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Modeling the number of mules in Turkey through Time Series Analysis and Artificial Neural Networks

Şenol Çelik

Bingol University, Faculty of Agriculture, Department of Animal Science, Biometry and Genetic Bingol, Turkey
Correspondence: Şenol Çelik (senolcelik@bingol.edu.tr)

ABSTRACT

The aim of this study is to make a production plan by using artificial neural networks (ANN) and time series analysis for establishing appropriate models and forecasting the mule population in Turkey over the years.
The years parameter was used as an input parameter in the development of time series analysis and artificial neural network, and the number of mules was used as an output parameter. Mean square error (MSE) and Mean Absolute Error (MAE) statistics were used to calculate the efficiency of the developed model. According to the results obtained, there will be a slow increase in the number of mules from 2021 to 2025.
It has been observed that ANN models outperform time series analysis in predicting mules population.

Key words: Artificial neural network, moving average, forecasting, mules

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1. INTRODUCTION

Mules and Hinnies combine the virtues of donkeys and horses. They are stronger than donkeys but less nervous and more resisitant to illness than horses. Through crossing them the enhancement known as Heterosis occurs: the off-spring are healthier, longer living and have more stamina than their parents [1].
Mules are a cross between a female horse and male donkey. They look more like horses than donkeys. Moreover, breeders rather keep one male donkey than many female donkeys. Male donkeys are more enthusiastic about mating with a female horse than a stallion is with a female donkey. A characteristic of the hybrids is that the male mule is sterile, the mares can, in rare cases, be fertile. The chance of successful reproduction is greatest when the female mule is mated with a stallion [1].
A mule is not a genus, species or breed, but a hybrid offspring of a donkey (*Equusasinus*) and a horse (*E. caballus*). Mules are sure-footed and sturdy animals. Mules can live longer than horses. They are generally known as less stubborn, faster, and smarter than donkeys [2, 3].
Historically, mules and donkeys showed enormous contribution to the development of civilizations, with extensive use in various tasks [4]. With the evolution of mechanical engineering the equide was directed to leisure and competition, and horses began to have enormous economic value [5]. Scientific research was mainly directed to horses and often extrapolating for other species such as mules and donkeys, which can often be a mistake [6, 7].
Mules in Thailand are bred from native mare and imported donkeys. Two breeds of jack are available in Thailand including the Australian mammoth and the Dengzhou. Mules are used as a packing animal along the country borders where the terrain is mountainous and inaccessible by automobile [8].
In Greece, mules and donkeys were used for many types of work: in agriculture, transport and in the army. The importance of these animals differed from region to region: in some places donkeys were carefully bred, in others the donkey was considered a lowly animal and treated accordingly [1].
About a century ago in Turkey, mules used to be raised in mountainous areas of Black Sea, Marmara Regions, and Taurus mountain range [2]. Nowadays mules are raised in provinces of Ordu, Van, Hakkari, Sirnak, Mardin, Icel, and Balikesir which have mountainous areas. In provinces of Van, Hakkari, Sirnak, Mardin mules are used for fuel-oil and cigarette smuggling between Turkey and Iran, and Turkey and Iraq [9].
The present study goals to model the number of mules in Turkey using time series analysis and the artificial neural network method and to make predictions for the coming years.

2. MATERIAL AND METHOD

Material

The material of the study is 1961-2020 number of mules values supplied from the www.tuik.gov.tr web address of Turkish Statistical Institute [10] and Food and Agriculture Organization of the United Nations [11]. The dependent variable was number of mule figures while the independent variable was year series. These variables were selected in order to be able to make reasonable estimations with the models to be performed using ANN and time series analysis methods.

Method

Simple Moving Average

Simple moving average operation can be applied to eliminate or flatten seasonal, cyclical or irregular fluctuations [12].
In Simple Moving Average (SMA) process the following formula will be used:

$$SMA = \frac{Y_t + Y_{t-1} + \cdots + Y_{t-(k-1)}}{k}$$

"K" refers to the number of stretches. Stretching is used to remove fluctuations gradually and flatten the graph of series. The process of determining the"k" depends on the researcher.
Briefly, a mean is simply the average of a set of numbers. A moving average is a (time) series of means; it's a "moving" average because as new data (like prices) are made, the older data is dropped and the newest data replaces it [13].
In a moving average, a body of data to be averaged moves forward with each new trading period. Old data is dropped as new data becomes available which causes the average to move along the time scale [14].
The forecast model given as the k-period moving average model is called. While this model adds this new value to the average calculation when a new observation value is obtained, it deducts the oldest period value included in the previous average from the calculation. Thus, the average of the observation values of the last k periods is taken as the predictive value [15].

