Conservation and Utilization Status and Development Strategies of Livestock and Poultry Germplasm Resources in Binzhou City

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Abstract This paper investigated and analyzed the conservation and utilization of four local livestock breeds in Binzhou City: Wadi Sheep, Bohai Black Cattle, Wudi Donkey, and Lubei White Goat. Shortcomings in the protection and utilization of local germplasm resources were pointed out, and strategies and recommendations were proposed to promote high-quality development of livestock and poultry genetic resources in Binzhou, including building a solid germplasm foundation, standardizing production, and driving innovation. This paper provides references for the conservation, development, and utilization of local genetic resources in Binzhou City.

Key words Livestock and poultry; Germplasm resource; Protection and utilization; Present situation; Development strategy
DOI:10.19759/j.cnki.2164-4993.2025.02.007

Livestock and poultry genetic resources are a vital component of biodiversity. Binzhou City, located in the core area of the Yellow River Delta and on the south coast of the Bohai Bay, harbors several outstanding local breeds formed due to its unique geographical environment, including Bohai Black Cattle, Dezhou Donkey, Wadi Sheep, and Lubei White Goat. In this study, an in-depth investigation was conducted on the conservation and utilization status of four local breeds, namely, Wadi Sheep, Bohai Black Cattle, Wudi Donkey, and Lubei White Goat in Binzhou City, and the shortcomings in the protection and utilization of local germplasm resources were analyzed, hoping to propose strategies for promoting the high-quality development of Binzhou's livestock and poultry genetic resources from the aspects of strengthening germplasm foundations, standardizing production and driving innovation.

Basic Information

There are three national-level livestock and poultry genetic resources conservation farms, six provincial-level conservation farms and 43 breeding farms in the city.

The national-level and provincial-level genetic resource conservation farms in Binzhou City are listed in Table 1 and Table 2, respectively.

Received: January 10, 2025 Accepted: March 15, 2025
Supported by Binzhou Social Sciences Planning Project in 2024 (24-SKGH-051); Binzhou Comprehensive Experimental Station Project of Shandong Provincial Forage Industry Technology System (SDAIT-23-10).
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Current Status and Analysis of Germplasm Resources

Lubei White Goat

General situation of the breed The Lubei White Goat originated in Binzhou, Dezhou, Liaocheng, and adjacent cities/counties such as Dongying and Jinan in Shandong Province. The central producing area is the plain area north of the Yellow River, and the breed is mainly distributed in Jiyang County and Shanghe County of Jinan City. The Lubei White Goat is a dual-purpose breed for both meat and skin. The goats have tender meat, delicious taste, beautiful appearance, compact structure, resistance to roughness and disease, and wide feed range, and can be raised by both house feeding and grazing. They have the characteristics of multiple births and high yield. The meat is tender and delicious, warm in nature, and has the effects of invigorating qi and nourishing yin, warming the middle warmer, tonifying deficiency, and stimulating appetite, showing high commodity value[1] and high competitiveness in international trade. The Lubei White Goat was included in *Livestock and Poultry Genetic Resource Conservation List of Shandong Province* in 1999 and the *National Conservation List of Livestock and Poultry Genetic Resources* in 2006. In 2011, Zhanhua County, its original production area, obtained National Agricultural Product Geographical Indication Registration and Protection from the Ministry of Agriculture, as well as a Geographical Indication Certification Trademark from the State Administration for Industry and Commerce[2].

Currently, there are 12 290 Lubei White Goats totally in Binzhou City, including 6 981 breeding ewes and 687 breeding rams. There is one provincial-level conservation farm, Wudi Fengda Animal Husbandry Co., Ltd., which was successfully designated as a Shandong Provincial core breeding farm for meat goats in 2023, providing critical support for breed conservation and selective breeding efforts.

