

Characterizing of growth curves with exponential equations and predicting weaning weights at the age of 6 months through some blood characteristics, milk production in buffalo

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Abstract

A sample of 50 Iraqi buffaloes heifers and their dams were used in the study, which was conducted in Baghdad (Al-Dhahab Al-Abyad/Abu Ghraib village area, 20 km west of Baghdad, and Al-Fadhiliya site, 20 km northeast of Baghdad) from the production season of 2021–2022. Following factor adjustment, the study's findings are as follows: The study reveals that an increase in milk supply by one kilogram per day leads to a significant increase in weaning weight for calves, with daily milk production accounting for 18% of their weight at weaning. The study found a positive correlation between weights at a young age and later weights, including weight at weaning, significantly influenced by udder milk production. Weight weaning had a significant association with fat percentage and protein percentage. The study used damsweight at birth to predict animal weights in buffaloes, and weight at weaning and six months of age to approximate real weights. The Brody and Logistic functions were accurate in estimating calves' weight up to six months old, with potential for extension to a year. Growth functions, focusing on sigmoid growth curve, are also available.

Keywords: growth curves, milk production, buffalo.



Introduction

Many nations around the world, particularly developing nations, place a high value on the economic contribution of buffaloes to the livestock sector (21). This animal has distinct since ancient times, and is therefore regarded as a significant source of their livelihood by many families who have lived in the southern part of Iraq, particularly in the Marsh lands (8)(9)(11). Roughage, including grass, legumes, and straw, makes up the majority of the buffalo's diet. Roughage can be fed in a variety of ways, including as fresh pasture, in a cut-and-carry system, or stored as hay or silage. Frequently, grains, concentrate, and agro-industrial byproducts like oil-seed cakes, sugar cane tops, etc. are added to the roughage to supplement it(17)(18). It is estimated that buffalo contribute 12.8% to global milk production. Buffalo milk has a special composition when compared to other sources of milk because it has a higher calcium content than other sources of milk and a higher fat content that gives milk a unique nature in the production of specialty cheese and cream (3)(6).

The production of milk and its components in buffalo is influenced by a variety of genetic factors, such as breed, and environmental factors, such as the productive year and the birth season, which include the effects of climate, nutrition, pasture, and health status, as well as the age of the female, the type of birth, the sex of the newborn, and herd management systems. (1)(22).

The metabolic processes of living things depend heavily on liver enzymes. The impact of liver enzymes on weight in newborn buffaloes has attracted attention

in recent studies. Understanding this relationship is crucial for identifying the elements that affect these animals' development and weight gain (2) The rate at which nutrients are metabolized and stored in the body may be impacted by certain liver enzymes (26).

According to earlier studies, it is necessary to improve the environment of the animal, assess and choose the animal's parents, and improve genetics in order to increase the productive performance of herds (13).

Using nonlinear mathematical functions to model individual growth help mathematical models reduce the short-term effects of the environment, and change the nonlinear relationship between age and live weight or body size is the best way to characterize growth curves. Using the appropriate growth function parameters, the development rates of animals from birth until physical maturity are estimated and predicted, and the best administrative strategy for the animals is then developed.(2)

The improvements are meant to increase buffalo productivity from milk and meat through selection (20). The breeder's objective is to maximize his herd's productivity and produce a high rate of return on investment. Herd productivity varies depending on the breeding purpose and specialization. (15)

Because it uses individual comparisons and corrected appearance values to estimate the breeding values of qualities of economic importance and in accordance with the productive efficiency of meat and



milk as well as macroeconomic efficiency, the process of selecting high genetically efficient agricultural animals is essential in animal husbandry (23)(27). The goal of

the current study was to use milk production and its constituent parts to predict the growth of postpartum pregnancies.

Material and Methods

A sample of 50 Iraqi buffalo heifers and their mothers were used in the study, which was conducted in Baghdad (Al-Dhahab Al-Abyad/Abu Ghraib village area, 20 km west of Baghdad, and Al-Fadhiliya site, 20 km northeast of Baghdad) from the production season of 2021–2022.

Measurement of liver enzymes: estimated liver enzymes Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), and Alkaline phosphatase (ALP) using a kit from Biolabo made from France. 100 microns of blood serum were added after 0.5 ml of the first reagent had been added, and the tubes containing the first reagent were then submerged in a water bath for 30 minutes. The tubes containing the first reagent, blood serum, and sample received 0.5 ml of the second reagent, were allowed to sit at room temperature for 20 minutes, and then 5 ml of sodium hydroxide solution (NaOH) was added to finish the reaction. Next, the optical device was zeroed with distilled water at a wavelength of 505 nanometers, and the absorbance of the final concentration of each enzyme was measured.