Artificial neural networks (ANN)

An ANN is an information processing model that can possession of, store and use empirical information to simulate human brainfunction. The network learns the relationship between datasetsand understands the details of the problem under investigation, and thus provides a comprehensive approach to solving nonlinear relationships and complex problems [16].
Inputs and outputs data is given to the network, processed, and then apatternthat identifies the intrinsic relationship between inputs and outputs. First, input and output data from the previous well was entered into the ANN model, and the analyzed data was imported to the new ANN model for a new well. Next, analyzed data from the previous well and input data from the new well was entered into the new ANN model, and the results would be reported as output parameter for a new well [17].
One of the most common used type of ANN is the feedforward network. The architecture of a feedforward neural network is nonlinear. Therefore, the output is obtained from the input through a feedforward arrangement. The multi-layer perceptron (MLP) is a type of feedforward neural network, consisting of input, hidden and output layers [18, 19].
The hyperbolic tangent (tanh) function produce a curve with an "S" shape, where the tanh output varies between [-1,1]. Mathematically, the tanh function is defined as follow [20].

$$\tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

To evaluate the precision of the predicted discharge volume, Mean Square Error (MSE) and Mean Absolute Error (MAE) were used [21, 22]:

$$MSE = \frac{\sum_{i=1}^{n}(y_i - y_{ip})^2}{n}$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|(y_i - y_{ip})\right|$$

Here, y_i is the real value of the dependent variable (number of mule), y_{ip} is the predicted value of the dependent variable (number of mule) and n is the number of samples.

3. RESULTS

The artificial neural networks and moving average method goodness of fit statistics (MSE and MAE) of number of mulebetween the years 1961-2020 in Turkey are displayed in Table 1. In the moving average method, 5 moving averages are used.The time series graph is shown in Figure 1.

Table -1 Model performance values

Fit Statistic	Moving Average (MA(5))	ANN
MSE	311 307 389.929	154945256.602
MAE	12 416.667	8448.118

While examining Table 1, when the moving average method and artificial neural network methods are compared according to MSE and MAE, artificial neural networks (ANN) with minimum MSE and MAE values (MSE=154945256.602and MAE=8448.118)are more suitablemodel.The hyperbolic tangent function was used as activation function when creating a model with the ANN method. The number of neurons in the input layer, the hidden layer and the output layer was determined as 3-12-1 each. 1000 iterations were used for the ANN method in the data series consisting of 60 observations between 1961-2020.

Fig. 1 Time series graph for mules population

The estimated and residual values are presented in Table 2 together with the real values of the ANN methodfor 1961-2020 period.

Table -2 Observed, predicted and residual values

Years	Actual	Predicted	Residual
1961	170200	NaN	NaN
1962	186900	NaN	NaN
1963	207800	NaN	NaN
1964	204919	210177.517	-5258.517
1965	216400	206466.355	9933.645
1966	225000	222150.248	2849.752
1967	238000	231672.966	6327.034
1968	259000	246798.187	12201.813
1969	273000	268440.894	4559.106
1970	290000	279574.899	10425.101
1971	299000	292216.607	6783.393
1972	301000	296540.561	4459.439
1973	312000	296806.708	15193.292
1974	302000	303442.249	-1442.249
1975	299000	295558.752	3441.248
1976	300000	295289.701	4710.299
1977	324000	296298.716	27701.284
1978	311000	309915.365	1084.635
1979	299000	299354.557	-354.557
1980	315000	293981.870	21018.130
1981	305000	305503.013	-503.013

