Genetics and Reproduction

Review

Water Buffaloes in Cuba II. Herd Evolution, Adaptation, and Current State

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ABSTRACT

Background: The introduction of buffaloes in Cuba is relatively recent; however, it has been established under several constraints, mainly cognitive ones. **Aim**. To conduct a detailed analysis of the introduction of Buffaloes in Cuba, and their adaptation to the environmental conditions and current development. **Development:** The study reports the evolution of herds since the arrival of the swamp subspecies and its current situation. **Conclusions**: The overall results indicate that the adaptation of buffaloes to the Cuban environment is a reality; however, to increase and maintain the productivity of this species it is necessary to implement a program based on new management and technological approaches whose guidance stems from the closed-cycle production and includes a coherent genetic breeding project.

Keywords: Buffaloes, adaptation, program development (*Source MeSH*)

INTRODUCTION

Livestock production systems are thought of as the most suitable social, economic, and cultural strategy to maintain population welfare, as it is the only activity that can offer simultaneous safety, daily support, ecosystem preservation, promotion of wildlife conservation, and satisfaction of the cultural values and traditions (FAO, 2022).

The rearing of water buffaloes is a reality; their adaptative features might constitute the most important support for livestock, and become the highest meat-producing species in the coming years, contributing to the people's diet. First, herd organization must be ensured along with self-management systems for the species for the two production purposes.

This review aims to characterize the cattle-raising scenario when the buffaloes were imported, to analyze the evolution of herds upon the arrival of Carabaos, and to lay out the current situation with the national herds.

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DEVELOPMENT

The decision to raise water buffaloes (*Bubalus bubalis*) in Cuba was made during a period (1983–1989) when cattle, poultry, and swine farming had developed through large livestock production programs, which at the beginning of the revolution, in 1959, were at the core of political and economic decisions to increase the production of foods from animal origin.

To understand the current state of the bubaline program in Cuba, it is necessary to highlight the premises that supported these transformations, which were not in place for buffaloes specifically in the guidelines.

Water buffaloes and artificial selection

Continuously, new advantages for the rearing of this species are presented, such as resistance to diseases and hostile environments, consumption of coarse foods that the animals convert into milk and meat, longevity, high reproductive and adapting capacity to different environments, tameness, higher total solid quantities in the milk, which offers an essential relevance for industrial processes and particular meat attributes (Grazziotto, Maidana, and Romera, 2021; Minervino *et al*., 2020; da Silva *et al*., 2021). However, this impressive capacity to adapt to adverse environments may become the main hindrance to development, as the general belief is against raising improvements in such areas to increase production.

The almost null artificial selection implemented in buffaloes, compared to other species, is the reason why these animals are very resistant to adverse conditions, and the ones causing such behaviors and characteristics.

Nevertheless, resulting from intensive rearing, the cows have been exposed to new stimuli favored by cattle-designed technologies (increased human contact, diet changes, a reduction of the space available, and the transition from manual to mechanical milking, etc.). These practices have caused health problems to the buffalo cows, with more lesions and other disorders, including the separation of the mother from the offspring (Salzano *et al*., 2019).

Fitness is the base of the evolutionary process of populations, resulting in several physiological functions and properties, which, as a whole, confer a higher functional adaptative component (Falconer and Mackay, 1996) to a particular genotype (species, breed, animal).

Genetic selection has increased the production levels of livestock species considerably. However, apart from a favorable production growth, the animals within a population selected to achieve high production efficiency are believed to be more exposed to behavioral, physiological, and immunological problems (Rauw *et al*., 1998). The costs of success in developing artificial selection are placed on the bred animals, which negatively impact their well-being, survival, reproduction, and biodiversity (Camargo, 2012).

In dairy cows, the traits associated with biological efficiency or fitness (reproduction and longevity) have deteriorated despite their importance for the viability of the productive entity (Rauw *et al*., 1998).

