to increased food security and reduced environmental impact. In conservation, animal genetics helps preserve endangered species by maintaining genetic diversity, identifying adaptive traits, and informing breeding programs that support species recovery. By applying genetic principles, breeders and conservationists can develop more efficient, sustainable, and resilient animal populations, ultimately contributing to global food security, biodiversity conservation, and ecosystem health.

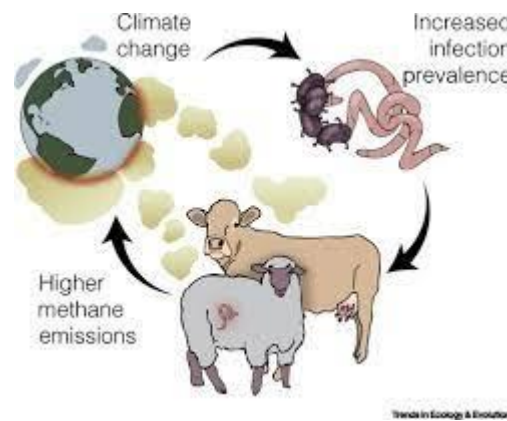
As the global climate continues to shift, animal genetics and breeding are facing unprecedented challenges, necessitating innovative adaptive strategies to safeguard food security and species survival. Rising temperatures, changing disease patterns, and altered environmental conditions are impacting animal populations, threatening genetic diversity and resilience. To mitigate these effects, breeders and conservationists must prioritize climate-resilient traits, leveraging advances in genomics and gene editing to develop animal populations that can thrive in a rapidly changing world. By adopting proactive and adaptive breeding strategies, we can ensure the long-term sustainability of livestock production and conservation efforts, ultimately supporting human well-being and ecosystem health.

IMPACTS OF CLIMATE CHANGE ON ANIMAL GENETICS:

Climate change is profoundly impacting animal populations, affecting their health, productivity, and survival. Rising temperatures are leading to heat stress, reduced fertility, and increased mortality, while changes in precipitation patterns and increased frequency of extreme weather events are altering resource availability, impacting animal nutrition and survival. Additionally, climate-driven shifts in ecosystems are facilitating the spread of disease-carrying insects, increasing the risk of disease transmission among animals. As a result, animal populations are facing unprecedented challenges, highlighting the need for adaptive strategies to mitigate these impacts and ensure their long-term survival.

Genetic diversity provides the raw material for adaptation, enabling animal populations to respond to changing environmental conditions. A diverse gene pool allows populations to tap into existing genetic variation, increasing the likelihood of individuals possessing traits that confer advantages in the face of environmental challenges. This diversity enhances the population's ability to adapt to shifting temperatures, altered disease patterns, and changing resource availability, ultimately improving their resilience and chances of survival. By maintaining genetic diversity, populations can better withstand environmental stressors and evolve to thrive in a rapidly changing world.

Climate change poses a significant threat to genetic diversity, as rapidly shifting environmental conditions can lead to population declines, fragmentation, and even extinction. As populations become isolated or reduced in size, genetic variation is lost due to genetic drift, inbreeding, and reduced gene flow. This loss of genetic diversity can compromise a population's ability to adapt to future environmental challenges, making them more vulnerable to disease, climate extremes, and other stressors. Furthermore, the loss of genetic diversity can also limit the potential for populations to evolve and adapt to changing conditions, ultimately threatening their long-term survival.



CHALLENGES FOR ANIMAL BREEDING PROGRAMS:

Breeding programs must prioritize climate resilience to ensure the long-term sustainability of livestock production and conservation efforts. As climate change continues to alter environmental conditions, breeding programs that focus on climate-resilient traits such as heat tolerance, disease resistance, and adaptability to changing resource availability will be better equipped to produce animals that can thrive in a rapidly changing world. By incorporating climate resilience into breeding goals, breeders can develop animal populations that are more robust, productive, and adaptable, ultimately supporting food security, ecosystem health, and species survival in the face of climate uncertainty.

Selecting for climate-resilient traits such as heat tolerance and disease resistance poses significant challenges. These traits are often complex, influenced by multiple genes, and can be difficult to measure accurately. Additionally, the expression of these traits can be affected by various environmental factors, making it challenging to identify genetic markers or breeding values that are consistently associated with climate resilience. Furthermore, selecting for climate-resilient traits may require trade-offs with other important traits, such as productivity or fertility, highlighting the need for careful consideration of breeding goals and strategies to balance competing priorities.