1982	299000	297029.007	1970.993
1983	285000	294848.442	-9848.442
1984	269000	285272.691	-16272.691
1985	213000	273553.016	-60553.016
1986	206000	210517.412	-4517.412
1987	216000	210294.359	5705.641
1988	205000	221792.076	-16792.076
1989	208000	206444.184	1555.816
1990	210000	211776.677	-1776.677
1991	191850	213634.525	-21784.525
1992	180840	190033.779	-9193.779
1993	172000	177312.652	-5312.652
1994	169000	165989.395	3010.605
1995	169000	161884.933	7115.067
1996	154000	161440.734	-7440.734
1997	142000	143520.302	-1520.302
1998	133000	129245.482	3754.518
1999	125000	118110.426	6889.574
2000	99000	108672.971	-9672.971
2001	97000	85081.601	11918.399
2002	94924	79697.735	15226.265
2003	92012	77167.961	14844.039
2004	83867	74845.820	9021.181
2005	81678	69186.061	12491.939
2006	75018	66761.008	8256.992
2007	68199	62580.738	5618.262
2008	62248	58227.907	4020.093
2009	51548	54628.015	-3080.015
2010	48076	49412.689	-1336.689
2011	48249	47314.776	934.224
2012	47205	47289.111	-84.111
2013	45762	46939.319	-1177.319
2014	41397	46332.486	-4935.486
2015	42523	44665.175	-2142.175
2016	38229	44890.206	-6661.206
2017	34360	43492.072	-9132.072
2018	30837	41990.281	-11153.281
2019	29452	40799.788	-11347.788
2020	25119	40346.185	-15227.185

The graph of the observed and estimated values obtained with ANN method ispresented in Figure 2.

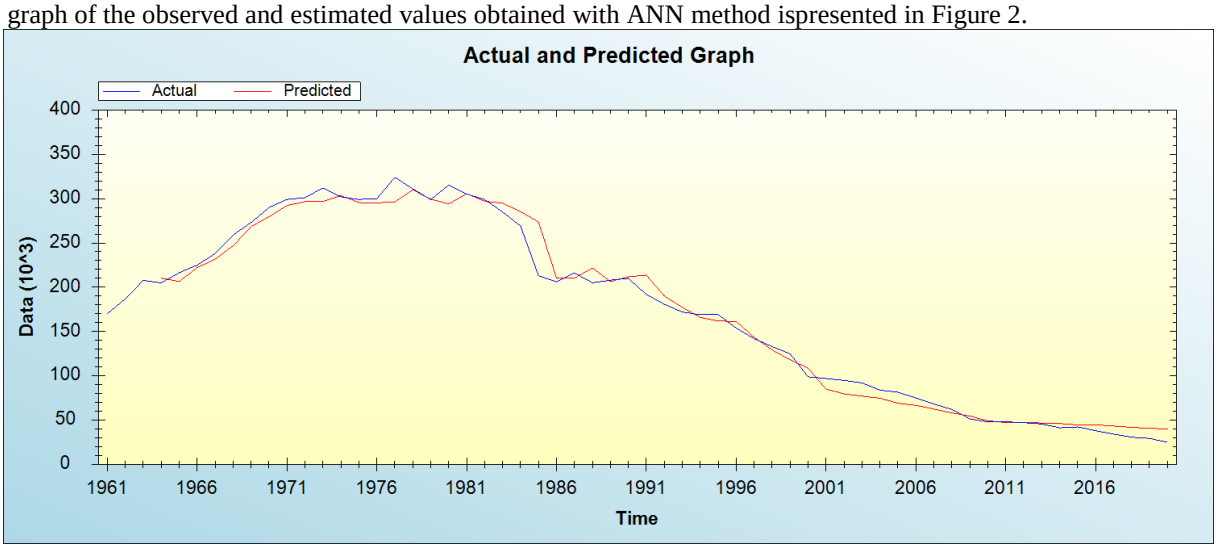

Fig. 2 The combined graph of observed and predicted values for number of mule

In Figure 3, meantime the joint graph of observed and residual values was observed, residual and observed values were found to be scattered free from each other and randomly. This situation shows that important hypotheses regarding the model are provided.