Solutions used to measure enzymes

The first reagent	0.5 ml
The second reagent	0.5 ml
Serum of blood	100 micron
NaOH	5 ml

the amount of milk produced each day. During the first three months of the production season, the daily milk output of each certified buffalo was measured using a graduated cylinder, in mm, twice a month. After Separating newborns from their mothers 12 hours before milking in afternoon while calves are milked in the morning.

Analysis of milk components

During the three months used to gauge milk production, each buffalo had its milk components analyzed twice. After the milk was weighed and thoroughly mixed in clean 50 ml plastic containers with tight lids, a sample of the milk was taken. After taking the sample, they were shut down and transported cool to a lab connected to the lab. Abu Ghraib dairy in order to examine the models in the Julie-Z7 milk component analysis device, Figure 1. The components of the milk are displayed on the device's digital screen. Each sample is placed into a special container designed for the apparatus. Two tubes extend from the apparatus in the middle of the container, allowing milk to enter the apparatus from one side and exit the other, displaying the relative proportions of the milk's constituents. The components that were measured were the percentages of protein,

fat, lactose, and non-fatty solids, which were displayed on the screen and recorded.

Measuring weights

Weights were measured at the following ages:

- Weight of calves at birth
- Weight of calves at weaning age
- Weight of calves at 6 months old

analytical statistics

The data were statistically analyzed using (24). to extract prediction equations, characterize the growth curve, and study the regression of each growth characteristic as well as calculated evidence on the level of liver enzymes and milk production and its components.

According to the following nonlinear regression models and exponential equations, the growth curves were described (7).

The first equation (Brody Equation):

$$Wt = A * (1 - B * (-K * t))$$

The second equation (Brody Equation):

$$Wt = A / (1 + B * e^{(-K * t)})$$

Since:

Wt : Live weight at a certain age

A: Live weight at a certain age

B: The turning point of growth as a value at time zero (t=0).

e: The natural logarithm of weight at primary age.

K: Growth rate between starting weight and age-specific weight at prediction

t: The time or age when the weight for age is recorded when forecasting.

And expressing the relationships between weights with curves according to Linear, Quadratic, and Cubic formulas.

As well as applying the following exponential equations according to simple non-linear regression analysis, while calculating and recording the coefficient of determination (R²):

Regression of weaning weight (WWT) on birth weight (BWT).

$$WWT^{\wedge} = a + bBWT^2$$

Regression of weight at 6 months (WT6) on birth weight (BWT).

$$WT6^{\wedge} = a + bBWT^2$$

Regression of weight at 6 months (WT6) on weight at weaning (WWT).

$$WT6^{\wedge} = a + bWWT^2$$

Regression of weaning weight (WWT) on maternal birth weight (DWT).

$$WWT6^{\wedge} = a + bDWT^2$$

Regression of weight at 6 months (WT6) on maternal birth weight (DWT).

$$WT6^{\wedge} = a + bDWT^2$$





Figure 1. A device for measuring milk components

Results and Discussion

1- Prediction of weaning weight (kg) of buffalo calves through maternal liver enzymes:

Since the regression coefficient of the mothers' enzymes blood (ALT and AST) on live weight at weaning of the buffalo calves. was 0.894 and 1.071, respectively.

Understanding this relationship can help us gain important knowledge about how these animals grow and develop. Buffalo newborns' weight is regulated by certain

Although ALP had no impact on the calves' weaning weight. The (R²) It was measured for ALT ,AST, ALP (0.21, 0.06, 0.06) respectively, and it did not have a significant effect

The body's various metabolic processes depend heavily on liver enzymes. The impact of liver enzymes on weight in newborn buffaloes is one area of interest. liver enzymes, including alanine transaminase (ALT) and aspartate transaminase (AST), according to research (12).

