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Conserving Indigenous Livestock Breeds Through Modern Breeding Approach

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Abstract

India possesses a rich diversity of indigenous livestock breeds that have evolved over centuries to thrive in varied agro-climatic conditions. These breeds are valued for their heat tolerance, disease resistance, low maintenance requirements, and cultural and economic significance, representing an essential genetic resource. However, factors such as uncontrolled crossbreeding, reduced use of draught animals, weak rural breeding infrastructure, and limited farmer awareness have led to declining populations. Conserving this biodiversity is crucial for climate resilience, sustainable farming, and long-term food security. Modern breeding strategies including digital herdbooks, blockchain, selective breeding, artificial insemination, genomic selection, embryo transfer, IVF, cloning, cryopreservation, machine learning, and community-based breeding programs enable precise breed identification, genetic improvement, and effective conservation. Integrating traditional knowledge with these scientific approaches not only safeguards endangered genetic resources but also enhances productivity and profitability for farmers. Promoting conservation-oriented management ensures that India's indigenous livestock continue to thrive for future generations.

Key words: Conservation, indigenous breed, genomic selection, IVF, ETT.

Introduction

India has always been home to a rich diversity of livestock breeds. From the hardy Gir and Sahiwal cattle to the drought-resistant Tharparkar and Kankrej, and from the well-adapted Murrah buffalo to higher numbers sheep, goat, camel, and poultry breeds. Our indigenous genetic resources are a treasure that has supported rural livelihoods for centuries. Beside this, unlike temperate and crossbred cattle, indigenous breeds are better suited to tropical climates due to their lower metabolic rate and efficient heat dissipation, allowing them to withstand high summer temperatures. These breeds have evolved through generations of natural and human selection to survive local climates, diseases, and insufficient nutrition; therefore, introducing themselves as far better than many exotic animals.

However, in the past few decades number of native animals are declining because of uncontrolled crossbreeding with high productive exotic animals. Whereas, the reduced use of bullock power in Indian agriculture has led to the neglect of many draught breeds, causing a

steady decline in indigenous cattle populations. Meanwhile, farmers face new challenges like climate change, emerging diseases, rising feed costs, and pressure to increase milk and meat output as per high demand. Finding a balance between conserving native breeds and improving farm productivity is now more important than ever.

There is also an urgent need to raise awareness among farmers about the importance of conserving indigenous livestock breeds. By encouraging farmers to understand their value and adopt conservation focused practices, we can help in protecting our genetic heritage and ensure sustainable livestock production for future generations. This is where modern breeding approaches come into play to conserve our traditional breeds while also improving their performance in a scientific and sustainable manner.

Why indigenous breeds are worth conserving

It is important to recognize why indigenous breeds hold such a vital place in today's agricultural system. Many locally adapted livestock breeds fall under various conservation or endangerment categories, making it crucial to preserve India's native genetic resources. Indigenous cattle populations in the country have been shown to possess rich genetic diversity based on microsatellite and mitochondrial DNA studies. Whereas, Small ruminants are source of income and livelihood for small and marginal farmers, as well as landless labourers, especially in dry and arid regions where crop cultivation and dairy farming are less feasible. Any decline in this diversity weakens their capacity to cope with environmental changes. For instance, Vechur cattle and Toda buffalo are classified as critically endangered; Punganur and Krishna Valley cattle, Sangamneri goat, Banni buffalo, Mandya and Gurez sheep are endangered; and Pulikulam, Bargur, Siri, and Mewati cattle, Manda buffalo, surti goat and Nilgiri sheep are considered vulnerable. With the growing challenges of global warming and climate variability, conserving native breeds becomes even more significant. Below mentioned certain unique and invaluable features of indigenous livestock that make their conservation imperative at any cost.

1. Excellent Climate Adaptation: Most Indian livestock breeds have evolved under harsh conditions like high temperatures, low-quality feed, water scarcity, parasites, and diseases. They naturally tolerate heat stress far better than exotic breeds. For example, breeds like Gir, Tharparkar, and Rathi maintain milk production even in hot summers when Holstein Friesian or Jersey animals struggle.
2. Strong Disease Resistance: Indigenous breeds possess natural immunity to many local diseases. This reduces veterinary expenses and mortality rates for farmers. For small and marginal farmers who cannot afford frequent medical treatment, indigenous breeds

are a safer option.