Table 1 National-level genetic resource conservation farms

No.	Code	Name	Enterprise	Type
1	C3710201	National Bohai Black Cattle Conservation Farm	Wudi Huaxing Bohai Black Cattle Breeding Industry Co., Ltd. in Shandong Province	National-level Conservation Farm (Announcement No. 453, Ministry of Agriculture)
2	C3711001	National Dezhou Donkey Conservation Farm	Wudi High-quality Livestock and Poultry Breeding Farm in Shandong Province	
3	C3711003	National Dezhou Donkey Conservation Farm	Shandong Junchi Donkey Industry Co., Ltd.	

Table 2 Provincial-level genetic resource conservation farms

No.	Code	Name	Enterprise	Type
1	C1610205	Bohai Black Cattle Conservation Farm	Wudi Huaxing Bohai Black Cattle Breeding Industry Co., Ltd. in Shandong Province	Provincial-level Conservation Farm (Announcement No. [2021]85)
2	C1611001	Dezhou Donkey Conservation Farm	Shandong Dezhou Donkey Original Breeding Farm	
3	C1611004	Dezhou Donkey Conservation Farm	Shandong Junchi Donkey Industry Co., Ltd.	
4	C1610704	Wadi Sheep Conservation Farm	Zhanhua Linong Animal Husbandry Co., Ltd. in Shandong Province	
5	C1610807	Lubei White Goat Conservation Farm	Wudi Fengda Animal Husbandry Co., Ltd.	
6	C1610708	Wadi Sheep Conservation Farm	Shandong Jizhi Bioengineering Co., Ltd.	Provincial-level Conservation Farm (Announcement No. [2023]46)

Current situation of breed conservation The Lubei White Goat is a locally protected breed in Shandong Province, but no provincial-level conservation farm has been established. Fengda Animal Husbandry in Wudi County raises 560 Lubei White Goats. The local standard for Lubei White Goat in Shandong Province, *Lubei White Goat DB37/T* 513-2004, was implemented on January 1, 2005. No national standards have been established. In earlier years, a research team led by Professor Wang Jianmin from Shandong Agricultural University studied the reproductive efficiency and hybrid utilization of Lubei White Goat. In 2019, Shandong Academy of Agricultural Sciences compared meat flavor metabolites among Lubei White Goat, Jining Grey Goat, and Boer Goat[3]. Systematic evaluations of economically important traits such as high fecundity, disease resistance, and meat quality characteristics, as well as genetic diversity assessments, have not been conducted. Notably, despite the breed's strong disease resistance, research on the molecular mechanisms and practical applications of this trait remains unexplored.

Lubei White Goats have a low degree of commercial development, primarily undergoing crossbreeding improvements with Boer Goats. Leveraging the breed's advantages of high fecundity and strong disease resistance, Lubei White Goats are used as the maternal line, while Boer Goats serve as the paternal line. In 1998, the breeding stock in the province reached nearly 20 million goats, declining to approximately 3 million goats by the end of 2006. In 2021, the purebred Lubei White Goat population in Zhanhua District was reported at 5 800 individuals.

Major issues in the conservation and utilization of Lubei White Goat First, the security of germplasm resources is increasingly critical. The Lubei White Goat population has sharply declined due to changes in husbandry practices and competition from introduced breeds. Additionally, genetic purity within the population has decreased due to crossbreeding with Boer Goats[4], particularly as Boer Goats are predominantly selected as breeding rams, leading to a drastic reduction in high-quality purebred breeding rams of Lubei White Goat[5]. Second, the conservation system is underdeveloped, with insufficient investment. No dedicated conservation farm exists, and funding for conservation remains inadequate. Although the Lubei White Goat is a locally protected breed in Shandong Province, no provincial-level conservation farm has been established. Fengda Animal Husbandry in Wudi County, which has been granted the Production and Operation License for Breeding Livestock and Poultry, is currently in the stage of applying for provincial-level conservation farm. It has not been provided with any conservation subsidies form provincial, municipal, or county governments. The technical inputs are minimal, and current management practices at Fengda Animal Husbandry remain rudimentary and limited to basic conservation breeding. Third, resource development and utilization are insufficient. While the breed's early sexual maturity and high fecundity are leveraged, its germplasm traits such as disease resistance and meat quality remain underexplored. Especially, industrialized development and utilization of the breed are notably underdeveloped[6].

