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Research Article

Correlation Between Body Measurements of *Gazella marica* Fawns After Weaning and Estimating Body Weight From These Measurements

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Abstract

This study aims to find out for the first time the change in body measurements of gazelle fawns from birth to weaning and the estimation of live weight based on body measurements (BW, BL, CC, CD, AC, SH) of a total of 42 fawns, 17 female and 25 male, taken after birth, and a total of 30 fawns, 15 female and 15 male, were taken after weaning. Weighings were made with electronic scales. Measurements were made with a 150 cm strip measure. At the end of the 165-day suckling period, female fawns gained an average live weight of 8.07 kg and male fawns gained an average live weight of 9.17 kg. There is no statistical difference between the measurements at birth and the body measurements after weaning depending on gender (P>0.05). In general, the highest correlation (0.910) according to body measurements is between chest circumference and body weight (P<0.01). In male fawns, body weight can be predicted by chest circumference at a rate of 89% (P<0.01). In female fawns body weight can be predicted by shoulder height and chest circumference at rate of 79% (P<0.01). By selecting breeding individuals based on the high correlations and prediction values investigated in this study we can ensure faster genetic progress in a gazelle herd.

Keywords: *Gazella marica*, Correlations, Estimating body weight, Body measurements, Body weight, Weaning

Introduction

Gazelles belong to the genus Gazella, from the antelope subfamily of the horned family, and have a wide habitat extending from China to North Africa. The lower range of gazelles, which belong to the *Gazella marica* species, extends from Yemen and Oman to Şanlıurfa [1-4]. Their numbers in the wild are reported to be 1750-2150 [5]. It is known that there are around 400-500 in the wild in Türkiye. The mating season begins in November and December and pregnancies last for about 5 months. Births generally occur from late April to mid-May. After a gestation period of five months, females usually give birth to one or two fawns [6]. Gazelle fawns suck their mother for approximately 4 months [7]. While suckling is most frequently observed in May, a few short-term suckling have been observed at least in August and in September [8]. However, the suckling period in small ruminants is kept shorter. For example the lactation period in lambs lasts approximately 3 months for economically. They are weaned from the age of 3 months and subjected to various fattening programs [9,10]. However, the main food source of gazelles in the first three months is milk. In addition to decreasing suckling behavior, grazing behavior is also increasing. Gazelles show interest in grass and exhibit grazing behavior when they are approximately 3-4 days old after birth [11]. Since gazelles grow rapidly, grazing behavior occurs inversely proportional to sucking behavior. As suckling decreases day by day, grazing also increases [8]. This plays an important role in the survival of baby gazelles. Birth weight has a major impact on the survival of offspring in ungulate species. Offspring with high birth rates have higher survival rates [12]. Male gazelle fawns are born heavier on average than female gazelle fawns. Additionally, single fawns have higher average birth weights than twin fawns [13,14].

Body weight and measurements are an important indicator of growth. These indicators depend on genetic and environmental factors [15]. It has also been reported that in *Capreolus capreolus*, male body size and higher horns are more effective for selection in males [16]. It has been reported livestock weight in lambs depends on breed, gender, nutrition, season, age, etc. [17]. Studies made on domestic and wild animals have reported positive correlations between body weight and body measurements [13,18,19]. Moreover, body weight can be estimated from body

measurements [20]. In a study made on goats, estimating live weight by chest circumference gives 91% confidence [21]. Many studies have been done on adult and young body measurements of gazelles [13,14]. In addition, the weights of their offspring were determined by the previous study [13]. To what extent the change in body measurements occurs during the suckling period has been wondered.

Based on this information, it was aimed to reveal to what extent the body measurements of gazelle fawns, whose body measurements were recorded after birth, changed after they were weaned naturally. We also aimed to find the unknown body measurements of gazelle fawns and to find the change in body measurements during the suckling period. In addition, we tried to find out whether there are differences in body measurements by gender and whether there is a correlation between body weight and body measurements, both on a gender basis and in general. We also tried to find out whether body weight could be predicted from body measurements.

Following the results, we aimed to be obtained, to lead the formation of weaning programs for gazelle fawns for gazelle breeding stations, the number of which is increasing day by day in our country and around the world. We also aimed to increase the importance of records made during the lactation period for the selection of gazelle fawns according to their phenotypic characteristics.

Material and Methods

Ethical Statement

The research permissions were obtained with the letter dated 23.03.2023 and numbered E-21264211-288.04-9308521 from the Ministry of Agriculture and Forestry, General Directorate of Nature Conservation and National Parks.