3. Low Cost of Maintenance: They require less feed and thrive well even on crop residues and grazing. Their ability to utilize low-quality feed efficiently makes them ideal for rural conditions.
4. Cultural and Economic Importance: Nati cows, local buffaloes, sheep, and goat breeds have been an integral part of rural culture, festivals, and agriculture. As a economical perspective, milk from indigenous breeds contains A2 milk, higher fat, protein, total solids, casein, lactose, ash, and beta-lactoglobulin levels than milk from temperate breeds, it contributing to better nutrition and human immunity. While, Indian goat and sheep breeds provide high-quality meat and wool, respectively.
5. Biodiversity Preservation: Every indigenous breed holds unique genes that may be crucial for future breeding programs, especially in dealing with climate change and new diseases. Losing a breed means losing valuable genetic material forever.

Why indigenous breeds are declining

Farmers naturally prefer animals with higher genetic potential for production, which creates a major obstacle to conservation initiatives. Moreover, livestock keepers are often reluctant to maintain breed diversity unless they receive adequate incentives. Several factors have led to the decline of indigenous livestock populations: intensive promotion of exotic and crossbred animals for improved yields, lack of farmer awareness about the importance of native breeds, lower market value of indigenous animals, weak breeding infrastructure in rural regions, absence of systematic breed improvement programmes, increasing urbanization, shifts in land use patterns, and shrinking of farmer's land. Resultant, this valuable "domestic animal diversity" is increasingly under threat.

Modern breeding approaches for conserving indigenous breeds

The Indian Council of Agricultural Research (ICAR) has established the National Bureau of Animal Genetic Resources (NBAGR) as the apex organization dedicated to identifying, evaluating, characterizing, and conserving India's vast livestock genetic wealth. Today, modern breeding strategies emphasize the scientific conservation, genetic improvement, and sustainable utilization of indigenous breeds. These approaches not only help preserve our unique animal genetic heritage but also empower farmers to achieve higher income and long-term productivity. Here, some explanations of key modern approaches:

1. **Digital Herdbooks and Blockchain:** 'Digital herdbooks' are electronic systems that store detailed livestock information, including pedigree, breeding, health, and genetic traits, with real-time accessibility for better herd management. Whereas, 'blockchain

technology' further enhances traceability by providing secure, tamper-proof records of animal movements, pedigree, and breeding practices. This transparency increases trust, ensures compliance with conservation efforts, and promotes accountability among breeders, ultimately supporting the preservation of genetic diversity.

2. **Selective Breeding:** It means choosing the pure males and females of the breed and using them for further breeding. Through proper mating strategies, selective breeding also reduces inbreeding related problems and strengthens the long term sustainability of breeds.
3. **Artificial Insemination (AI):** It has become one of the strongest tools for breed improvement and conservation. It allows the widespread use of genetically valuable males, helping to improve desirable traits while preventing the loss of purebred populations. It is also an essential for ex-situ conservation, where semen from rare or endangered breeds can be collected, cryopreserved, and stored in gene banks for future use. This protects genetic diversity and provides a long-term safeguard against breed extinction. To strengthen this, many AI centers established by government now offer semen of several indigenous breeds including Gir, Sahiwal, Rathi, Kankrej, Ongole, Murrah, Surti, Mehsana, and many local goat and sheep breeds. A National Animal Gene Bank has also been established where more than 1,20,000 cryopreserved doses of semen from Punganur, Amrith Mahal, Hariana, Gir, Kangayam, Dangi, Sahiwal, Tharparkar, Red Sindhi and Krishna Valley breeds are maintained.
4. **Genomic Selection:** It is a modern breeding approach that enables the efficient identification of superior animals using detailed DNA information. With advanced tools such as SNP chips/arrays and next-generation sequencing methods (GBS, RADseq, ddRADseq), scientists can now detect 50,000-100,000 SNP markers across the genome. These technologies help to find genomic regions associated with key traits like environmental adaptation, production performance, reproductive efficiency, and disease resistance. By using this information, breeders can select high-potential calves at an early age, accelerate genetic improvement, and more accurately assess the true genetic merit of animals. The expression level of HSP gene can serve as a stress indicator across species, helping them cope with challenges arising from climate change. For example, expression of HSP genes among goat breeds: heat-susceptible breeds like Sirohi and Jakhrana exhibit higher expression of HSP60, HSP70, and HSP90, whereas heat-tolerant breeds like Barbari show lower levels.