Table 1. Prediction of weaning weight (kg) of buffalo calves through maternal liver enzymes

Recorded qualities of dams	Regression coefficient ((b) (U/L)	(Prediction equation)	Significant level	coefficient of determination (R ²)
(U/L) ALT	0.894	$Y^{\wedge}= 10.19 +0.894X$	*	0.21
(U/L) AST	1.071	$Y^{\wedge}= 11.28 +1.071X$	*	0.06
(U/L) ALP	12.637	$Y^{\wedge}= 11.05 -0.855X$	NS	0.06

not significant :NS ,(P≤0.05) *

Prediction of weight at 6 months of age in buffalo calves through maternal liver enzymes:

The relationship between liver enzymes and weight in 6 months of buffalos has drawn more attention in recent years. According to table 2, , there was no significant effect of the enzyme ALT and ALP on the weights at weaning, while AST had a significant effect on the weight of weaning with a regression coefficient 1.766 this may be due to the metabolic processes that control weight gain and

body composition heavily depend on liver enzymes. It may have a big impact on the livestock industry and veterinary medicine to understand how liver enzymes affect weight in newborn buffalo. This section examines the current state of knowledge on the subject and emphasizes the need for additional study to fully comprehend the intricate interactions between liver enzymes and weight regulation in newborn buffaloes (25).

Table 2. Prediction of weight at 6 months of age (kg) in buffalo calves through maternal liver enzymes

Recorded qualities of dams	Regression coefficient ((b) (U/L)	(Prediction equation)	Significant level	coefficient of determination (R2)
(U/L) ALT	0.318	$Y^{\wedge}= 28.58 +0.318X$	NS	0.13
(U/L) AST	1.766	$Y^{\wedge}= 27.93 +1.766X$	*	0.17
(U/L) ALP	15.94	$Y^{\wedge}= 31.18 -15.94X$	NS	0.04
.not significant :NS ,(P≤0.05) *				

Prediction of weight at weaning in calves of buffalo by milk production Daily and main milk ingredients for mothers:

Table 3 shows that when milk supply increases by one kilogram per day, weaning weight increases by 6.017 kg. For calves, this gain is favorable and statistically significant (P 0.05). The buffalo's daily milk production can account for 18% of their weight at weaning, according to the relationship's determination coefficient R2, which was 0.18. In buffalo's herds, including those under study, mothers are typically left .

without milking so that the mother's milk can be utilized by the newborn and be reflected in growth. This is consistent with research showing that calf development is influenced by mother's milk production(19).

Additionally, at a significant level (P0.01), the regression coefficient between weight and the percentage of lactose was (-0.855), and the determination coefficient R2 was 0.27. This is consistent with research showing that calves are impacted by a



mother's milk's increased lactose content (14).

Table 3. Prediction of weight at weaning (kg) in calves of buffalo by milk production Daily and main milk ingredients for mothers

Recorded qualities of dams	Regression coefficient (b)	(Prediction equation)	Significant level	coefficient of determination (R ²)
Daily milk production(gm)	6.017	$Y^{\wedge}= 10.74 +6.017X$	*	0.18
(%) Fat in milk	0.397-	$Y^{\wedge}= 11.74 -0.397X$	*	0.07
lactose in milk (%)	0.855-	$Y^{\wedge}= 12.08 -0.855X$	**	0.27
(%) Protein in milk	0.171	$Y^{\wedge}= 12.47 +0.171X$	NS	0.03
non-fat milk (%) solids in milk	0.736	$Y^{\wedge}= 22.71 +0.736$	*	0.22
.not significant :NS ,(P≤0.01) **, (P≤0.05) *				

Prediction of weight at the age of 6 months in calves of buffalo by Daily milk and main milk ingredients:

According to (table 4), we have a positive correlation between weights at a young age and later weights, including the weight at weaning, so the regression coefficient of Daily milk production was 5.934.

(5)(22) research that discovered a statistically significant connection

between birth weight and later weight supports this. Additionally, the findings of this study indicated that weight weaning had a highly negative statistically significant association with percentage of fat (b = -0.1208), while the R² was 0.11, while it had a positive statistically significant association with percentage of protein b = 0.795, with R² 0.27.

Table 4. Prediction of weight at the age of 6 months (kg) in calves of buffalo by Daily milk and main milk ingredients

Recorded qualities of dams	Regression coefficient (b)	(Prediction equation)	Significant level	coefficient of determination (R ²)
Daily milk production(gm)	5.934	$Y^{\wedge}= 26.+195.934X$	*	0.15
(%) Fat in milk	0.1208-	$Y^{\wedge}= 29.37 -0.0208X$	*	0.11
lactose in milk (%)	0.624-	$Y^{\wedge}= 34.84 -0.624X$	NS	0.09

Protein in milk (%)	0.795-	$Y^{\wedge}= 27.77 -0.795X$	*	0.27
non-fat milk solids in milk (%)	0.281	$Y^{\wedge}= 33.82 +0.281X$	NS	0.06
.not significant :NS ,(P≤0.05) *				

Weight gain between weaning and 6 months of age:

The current study's findings revealed that there is a significant positive (P0.01) and (P0.05) regression coefficient in the age of calves between birth and 6 months on the percentage of lactose and non-fatty solids

milk, respectively, with an average $b=(1.259$ and $0.461\text{kg/kg})$ and R^2 0.13 and 0.17, respectively. (table 5) This is in line with study (16) which discovered a link between birth and weaning weight and proposed that it could be due to variations in the amount and composition of breast milk production in mothers of buffalo.

