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The Water Buffalo (Bubalus bubalis) as an Autochthonous Genetic and Dairy Resource in Republic of Serbia

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Abstract

Autochthonous breeds are considered as valuable reservoirs of genetic diversity owing to their capacity to adapt under specific ecological and economic conditions. Among these, the water buffalo (*Bubalus bubalis*) holds particular importance in European agriculture, especially in Italy, Romania, Bulgaria, and parts of the Balkans. In Serbia, buffalo populations have traditionally been concentrated along major river basins. Most herds are found in central and southern Serbia, restricted to areas where traditional buffalo husbandry has been maintained due to geographic factors and cultural practices. However, according to FAO data, their numbers have markedly declined over the past decades, with some local populations approaching extinction. Over the past five years, the Serbian water buffalo population has ranged between approximately 1,100 and 1,600 head, having a peak in 2022. According to the most recent records, the population now numbers just under 1,500 animals. In general, water buffalo are classified into Swamp and River subspecies, each with unique production traits and geographic distribution. Swamp buffalo are primarily kept in South and Southeast Asia, where they serve as draught animals and produce modest quantities of milk and meat. In contrast, River buffalo, which predominate in Europe, have been selectively bred for high milk yields and are the foundation of traditional dairy industries that produce specialty cheeses highly valued by consumers. Buffalo milk is characterized by its rich composition, containing 6–8% fat, elevated protein levels, and a high proportion of total solids, making it particularly suitable for processing into mozzarella and various traditional cheeses.

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In addition to their valuable milk traits, buffaloes are recognized for their ability to thrive under suboptimal conditions, their effective feed utilization, and their resilience to various infectious diseases. Conservation of this genetic resource is fundamental for maintaining adaptive capacity and supporting the socio-economic sustainability of rural production systems. It is essential to implement selection and conservation programs and promote the valorization of buffalo-derived products in order to preserve this culturally valuable species in Europe.

Keywords: Water buffalo, milk fat, genetic resource, conservation

Introduction

Autochthonous livestock breeds constitute valuable reservoirs of genetic diversity and cultural heritage, especially in areas where traditional agricultural practices are still prevalent. The water buffalo (*Bubalus bubalis*) is an animal with a great potential for the future of agriculture in Serbia. First of all, they produce milk with a rich and unique composition (ZICARELLI et al., 2020). Buffaloes exhibit strong resilience and adaptability to specific ecological and economic conditions (VIANA et al., 2025). A characteristic external morphological feature of the buffalo cow includes black, long, and sparse hair, curved horns, notched ears, shiny eyes, and a well-developed mammary gland. Body weight in adult female water buffaloes is largely influenced by the rearing system and environmental conditions. Under extensive or semi-intensive management, mature buffalo cows typically weigh between 450 and 600 kg, although individuals reaching up to 700 kg have been recorded, primarily due to enhanced nutritional input and improved feeding regimes (BORGHESE, 2013). Among such breeds, the **water buffalo** holds a prominent role due to its adaptability to diverse agroecological conditions. This animal connects tradition with modern needs, because it offers opportunities for innovation in food production, especially in dairy industry(NAPOLITANO et al., 2021).Globally, the distribution of buffalos is predominantly concentrated in Asia, where approximately 98% of the total buffalo population is primarily located within South and Southeast Asian countries (BORGHESE et al., 2022).In Europe, the River buffalo has historically been present across Italy, Romania, Bulgaria, and eastern parts of the Balkan peninsula. In these areas, buffaloes have traditionally contributed to local economies through their capacity for milk and meat production. River buffaloes have been selectively bred for high milk yield, rich in fat, protein, and total solids, making them ideal for making dairy products such as mozzarella and other specialty cheeses (STEPIC et al., 2024). In Serbia, the presence of buffalo has a longstanding historical significance, particularly in lowland regions near river basins, where extensive and semi-extensive systems of husbandry were traditionally practiced. Historically, water buffalo were present in substantial numbers throughout the Balkans, including

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Serbia. In Serbia, this species is primarily found in the Raška and Zlatibor districts, specifically in the municipalities of Novi Pazar, Tutin, and Sjenica (Pešter–Sjenica plateau area), as well as in the region of Kosovo and Metohija and on the Stara Planina mountain (GRITTNER et al., 2021). Nevertheless, the shift toward intensive and mechanized agricultural systems has contributed significantly to their population decline.

