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Morphological characterization and the relationship between morphometric indices of a local Cyprus fat–tailed Sheep breed in Cyprus

Caracterización morfológica y relación entre los índices zoométricos en la raza local de ovejas de cola gruesa en Chipre

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ABSTRACT

With many local breeds in danger of extinction or genetic erosion, the loss of genetic variety in farm animal genetic resources is an increasingly critical concern. Conserving diverse sheep breeds is crucial for long–term agricultural sustainability and ecosystem health. The current research focused on the Cyprus fat–tailed sheep, which is important for both meat and milk production, particularly to produce Halloumi cheese. A study on a Cyprus sheep production farm was carried out with the aim to characterize the morphological traits of Cyprus fat–tailed sheep breed for its conservation. The study found that in female Cyprus fat–tailed sheep, white, white–black, and brown coat color patterns were the common ones recorded with proportions of 75, 12.5, and 12.5%, respectively. Sixty seven percent of males were white–black followed by white coat color in 33%. Male sheep are all characterized by white fleece, while females had a range of fleece colors with the majority in white (75%) followed by pale greyish brown in 18.75% and fawn fleece in 6.25%. On the other hand, male Cyprus fat–tailed sheep had higher values ($P<0.05$) for wither height, heart girth, chest width, hip height, foreleg length, compact index, area index, and body weight than females. Morphometric traits, such as head length, wither height, heart girth, chest depth, body length, and hip height, were significantly positively ($P<0.01$) correlated with body weight. The study concludes that the characterization of the Cyprus fat–tailed sheep breed's physical and morphological traits is essential and useful for its conservation.

Key words: Cyprus fat–tailed sheep; morphological body measurements; indices; biodiversity; sustainable animal production, native sheep breed

RESUMEN

Como muchas razas locales en peligro de extinción o erosión genética, la pérdida de variedad genética en los animales de granja es una preocupación cada vez más crítica. La conservación de diversas razas de ovejas es crucial para la sostenibilidad agrícola a largo plazo y la salud del ecosistema. La investigación se realizó en la oveja de Chipre de cola gruesa, la cual juega un rol importante para la producción de carne y leche, en particular para la producción de queso Halloumi. El estudio se llevó a cabo en una granja de producción de ovejas con el objetivo de caracterizar los rasgos morfo–biométricos de la raza de ovejas de cola gorda de Chipre como parte en los planes para su conservación. Los resultados obtenidos del estudio, indicaron que los patrones de color de pelaje blanco, blanco–negro y marrón fueron los más comunes registrados en proporciones del 75, 12,5 y 12,5 %, respectivamente. El 67 % de los machos resultaron ser de color blanco–negro, seguido por los del color totalmente blanco quienes representaron el restante 33 %. Todos los ovejos de esta raza se caracterizaron por tener lana de color blanco, mientras que las hembras tenían distintos colores de lana, la mayoría en color blanco (75%), seguido de marrón grisáceo pálido en 18,75 % y lana de color leonado en 6,25 %. Por otro lado, los corderos de cola gruesa de Chipre tuvieron valores más altos ($P<0,05$) para la altura de la cruz, el perímetro torácico, la anchura del pecho, la alzada a la grupa, la longitud de las patas delanteras, el índice de compactacidad, el índice de área y el peso vivo que las hembras. Se obtuvo una correlación significativa positiva ($P<0,01$) entre los rasgos morfométricos, como la longitud de la cabeza, la altura de la cruz, el perímetro torácico, la profundidad del pecho, el largo del cuerpo y la alzada a la grupa, con el peso vivo del animal. El estudio concluye que la caracterización de los rasgos físicos y morfológicos de la raza ovina de cola gorda de Chipre son primordiales y resultan ser útiles en su conservación.

Palabras clave: Oveja de cola gorda de Chipre; medidas morfométricas; índices; biodiversidad, producción animal sostenible; raza ovina autóctona

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INTRODUCTION

Sustainable development encompasses environmental protection, economic growth, and social equity across generations. Animal genetic diversity, including sheep breeds, plays a crucial role in climate adaptation and geographical considerations [1]. Local sheep (*Ovis aries*) breeds are vital for adapting to local climates, sustainable land management, preserving cultural heritage, supporting research and genetic improvement, and building resilience to climate change [2]. Preserving diverse sheep breeds is essential for the long-term sustainability and rural livelihoods of agriculture and ecosystems [3].

