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Development of Predictive Equations for Body Weight Estimation in Al-Nuaimi Sheep Using Phenotypic Traits in Qassim Region

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Abstract

Data on 3600 records from 300 sheep local breed of Al-Nuaimi were recorded through the period from November 2022 to May 2023. Study data were collected from 4 private smallholder farms from Al Mothnb and from Bukayriyah 150 males and 150 females in ages 12, 18 and 24 months in Qassim region, KSA. Twelve traits of body measurements were taken by using a measuring tape. The traits under study were Body Length (BL), Tail Length (TL), Tail Width (TW), Height at Center Point (HC), Chest Width (CW), Cannon Circumference (CC), Rump Heights (RH), Ear length (EL), Head Length (HL), Muzzle Diameter (MD), and Cheekbone Distance (Ck). After trying many linear and non-linear equations on the traits under study to best equations to predict the weights, equation $\hat{Y} = 1.00 + 2.6$ BL was preferred over all the 150 equations that were tried to predict body weight from body length with accuracy 0.97. While equation $\hat{Y}^2 = 1792.65 + 3.103e$ (BW) predict the body length from the body weight with accuracy 0.894. To predict the body weight from ear length; equation $\hat{Y} = 8.93 + 3.34$ is achieved was chosen with $R^2 = 0.94$, while the equation $\hat{Y}^2 = a + b/x^2$ with $R^2 = 0.91$ to predict EL from BW with coefficient a = 163.17, b = -401413.6. From the head length we predict body weight by the equation $\hat{Y} = a + bx$ were a = 2986 and b = 0.976. The equation $\hat{Y} = 2.720 + 3.698$ (TL) predicted body weight from tail length $\hat{Y} = 0.80 + 3.20$ (CH) was best equation to predict BW from the CH, while the two coefficients were a = 5.305 and b = 0.262 but with less $R^2 = 0.68$ when we predict CH from the BW. From the trait chest width, we got the best equation at all with a = 23.30 and b = 3.50 with accuracy = 0.90. The height at wither (RH) the intercept a = -6150 and b = 1.57, with $R^2 = 0.93$. (MD) trait had a best equation chosen $\hat{Y} = 39.61 + 8.78$ (MD) to predict BW from it, while, when predict the (MD) from body weight the estimate of coefficient a = 32.33 and b = (-85728.61) in the equation $\hat{Y}^2 = a + b/x^2$. Equation with $\hat{Y} = 47.00 + 1.657$ (TL) and $R^2 = 0.96$ was preferred than all. While equation $\hat{Y}^{-1} = .43 + (-0.0006)$ (BW) with $R^2 = 0.99$. The (Ck) trait was less accurate when compared with other traits when we used to predict BW by equation Y = a + bx, a = 18.56 and b = 9.58 and low R^2 (0.67). (CC) trait got equation $\hat{Y} = 42.68 + 7.73$ (CC) with $R^2 = 0.91$, while $\hat{Y} = 4.34 + (-3.33E-3)$ (BW) in equation $y^2 = a + b - x$ with $R^2 = 0.95$. As a conclusion 7 morphological measurements; body length, width of chest, tail length, cannon circumference, ear length, muzzle diameter and head length occupy the top positions of 11 traits and can be used as independent variables to predict body weight as dependent variable in linear equation. The estimated coefficients of determination (R^2) were at least 0.89. The body weights were used also to predict the 6 of these morphological traits namely HC, TL CC, EL, MD and HL with accuracy ranging from 0.42 to 0.84.

Keywords: body weight, linear equations, coefficient of determination, accuracy

1. Introduction

Sheep population in Saudi Arabia was estimated to be around 9.4 million head (FAO, 2023) which contribute 56.22% of the total farm animals. Morphological traits are used as selection criteria to improve the growth rate of animals (Tyasi et al., 2020). Rotimi et al. (2020) reported that morphological traits are used to estimate the body weight (BW) of sheep at the adult (12-18-24 months). Body weights of sheep at different stages of life cycle are very important traits for judging its performance adaptability to existing environmental conditions. The body weight is supplemented with measurements which describes an individual or population more completely than conventional methods of weighing or grading. Body measurements of animals are also necessary for establishing breed standards which we desperately need to elevate this local breed to global status.