Moreover, by analysing patterns such as homozygosity, heterozygosity, and runs of

homozygosity, scientists can detect issues like inbreeding, genetic bottlenecks, and risks of extinction. These analyses help identify genetic weaknesses in breeds and guide management strategies to prevent genetic erosion. Monitoring these genomic parameters is essential for maintaining genetic diversity, understanding the effects of past selection, and making informed breeding decisions that support the future genetic health of livestock populations.

5. Embryo Transfer Technology (ETT): It is a method of producing multiple calves from elite cows. As we know, some cows are exceptional producers or very high milk yielders; where, ETT allows such cows to produce many calves in a year. The embryo formed from the elite cow is transferred into another female (surrogate), allowing rapid multiplication of superior genetics. It promotes population of indigenous breeds, faster genetic improvement, Conservation of rare breeds. A notable example of this is the National Kamdhenu Breeding Initiative have used ETT extensively to increase populations of Gir and Sahiwal.
6. In Vitro Fertilization (IVF): It is a reproductive technology in which fertilization occurs outside the animal's body, giving breeders greater control and enabling the selection of animals with desirable genetic traits. It is particularly useful for conserving indigenous breeds that struggle to maintain healthy population sizes, preserve valuable genetic material from superior animals and supporting long-term breed sustainability.

Another is cloning, it is especially through somatic cell nuclear transfer (SCNT), allows the creation of genetically identical animals from a single cell. This technique also offers significant potential for conserving rare or endangered livestock breeds. By replicating high value or threatened genetic lines, cloning prevent the loss of important traits and supports the recovery of declining populations.

7. Cryopreservation: It means freezing semen, eggs, or embryos at extremely low temperatures (−196 °C) so they remain usable for decades. It acts as a genetic insurance for future generations, contributes in revive endangered and extinct breeds, and allows long-term storage of elite genetics. For example, National Gene Banks maintained by ICAR and NBAGR in India store thousands of samples of indigenous livestock.
8. Machine learning (ML) algorithms: ML tools can process genetic information and phenotypic traits to accurately recognize and categorize various livestock breeds. This approach is particularly valuable for evaluating genetic diversity and monitoring breeding programs. In fact, ML models have demonstrated very high precision (>99%) in correctly assigning animals to their breeds using genetic markers. Such techniques

not only support breed identification but also play a crucial role in tracking and safeguarding genetic variation within livestock populations. Additionally, ML can examine both past and present data to predict potential threats to different breeds and evaluate their conservation priorities.

9. Community-Based Breeding Programs (CBBPs): These programs involve local farmers directly in conservation and improvement. Where, farmers maintain the breed under natural village conditions while experts guide them in selecting the best breeding males and females. Government bodies and universities run breed societies and specialized cattle farms that house superior bulls and elite females of breeds. These institutions use scientific methods to select the best animals, and farmers can access semen from these genetically superior bulls through artificial insemination (AI). It assists in empowerment of local farmers, conservation in the natural habitat (in situ conservation), increased income through better-quality animals, encourages pride in maintaining indigenous breeds. CBBPs have shown success in improving goat breeds like Barbari and Black Bengal and can be expanded to cattle, sheep, and other species.

What Farmers Can Do to Support Conservation

Here are simple steps farmers can take to protect indigenous breeds while improving productivity like avoid unnecessary crossbreeding with exotic animals, use AI from high-quality and pure indigenous bulls, join breed societies or local breeding cooperatives, maintain breed purity and register animals, participate in village-level breeding programs, prefer indigenous breeds for organic or low-input farms, and promote indigenous products in the market. Government programs like Rashtriya Gokul Mission also support farmers financially for maintaining indigenous breeds, setting up Gokul Grams, and receiving incentives for AI and calf registration.

Conclusion

Indigenous livestock breeds are more than just animals, they are a part of India's heritage, livelihood, and ecological balance. In the era of climate change and increasing disease challenges, these breeds offer the resilience and sustainability that modern agriculture demands. However, conservation does not mean going backward. By integrating modern breeding approaches such as selective breeding, AI, genomics, ETT, IVF, and cryopreservation, we can improve indigenous breeds while preserving their unique traits. These tools help farmers achieve higher productivity, better profits, and long-term sustainability. The future of livestock farming depends on how well we combine traditional knowledge with modern science. By conserving and improving indigenous breeds today, we secure a stronger,

more resilient agricultural future for tomorrow.

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