Genomics plays a crucial role in identifying climate-resilient genes by enabling the analysis of an organism's entire genome to detect genetic variations associated with climate-resilient traits. Through genome-wide association studies and genomic selection, researchers can identify specific genes or genetic markers linked to traits such as heat tolerance, disease resistance, and drought tolerance. This information can be used to develop genetic tests, inform breeding programs, and select for animals with enhanced climate resilience, ultimately accelerating the development of climate-resilient livestock and conservation populations.

ADAPTATION STRATEGIES:

Breeding strategies for climate resilience involve selecting for traits that enable animals to thrive in challenging environmental conditions. This can include selecting for heat tolerance, improving water efficiency, and enhancing disease resistance. Breeders can use a range of approaches, such as genomic selection, gene editing, and traditional breeding techniques, to develop animals that are better adapted to projected climate conditions. By prioritizing climate-resilient traits, breeders can

help ensure the long-term sustainability of livestock production and conservation efforts, while also improving animal welfare and reducing the environmental impact of agriculture.

Genetic technologies, such as gene editing and genomic selection, offer powerful tools to enhance climate resilience in animals. Gene editing technologies, like CRISPR-Cas9, enable precise modifications to an organism's genome, allowing for the introduction of climate-resilient traits such as heat tolerance or disease resistance. Genomic selection, on the other hand, uses genome-wide genetic markers to predict an animal's breeding value for climate-resilient traits, enabling breeders to select for superior genetics more efficiently. By leveraging these technologies, breeders can accelerate the development of climate-resilient livestock and conservation populations, improving their ability to thrive in a rapidly changing world.

Several species have demonstrated successful adaptation strategies to climate change, such as the heat-tolerant cattle breeds developed through selective breeding in tropical regions. For example, the Brahman cattle breed has evolved to thrive in hot climates, while the Senepol breed has been developed for its heat tolerance and resistance to ticks and other parasites. Additionally, some conservation programs have successfully used genetic management to adapt species to changing environments, such as the efforts to conserve the genetic diversity of polar bears and other Arctic species impacted by climate change. These examples demonstrate the potential for targeted breeding and conservation strategies to enhance climate resilience in various species.

OPPORTUNITIES AND FUTURE DIRECTIONS:

Climate-resilient animal breeding offers several potential benefits, including improved food security through enhanced livestock productivity and resilience in the face of climate-related stressors. By developing animals that are better adapted to projected climate conditions, breeders can help ensure the long-term sustainability of livestock production, reducing the risk of crop failures, livestock mortality, and decreased productivity. Additionally, climate-resilient breeding can also contribute to reduced greenhouse gas emissions by promoting more efficient production systems and selecting for animals with lower environmental footprints. This can help support global efforts to mitigate climate change while ensuring food security for a growing global population.

Emerging trends and technologies in animal genetics and breeding include the use of artificial intelligence and machine learning to analyze large datasets and predict breeding outcomes, as well as the application of gene editing technologies like CRISPR-Cas9 to introduce desirable traits. Additionally, genomic selection and precision breeding are becoming increasingly important, enabling breeders to make more informed selection decisions and accelerate genetic progress. Other emerging technologies include the use of epigenomics, microbiome analysis, and synthetic biology to further enhance animal breeding and genetics. These advancements are transforming the field, enabling breeders to develop more resilient, efficient, and productive animals that can thrive in a rapidly changing world.

Continued research and investment in climate-resilient animal breeding are crucial to address the pressing challenges posed by climate change. As global temperatures continue to rise, the development of animal breeds that can thrive in changing environmental conditions is essential for ensuring food security, reducing poverty, and promoting sustainable agriculture. Further research is

needed to identify novel genetic traits, develop more accurate breeding tools, and evaluate the effectiveness of climate-resilient breeding programs. Investment in this area will enable scientists and breeders to develop innovative solutions, ultimately supporting the well-being of both humans and animals in a rapidly changing world.

CONCLUSION

In conclusion, developing climate-resilient animal breeds is critical for ensuring the long-term sustainability of livestock production and conservation efforts in the face of climate change. By leveraging advances in genetics, genomics, and breeding technologies, we can create animals that are better equipped to thrive in changing environmental conditions, ultimately supporting food security, animal welfare, and ecosystem health. Continued research and investment in this area will be essential for addressing the complex challenges posed by climate change and promoting a more resilient and sustainable food system for future generations.