Many researchers give an attention to the body measurements of sheep as good indicators of growths. Body measurements are necessary data sources in terms of reflecting the breed standards (Riva et al., 2004; Afolayan & Adeyinka, 2006). Also, measurements are important in giving information about the morphological structure and development ability of the animals. Body measurements differ according to the factors such as breed, sex, type of birth and age (Shirzeyli et al., 2013; Birteeb et al., 2012). Most of the studies reported highly significant correlations between linear body measurements and live body weight (Otoikhian et al., 2008; Moneim et al., 2009; Cilek & Petkova, 2016). Body measurements have also been used to differentiate and identify the Saudi local breed as a phenotypic characterization (Suparyanto et al., 1999; Mansjoer et al., 2007). The phenotypic characterization in sheep can be measured through body size, which can be used for visual identification and to determine the idea growth of the animal (Ghahri et al., 2019; Wid et al., 2016). Serval body measurements such as height at withers (WH), body length (BL), heart girth (HG), have correlations with each other and body weight so it can be used to predict body weight and describe the performance of sheep (Hardjosubrato, 1994; Iqbal et al., 2019; Haque et al., 2020). Body measurements were easy to process than body weights, which need weighting, scale while surveying farms.

Classify genetic sources of sheep and goats and characterized each breed accurately and maintain continuously filtering and culling is considering the first step to making global breed which must have restricted phenotypic and genetic characters. Increasing the effective of that selected performances animals by inter-Ce-mating will be the second step to have one breed after we should have restricted production characteristic.

To evaluate the performance traits such as body weight of sheep, adaptability to existing environmental conditions looking at different stages of the life cycle can be used (Rather et al., 2021). There were positive phenotypic correlations from the review between body weights and morphological body traits arranged from 0.31between body weight and ear width to 0.91 between body weight and body length on Kashmir merino sheep (Gül et al., 2019; Kumar et al., 2018a, 2018b) and most of the other breeds took the same trend. The correlations of body weight with body measurements indicated that body measurements can be used to predict body weight in sheep when weighing scales may not be available under field conditions. The findings of the current study can assist the communal farmers farming with Al-Nuaimi sheep to identify which morphological traits might be used as selection criteria during the breeding program to enhance the body weight.

2. Method

2.1 Location

It is both conventional and expedient to divide the Method section into labeled subsections. These usually The study was conducted from November 2022 to May 2023 in Animal Production and breeding department, Saudi Arabia. A total of 3600 records from 300 animals 150 males and 150 females in three categories of age 12, 18, 24 months of Al-Nuaimi local breed. Study data were collected from 4 private smallholder farms 2 from Al Mothnb and 2 Bukayriyah in Qassim region. Twelve traits of body measurements were taken by using a measuring tape.

2.2 Studied Traits

11 measuerments were estimated for each individual the measurement and their definitions are as follows:

Head length (HL): The distance from the highest point of the head to the nose; Ear length (EL): length of ear from base of ear to the end; Muzzle diameter (MD): The circumference of the mouth; Cheekbone (Ck): is the distance between zygomatic arche bone; Tail length (TL): is the length of the tail; Tail Width (TW): is the width of the tail; Body length (BL): The height from the bottom of the rear foot to the highest point of the thighs (buttocks); Rump height (RH): is a measurement from the ground to the top of the Rump; Body weight (BW): is the body weight at mature; Width of the chest (CW): is the distance of the chest from one shoulder to the other; Height at the center point (HC): The height at the center point of the body and Body weight.

2.3 Statistical Analysis

SAS software Ver.9.0 (SAS, 2002) was used for analysis of variance of quantitative traits. Estimation the least square mean for different measurements traits and analysis of variance for three-fixed effect of sex, age and farms. The modal used as:

$$Y_{ijmk} = \mu + Si + Aj + Bm + ei_{jmk} \quad (1)$$

where, μ: is the overall mean; S: is the fixed effect of the sex, where, i = 2; A: is the fixed effect of the age, where, j = 3; B: is the fixed effect of farms m = 4; and ei_{jmk} = random error.

