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COMPARATIVE TIME SERIES ANALYSIS OF ANATOLIAN WATER BUFFALO STOCK IN TÜRKİYE

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ABSTRACT

Water buffalo holds an important place in the livestock heritage in Türkiye. In the current study, buffalo numbers between 2023 and 2032 were estimated by using buffalo number data from 1991 to 2022. In the study, FAOSTAT data between 1961 and 2021 and TÜİK data for 2022 were used to obtain the time series. ARIMA modeling method was used in the study conducted in R programming language. ARIMA is a time series model that can make predictions from time series based on explaining univariate data. According to the results of the analysis made in the study, it is seen that the number of buffaloes in Türkiye will continue to decrease. According to the results obtained, it is estimated that the number of buffaloes will be 157,755 heads in 2023, 96,851 heads in 2027 and 19,136 heads in 2032. The disease resistance of buffaloes, their high adaptability, the high demand for water buffalo products, the preference for high-yielding cows for milk production despite government support payments, increasing mechanization, the reduction of buffalo habitats and the increase in input costs have led to a decline in Anatolian water buffalo populations. To prevent the Anatolian water buffalo from being threatened with extinction, the population decline must be halted and improved. To ensure this, the decline of the pastures that form the buffalo's habitat must be halted, pasture areas must be increased, and existing pastures rehabilitated, government subsidies for buffalo and calf rearing must be increased and market opportunities for buffalo products must be expanded.

Keywords: *Bubalus bubalis*, buffaloes, water buffalo, time series analysis, breeding

INTRODUCTION

Buffalo is a valuable animal material used for meat and milk production and power in soil cultivation in rural areas of many Asian countries and some Mediterranean countries such as Türkiye (Singh *et al*., 2019; Soysal, 2014). Buffaloes, which have economic importance among cattle in terms of milk and meat yield, are raised in Asia, South America, North Africa, Mediterranean countries, some Central European countries, and Australia (Akkulak and Kul, 2023; Al-Najjar, 2022; Yilmaz

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et al., 2012). Domestic buffalo, which belongs to the *Bubalus bubalis* species, is divided into two different groups: river buffalo and swamp buffalo (Ağyar *et al*., 2022). The river buffalo, which spreads more widely around the world, is a dominant species in Egypt, Italy, the Balkans, Türkiye, and Australia (El Debaky *et al*., 2019); The swamp buffalo is found as the more dominant species in many Asian countries, including China (Pineda *et al*., 2021).

Buffaloes differ in chromosome number, phenotypic characteristics, and generally their geographical location (Colli *et al*., 2018; Degrandi *et al*., 2014; Zhang *et al*., 2020). The two species also differ in chromosome numbers (river buffalo 2n=50, swamp buffalo 2n=48) (Ulbrich and Fischer 1967; Fischer and Ulbrich, 1967). And it is morphologically different too. While the river buffalo has a black body and usually curved horns, the swamp buffalo usually has a dark gray color (Zhang *et al*., 2020). While swamp buffaloes generally benefit from their traction power and meat yield, river buffaloes are valuable in terms of both meat and milk yield (Çetin *et al*., 2022). Additionally, around the world, buffaloes are generally raised by smallholders and contribute to the household in many ways (Yilmaz *et al*., 2012).

Anatolian water buffalos found in Türkiye are characterized as a river buffalo species belonging to the Mediterranean group (Ağyar *et al*., 2022; Yilmaz *et al*., 2012) and have low milk production (approximately 800 to 900 kg per lactation) (Muruz and Selçuk, 2019), low fatty acid profile in milk and meat (Çınar *et al*., 2019; Sahin *et al*., 2022), and carcass weight (approximately 800 to 900 kg per head (Soysal, 2014). Buffalo breeding has advantages such as high resistance to natural conditions and diseases, high feed conversion rate and lower costs compared to breeding cattle (Michelizzi *et al*., 2010; Özdemir, 2021).

Auto Regressive Integrated Moving Average (ARIMA) is a time series analysis method that provides results based on observation value in order to make future predictions (Khan and Alghulaiakh, 2020). The ARIMA time series model is used for situations that show random variations and are not dependent on specific situations (Filder *et al*., 2019), and it has been reported to give good performance for studies that want to create short-term forecasts (Ariyo *et al*., 2014).