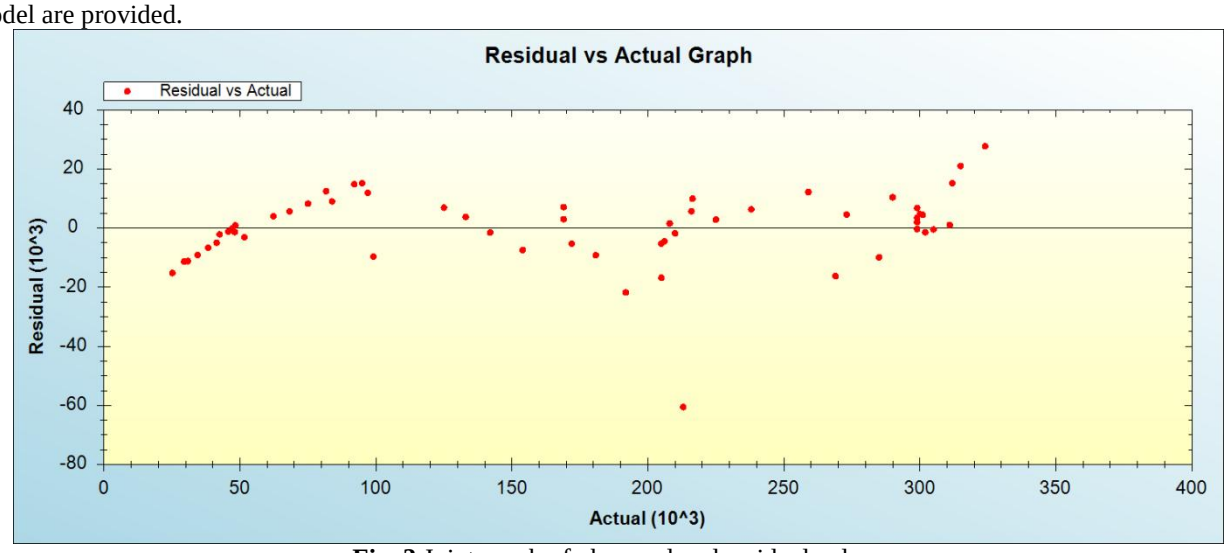

Fig. 3 Joint graph of observed and residual values

Estimated and residual values are presented together in Figure 4.

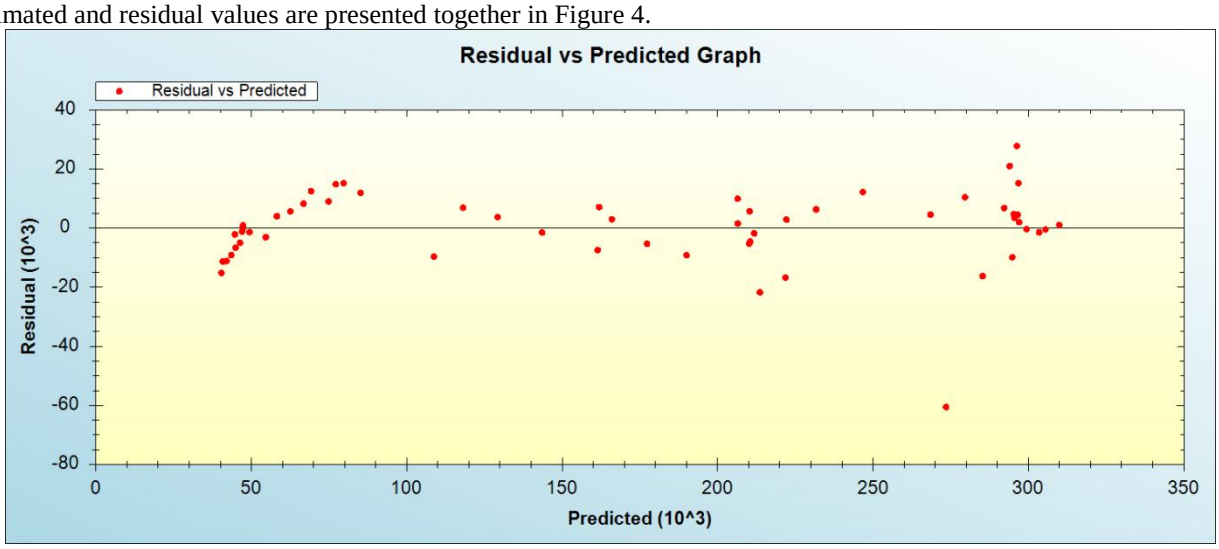

Fig. 4 Joint graph of predicted and residual values

The possible 2021-2025 number of mule forecasted with moving average and ANN methods are given in Table 3.

Table -3 Number of mule forecasting

Years	Simple Moving Average (SMA)	Artificial Neural Network (ANN)
2021	22711	39071
2022	19748	43456
2023	16785	45508
2024	13822	46187
2025	10859	46473

The prediction results were different in the moving average and ANN methods. In the 2021-2025 period, it is expected that there will be a decrease in the number of mules as a result of the moving average method, while it is expected that there will be an increase as a result of the ANN method (Table 3). The graph showing the actual and predicted values of the number of mule is shown in Figure 5.