These traits would be expected to be part of the objectives of genetic breeding programs, due to their biological and economic significance. On the contrary, these programs regularly lead to a fitness decline, eighter as a consequence of consanguinity or selection based on other traits. Many of these traits have one-allele genes that raise their value, which natural selection has kept under low frequency due to their negative effects on fitness. The above suggests that the determinant traits of fitness tend to decline as a consequence of artificial selection for other traits, though it is not predicted by the genetic correlation of the base population (Goddard, 2009). It does not occur in buffaloes, whose selection began in the mid-twentieth century (Cockrill, 1974), so they can adapt to the tropical environments. Additionally, there is a need to know them thoroughly to achieve the expected production results under these conditions.

A short review of the Cuban livestock context before 1980

The Agrarian Reform laws enacted in 1959 and 1963 laid the bases for a new national development model in agriculture, where the state became the main economic entity in the sector. The national livestock raising strategy relied on the transformation of extensive practices, with the implementation of large-scale highly specialized technological systems with administrative centralization and intensive production, supported by improvements of the genetic potential of national herds; the creation of technical-productive infrastructure according to the new requirements; sanitary control; the promotion of national feeding bases depending on each species' needs, or the availability of grains imported from the socialist camp at preferential prices, regardless of the inclusion of some national products, like molasses and processed wastes to accomplish development plans, which underwent heavy investment, along with the creation of a technical-professional base (Aguilar *et al*., 2004).

The livestock program did not include the coastal areas administered by the state livestock companies, where the natural conditions were unfavorable for animal production. In these areas, the water buffaloes were located.

Effect of the economic crisis of the 1990s on livestock production

The strong external adjustment undergone by the national economy from 1990 on had a severe repercussion on livestock production, which until then depended largely on imports. It led to a steep reduction of feedstuffs, fertilizers, fuels, and other basic resources, which affected cattle populations and therefore production, mainly in state-owned entities, with the largest production levels (Aguilar *et al*., 2004). Likewise, the swine and poultry populations and productions declined significantly, which forced companies to put most of their efforts to stop the declining tendencies; the recently imported buffalo herds were exposed to spontaneous development.

Buffalo introduction

In the years before the economic depression, the water buffaloes were introduced in areas where it was hard for other animals to survive, by the Los Naranjos Livestock Company, in the 1980s, in Cuba. The locations were prepared using minimum conditions for herd control and draining. Overall, 6307.4 hectares from a coastal swampy stripe in the south of the current province of Artemisa were populated with buffaloes. The import criteria were rusticity, consumption of low nutritional quality foods, and semiaquatic habits that made them ideal for extensive raising in those areas, in addition to the internationally recognized nutritional and industrial qualities of production. These concepts were the base of the program that was later developed.

The initial purpose was to purchase animals of the River subspecies from countries like Panama, and the Buffalypso from Trinidad and Tobago. However, the supply was insufficient in relation to the program needs, forcing the companies to import swamp subspecies or Carabao from Australia. A total of 2 984 animals from the two subspecies were imported, including River buffaloes (266 females and 13 males), 2948 Carabao females, and 57 Carabao studs, all without reproductive or productive control. The River buffaloes have 50 chromosomes, whereas the swamp buffaloes have 48 (Dzitsiuk *et al*., 2020; Iannuzzi, Parma, and Iannuzzi, 2021; Minervino *et al.*, 2020; Shaari *et al*., 2019; Singh *et al*., 2020, 2021; Vani *et al*., 2020). Crossing the two subspecies is possible, the F_1 has 49 chromosomes and the males and females are fertile (Yore *et al*., 2018).

The location of herds on coastal areas with little or no infrastructure and adverse conditions for different raising systems, together with higher maintenance and organization costs were some of the causes that hindered the development of the program. The extensive herds became semi-wild animals due to little relation with humans, with the absence of zootechnical flow, reduced feed supply, increased male-female interaction with a negative impact on animal organization and husbandry, lack of individual and population control, and the bad reputation of the species among cattle breeders, which led to a rejection of buffalo production in some locations. It is worth mentioning that Cuban cattle breeders did not know how to deal with the buffaloes, whose management is very different from that given to cattle. Consequently, the expected production results were low due to inappropriate human-animal interaction.

