Review

Genetic and genomic resources of Mithun – An update

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ABSTRACT

Mithun (*Bos frontalis*) is a unique bovine species native to the tropical rainforest regions of Northeast India and neighboring countries. This paper reviews the genetic and genomic resources of Mithun, highlighting its morphological diversity across distinct strains such as Arunachali, Nagami, Manipuri and Mizo Mithun. Each strain exhibits unique characteristics shaped by selective breeding and adaptation to varying environments. Recent genomic studies have provided insights into the genetic makeup of Mithun, revealing significant diversity and evolutionary connections with other bovine species, particularly the Gaur (*Bos gaurus*). However, Mithun populations face severe threats, including habitat fragmentation, inbreeding and increasing commercialization, which adversely affect their genetic health and ecological roles. Conservation efforts, including cryopreservation and artificial insemination, show promise for maintaining genetic diversity. The paper emphasizes the need for comprehensive strategies that integrate genomic research with sustainable breeding practices and habitat conservation. Collaborative efforts among government, researchers and local communities are essential to ensure the long-term viability of Mithun populations, preserving their cultural and ecological significance in the region.

Key words: Bovine species, Conservation, Genetic diversity, Mithun

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INTRODUCTION

Mithun, scientifically referred to as *Bos frontalis* (Lambert, 1807), is a species of bovine that lives in open areas within tropical rainforest habitats of India, Bangladesh, Bhutan, China, and Myanmar (Mondal *et al*., 2004). Mithun is believed to have evolved from the Gaur (*Bos gaurus*), a wild bovine species found in South and Southeast Asia. It possesses a sturdy and well-balanced physique and exhibits aggression when subjected to confinement. The body has a strong and balanced structure, with noticeable muscles. The skull is shaped in a 'V' formation, with a wide and easily identifiable frontal bone. The coat that covers the head is typically black, with a forehead that is either grayish or white, extending to the face. The horn exhibits a substantial size at its base, protruding outward, and gracefully curving upward with a gradually narrowing tip. The horn tips are rounded, and the eyes are vivid and alert, with thick black eyebrows. Male individuals have greater muscular development and possess more prominent horns compared to their female counterparts.

Mithun has a prominent dorsal ridge, which is more pronounced in males compared to females, in contrast to indigenous cattle that have a hump. The neck is robust and highly developed, exhibiting a substantial dewlap and prominent creases. The chest was robust and wide. These animals possessed a dense and sleek dermis that was tightly connected to their bodies, resembling that of typical bovine livestock. The udder exhibited strong attachment, small size, and correct positioning, including teats that were either black or white. Mithun bulls possess sizable scrotums that are blackish brown in color. Mithun possesses a lengthy tail that extends to the hock joint, featuring a tail switch that can be either black or white (Mukherjee *et al.*, 2014).This paper presents an overview of the genetic and genomic resources related to Mithun, the pride of Northeast India.

Mithun genetic resources

Mithun, characterized by its distinctive morphology and behaviour, has adapted to the diverse and challenging environments of the region. Through centuries of domestication and selective breeding, the Mithun has developed into several distinct strains, each with its own morphological and genotypic characteristics.

Arunachali Mithun

The Arunachali Mithun is one of the prominent strains distinguished by its unique morphological features.

Morphological Characteristics

Arunachali Mithuns are noted for their convex forehead and short, stump-like horns. The horns are relatively smooth and not very massive compared to other strains. The body weight of Arunachali Mithuns is moderate, and their overall physique is robust yet less imposing in size (Fig. 1).

Appearance

The Arunachali Mithun's body is generally covered with short, dense hair. The color of the coat is typically a shade of brown/black with varying white patches. One

of the unique features of Arunachali Mithun is the dorsal side of the forehead in between the horns is convex (Ajit *et al*., 2010; Chaudhry *et al*., 2011).

Fig.1: *Female ArunachaliMithun*

Fig. 2: *Male Nagami Mithun*

Nagami Mithun

The Nagami Mithun is another significant strain with distinct characteristics.

Morphological Characteristics

Nagami Mithuns are distinguished by their straight forehead and large, curved, upward-reaching horns, which are often corrugated. These massive horns contribute to the breed's impressive appearance. The body of the Nagami Mithun is large and robust, reflecting its well-adapted nature to its environment (Fig. 2). The typical characteristic features of Nagami Mithun are black coat colour with white stockings in

the legs. The dorsal side of the forehead in between is a straight lune in Nagami Mithun (Viro 2016).

Appearance

The Nagami Mithun exhibits a more muscular and massive physique compared to other strains.

Manipuri Mithun

Manipuri Mithuns are renowned for their distinctive coloration and physical attributes.

Morphological Characteristics

One of the most noticeable features of Manipuri Mithuns is the prevalence of black stockings on their legs. Over 60% of Manipuri Mithuns have a jet-black coat, with the rest of the body often displaying a rich, dark brown color. This black coloration is one of the key differentiators from other strains (Fig. 3).

Appearance

Manipuri Mithuns have a sleek and elegant appearance with a well-defined body structure. Their coat is uniformly dark, adding to their unique and striking appearance.