2.4 Mathematical Models

Linear equations analysis was made to identify the best predictor variable for estimating body weight from body measurements. Simple linear regression analysis was performed as $\hat{Y} = a + b(x)$ including a = intercept (constant cute the Y axis on this point) and b = is the regression coefficient which is the slope on the X axis (different body measurement as independent variables and body weight as dependent variable Y.

The Table Curve 3DV4.0 statistical package was used to get the two parameters A, B and the coefficient of determination of the equation R^2.

3. Results

Table 1 presents descriptive statistics (Mean ± SE) for various morphological traits measured in the studied population. The obtained estimates fall within the expected range reported for most breeds. However, direct comparisons between breeds may not be entirely appropriate, as morphological traits are inherently influenced by genetic and environmental differences specific to each breed. The range of mean values observed in this study is generally consistent with findings reported by Sun (2020), Haque et al. (2020) on Ripolles sheep, Ravimurugan et al. (2015), and Feyissa et al. (2018) who studied Borana sheep.

Table 1. Estimates of morphological measure of the studied traits for all animals (Mean±SE)

Trait	Mean±SE		
	Overall	Male	Female
Body length (BL)	68.50±17.15	70.50±14.15	62.50±15.15
Ear length (EL)	15.05±9.26	16.05±5.26	13.05±5.26
Head length (HL)	19.02±2.57	21.22±2.01	14.02±2.77
Tail length (TL)	21.29±5.43	21.40±6.43	20.29±6.44
Tail width (TW)	30.9±17.91	35.9±13.91	31.30±9.91
Height at Center Point (HC)	77.34±21. 43	79.34±19. 35	73.34±18. 47
Chest Width (CW)	30±23.79	37±23.80	33±22.79
Cannon circumference (CC)	9.71±1.91	10.71±2.10	9.71±1.91
Rump heights (RH)	82.48±19.96	84.48±21.01	82.48±19.96
Muzzle diameter (MD)	18.10±4.19	19.10±3.19	18.10±4.19
Body weight (BW)	58.11±11.62	60.11±13.52	55.30±18.55
The distain between cheekbone (Ck)	9.65±2.2	10.65±2.23	10.65±2.7

Table 2, show equations with coefficient B were closely to 0 for traits (TL&BW) and (CC&BW), these mean that there wasn't regression relationship between these traits. While, when the b got negative value in equation (EL&BW) mean that when the three was negative relationship between ear length and body weight

Regression	$\hat{Y}$	R^2	Best Equation
BW on BL	$Y = a + bx$	0.969	$\hat{Y} = 1.00 + 2.6\ (BL)$
Ck on BW	$Y^2 = a + b/x^2$	0.782	$\hat{Y} = 0.80 + 3.20\ (BW)$
BW on WC	$Y = a + bx$	0.901	$\hat{Y} = 23.30 + 3.30\ (WC)$
BW on TL	$Y = a + bx$	0.961	$\hat{Y} = 47.00 + 1.657\ (TL)$
TL on BW	$Y^{-1} = a + bx$	0.988	$\hat{Y}^{-1} = .43 + (-0.0006)\ (BW)$
BW on CC	$Y = a + bx$	0.910	$\hat{Y} = 42.68 + 7.73\ (CC)$
CC on BW	$Y^2 = a + b/x^2$	0.917	$\hat{Y} = 4.34 + (-3.33E-3)\ (BW)$
BW on EL	$Y = a + b$	0.958	$\hat{Y} = 8.93 + (3.34)\ (EL)$
EL on BW	$\hat{Y}^2 = a + b/x^2$	0.902	$\hat{Y}^2 = 163.17-401413.6\ (BW)$
BW on MD	$Y^{1/2} = a + bx^2 \ln x$	0.910	$\hat{Y}^{1/2} = 39.61 + 8.78\ (MD)^2 \ln\ (MD)$
MD on BW	$Y^2 = a + b/x^2$	0.426	$\hat{Y}^2 = 32.33 + b/(MD)^2$
BW on HL	$Y = a + bx$	0.889	$\hat{Y} = 29.86 + (0.972)\ (HL)$
HL on BW	$Y^2 = a + bx^{1/2}$	0.894	$\hat{Y}^2 = 1792.65 + 3.103e\ (BW)$

Note. Body Length (BL), Tail Length (TL), Tail Width (TW), Height at Center Point (HC), Chest Width (CW), Cannon Circumference (CC), Rump Heights (RH), Ear Length (EL), Head Length (HL), Muzzle Diameter (MD), and Cheekbone Distance (Ck).