This study was carried out with the aim of estimating the number of water buffalos in Türkiye between 2023 and 2032, using the number between 1961 and 2022.

METERIALS AND METHODS

In this study, buffalo numbers between 2023 to 2032 were estimated by using buffalo number data from 1691 to 2022. In the study, FAOSTAT data between 1961 and 2021 and TURKSTAT data for 2022 were used to obtain the time series.

The data series used in the research were produced with the R programming language and data analysis was performed using the R-Studio (2023.09.1-494) package program. The “forecast” package and time series command were used in the R programming language. Additionally, ARIMA was used as a modeling method. ARIMA is a time series model that can make predictions from time series based on explaining univariate data.

RESULT AND DISCUSSION

While there were 96 million 960 thousand head of buffalo in the world in 1961, there were 1

million 140 thousand head of buffalo in Türkiye in the same year. In addition, while the number of buffaloes reached more than 230 million heads in the world in 2022, it decreased to 171 thousand 835 heads in Türkiye (FAOSTAT, 2023). There will be more than 200 million buffaloes in 2022 in the Asian continent, where buffaloes are most abundant (FAOSTAT, 2023). Between 1961 and 2022, there was a decrease of 84.93% in the number of buffaloes in Türkiye (Figure 1).

It is thought that the public buffalo breeding project has made a significant contribution to the increase in the number of buffaloes in Türkiye in recent years. In addition, the establishment of Buffalo Breeders' Associations in 2008 in provinces where buffalo breeding is carried out (Yılmaz and Kara, 2019) and the establishment of the Turkish Breeding Buffalo Breeders' Central Union in 2012 are considered important steps in terms of organization (Soysal, 2013).

Among the 10 countries with the most buffaloes in the world in 2022, only Egypt has the river buffalo species, while all other countries have the swamp buffalo (Table 1). While India had the highest number of buffalos in all departments between 1961 and 2021, Brazil, Pakistan and Nepal were the countries with the highest percentage increase between these years. In the world rankings, Egypt, which has the river buffalo species, is ranked 10th, Italy is ranked 17th and Türkiye is ranked 20th. While there were 1 billion 501 million head of buffalo in Egypt in 1961, it decreased to 1 billion 419 thousand 927 heads in 2022. Italy increased the number of buffaloes from 18 thousand to 416 thousand in the same period. While Türkiye had a significant number of buffalos with 1 billion 140 thousand heads in 1961, it decreased to 171 thousand 835 heads in 2021 with a great decrease.

According to the forecast results, the number of buffaloes will continue to decrease in the coming years. The number of buffaloes in Türkiye is estimated as 159 thousand 755 in 2023, 81 thousand 308 in 2028 and 19 thousand 196 in 2032 (Figure 2).

Buffaloes have been found in many tropical countries around the world since they were domesticated between 3,000 and 6,000 years ago. They play a role in the agricultural economies of developing countries as they are an important source of milk, meat and meat products, horn, and leather (El Debaky *et al*., 2019). In addition, buffalo manure is used as a type of fertilizer that enriches the soil and reduces the need for chemical fertilizers (El Debaky *et al*., 2019). In feeding, buffalo may use lower quality and less digestible feeds and grazing options. This makes it easier for them to feed on locally available roughage. They also have advantages over cattle, such as resistance to many diseases, quality milk and meat products, and live weight gain (Hamid *et al*., 2017).

Considering the buffalo population, it is 97% in Asia, 2% in Africa, 1% in South America, and less than 1% in Australia and Europe (El Debaky *et al*., 2019). Buffalo breeding is still raised for products such as milk, meat, leather, and manure. In many developing and underdeveloped countries, buffalo breeding continues at a high rate due to reasons such as the high cost of cultured cattle and the inability to meet the desired productivity conditions, longevity, tractive strength, and resistance to heat stress.