In the context of global initiatives aimed at preserving agrobiodiversity and promoting sustainable, climate-resilient livestock systems, the conservation of the Serbian water buffalo holds considerable strategic importance. As a locally adapted and underutilized genetic resource, this species exhibits several favorable traits including resilience to endemic diseases, efficient feed utilization, and adaptability to low-input production environments which are critical for sustainable animal husbandry (CHIARIOTTI et al., 2025). Nevertheless, the persistent decline in population size, along with limited commercialization and the lack of organized breeding and conservation programs, presents a substantial threat to its long-term preservation and productive potential. The conservation of these breeds is crucial not only for preserving unique genetic traits but also for maintaining the resilience of rural communities.

The aim of this study was to assess the current status and conservation relevance of the water buffalo with particular emphasis on population trends, production potential, and genetic resource value. To achieve this, we conducted a retrospective analysis of population trends, production traits, and factors affecting the species' conservation status.

Material and methods

This study is based on a comprehensive review and synthesis of available data related to the population dynamics, geographical distribution, and production characteristics of **water buffalo (***Bubalus bubalis***)** in Serbia. Data were gathered from the following sources: Official national statistics published by the Statistical Office of the Republic of Serbia (SORS), Ministry of Agriculture, Forestry and Water Management, FAOSTAT and other publicly available databases maintained by the Food and Agriculture Organization (FAO). Also, we collected data from peer-reviewed scientific literature.

Results

Population trends in Serbia

An analysis of data presented by UROŠEVIĆ et al. (2023) indicates that the population of water buffalo in Serbia remains relatively small and geographically

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constrained. Over the past four years (2019–2023), the total number of registered animals has fluctuated between 1,100 and 1,600 animals, with a peak recorded in 2022 at approximately 1,600 animals. According to the most recent data from 2024, the current population numbers just under 1,500 head (Figure 1).

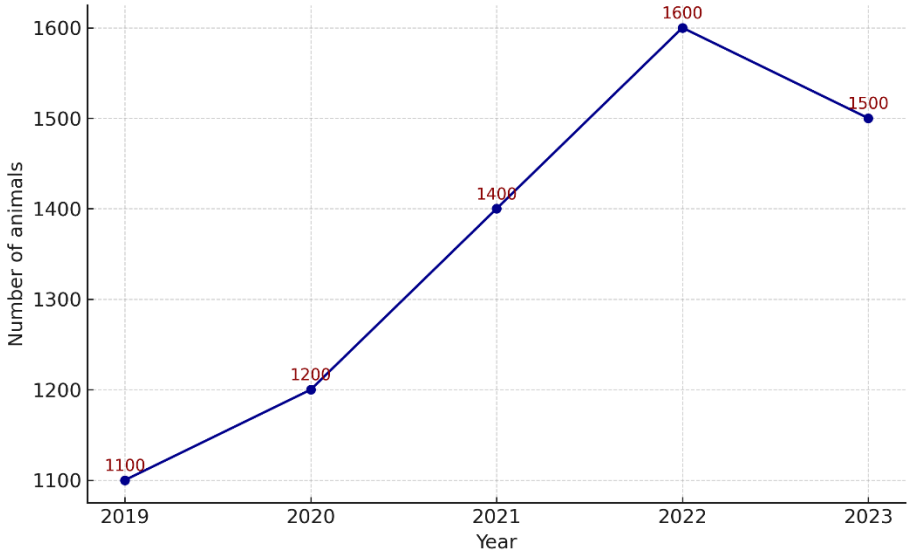

Figure 1: Water buffalo population in Serbia (2019-2023)
Urošević et al., 2023

Geographic distribution

According to available literature, buffalo husbandry in Serbia has historically been concentrated in lowland and riverine regions, especially along major river basins such as the Danube or Morava. Over time, populations have become confined to localized and fragmented areas, with evidence suggesting limited commercial expansion and only minimal structured breeding initiatives. Despite this tradition, the species is now found only in highly localized and fragmented areas, with some micro-populations being critically endangered. There is currently no evidence of significant commercial expansion, and breeding programs are extremely limited.

Production characteristics

Buffaloes raised in Serbia belong to the River buffalo type, which is globally recognized for its dairy productivity. However, due to the lack of structured selection and improvement programs, average milk yields remain modest compared to commercial herds in countries such as Italy or India. Milk yield in Serbian conditions is estimated between 1,000 and 1,500 liters per lactation, depending on management practices (PERISIC et al., 2015). Milk composition is characterized by: fat content:

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6–8%, protein: 4.0–4.8%, total solids: over 16% (Becskei et al. 2020). This rich composition makes buffalo milk particularly suitable for cheese production, especially traditional dairy products such as mozzarella and local traditional cheeses. However, due to limited demand and lack of organized milk collection systems, no major dairies in Serbia currently collect buffalo milk.