Wadi Sheep

General situation of the breed The Wadi Sheep, originating from the Yellow River Delta region in Shandong Province, is primarily distributed in Binzhou City, and five counties (districts), namely, Zhanhua, Wudi, Bincheng, Yangxin, and Huimin. Small populations also exist in parts of Dongying, Weifang, and Qingdao. This local breed is renowned for meat production, characterized by high fecundity and prolificacy, rapid growth rate, excellent meat quality, strong adaptability, tolerance to coarse feed, resilience to harsh conditions, and resistance to foot rot. The Wadi Sheep was recorded in *Livestock and Poultry Breeds in Shandong Province* (1999) and *Livestock and Poultry Genetic Resources in China: Sheep and Goat Volume* (2011), included in the *National Conservation List of Livestock and Poultry Genetic Resources* in 2006, and in the *Livestock and Poultry Genetic Resource Conservation List of Shandong Province* in 2010. In 2011, Wadi Sheep from Zhanhua County, its original production area, obtained National

Agricultural Product Geographical Indication Registration and Protection from the Ministry of Agriculture, as well as a Geographical Indication Certification Trademark from the State Administration for Industry and Commerce. The national standard *GB/T* 37310-2019 *Wadi Sheep* was officially implemented in 2019.

The city currently has two provincial-level conservation farms, namely, Shandong Zhanhua Linu Animal Husbandry Co., Ltd. and Shandong Jizhi Bioengineering Co., Ltd., the latter of which was recognized as an "Outstanding Enterprise for the Development and Utilization of Livestock and Poultry Genetic Resources" in Shandong Province in 2023.

Current status of breeding and conservation The Wadi Sheep is a locally protected breed in Shandong Province, but no provincial-level conservation farm has been established. Only Shandong Zhanhua Linu Animal Husbandry Co., Ltd. has applied for and obtained a Breeding Livestock and Poultry Production and Operation License as a Wadi Sheep breeding farm. No financial subsidies are provided by provincial, municipal, or county governments. The enterprise lacks technical capacity, resulting in insufficient efforts for purebred conservation, purification, and rejuvenation of Wadi Sheep. Indiscriminate crossbreeding improvements have reduced the genetic purity of the population. Wadi Sheep was included in the *Livestock and Poultry Genetic Resource Conservation List of Shandong Province* in 2010 and the *National Conservation List of Livestock and Poultry Genetic Resources* in 2006. The breed has long been promoted as a key breed in Shandong Province. In 2011, Wadi Sheep from Zhanhua County, their original production area, received National Agricultural Product Geographical Indication Registration and Protection from the Ministry of Agriculture, as well as a Geographical Indication Certification Trademark from the State Administration for Industry and Commerce. The national standard *GB/T* 37310-2019 *Wadi Sheep* was officially implemented in 2019[7].

Shandong Binzhou Animal Science and Veterinary Medicine Academy has conducted continuous selective breeding research on Wadi Sheep. In recent years, molecular biological techniques have been employed to explore and utilize high-fecundity trait genes in Wadi Sheep, identifying prolificacy-associated genes such as *FecB*, *GDF*9, *BMPP*15, and *ESR*. Collaborating with Professor Li Menghua's team from China Agricultural University, the academy explored and utilized candidate genes and regulatory elements for traits such as high fecundity, multiple nipples, and tail fat in Wadi Sheep.

Market-oriented development and utilization In the commercial development of Wadi Sheep, their high fecundity is primarily leveraged by using them as the maternal line and crossbreeding with superior meat sheep breeds as the paternal line for hybrid improvements. Shandong Binzhou Animal Science and Veterinary Medicine Academy has conducted studies on reproductive traits and established hybrid combinations such as Dongwa and Duwa. However, these efforts remain experimental and have not yet been scaled up or widely applied. Meanwhile, farmers engage in unregulated crossbreeding practices by introducing Dorper Sheep and Small-tailed Han Sheep[8].