However, in many industrialized and developing countries, cattle are preferred to buffalo because they have disadvantages such as late sexual maturity, weak oestrus symptoms, long ovulation period after birth, low pregnancy rate, and the genetic structure that determines economic traits is not fixed. In addition, the use of animal power

in agriculture has decreased to a minimum with the development of agricultural equipment and machinery, which is considered one of the reasons for the decline in buffalo numbers.

In many developing countries such as Türkiye, the habitat of the water buffalo continues to shrink due to the expansion of settlement areas towards rural areas and the construction of infrastructure such as airports, highways, railway, and bridges. In addition, important wetlands such as lakes and swamps are gradually disappearing due to global warming and drought. All these developments pose a significant threat to buffalo breeding and the buffalo population.

The lack of a comprehensive breeding and breeding program compared to cattle is one of the reasons why buffalo breeding has fallen behind. One of the factors for this is the lack of adequate connections between research institutes, breeders, and farmers. In addition, buffalo breeding is mostly done using traditional methods in the world. Using the progress in genomics in ruminants in buffalo breeding can accelerate development. With breeding programs using omics approaches, genetic advancement of economically important traits can be expected.

Farmers do not have enough information about buffalo breeding. Due to the lack of basic knowledge about buffalo, it causes great economic losses worldwide. Losses arising from lack of information can be minimized by providing training to producers on buffalo breeding and development, increasing university-farmer cooperation, and advertising buffalo products. In addition, the number and productivity of buffaloes can be increased by increasing the work done on buffaloes and using higher technology.

CONCLUSIONS

The decrease in the number of buffaloes can be thought of as the preference for high-productivity cattle in meat and milk production, the increase in mechanization and the fact that consumers do not prefer buffalo products. Even if cattle can reach higher productivity under conventional conditions, they cannot adapt to disease resistance and lower quality nutrition conditions as much as buffalo. Water buffaloes have been raised in Türkiye for more than 1000 years. Protecting buffaloes means protecting genetic resources as well as animal production. The risk of extinction of the buffalo population in Türkiye should be seen as the loss of one more genetic resource from Anatolian lands.

The disease resistance of buffaloes, their high adaptability, the high demand for water buffalo products, the preference for high-yielding cows for milk production despite government support payments, increasing mechanization, the reduction of buffalo habitats and the increase in input costs have led to a decline in Anatolian water buffalo populations. The current decline in animal numbers will put the impending extinction of the Anatolian water buffalo back on the agenda, like the situation before 2010. The buffalo has been bred in Türkiye for over a thousand years. To prevent the Anatolian water buffalo from being threatened with extinction, the population decline must be halted and improved. To ensure this, the decline of the pastures that form the buffalo's habitat must be halted, pasture areas must be increased, and existing pastures rehabilitated, government subsidies for buffalo and calf rearing must be increased and market opportunities for buffalo products must be expanded.

Table 1. Change in the number of buffaloes by years in the countries with the highest number of buffaloes in the world in 2022 (1961-2021) (FAO, 2023).

No.	Country	1961	1971	1981	1991	2001	2011	2022	Change (%)
1	India	51,207,920	56,876,000	67,500,000	82,160,000	95,173,000	108,063,000	111,856,246	118.44
2	Pakistan	6,700,000	9,545,000	11,917,000	17,818,000	23,335,000	31,725,000	43,676,000	551.88
3	China	8,369,516	1,627,3220	18,573,839	21,712,036	22,764,781	28,156,124	26,875,125	221.11
4	Nepal	795,000	1,127,000	2,500,000	3,043,920	3,624,027	4,993,650	5,132,931	545.65
5	Philippines	3,452,000	4,555,700	2,849,940	2,647,000	3,065,812	3,075,300	2,774,471	-19.63
6	Vietnamese	2,252,000	2,289,100	2,380,400	2,858,600	2,807,874	2,712,000	2,231,600	-0.91
7	Myanmar	1,048,523	1,597,499	1,969,000	2,072,000	2,502,000	3,096,887	2,000,000	90.74
8	Brazil	63,000	129,000	542,000	1,432,112	1,118,823	1,278,075	1,598,268	2436.93
9	Bangladesh	500,000	700,000	476,000	807,000	920,000	1,394,000	1,508,000	201.60
10	Egypt*	1,501,000	2,058,000	2,370,054	2,526,700	3,532,244	3,983,167	1,419,927	-5.40
17	Italy*	18,000	54,580	102,500	94,500	182,000	354,402	416,000	2211.11
20	Türkiye*	1,140,000	1,117,000	1,031,000	371,000	146,000	84,726	171,835	-84.93

*Countries with river buffaloes.