Eventually, as a result of the negative results of uncontrolled buffalo production in the coastal ecosystems, the Ministry of Science, Technology, and the Environment declared buffaloes as an invading exotic species. These populations are located in the north wetlands of Cuba, particularly in Sagua la Grande, Villa Clara, and Pinar del Rio, causing damage to Cuban vulnerable ecosystems, apart from being dangerous for their aggressiveness and as carriers of diseases like brucellosis and tuberculosis (Armiñana-García *et al*., 2020). Hence, there is a pressing need to maintain proper zootechnical management of the buffaloes in these locations.

Evolution of the national herd upon the arrival of Carabaos

Three working lines were designed as part of the Genetic Breeding Program of the Carabaos, which were placed in extensive areas with minimum control. The purpose was to obtain animals with dairy attributes, which relied on the maintenance and improvement of all the river animals, maintenance and improvement of 20% swamp animals, and absorption of 80% swamp females by the river subspecies, evaluating the crossings. F_1 River x Swamp; R_1: ¾ River x ¼ Swamp and 5/8 River x 3/8 Swamp. The plan for the Carabaos and their crossings failed, then maintenance and improvement of Buffalypsos included animals from the absorption program due to their morphological similarity.

In September 1985, the Los Naranjos Company obtained the first experimental future studs of Buffalypso, and in 2006 performance tests were conducted in 11 companies in the country, using males from this breed and their crossbred with Carabao, which related to the river subspecies morphologically. During this period, the selection was empirical.

The crossing program for the swam species began in August 1987, in the Los Naranjos Company, and went on until 1989 in the provinces of Matanzas, Villa Clara, Ciego de Avila, and Granma. Then, the controlled birth of the first F_1 (Buffalypso x Carabao) occurred in July 1988, and the second hybrid generation occurred in 1990. The first F_1 young cows were incorporated into reproduction in 1989; the Carabao and F_1 female buffaloes were not milked due to little udder development. In 1990, controls were made on extensive herds.

In August 1996, the Los Naranjos livestock company sent 30 buffalo cows and two studs to set up a dairy facility in every provincial capital city, and the special municipality of Isla de la Juventud, to spread the experience throughout the country. From 1997 on, the new dairies underwent population excess resulting from the high natality and low mortality of the species. The excess animals were sent to the areas holding extensive herds; in other locations, the animals remained in the diaries, causing problems to raising.

In 2000, a national program aimed to increase the number of buffalo dairies; the females with a negative selection due to their production were sent to other units. The dual-purpose character of the production system of this species was not included, which could have taken advantage of the little milk-producing females to create herds for meat production.

In the 1989-2002 period, the decline of the cattle herds (Figure 1) caused the inability of many dairy farms. After 2000, some of these farms were populated with Buffalypso or crossbreds, due to the growth of the species.