Population trends In 1997, statistics indicated over 1.5 million Wadi ewes. By 2006, the population had declined to approximately 400 000 sheep[9]. In 2021, the purebred Wadi Sheep population in Zhanhua District was reported at 11 600 sheep.

Current status of breeding and conservation The security of Wadi Sheep germplasm resources has become increasingly critical, manifesting in two primary aspects. First, the population size of Wadi Sheep has sharply declined. On the one hand, Changes in feeding method lead to the reduction of their numbers. With the acceleration of the scale of livestock and poultry breeding, grazing has been changed to house feeding, and free-range breeding has been changed to large-scale breeding. However, the large-scale breeding of Wadi Sheep has not been formed, leading to a decrease in the population size. On the other hand, market competition has severely impacted the breed, leading to a sharp decline in the number of Wadi Sheep. Over the past decade, imported meat sheep breeds, favored for their rapid growth rate and high feed conversion efficiency[10], have led farmers to phase out Wadi Sheep, which are smaller in body size and possess a thick fatty tail that reduces slaughter yield. Second, genetic purity within the population has declined due to hybridization with introduced breeds. A large number of unregulated crossbreeding has reduced the purity of the Wadi Sheep population. On the one hand, in the core production areas, Wadi Sheep coexist with Small-tailed Han Sheep, leading to unregulated crossbreeding and the emergence of hybrid "Wei-Han hybrid." On the other hand, influenced by market demands, farmers have widely introduced foreign meat breeds such as Dorper Sheep for indiscriminate crossbreeding with Wadi Sheep. Field surveys indicate a continuous decline in the Wadi Sheep population and a gradual contraction of its core production zones. According to statistics, the Wadi Sheep population in Zhanhua District totals 11 600 head, primarily raised by scattering raising households. However, these farmers typically keep Wadi ewes, while breeding rams primarily consist of meat breeds such as Dorper Sheep, making purebred breeding impossible. Within 3 – 5 years, purebred Wadi Sheep in backyard farming systems are projected to be depleted. Third, the development and utilization of germplasm resource advantages remain insufficient. Although Shandong Binzhou Animal Science and Veterinary Medicine Academy has conducted some studies on Wadi Sheep's growth rate, meat production performance, and reproductive traits, the evaluation and exploration of their superior characteristics are not in-depth and systematic. Comprehensive assessments of the breed's germplasm traits, adaptability, genetic diversity, and gene flow have yet to be conducted. Hybrid utilization of Wadi Sheep remains experimental, and their advantageous traits such as high fecundity and disease resistance have not been effectively exploited.

Bohai Black Cattle

General situation of the breed The Bohai Black Cattle, originally named "Wudi Black Cattle" or colloquially "Zhuadihu Cattle" are primarily produced in Wudi County, Shandong Province, and distributed across northern Shandong. It is the only black-coated cattle breed in China, one of the three major black-coated cattle breeds globally, and one of China's eight renowned cattle breeds, serving as an excellent breed for producing high-end beef. Their key characteristics include black coat, hooves, horns, nose

and tongue, well-developed hindquarters, a robust physique, early sexual maturity, stable genetic performance, strong adaptability and stress tolerance, and tender marbled meat rich in nutrients[11]. In 1983, the Bohai Black Cattle was recorded in *Livestock and Poultry Breeds in Shandong Province and Cattle Breeds in China*, and in August 2000, it was included in the *National Conservation List of Livestock and Poultry Genetic Resources*. The current Bohai Black Cattle population in Bohai City totals 626 head, including 266 breeding cows and 35 breeding bulls. There is one national-level conservation farm for Bohai Black Cattle.

Current status of breeding The breeding cows in China are less than 3 000 head, showing a decreasing trend year by year, and they may reach a critical state in the next 10 years. Conservation efforts for Bohai Black Cattle are urgently required.