Conservation significance

Although no comprehensive genetic studies have been conducted on Serbian buffalo populations in recent years, historical isolation and the small effective population size suggest the existence of a distinct genetic pool. There is no documented evidence of genetic introgression from foreign breeds, and the populations have remained reproductively isolated for decades.

Discussion

The findings of this study highlight the vulnerable status of the Serbian water buffalo, both in terms of population size and genetic conservation. Despite belonging to the River buffalo type, known for superior milk composition and adaptability to low-input systems (BORGHESE, 2013), buffaloes in Serbia remain severely underrepresented in the national livestock sector. Similar challenges have been reported in other European countries with marginal buffalo populations, where lack of institutional support, economic incentives, and genetic programs has led to stagnation or decline in herd numbers (EL DEBAKY et al., 2019). Genetic monitoring and molecular characterization have not been systematically conducted in Serbia. This absence limits the ability to identify potential private alleles or unique haplotypes that could confirm the autochthonous status of the population. In contrast, studies from Bulgaria, Romania, and Hungary have reported regional genetic structuring and variability within River buffalo populations (BODNAR et al., 2017), supporting the need for national-level initiatives in Serbia to document and preserve its buffalo gene pool. The population has remained relatively stable over the past five years, but at critically low numbers that suggest stagnation rather than recovery. This pattern reflects the absence of structured breeding programs, inadequate conservation strategies, and limited economic motivation for buffalo farming. While buffalo milk possesses a rich composition, characterized by high levels of fat, protein, and total solids (6–8%, 4–4.8%, and >16%, respectively). However, its potential remains underutilized due to the absence of organized milk collection systems, low consumer awareness, and lack of brand development for buffalo-based dairy products (BECSKEI et al. 2020). Geographically, buffaloes are still found in traditional lowland areas along the Danube, Sava, and Morava river basins. These regions provide optimal conditions for extensive and semi-extensive management systems. However, the continuing depopulation of rural areas, coupled with the abandonment of livestock farming by younger generations, leads to the progressive

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loss of traditional knowledge, breeding practices, and cultural associations linked to buffalo husbandry (FAO, 2022). Although commercial interest in buffalo production is minimal, the species holds significant potential for sustainable rural development. Its ability to thrive in marginal environments, combined with its nutritional and cultural value, makes the water buffalo a promising candidate for inclusion in resilient food production systems (BORGHESE, 2023). Lessons from countries like Italy and India demonstrate that strategic support such as targeted breeding, niche product development, and farmer education can successfully revitalize buffalo production (CAPPELLI et al., 2021; SHARMA et al., 2023).Over the past decade, the Serbian government has introduced targeted subsidy schemes to encourage buffalo breeding, with support levels determined by age category: €100 for calves up to six months, €150 for young stock aged six to twenty-four months, and €250 for adult cows and bulls. While this represents a positive policy intervention, its impact is limited without parallel infrastructure and market integration. In Italy, a mandatory tracing system implemented via ministerial decree has been used to regulate and monitor buffalo milk production across the supply chain (CAPPELLI et al., 2021).

Therefore, to ensure the survival and potential revitalization of buffalo farming in Serbia, it is necessary to adopt integrated approaches that include genetic monitoring, development of selective breeding programs tailored to extensive systems, and structured market channels. To confirm the existence of a distinct genetic pool and to assess the level of genetic diversity within the Serbian water buffalo population, it is essential to implement comprehensive molecular characterization studies using microsatellite markers and other genomic tools, as demonstrated in previous research conducted on water buffalo populations in North India (VOHRA et al., 2021).

Conclusion and recommendation

Water buffaloes in Serbia represent a genetically and culturally valuable livestock resource, yet remain confined to small, fragmented populations with limited support. While milk composition and ecological adaptability offer clear production advantages, the lack of structured conservation and breeding strategies continues to hinder population recovery and sustainable use. To ensure the preservation of this genetic resource, it is essential to develop and implement nationally coordinated programs that include comprehensive genetic characterization and long-term monitoring. These efforts should also incorporate selection and conservation strategies adapted to local environmental and production conditions, while simultaneously enhancing the economic viability of buffalo-derived products through targeted education, appropriate financial support mechanisms, and better access to sustainable markets. Without such interventions, the future of water buffaloes in Serbia will remain uncertain, risking the irreversible loss of a

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multifunctional species with strong ties to both rural livelihoods and national agrobiodiversity.

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