Table 5. prediction of weight gain between weaning and 6 months of age (kg) in calves of buffalo

Recorded qualities of dams	Regression coefficient (b)	(Prediction equation)	Significant level	coefficient of determination (R^2)
Daily milk production(gm)	6.056	$Y^{\wedge}= 14.83 +6.056X$	*	0.18
(%) Fat in milk	0.0217-	$Y^{\wedge}= 13.96 -0.0217X$	NS	0.06
lactose in milk (%)	1.259	$Y^{\wedge}= 14.27 +1.259X$	**	0.13
Protein in milk (%)	0.236-	$Y^{\wedge}= 12.867 -0.236X$	NS	0.05
non-fat milk solids in milk (%)	0.461	$Y^{\wedge}= 14.072 +0.461X$	*	0.17
.not significant :NS ,(P≤0.01) **, (P≤0.05) *				

Description of growth curves of buffalo calves by exponential equations:

The weight of weaning on the weight at birth according to the formula of Prediction equation $WWT=a + bBWT^2$ has been shown positive amount 0.198 with R^2 0.26 for the growth of young

buffalo. This is because the exponential equation was applied according to a straightforward nonlinear regression. While the weight at six months on the weight at birth and the weight at six months on the weight of weaning, respectively, were 0.377 amount with R^2

0.31 and 0.402 amount with R^2 0.46, according to the formula $WWT=a + bBWT^2$, Therefore, assessing and forecasting weight at six months after weaning is appropriate, particularly in light

of the fact that this age is one of the marketing ages and has a favorable correlation with subsequent weights. This is consistent with what was stated in the study (10).

Table 6. Description of growth curves of buffalo calves by exponential equations

Recorded qualities of dams	Regression coefficient (b)	(Prediction equation)	Significant level	coefficient of determination (R^2)
weight of weaning on the weight at birth	0.198	$Y^{\wedge}= 24.78 +0.198 BWT^2$	*	0.26
weight at sex months on the weight at birth	0.377	$Y^{\wedge}= 24.91 +0.277 BWT^2$	*	0.31
weight at sex months on the weight of weaning	0.402	$Y^{\wedge}=32.27 +0.302 WWT^2$	**	0.46
.($P \leq 0.01$) **, ($P \leq 0.05$) *				

The mother's weight at birth was used to predict the expected animal weights at birth as showed in table 7, and that the weight at weaning and at six months of age was used to approximate the real weights in buffaloes by using two functions. Logistic and Brody Equations. Additionally, this outcome demonstrates the accuracy of the Brody function and the second degree Logistic function in estimating the weight of calves up to 6 months old, with the potential to extend its use to the age of a year. When using the Brody Equation function to calculate

weight at birth, weaning, and at 6 months, the R^2 factor was 0.69, 0.72, and 0.79, respectively; however, when using the Logistic Equation, the R^2 reached 0.65, 0.69, and 0.74, respectively. There are growth functions available, according to additional research. The measure used to assess growth potential models using equations (Logistic, Brody) that concentrate the most important growth traits. The fact that growth assumes a sigmoid shape makes these nonlinear models effective (4).

Table 7. Average real and expected weights from birth to 6 months of age for buffalo calves

Character	Average standard \pm real error	standard error \pm Average expected	
		Brody Equation	Logistic Equation
Weight at birth	0.79 \pm 22.84	0.64 \pm 23.97	0.77 \pm 22.75
Coefficient of determination R ²	-	0.69	0.65
Weight at weaning	1.06 \pm 35.94	0.96 \pm 36.63	1.16 \pm 35.84
Coefficient of determination R ²	-	0.72	0.69
Weight at the age of 6 months	1.73 \pm 45.81	2.05 \pm 45.26	1.92 \pm 46.29
Coefficient of determination R ²	-	0.79	0.74

Conclusion

According to a study, Iraqi buffalo heifers' weaning weight increases noticeably by one kilogram per day, or 18%, and accounts for a significant portion of their weight. Weight gain and loss are largely influenced by breast milk production, which also has an impact on the

proportions of fat and protein. For an accurate estimation, the study used the subjects' birth weight, weight at weaning, and age six months.

Conflict of interest

The authors declare no conflict of interest.

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