To rescue and conserve Bohai Black Cattle germplasm resources, Wudi County has established a Bohai Black Cattle Seedstock Breeding Base to develop a core breeding herd. The project is managed by Wudi Huaxing Animal Husbandry Co., Ltd. In June 2010, Wudi Huaxing Bohai Black Cattle Breeding Co., Ltd. of Shandong Province was officially founded. In October 2011, the original breed farm of Bohai Black Cattle in Shandong Province, which was responsible for the National Bohai Black Cattle Conservation Zone, was moved to the farm of Wudi Huaxing Bohai Black Cattle Breeding Co., Ltd. The conservation herd within the National Bohai Black Cattle Conservation Zone is tasked with providing purebred Bohai Black Cattle frozen semen for purebred breeding by the company.

Wudi Huaxing Bohai Black Cattle Breeding Co., Ltd. of Shandong Province is a private enterprise integrating Bohai Black Cattle breed conservation, genetic improvement, purebred breeding, selective breeding improvement, experimental promotion, beef cattle slaughtering and processing, and forage cultivation and processing. The company has been recognized as a "National Bohai Black Cattle Conservation Farm", "National Standardized Livestock and Poultry Breeding Demonstration Farm", "National Core Beef Cattle Breeding Farm", "Shandong Bohai Black Cattle Original Breeding Farm" and "Municipal Key Agricultural Industrialization Farmer Cooperative". Since 2014, it has continuously signed beef supply contracts with Shandong Sports Training Center, and its beef products are highly praised by sports professionals. The company's products have been certified as "Shandong Time-honored Brand", "Shandong Famous Brand", "Shandong Well-known Regional Public Brand for Agricultural Products", and "Shandong High-Quality Brand". Through the development concept and management of both conservation and development over the past decade, the Bohai Black Cattle industry has achieved healthy and stable growth.

Bohai Black Cattle currently face challenges such as insufficient consumer awareness and marketing efforts, resulting in premium beef failing to command premium prices, which undermines the sustainability of conservation efforts. Additionally, inadequate promotion of Bohai Black Cattle frozen semen has led to low financial returns, threatening the continuity of conservation initiatives.

Wudi Donkey

General situation of the breed The Dezhou Donkey, also known as Wudi Donkey, originated from Wudi County. It comprises two breeds: the "Wutou Donkey" and the "Sanfen Donkey", which exhibit differences in body type and physical appearance. The Wutou Donkey is characterized by an entirely black coat, robust build, and docile temperament. The Sanfen Donkey displays three pinkish-white patches (around the nose, eyes, and abdomen) against a black coat, and exhibits a slender and agile physique. The Sanfen Donkey, prized for pure meat percentage, is raised for meat production, while the Wutou Donkey, valued for its high hide yield, is utilized for hide processing to produce donkey-hide gelatin (Ejiao). In 1998, the Dezhou Donkey was included in the *Livestock and Poultry Genetic Resource Conservation List of Shandong Province*. It was added in the *National Conservation List of Livestock and Poultry Genetic Resources* in 2004, followed by its conclusion in the *National Local Breed Conservation List* in 2006. In 2011, the "Wudi Donkey" received geographical indication certification from the State Administration for Industry and Commerce in.

The Dezhou Donkey population in Binzhou City totals 1 235 head, including 735 breeding female donkeys and 57 breeding male donkeys. There are two national Dezhou Donkey conservation farms: Shandong Wudi High-quality Livestock and Poultry Breeding Farm and Shandong Junchi Donkey Industry Co., Ltd.