The main breeds present in Cyprus are the local Cyprus fat-tailed, Chios, and Awassi sheep breeds, and the wild Ovis Mouflon population [4]. The Cyprus fat-tailed sheep breed has historical significance, and its population should be strictly protected due to its importance in the Country's sheep flock composition. However, the breed is facing the risk of extinction [5, 6, 7], mainly due to uncontrolled crossbreeding. Maintaining genetic diversity is crucial for viable breeding programs in the future and the preservation of the Cyprus fat-tailed breed [8].

Besides, milk obtained from Cyprus fat-tailed sheep, Awassi, Sakız, Hair goats, and Damascus goats was mainly used to produce the traditional Halloumi cheese, which is one of the most economically important dairy products of Cyprus today [9]. That's why for Halloumi, there had been an application for the registration of the names 'Χαλλουμι' (Halloumi)/'Hellim' as a Protected Designation of Origin for cheese made predominantly from ewes' and/or goat milk under Quality Regulation (EUA) No 1151/2012.

In this context, the protection of domestic breeds is even more important. It is worthy to mention that the Sustainable Development Goals (SDGs) focus on the conservation of the genetic diversity of farm and domestic animals. Both the DAD-IS system and the SDG indicator are programs that monitor the global population of local breeds and classify Cyprus fat-tailed sheep as being at a high risk of extinction, marked at the red level [10]. At the moment, the estimated population of this breed is alarmingly low, with numbers ranging from 300 to 500 heads.

Morphological characterization of indigenous breeds [9, 11, 12, 13, 14, 15, 16], including the Cyprus fat-tailed sheep, is essential for establishing conservation programs for zoo-genetic resources. Quantifying and expressing morpho-structural characteristics through body measurements is important for accurate identification and understanding of the breed. Morphometrics provides a powerful set of tools for analyzing morphological variation, contributing to comparative studies and developmental research.

This study aims to identify for the first time the physical and morphological traits of the indigenous Cyprus fat-tailed sheep breed to support its accurate identification and conservation.

MATERIALS AND METHODS

Study area

Cyprus Fat Tailed Sheep were raised either in a semi-intensive (FIG.1) or extensive rearing system (FIG. 2) in Southern and Northern Cyprus. There are a few Cyprus fat-tailed sheep kept on some commercial farms as a tradition, and we also found some farmers who raised this breed as a hobby. Because of facing the threat of extinction, finding, and keeping animals for the assessment was a difficult step. Therefore, the number of animals used in this study was less.

FIGURE 1. Typical Cyprus fat-tailed sheep with white coat color (Photo courtesy: Prof. Dr. Dilek Arsoy)

All the sheep taken in the study were of the Cyprus Fat-tail sheep breed. The research was approved by the Near East University, Animal Ethics Committee (2019/04, 17.04.2019/73).

Cyprus has the typical Mediterranean climate with prolonged, warm, and dry summers starting from mid-May to mid-October. The winter, from December to February, is mild and wet. And completing the seasons of the year with short autumn and spring periods. The temperature reaches 34°C and even 40°C in the hottest months (July and August) and ranges from 7° to 15°C in the coldest months.

FIGURE 2. A historical flock of Cyprus fat-tailed sheep with a shepherd (Source: anonym).

Data collection

Finding animals of this breed proved to be a challenging task. Fortunately, we were able to identify up to 24 animals of this breed on the same farm in Northern Cyprus. Consequently, all 24 animals were considered for morpho-biometric evaluation.

Of the 24 animals, 18 are females and 6 are males. They were classified by age category as follows:

» 1-year-old: 5 animals (4 females, 1 male)

» 2-year-old: 7 animals (5 females, 2 males)

» 3-year-old: 5 animals (4 females, 1 male)

» 4-year-old: 7 animals (5 females, 2 males)

The animals had ear-tagged identification. There were 8 qualitative traits (presence of horn, horn shape, presence of wattle, beard, head shape, coat color, fleece color and tail type) and 10 quantitative morphological traits like body weight, ear length, head length, withers height, heart girth, chest depth, chest width, body length, hip height, and tail length and tail width (TABLE I) were recorded according to procedures described by [17, 18]. In this study, there were a total of 24 Cyprus fat-tailed sheep, and all the measurements were performed by the same group of persons in order to minimize errors during the data collection phase of the study.