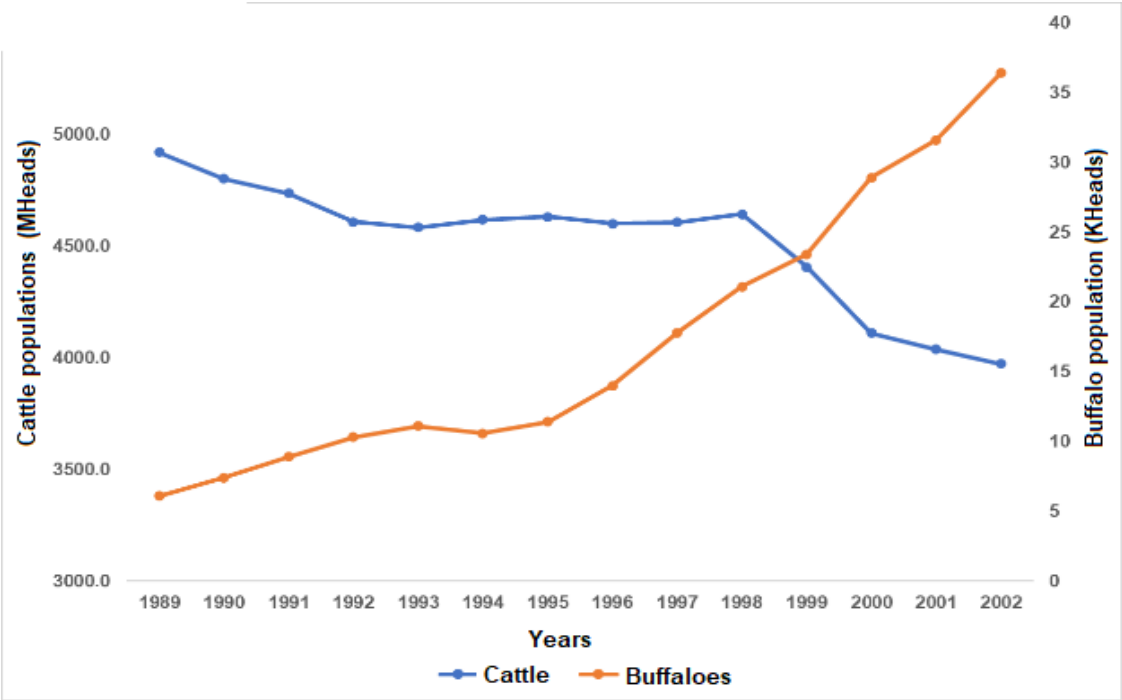

Figure 1. Evolution of cattle and buffaloes in the 1989-2002 period

Characteristics of buffalo milk and meat

The demand for healthy foods is rising with a growing interest in food quality. The advantages of buffalo milk compared to that of cattle lies in its physicochemical attributes, composition, sensorial attributes, and the nutritional and health aspects (Mane and Chatli, 2015). The proteins found in buffalo milk have a high biological value and contain every essential amino acid in the proportions required by humans (Khedkar, Kalyankar, and Deosarkar, 2016). Besides, buffalo's milk and its derivatives might become a good source of conjugated linoleic acid (CLA), which favors human nutrition (Khanal and Olson, 2004). In recent decades, several studies have been conducted to improve the composition of fatty acids (FA) from milk, increasing its production as they have beneficial effects on human health, using more appropriate technologies (Hanuš *et al*., 2018). The finding of AG profiles and triglycerides contained in low fusion milk fat fractions suggest that their therapeutical value in buffalo's milk is higher than in cattle's milk (Khan *et al*., 2019). The differences in the chemical composition of buffalo's milk as well as the milk from other species are explained by Becskei *et al*. (2020) and Garau *et al*. (2021); Zhou *et al*., 2018), and the colostrum and milk from Murrah and Murrah x Carabao (Bondoc *et al*., 2021; Bondoc and Ramos, 2022).

The excellent nutritional characteristics of buffalo meat make it a type of food that should be included in the human diet. Research results suggest that buffalo meat could be a healthier alternative to that of cattle for healthy people under particular physiological conditions (pregnancy), with the risk of suffering from cardiovascular and cerebrovascular diseases

(Guerrero-Legarreta *et al*., 2020; Tamburrano *et al*., 2019). The meat from the river buffalo is redder, with higher protein contents than beef (Guerrero-Legarreta *et al*., 2018; Guerrero-Legarreta *et al*., 2020). Besides these and other chemical characteristics of buffalo's meat (Hassan *et al*., 2018; Di Stasio and Brugiapaglia, 2021), it is necessary to identify and correct the practices that trigger contamination, reduce the stability of buffalo's meat, and suggest proper preservation and packing methods for sale. The sale of buffalo's meat poses an enormous challenge to farmers and researchers, as it requires a multi and interdisciplinary approach that favors a detailed examination of every link of the production chain (Cruz Monterrosa *et al.*, 2020).

Present situation of Cuban herds

In the 2000-2020 period, the buffalo population increased by 34.1 Kheads, but between 2009 and 2020, there was a 3.8 Khead decline. A comparison of this behavior with the total cattle population evidenced a better performance of buffaloes, still insufficient to cope with the species' characteristics, considering the steady annual growth between 2000 and 2009 (Figure 3).