Ethical approval was also obtained by Harran University Animal Experiments Local Ethics Committee Presidency with decision number 2023/01/02 and ethics committee permission dated 11/01/2023 and numbered 196981.

Animals

The research was carried out at the Ceylan Breeding Station in Yeniköy (Cudeyde) of Haliliye District of Şanlıurfa Province. The origin of gazelles in Şanlıurfa Ceylanpınar Gazelle Breeding Station. The location of the Breeding Station is at 37° 07′ 31″ North latitude and 38° 50′ 24″ East longitude and is located at an altitude of 449 meters above sea level.

Study Program

Fawns were recorded by taking measurements at 1-2 days of age from birth and after weaning. The study started on May 1 and continued until November 30. Weaning time

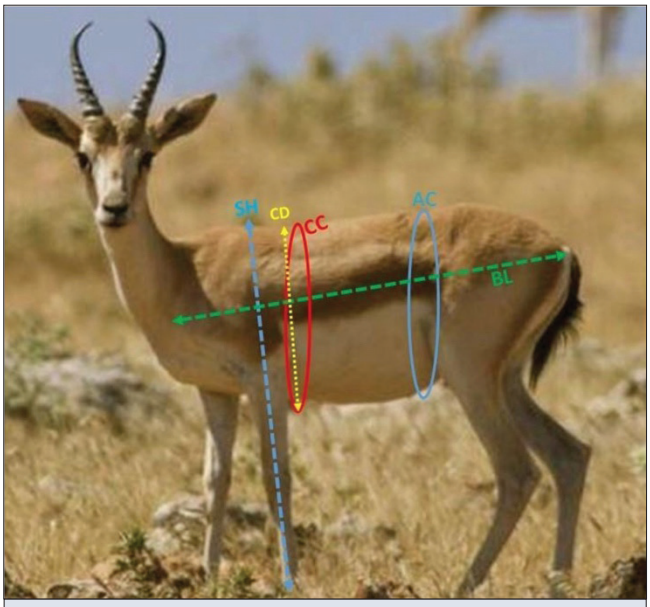

Fig 1. Body measurements *Gazella marica*. BL: Body Length, CC: Chest Circumference, CD: Chest Depth, AC: Abdominal Circumference, SH: Shoulder Heigth

was recorded as 165 days. Because the suckling detected was observed during this period. In addition, after this period, pre-mating preparations of the broodstock begin. The fawns born on May 15 were weaned in November. Since estrus begins in October and November, suckling is completed at the end of this period. In addition, this period was kept optimal as it allowed mothers' mammary glands to rest for the next pregnancy and birth. Body measurements taken are as follows: Body Weight, (BW), Body Length, (BL), Chest Circumference, (CC), Chest Depth, (CD), Abdominal Circumference, (AC), Shoulder Heigth (SH) *(Fig. 1)* [30]. After birth, body measurements were taken from 25 male and 17 female fawns. All of these individuals were born as a result of a single-fawn birth. The ages of the mothers ranged from 2 to 8 years. However, after 165 days due to deaths of male and female offspring and the sale of male offspring, final body measurements were taken only from 15 males and 15 females. While the herd was divided into groups after weaning and before the mating of the mothers, these body measurements of the fawns were taken again and recorded. Adult and young males were kept separate from the herd during pregnancy and birth to prevent harm to the mother and the fawns. It is kept together with females only during the mating season.

Care and Feeding of Mother and Fawns

Gazella fawns suckled their mothers freely. The fawns stayed with their mothers throughout the lactation period. No artificial milk or hand feeding was used. While the fawns started grazing, they consumed the *Medicago sativa* grown in the area. They consumed

ready-made fattening feed ration as supplementary feed. The content of the ready feed given was as follows: 18% Crude protein, 10% Crude fiber, 3% Crude fat, Dry matter 88%, Metabolic energy 2800 Kcal/kg. They were fed on a total of 10 decares of land, 8 decares of grazing land and 2 decares of empty land. *Medicago sativa* is cultivated in the 8-decare cultivated area for 12 months of the year and is constantly irrigated. The 8-decare area is divided into two according to need, and grazing is done alternately. Mother gazelles were given cracked barley (Crude protein 10.30%, Crude fat 2.48%, Dry matter 92.56%, NDF 20.7%) as concentrated feed as well as dairy feed. There was 120 gazellas in breeding stations. When we were starting to feding, barley and dairy feed was given to 120 gazellas 3 times a day, with a total of 45 kg of cracked barley, 13.5 kg per day.