Fig. 3: *Male Manipuri Mithun*

Mizo Mithun

The Mizo Mithun, also known for its unique traits, adds to the diversity of the Mithun population.

Morphological Characteristics

Mizo Mithuns typically have a robust and muscular build with a distinctive head shape and horn structure. The horns are not as pronounced as those of the Nagami Mithun but are still significant in size and curvature. The coat color of Mizo Mithuns varies from brown to dark brown, with some individuals exhibiting lighter shades.

Appearance

The Mizo Mithun's body is well-adapted to the hilly terrain of Mizoram, showing a strong and agile physique. Their coat color and horn structure contribute to their adaptability and resilience.

The morphological and genotypic characteristics of the four strains of Mithun—Arunachalee, Nagami, Manipuri, and Mizoram—highlight the rich diversity within this species. Each strain exhibits unique features that are a result of adaptation to specific environments and selective breeding practices. Understanding these variations is crucial for the effective management and conservation of Mithun populations, as well as for optimizing their roles in the agricultural and cultural landscapes of the Northeastern region of India.

Mithun Genomic Resources

Mithun Genome Sequence and Draft Assembly

Recent genomic research on *Bos frontalis* (Mithun) and closely related species have yielded significant insights into their genetic composition and evolutionary connections. In their study, Mukherjee *et al*., (2019) successfully obtained a genome assembly of the Indian Mithun that is of excellent quality. The assembly consists of 5,015 scaffolds and reveals a total of 28,044 distinct protein-coding genes. Additionally, they found that approximately 43.66% of the genome is composed of repeat sequences. Ren *et al.,* (2017) conducted an analysis of the mitochondrial genome of the Gayal (*Bos frontalis*). They emphasized that the genome consists of 16,340 base pairs and contains 37 genes, including 13 protein-coding genes. The researchers also observed that the Gayal shares genetic similarities with other *Bos* species, which is of great importance for conservation initiatives. Prabhu *et al.,* (2019) conducted a study on the mitochondrial genome of the Indian Mithun. They found a strong evolutionary connection between the Indian Mithun and the gaur (*Bos gaurus*). Additionally, they observed notable differences in the mitochondrial genomes of Indian and Chinese Mithuns. Deb *et al.,* (2020) conducted a study on the Bangladeshi *Bos frontalis*, where they analyzed its mitochondrial genome. They found that the genome consists of 16,347 base pairs and has a high proportion of AT pairs. Additionally, they discovered that 68.93% of the genome is made up of protein-coding genes. This research contributes to a better knowledge of the species and helps in its conservation efforts.

Genomic diversity of Mithun

Qu *et al.,* (2012) conducted a study on the Yunnan Mithun in China and discovered that despite the tiny population size, there was no significant genetic bottleneck. This was due to the introduction of genes from local zebu and yellow cattle. In their study, Mukherjee *et al.,* (2022) employed microsatellite markers to evaluate genetic diversity among different

bovine populations. They observed substantial variance and distinct genetic traits between Mithun and Gaur, while also discovering a minor reduction in the Gaur population. In their study, Mukherjee *et al.,* (2019b) performed a thorough analysis of the genetic makeup of Mithun populations in the North-Eastern Hilly States of India using a high-density SNP approach. The results showed that there is significant genetic diversity within each population, but limited genetic differences between populations. The researchers also observed some inbreeding, particularly in the Manipur population, but no distinct subgroups were identified. Genetic markers can be utilized with a specific emphasis on their functions in confirming parentage, identifying individuals, and detecting genetic diseases. DNA markers are crucial for the identification of quantitative trait loci (QTLs) in order to improve genotypic selection in breeding programs and livestock genome mapping, despite its complexity, shows potential for identifying functional genes, QTLs, and genes associated with disease resistance (Marle-Köster *et al.*, 2003).

Conservation of Mithun

The study conducted by Mukherjee *et al.,* in 2018 presents a detailed analysis of the genetic makeup of two distinct populations of Indian Mithun (farm and field) using advanced genotyping techniques. The findings indicate that these populations have a relatively homogeneous genetic background with very limited interbreeding with indicine (*Bos indicus*) cattle. The farm Mithun population shows more frequent short runs of homozygosity (ROHs), indicating recent inbreeding, while the field population exhibits longer ROHs, suggesting older founder effects and genetic drift. Both populations exhibit genetic similarity and homogeneity, with only minimal introgression from indicine and taurine (*Bos taurus*) breeds.

Apum *et al.*, 2020 examined the population situation and conservation initiatives for the Mithun (*Bos frontalis*), a partially domesticated animal highly esteemed by the Adi tribe in Arunachal Pradesh, India. Although the Mithun population in the area is currently high, it is facing a declineas a result of its widespread utilization in the social, economic, cultural, and political activities of the Adi people. The Adi community has undertaken conservation efforts to save the cultural significance of the Mithun. These initiatives are being carried out by groups such as the Adi Baane Kebang, Adi Cultural and Literary Society, and Adi Students Union.