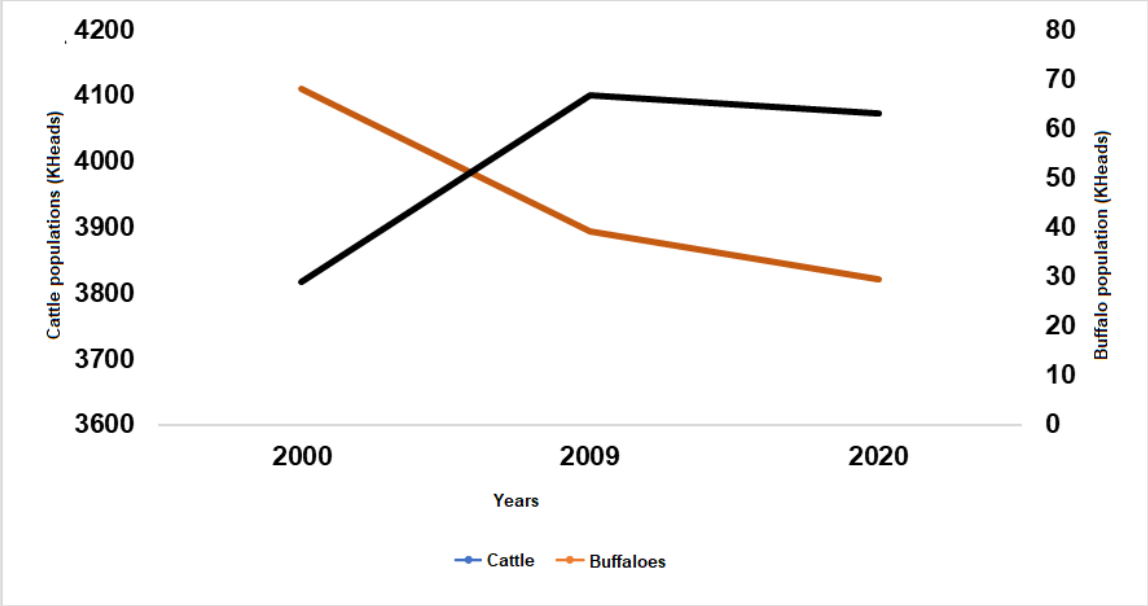

Figure 2. Evolution of cattle and buffalo populations between 2000 and 2020 in Cuba.

By late 2020, the national buffalo herd rose to 54.1 Kheads (18-fold), indicating its capacity of adjusting (fitness) to the environment. Of them, 90.5% belonged to the state, and the rest was owned by the Basic Units of Cooperated Production (UBPC), and Agricultural Production Cooperatives (CPA). The female population accounted for 22 525 heads, 14 447 of them buffalo cows located throughout the country. The largest populations are located in the provinces of Artemisa, Mayabeque, Villa Clara, Sancti Spiritus, and Camagüey, accounting for 64.1%. Starting in January 2021, the milk, meat, and subproducts from this species can be sold in

different markets. This decision is an important step forward, as the farmers will receive the sales income directly, which will have a positive impact on the development of the species.

There are several elements to claim for the need to use technology for milk and meat production without specialization. The remarkable yields in every national scenario, high natality and low mortality; high industrial value of the milk, thanks to the larger contents of total solids. Consequently, farmers will have considerable subproduct and income increments thanks to savings in raw materials when buffalo and cattle milk are available. For instance, comparing the yields of one kilogram of the product when the buffalo milk goes to the industry to cow's milk, there is a 40% milk reduction for yogurt, 39% for Mozzarella cheese, 29% milk sweet, 25% for butter, and 20% for Provolone cheese (Hühn *et al*., 1986).

CONCLUSIONS

The adaptation of buffaloes to the Cuban environment under minimum raising conditions is a fact. However, it requires an updated and thorough look at program development; a specific production program that suits the species in terms of technical and social concepts of raising is needed for the optimization of production, so they can impact food production and the family economy of the country in the present and future conditions.

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AUTHOR CONTRIBUTION

Conception and design of research: AMV; redaction of the manuscript: AMV.

CONFLICT OF INTERESTS

The author declares the existence of no conflicts of interest.