Weighing and Measurements

Portable Electronic Scale PLT Power A08 model scale, which can weigh up to 50 kg, has a sensitivity of 5 grams for 0-10 kg and a sensitivity of 10 grams for weights of 10-50 kg, was used for weighing the fawns. Additionally, another TEM BM2CAA 35*40 150 kg electronic scale was used to control the weighing results. A 150 cm strip measure was used for body measurements. Body measurements; Body Weight, (BW), Body Length, (BL), Chest Circumference, (CC), Chest Depth, (CD), Abdominal Circumference, (AC), Shoulder Heigth (SH), postnatal and post-weaning measurements were recorded.

Vaccination, Protection and Treatment

As a vaccine, a combination vaccine is given twice a year only against enterotoxemia. Vitamin B, A, D, E and K were used as vitamin supplement. Mineral licking stone blocks were used for salt and minerals.

Statistical Analysis

Normality test of body measurements was made by Shapiro-Wilk. The data are normally distributed according to Shapiro-Wilke. According to the relation between genders and body measurements was tested with Independent Samples T test. We analyzed correlation body weight with body measurements with Pearson Correlation test. We performed Linear Regression analysis to estimate body weight by body measurements. All regression analyses were performed to determine which independent variables best predicted live weight. The best regression equations were obtained using a stepwise procedure. The multiple regression equations were evaluated with the determination coefficient (R2) and the residual standard deviation (RSD).

Significance levels were taken as $P<0.05$. All data were analyzed by SPSS (version 28.0) statistical program.

Results

The average birth weight of male fawns was found as 1.71 kg and the average birth weight of female fawns was 1.64 kg. The general average body weight was found to be 1.68 kg. The average body length of female fawns is slightly longer than that of male fawns. CD and SH were slightly higher in male offspring than in female fawns, but CC and AC were on average higher in female fawns than in males. There are no significant differences between genders and body measurements ($P>0.05$) *(Table 1)*.

Table 1. *Body measurements of birt*

Measure		Females (n = 17)		Males (n = 25)		P
		Min–max	Mean±SE	Min–max	Mean±SE	
General (G.)	BW (kg)	0.91-2.30	1.64±0.08	1.26-2.36	1.71±0.06	0.47
	BW (kg) G.		1.68±0.51	0.91-2.36		
	BL (cm)	16.0-29.0	23.77±0.73	20.5-29.0	23.44±0.43	0.69
	BL (cm) G.		23.57±0.39	16.0-29.0		
	CC (cm)	21.0-30.5	26.28±0.57	22.0-30.0	26.14±0.43	0.84
	CC (cm) G.		26.20±0.34	21.0-30.5		
	CD (cm)	7.0-11.0	9.15±0.28	7.5-11.0	9.20±0.22	0.88
	CD (cm) G.		9.18±0.17	7.0-11.0		
	AC (cm)	21.0-33.0	26.38±0.71	21.5-30.0	25.76±0.45	0.44
	AC (cm) G.		26.01±0.39	21.0-33.0		
	SH (cm)	25.0-35.0	30.29±0.62	28.0-38.0	31.74±0.55	0.09
	SH (cm) G.		31.16±0.42	25.0-38.0		

BW: Body Weight, BL: Body Length, CC: Chest Circumference, CD: Chest Depth, AC: Abdominal Circumference, SH: Shoulder Heigth, n: Number of induviduals, SE: Standart Error, Min: Minimum, Max: Maximum

Table 2. *Body measurements after weaning*

Measure		Females (n = 15)		Males (n = 15)		P
		Min-Max	Mean±SE	Min-Max	Mean±SE	
General (G.)	BW (kg)	8.33-11.58	9.71±0.27	6.23-14.44	10.90±0.66	0.11
	BW (kg) G.		10.31±0.37	6.23-14.44		
	BL (cm)	42.0-56.0	48.53±1.04	39.0-57.0	50.70±1.41	0.23
	BL (cm) G.		49.62±0.89	39.0-57.0		
	CC (cm)	47.5-55.0	52.03±0.61	44.5-60.0	53.10±1.21	0.44
	CC (cm) G.		52.57±0.6	44.5-60.0		
	CD (cm)	17.5-23.0	20.70±0.40	15.0-26.0	21.47±0.79	0.39
	CD (cm) G.		21.08±0.44	15.0-26.0		
	AC (cm)	41.0-57.0	49.63±1.24	42.0-57.0	50.43±1.10	0.63
	AC (cm) G.		50.03±0.82	41.0-57.0		
	SH (cm)	45.0-53.0	49.70±0.58	46.0-56.0	51.53±0.77	0.07
	SH (cm) G.		50.61±0.50	45.0-56.0		