Current status of breeding Dezhou Donkeys exhibit strong environmental adaptability, tolerance to coarse feed, and ease of husbandry. However, their long growth cycle, high feed input, slow weight gain, and low economic efficiency pose challenges[12]. Binzhou City currently hosts one national Dezhou donkey conservation farm (No. 03705002), and Shandong Junchi Donkey Industry Co., Ltd. which engages in industrialized donkey farming. Shandong Dezhou Donkey Original Breeding Farm, located within Wudi High-quality Livestock and Poultry Breeding Farm, integrates selective breeding, hybrid improvement, and breeding promotion of Dezhou Donkeys. Its primary tasks include the conservation and utilization of local livestock breeds, as well as the introduction and breeding of improved fine breeds. The farm employs 236 staff members, including 17 animal husbandry and veterinary technicians. It has a dedicated organizational management structure comprising 1 farm director (senior veterinarian), 2 technicians (1 with senior and 1 with intermediate certificates), 2 support staff, and 4 breeders. The farm has the equipment and facilities (including laboratories and semen processing equipment) necessary for routine breed conservation and development and utilization. Various management systems have been established in the farm. In the production and management of Dezhou Donkeys, the breeding plan and implementation plan of Dezhou Donkeys have been made. The current breeding male donkeys are derived from seven distinct bloodlines with clear pedigrees, meeting the Shandong provincial standards. Among them, 84% of the female donkeys are classified as Grade 1 or above, while all male donkeys meet or exceed the Grade 1 criteria. Shandong Junchi Donkey Industry Co., Ltd., established in 2016 with a registered capital of 12 million yuan, covers an area of approximately 40 hm^2. The company adopts an eco-friendly farming model, operating 50 high-standard breeding barns with a herd size of 1 200 donkeys and two donkey meat

processing lines. However, challenges persist, including a limited number of female donkeys, low reproductive rates and decentralized farming, and it is difficult to popularize and apply epidemic prevention technology and other related technologies.

Research of Development Strategies

Based on the current status and challenges in the conservation and utilization of livestock and poultry genetic resources in Binzhou City, following development strategies and recommendations are proposed:

Strengthening the livestock and poultry genetic resource conservation system

It is necessary to formulate scientifically viable regulations for the conservation of livestock and poultry genetic resources to define clear conservation objectives, tasks, and measures. The guiding role of the government should be reinforced to ensure comprehensive protection of genetic resources, implement rescue conservation for endangered resources, and prioritize the safeguarding of nationally and provincially protected breeds[13]. Participation of enterprises, research institutions, universities and other societal stakeholders in the conservation of germplasm resources should be actively encouraged, so so to foster a diversified framework for conservation efforts.

Increasing financial investment and technical support

The government should raise conservation funds through multiple channels to ensure the smooth implementation of livestock and poultry germplasm resource conservation and utilization. Funds for research and development (R&D) and extension activities in research and technology extension departments should be increased to accelerate the conservation and utilization of local breeds. Enterprises can be actively guided to engage in extensive and in-depth collaboration with research institutions, and develop high-quality, market-adapted new breeds (lines) leveraging local livestock and poultry genetic resources, thereby enhancing the market share of local genetic resources[14].

Implementing dual strategies of breed conservation and development

While strengthening conservation efforts, the development and utilization of livestock and poultry germplasm resources should be emphasized. The production performance and product quality of livestock and poultry can be improved by introducing, breeding and popularizing excellent breeds. It is necessary to strengthen the industrialization development of livestock and poultry germplasm resources and promote the transformation, upgrading and high-quality development of related industries[15].

Strengthening supervision and services

Robust regulatory mechanisms for the conservation and utilization of livestock and poultry germplasm resources should be established to intensify monitoring and inspection of conservation initiatives. Comprehensive service support should be provided, involving technical consultation, training guidance, and policy advocacy, to help enterprises and farmers improve their ability to protect and utilize high-quality livestock and poultry germplasm resources.

Promoting green development in animal husbandry

In the process of conserving and utilizing livestock and poultry germplasm resources, emphasis should be placed on ecological environment protection and sustainable development. The promotion of green farming technologies and models should be prioritized to reduce environmental pollution and degradation caused by livestock and poultry farming. Efforts should be strengthened to enhance the resource utilization of livestock waste, driving the organic integration and circular development of animal husbandry and crop cultivation.

In summary, Binzhou City has achieved certain progress in the conservation and utilization of livestock and poultry germplasm resources. However, efforts are still required to strengthen the development of protection mechanisms, increase financial investment and technical support, implement a dual strategy of conservation and development for breeding resources, enhance regulation and services, and promote green development in animal husbandry. Through the implementation of these measures, the protection and utilization level of livestock and poultry germplasm resources in Binzhou City can be further improved, facilitating the sustainable and healthy development of the animal husbandry industry.

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