The research on Mithun semen cryopreservation underscores its efficacy in preserving genetic material and facilitating artificial insemination (AI). The utilization of cryopreserved Mithun sperm has yielded a 75% success rate in achieving conception, leading to the birth of live calves. Although there is a decline in sperm quality after freezing, it nevertheless remains sufficient for achieving effective artificial insemination and genetic enhancement. Cryopreservation aids in reducing the dangers of inbreeding, hence promoting the preservation of genetic variety in Mithuns by artificial insemination (Mondal *et al*., 2010).

Breeding and Improvement Programs

The Mithun population is decreasing as a result of ongoing inbreeding practices worsened by the fragmentation of their habitat, the restricted presence of certified sires, and the preference of farmers for dominating bulls. The process of inbreeding has resulted in a decrease in size, productivity, and reproductive efficiency. This has been further exacerbated by deforestation, poaching, and habitat devastation caused by the spread of agriculture and climate change. Mithuns, a species that flourishes in elevated, wooded regions, are facing difficulties as a result of diminishing habitats and a decrease in the supply of food. In addition, the dissemination of contagious diseases and interbreeding with indigenous zebu cattle are worseningthe decline of distinctive Mithun attributes. The frequent killing of high-grade Mithuns for their meat poses an additional danger to their population. In order to effectively address these concerns and ensure the preservation of Mithuns, it is imperative that there needs to be a collaborative approach including many stakeholders such as the government, researchers, and local populations. This approach should focus on the development and implementation of comprehensive conservation policies (Ponraj, 2018).

Mithuns, originally employed as a means of trade, have experienced a growing trend of commercialization owing to their high desirability and ease of conversion into cash. This is mostly driven by their worth as a source of meat, milk, hides, and skin. The increasing economic worth of these products has led to a greater utilization and commercialization in the area, which can open up opportunities for sustainable breeding programs (Moyong, 2012).

Future Directions

Research Priorities

Thorough investigations are necessary to comprehend the genetic diversity present in Mithun populations, particularly in geographically isolated and under-researched regions. This understanding is crucial for implementing effective conservation and breeding initiatives.

Ecological Roles

There is a lack of research on the ecological influence of Mithuns in their natural environments. Additional research is required to reveal the functions of these organisms in forest ecosystems and their relationships with other species and environmental conditions.

Disease Resistance

Although there is some existing study on the disease resistance of Mithun, further investigations are necessary to examine their genetic ability to withstand developing diseases and environmental stressors, especially in the context of changing climates.

Impactof Commercialization

The impact of commercialization on Mithun populations, particularly alterations in breeding techniques, is still not well comprehended. Additional research is required to investigate the long-term effects on genetic health and population dynamics.

Ongoing research is necessary to comprehend the ways in which Mithuns adapt to climate change, particularly by studying genetic markers associated with heat stress and drought resilience. Performing high-resolution genetic mapping will helpuncover genes associated with qualities such as disease resistance and climate tolerance. Long-term ecological study will enable theevaluation oftheir role in habitats and the impact of environmental changes on their survival. The objectives include creating comprehensive health monitoring programs to monitor disease patterns and guide breeding and conservation strategies; assessing the effects of commercialization on breeding methods and genetic diversity; and studying genetic and phenotypic adaptations to climate fluctuations to improve resilience.

In order to efficiently oversee Mithun genetic resources, policies should encompass the implementation of conservation programs aimed at safeguarding genetic diversity through the establishment of gene banks and protected areas. Additionally, there should be regulations in place to control commercialization activities and mitigate any potential adverse effects on populations. Furthermore, it is crucial to integrate climate adaptation strategies into conservation endeavors. Genomic data should serve as the basis for disease management in order to create vaccines and treatments. It is recommended that governments allocate funds for research, enforce measures to safeguard habitats, and promote collaboration among stakeholders. On the other hand, NGOs should prioritize lobbying, field-based conservation programs, and research partnerships. Collectively, these actions will augment the preservation of Mithun and guarantee their continued existence and ecological importance.

CONCLUSION

Overall, the Mithun (*Bos frontalis*) is a distinctive example of a partially domesticated bovine animal that holds considerable cultural, economic, and ecological significance in Northeast India and its surrounding areas. Although Mithun possesses a strong and adaptable physical structure suitable for temperate rainforest environments, it is currently confronted with significant challenges such as inbreeding, habitat fragmentation, and heightened commercialization. The complexities arising from climate change exacerbate the problem by influencing the availability of feed, the prevalence of diseases, and the occurrence of heat stress. Consequently, these factors have a direct impact on production and welfare.

A comprehensive strategy is necessary to preserve and enhance Mithun populations. Genomic research provides valuable opportunities for deepening our knowledge of genetic variation, reducing the dangers of inbreeding, and strengthening the ability to withstand environmental pressures and diseases. The efficacy of cryopreservation and artificial insemination in maintaining genetic material highlights the capacity of these methods to aid in the preservation and improvement of Mithun populations. By combining conservation measures with genetic developments, we may provide a solid basis for sustainable management and breeding operations. Effective initiatives require collaboration among stakeholders, including government entities, researchers, and local people. To ensure the preservation and sustainable growth of Mithun populations, it is necessary to address the issues of habitat loss, climate change, and commercialization by educated and coordinated activities.

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