BW: Body Weight, BL: Body Length, CC: Chest Circumference, CD: Chest Depth, AC: Abdominal Circumference, SH: Shoulder Heigth, n: number of induviduals, SE: Standart Error, Min: Minimum, Max: Maximum

Table 3. *Body measurements changes over 165 days*

Measure		Females (n = 15)		Males (n = 15)		P
		Min-Max	Mean±SE	Min–max	Mean±SE	
General (G.)	BW (kg)	6.70-9.58	8.07±0.25	4.87-12.43	9.17±0.60	0.10
	BW (kg) G.		8.61±0.34	4.87-12.43		
	BL (cm)	17.0-32.5	24.60±1.33	14.0-35.0	27.50±1.34	0.14
	BL (cm) G.		26.05±0.97	14.0-35.0		
	CC (cm)	21.0-29.5	25.71±0.68	19.5-32.0	26.93±0.96	0.31
	CC (cm) G.		26.32±0.59	19.5-32.0		
	CD (cm)	9.0-14.0	11.60±0.39	7.0-17.0	12.13±0.74	0.53
	CD (cm) G.		11.87±0.41	7.0-17.0		
	AC (cm)	14.5-32.0	23.07±1.43	19.5-31.0	24.87±0.72	0.27
	AC (cm) G.		23.97±0.80	14.5-32.0		
	SH (cm)	15.0-24.0	19.37±0.69	16.5-24.0	20.20±0.56	0.36
	SH (cm) G.		19.78±0.45	15.0-24.0		

BW: Body Weight, BL: Body Length, CC: Chest Circumference, CD: Chest Depth, AC: Abdominal Circumference, SH: Shoulder Heigth n: Number of induviduals, SE: Standart Error, Min: Minimum, Max: Maximum

The body measurements of the same fawns taken after weaning as a result of the suckling period are presented in *(Table 2)*. While the average body weight of male fawns was 10.90 kg, the average body weight of female fawns was 9.71 kg. While the average chest circumference of male fawns is 53.10 cm, it is 52.03 cm for females. While the average shoulder height of female fawns was 49.70 cm, this height reached 51.53 cm for male fawns. There are no significant differences between genders and body measurements (P>0.05).

The differences between the body measurements at the end of the suckling period and the body measurements taken after birth during the 165-day suckling period are presented in *(Table 3)*. Male fawns gained an average live weight of 9.17 kg during this period, while female fawns gained an average live weight of 8.07 kg. This means an average daily live weight gain of 55.58 g in males during the suckling period. In female fawns, there was an average daily live weight gain of 48.91 g during the suckling period. While the abdominal circumference of male

Table 4. *Correlation coefficients between body measurements of males (above diagonal) and females (below diagonal) after weaning*

Measurements	BW (kg)	BL (cm)	CC (cm)	CD (cm)	AC (cm)	SH (cm)
BW (kg)		0.762**	0.945**	0.736**	0.755**	0.806**
BL (cm)	0.532*		0.672**	0.690**	0.593*	0.579*
CC (cm)	0.800**	0.451		0.790**	0.783**	0.813**
CD (cm)	0.587*	0.613*	0.464		0.713**	0.775**
AC (cm)	0.692**	0.604*	0.714**	0.451		0.684**
SH (cm)	0.728**	0.548*	0.495	0.895**	0.463	

*BW: Body Weight, BL: Body Length, CC: Chest Circumference, CD: Chest Depth, AC: Abdominal Circumference, SH: Shoulder Heigth ** P<0.01*

Table 5. *Correlation coefficients between body measurements after weaning*

Measurements	BL (cm)	CC (cm)	CD (cm)	AC (cm)	SH (cm)
BW (kg)	0.707**	0.910**	0.715**	0.654**	0.785**
BL (cm)		0.615**	0.670**	0.588**	0.597**
CC (cm)			0.730**	0.707**	0.714**
CD (cm)				0.579**	0.793**
AC (cm)					0.565**