From the results in Table 2, it is noticeable that we prefer equation $\hat{Y} = 1.00 + 2.6$ (BL) from more than about 100 equations tested to predict body weight from body length with accuracy 0.97. Equation $\hat{Y}^2 = 1792.65 + 3.103e$ (BW) predict the body length from the body weight with accuracy 0.894. To predict the body weight from Ear length (EL), we got the prefer equation with coefficient a = 8.93, b = 3.34 as in Table 2 and $R^2 = 0.94$, while we prefer $\hat{Y}^2 = a + b/x^2$ with $R^2 = 0.91$ to predict El from BW and realized the coefficient a = 163.17, b = -401413.6.

From the head length (HL), we predict body weight by the equation $\hat{Y} = a + bx$ were a = 2986 and b = 0.976. The equation $\hat{Y} = 47 + 1.657$ (TL) predicted body weight from tail length. $\hat{Y} = 0.80 + 3.20$ (CH) was best to predict BW from the CH, while the two coefficients were a = 5.305 and b = 0.262 but with less $R^2 = 0.68$ when we predict CH from the BW. From the trait chest width (CW), we got the best equation at all with a = 23.30 and b = 3.50 with accuracy = 0.90. The height at wither (RH) the intercept a = -6150 and b = 1.57, with $R^2 = 0.93$. (MD) trait had a best equation $\hat{Y} = 39.61 + 8.78$ (MD) to predict BW from it while, when predict the (MD) from body weight the coefficient takes a = 32.33 and b = (-85728.61) in the equation $\hat{Y}^2 = a + b/x^2$. Equation with $\hat{Y} = 47.00 + 1.657$ (TL) and $R^2 = 0.96$ was preferred than all. While equation $\hat{Y}^{-1} = 0.43 + (-0.0006)$ (BW) with $R^2 = 0.99$. The (Ck) trait was less accurate when compared with other traits when we used to predict BW by equation Y = a + bx, a = 18.56 and b = 9.58 and low R^2 (0.67). (CC) trait got equation $\hat{Y} = 42.68 + 7.73$(CC) with $R^2 = 0.91$, while $\hat{Y} = 4.34 + (-3.33E^{-3})$ (BW) in equation $y^2 = a + b - x$ with $R^2 = 0.95$. We noted that there are three traits that have a strong relationship with body weight, namely BL, TL, and EL, and two traits that have a weak relationship with body weight, which are MD and Ck.

We noted that there are three traits that have a strong relationship with body weight, namely BL, TL, and EL, and two traits that have a weak relationship with body weight, which are MD and Ck.

4. Conclusion

Seven morphological measurements occupy the top positions of 11 traits to predict body weight and interpreted about more than 0.89 of the body weights they are body length, width of chest, tail length, cannon circumference, ear length, muzzle diameter and head length.

The body weights had been used also to predict the 6 morphological traits as CH, TL CC, EL, MD and HL with accuracy ranged from 0.98 to 0.42.

A specific description of the Al-Nuaimi native breed had been done by the estimated the least square means of that morphological traits as the first step to identify the breed and to rise to the rank of the species through our knowledge of its formal specifications after that we can select from it in which selection programs in the future

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Authors Contributions

Dr. Mousa and Prof. Elzarei were responsible for study design, revising and drafted the manuscript. Mr. Aloufi, Al-Sharari, Al-Fneikh, and Alrashidy, were responsible for data collection. All authors read and approved the final manuscript.

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Data Sharing Statement

No additional data are available.