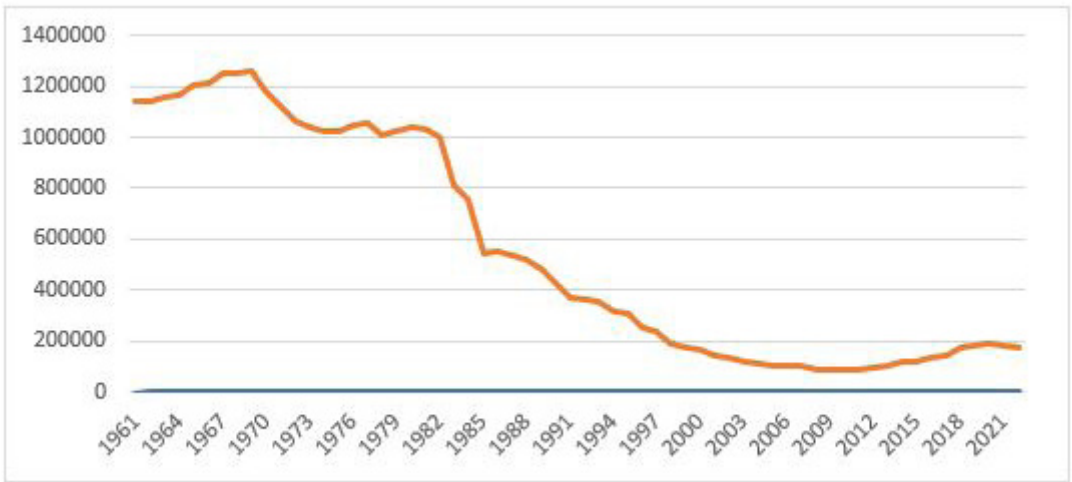

Figure 1. Number of water buffalos in Türkiye between 1961-2022.

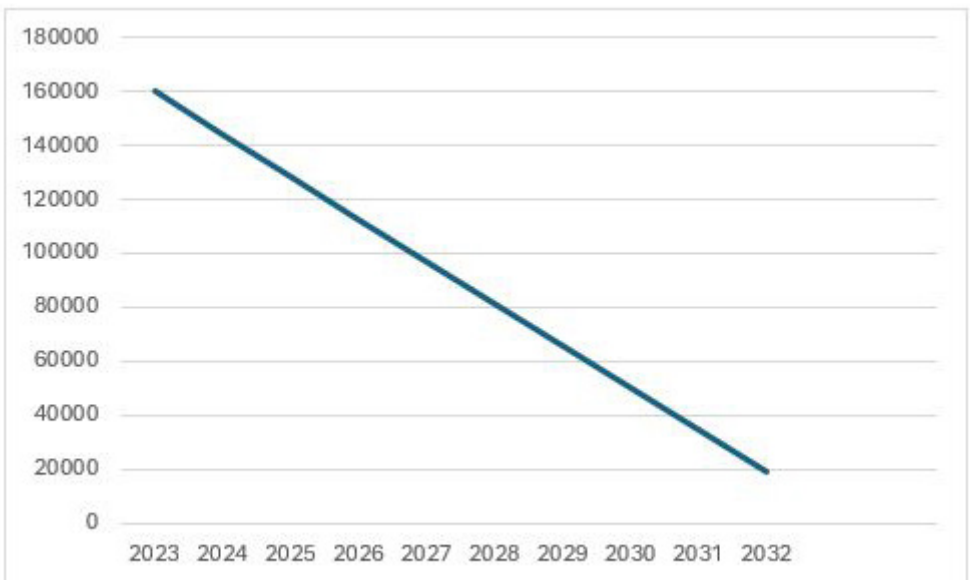

Figure 2. Estimated number of water buffalos in Türkiye between 2023-2032.

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