*BW: Body Weight, BL: Body Length, CC: Chest Circumference, CD: Chest Depth, AC: Abdominal Circumference, SH: Shoulder Heigth ** P<0.01*

Table 6. *Multiple regression equations for chest circumference, shoulder heigth and body length for predicting live weights of Gazella marica*

Dependent Variable	Gender	Model	Intercept	Independent Variables			$^{b}R^2$	^{a}RSD	P
				CC	SH	BL			
Body Weigth	Male	1	-16.40	0.5	-	-	0.89	0.95	<0.01
	Female	1	-8.7	0.35	-	-	0.64	0.80.	<0.01
		2	-13.83	0.26	0.20	-	0.79	0.87	<0.01
	General	1	-15.73	0.5	-	-	0.83	0.94	<0.01
		2	-20.27	0.39	0.2		0.87	0.93	<0.01
		3	-19.82	0.35	0.16	0.08	0.88	0.94	<0.01

CC: Chest Circumference, SH: Shoulder Heigth, BL: Body Length, ^{a} RSD: Residual standard deviation, ^{b} R^2: Determination coefficient. Model 1: Predictors: (Constant), Chest Circumference, Model 2: Predictors: (Constant), Chest Circumference, Shoulder Heigth, Model 3: Predictors: (Constant), Chest Circumference, Shoulder Heigth, Body Length

fawns increased by 24.87 cm on average, the abdominal circumference of female fawns increased by 23.07 cm. There are no significant differences between genders and body measurements (P>0.05) *(Table 3)*.

The correlation between body measurements in male and female fawns after weaning is presented in *(Table 4)*. In male fawns, there is a very high positive correlation (0.945) between body weight and chest circumference, while there is a medium positive correlation (0.579) between body length and shoulder height. There is a high positive correlation (0.783) between abdominal circumference and chest circumference (P<0.01). There is a high positive correlation (0.800) between body weight and chest circumference in female fawns. However, it is slightly lower than that of males. However, in female fawns, the highest correlation (0.895) is between chest depth and shoulder height. The lowest correlations are between chest circumference and body length (0.451) and between abdominal circumference and chest depth (0.451), with a near-medium correlation (P<0.01).

There is a very high positive correlation (0.910) between body weight and chest circumference. There is a moderate

positive correlation (0.565) between shoulder height and abdominal circumference. There is a moderate positive correlation between body length and chest circumference, chest depth, abdominal circumference, and shoulder height, respectively (0.615, 0.670, 0.588, 0.597) (P<0.01) *(Table 5)*.

In male gazelle fawns, body weight can only be estimated based on chest circumference. Body weight can be predicted by chest circumference at a rate of 89% (P<0.01). In female gazelle fawns, body weight can be estimated by both chest circumference, chest circumference and shoulder height. In female offspring, 64% of body weight can be predicted by chest circumference (P<0.001). Body weight can be predicted by 79% with shoulder height and chest circumference measurements (P<0.01). In general, 83% of body weight can be estimated by chest circumference measurements (P<0.01). In general, body weight can be estimated as 87% by measurements of shoulder height and chest circumference (P<0.01). Body weight can be predicted by 88% with body length, shoulder height and chest circumference (P<0.01) *(Table 6)*.

Discussion

In this study, no statistically significant difference was found between body measurements and gender in gazelle fawns after birth and after the suckling period. There were small differences between males and females, but there was no statistical difference. The body size of male fawns is larger than females. This is because male fawns are thought to grow faster and more dominant than females. After birth, the average body length of female fawns was longer than male fawns, while after weaning, the average body length of males was longer than females. It has been reported that the average weight of the newborn fawns is around 1.84 kg for females and 1.95 kg for males. It has also been reported that the average birth weight of single-born is 1.92 kg and the average birth weight of twins is 1.82 [13]. In addition, Martin et al.[14] reported male gazelle fawns of *Gazella arabia* are born heavier than females. The results of Gürler et al.[13] and Martin et al.[14] are similar to each other. However, our results showed that the average body weights of male and female fawns were lower than those of reported by Gürler et al.[13] and Martin et al.[14]. One of the reasons for this is that the study maden Gürler et al.[13] included fawns born between 1-3 days. This may be due to the fact that the study we studied was on fawns that were 1-2 days old. These results show that if gazelle fawns can be detected at the first day of age, they will have lower birth weights and body measurements. The body weight, chest circumference and shoulder height results we found after weaning are similar to the studied on young gazelles maden by Gürler et al. [13]. Gazelle fawns can reach the same body size as youngsters in 5.5 months. Since Gürler et al.[13] measured fawns and juveniles in the same period, the gazelles specified as young were those that had completed one year of age. Gazelles raised in semi-captive conditions will have higher body weight and body measurements starting from 5.5 months, thanks to good care and feeding conditions [13]. After 165 days of suckling peiod, the fawns gained an average daily live weight of 49-55 g. Post-weaning body changes in *Capreolus capreolus* fawns in roe deer species in two different regions were reported to be 0.017 kg/day in Chizé and 0.014 kg/day in Dourdan for the October-March period [22]. Daily live weight gain after weaning in Central Anatolian Merino (CAM) and Malya sheep lambs was reported as 310 g and 280 g, respectively [23]. In Kıvırcık lambs, an average daily live weight gain of 0.203 kg was achieved during the 75-day fattening period from birth [24]. In addition, if the feed given to gazelle fawns is made as a result of a controlled study, the feed conversion rate can be found.

