

ADAPTIVE GENOMICS AND CONSERVATION OBJECTIVES: BALANCING HYBRID VIGOR AND CLIMATE RESILIENCE IN PAKISTAN'S YAK POPULATION

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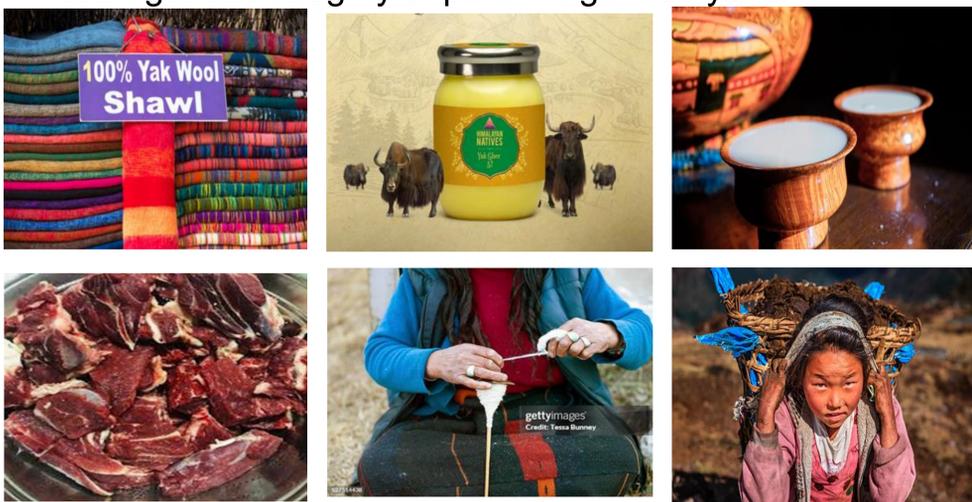
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INTRODUCTION & AIM

The yak (*Bos grunniens*) is the biological foundation for pastoral families in the Karakoram–Himalayan region of Northern Pakistan (Gilgit-Baltistan and Chitral).

- ❖ **Altitude:** Sustains life at elevations up to 4,500 meters.
- ❖ **Resources:** Provides essential milk, meat, fiber, and transport.
- ❖ **Population:** Approximately 25,000 pure yaks and over 100,000 crossbreds (Zo/Zomo).
- ❖ **The Crisis:** Widespread hybridization is causing **genetic dilution**, threatening millennia-old adaptations to extreme cold and oxygen deprivation.
- ❖ **Aim:** To implement a genomics-based strategy that balances the economic benefits of hybrids with the long-term genetic integrity of pure indigenous yaks.



METHODS

The proposed strategic overhaul utilizes a two-pronged population genetics approach:

A. Genomic Conservation

- **SNP Genotyping:** Use high-density SNP genotyping to measure genetic worth.
- **Diversity Monitoring:** Estimate effective breeding population size (N_e) and monitor genetic diversity.
- **Germplasm Repositories:** Establish secure banks to protect irreplaceable adaptive genes.

B. Hybrid Optimization

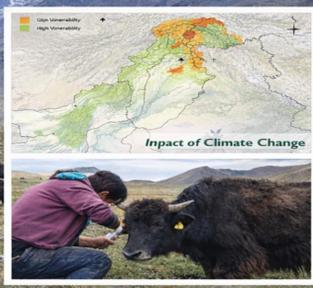
- **Genomic Selection:** Integrate selection into crossbred populations to improve economic performance.
- **DNA Control:** Strictly minimize the harmful influx of cattle DNA into the pure yak genome.

Conservation Challenges of Yak (*Bos grunniens*) Husbandry in the High-Altitude Ecosystems of Gilgit-Baltistan

Key Challenges:

- ❖ Impacts of Climate Change
- ❖ Overgrazing and Habitat Degradation
- ❖ Limited Veterinary Services

Gilgit-Baltistan



RESULTS & DISCUSSION

- ❖ **Socioeconomic Value:** By stabilizing the Zo/Zomo hybrid (known for superior strength and mid-altitude productivity), the local economy is protected.
- ❖ **Climate Resilience:** Preserving pure yak genetics ensures the survival of high-altitude livestock farming against climate change.
- ❖ **Precision Management:** Genomic tools provide "unprecedented precision" compared to traditional breeding.

CONCLUSION

Securing the genetic heritage of the Pakistani yak is a requirement for regional food security. By embracing modern genomic strategies, we can maximize hybrid productivity without sacrificing the unique biological adaptations of the pure *Bos grunniens*.

FUTURE WORK

The following text highlights the next logical steps for this research, focusing on the practical application of genomic tools:

- ❖ **Establishment of a National Yak Gene Bank:** Creating a centralized cryopreservation facility for the long-term storage of pure indigenous yak semen and embryos to safeguard against genetic erosion.
- ❖ **Precision Breeding Programs:** Launching a community-based genomic selection (CBGS) scheme that empowers local pastoralists in Gilgit-Baltistan and Chitral to select superior Zo/Zomo hybrids without compromising the purebred gene pool.
- ❖ **Climate-Adaptive Mapping:** Utilizing Whole-Genome Sequencing (WGS) to identify specific alleles associated with heat tolerance.
- ❖ **Policy Integration:** Working with the Livestock and Dairy Development Department to create "Purebred Protection Zones" where hybridization is restricted to maintain a genetic "source" population.

REFERENCES

- Hussain, T., et al. (2021). Molecular Phylogeny and Genetic Diversity of Domestic Yaks (*Bos grunniens*) in Pakistan based on Mitochondrial and Microsatellite Markers. *Veterinarska stanica*, 52(6), 671-684.
- Naz, S., et al. (2025). Genomic Adaptation, Environmental Challenges, and Sustainable Yak Husbandry in High-Altitude Pastoral Systems. *Animals*, 12(8), 714.
- Khan, J., et al. (2023). Assessing Genetic Diversity in Domestic Yak (*Bos grunniens*) of Pakistan through DRB3 gene exon 2. *Pakistan Journal of Zoology*.
- Qiu, Q., et al. (2012). The yak genome and adaptation to life at high altitude. *Nature Genetics*, 44(8), 946-949. (Foundational study for yak genomics).
- Tariq, M. (2023). Future policy interventions for the development of livestock sector in Pakistan. *Sustainable Development Goals Policy Brief*.