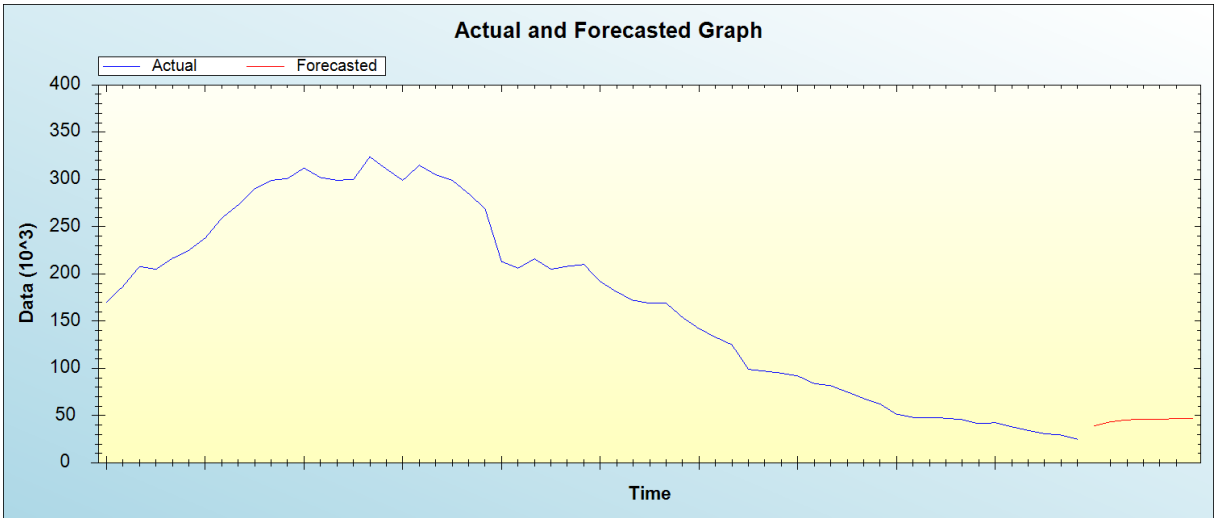

Fig. 5 The joint graph of observed and estimated values

4. DISCUSSION

In our study, we have obtained an appropriate model for predicting moving average and ANN methods.Using these models, it is possible to predict that the number of mules in the future will fluctuate.

The prevalence of epizootic lymphangitis in 309 cart-mules in Bako and Ejajitowns,Western Ethiopia using clinical and microbiological examinations was determined. There was found significant ($\chi^2 = 133.5$) relation between tick infestation and epizootic lymphangitis lesions in study cart-mules [23]. In a study of 236 mules in some provinces of east and southeast Turkey the analysis of variance and Students t-test functions of the were used to analyze data. Average withers height, rump height, body length, heart girth, chest depth, cannon circumference and head length were calculated 130.6 ± 0.49 cm, 130.7 ± 0.50 cm, 133.9 ± 0.49 cm, 149.6 ± 0.46 cm, 59.7 ± 0.34 cm, 16.5 ± 0.07 cm and 55.6 ± 0.26 cm, respectively [9].[8] carried out to test the accuracy of body weight estimation in mule using a horses and ponies weight tape, cattle weight tape, weight estimation equation for horse and weight estimation equation for donkey compare to body weight obtained from a digital scale. Authors compared by using the Independent t-test to evaluate the difference between the means of two independent groups according to data of body weight between genders. They calculated Mean absolute error (MAE) and mean absolute percent error (MAPE) for each method of obtaining body weight.

There are some studies in the field of livestock that employed artificial neural networks and time series. For instance, ANN was used to forecasting the number of pig and camel [24, 25].

5. CONCLUSION

The number of mules in Turkey was estimated by employing artificial neural networks and moving average models in this research. The input variables are the years (1961-2020), one independent variable, and the number of mules as the output variable. For the next stage, the preparation, testing and verification processes of the network were conducted and the estimation process was carried out.

The results point out that the proven ANN method provides better estimates than moving average models. This is also supported by the low MSE and MAE values in the preparation, testing, and verification phases.

Considering the prediction of the number of mules, the said figure, which was 25119 in 2020, is predicted to increase by 85.01% and reach 46473 in 2025. In the 2021-2025 period, there will be an increase.

It is noted that good results in animal population can be obtained by comparing artificial neural networks and alternative techniques in future prediction studies.

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