Studies on some sheep breeds have reported that morphometric measurements differ from each other [25]. In a study done to by Topai and Macit [18] estimating body weight in Morkaraman sheep, it was reported that the highest correlation (0.867) was found between heart circumference and body weight, while the lowest correlation (-0.014) was between chest circumference and body length. In another study, it was reported that there was a high positive correlation (0.078) between body weight and body length in Tahalli sheep [26]. In a study done on dwarf goats in Ghana, it was reported that there was a medium correlation (0.44-0.59) between body weight and body length, shoulder height, chest/heart circumference, shoulder tip width, rump length and rump width [19].

In studies done on domestic sheep in Pakistan, it was reported that there was a high level of positive correlation between chest circumference and body weight (0.744) and a medium significant relationship between shoulder height and body weight (0.419) [27]. In their study, Esen and Elmaci [28] reported that the highest correlation between body measurements and live weight in meat type lambs was chest circumference. In addition, body weight estimation based on body measurements varies between 74% and 92% according to race. In a study done on the species *Gazella rufifrons kanuri*, it was reported that there was a positive correlation between body weight, body length and horn length [22]. It is reported that *Gazella dorcas* has a correlation coefficient of 0.79 between body length and chest circumference, and *Redunca redunca* antelope has a correlation coefficient of 0.99. The rate of estimating the body weight of *Gazella dorcas* based on its body measurements varies between 78% and 89% [20]. In a study maden on Florida White-tailed Deer *(Odocoileus virginianus),* it was reported that chest circumference was the single best determinant of body mass, and sub-gender,

age and sub-species information did not affect determining body mass [29]. When estimating body weight using chest circumference, shoulder height and body length; Body weight cannot be estimated based on chest depth and abdominal circumference. Since these values constantly change, it becomes difficult to obtain accurate results [30]. When examined in general, body weight estimation can be made in gazelle fawns with 3 different models. These are chest circumference, chest circumference and shoulder height respectively, and finally, chest circumference, shoulder height and body length and body weight are estimated. In the study done on Gazella dorcas, it was reported that the estimated body weight according to age and gender was 76% [30]. In Eastern Anatolian Red calves, live weight estimation can be estimated at a level of 95% based on chest circumference from birth to the 6th month [31]. In a study done on Madura cattle breeds, it was reported that the estimated growth curve with body weight was 68-70% [32].

As a result, selecting new individuals as breeders according to their phenotypic characteristics is very important for herd's future. The offspring, consisting of individuals with high body sizes, will carry the characteristics of their parents [33-35]. In addition, selecting better individuals under the same care and feeding conditions will result in higher genetic progress. This situation can also be used in gazelles. For example, in male gazelles, selecting individuals with larger body sizes and the same care and feeding conditions will facilitate selection. It will be beneficial in obtaining new individuals with high average scores within the herd. When female individuals reach sufficient body size, it will be easier for them to be used in breeding. A better selection can be made by genetic analysis in addition to body measurements [36]. In this way, the transmission of hereditary diseases found in breeding individuals to new individuals can be prevented. Selecting breeding individuals based on the high correlations and prediction values we have obtained will ensure faster genetic progress in the herd.

Declarations

Availability of Data and Materials: The data results obtained in this study are available from the corresponding author (A. Uztemur) upon request.

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Author Contributions: AU: Field work and data collect, AO: Statistical analyze, AU and AO: writing manuscript.

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