Morphological indices and body weight were calculated according to the procedures described by Salako [11] as follows:

$$Body\ weight = \frac{body\ length \times heart\ girth \times heart\ girth}{10838}$$

$$Body\ index = \frac{Body\ length}{Heart\ girth} \times 100$$

$$Length\ index = \frac{Body\ length}{Wither\ heigth}$$

TABLE I
Morphological body measurement

Traits	Description
Body length (BL) [cm]	Measured as the diagonal distance from the tip of the sternum to the base of the tail
Chest girth (CG) [cm]	Measured as the circumference of the body immediately behind the shoulder blades in a vertical plane perpendicular to the long axis of the body
Chest depth (CD) [cm]	It was the distance from the backbone at the shoulder to the brisket between the front legs
Rump height (RH) [cm]	Height from the ground to the spina iliac
Rump length (RL) [cm]	Distance from the anterior point to the posterior extremity of the pin bone
Wither height (WH) [cm]	Measured from the bottom of the front foot to the highest point of the shoulder between the withers
Pelvic width (PW) [cm]	Measured as the distance between pelvic bones across the dorsum
Horn length (HL) [cm]	Measured as the length of the horn on its exterior side from its root at the poll of the tip
Tail length (TL) [cm]	Measured as the distance from the base to the tip of the tail on the outer side of the tail
Tail Width (TW) [cm]	Measured at the thickest point

$$Depth\ index = \frac{Chest\ depth}{Wither\ heigth}$$

$$Foreleg\ length = Wither\ height - Chest\ depth$$

$$Compact\ index = \frac{Body\ weight}{Wither\ heigth} \times 100$$

$$Relative\ Cannon\ Thickness\ Index = \frac{Cannon\ circumference}{Wither\ heigth} \times 100$$

$$Area\ index = Wither\ height \times Body\ length$$

$$Proportionality\ index = \frac{Wither\ height}{Body\ length} \times 100$$

Statistical analyses

Data obtained from the farm were analyzed using IBM SPSS (Statistical Program for Social Sciences) version 20 for Windows [19]. Qualitative physical traits were analyzed using the frequency and descriptive statistical procedures of the package. A two-way ANOVA test was used to analyze the morphological body measurement and check possible interaction between age and gender considered as fixed factors. Pearson's correlation coefficient was calculated between linear body measurements and body weight. The significance level was determined at $P \leq 0.05$.

The model used was: $Y_{ijk} = \mu + A_i + B_j + AB_{ij} + \varepsilon_{ijk}$,

- μ = the common mean,
- A_i = the gender effect (males, females),
- B_j = the age effect (j=1 year old, 2 years old,..., 4 years old),
- AB_{ij} = the interaction effect between the i^{th} gender and j^{th} age group,
- ε_{ijk} = effects of the uncontrolled effects on the experimental units or random errors.

All effects in the model were considered fixed except the experimental error, which is assumed to be NID $(0, \sigma_e^2)$.

RESULTS AND DISCUSSION

In the present study, it was evaluated the morphometric and physical traits of the local Cyprus fat-tailed sheep breed. According to the knowledge, this is the first study in Cyprus to measure and evaluate the morphometric and physical traits in local Cyprus fat-tailed sheep. Chiemela *et al.* [20] have reported that physical traits, structural indices, and morphometric measurements are of great importance to determine the type, function of the animal and to estimate animal performance due to their relation to productivity parameters.

Qualitative traits in Cyprus fat-tailed sheep breed

The percentage of each qualitative trait of Cyprus fat-tailed sheep are presented in TABLE II. In the studied population all males had a horn with an arc shape, however, no female was found with a horn. All Cyprus fat-tailed sheep of both sexes were characterized by wattles and bears and had convex head shapes. The majority of female Cyprus fat-tailed sheep (75%) had a white coat color pattern, followed by white-black and brown coat colors at the same rate (12.5%). For males, the study found a higher (67%) percentage for white-black followed by white coat color in 33%. Male Cyprus fat-tailed sheep are all characterized by white fleece, while females had a range of fleece colors with the majority in white (75%) followed by pale greyish brown in 18.75% and fawn fleece in 6.25%.

TABLE II
Frequency of qualitative traits status in Cyprus fat-tailed sheep

Qualitative traits	Trait status	Percentage of the flock	
		Female	Male
Horns	Present	–	100
	Absent	100	–
Horn shape	Arc	–	100
Wattles	Present	–	–
	Absent	100	100
Beard	Present	–	–
	Absent	100	100
Head shape	Convex	100	100
Coat color	White	75	33
	White-black	12.5	67
	Brown	12.5	–
Fleece color	White	75	100
	Pale greyish brown	18.75	–
	Fawn	6.25	–
Tail type	Fatty long	100	100

This study demonstrated that all the males of the evaluated population of Cyprus fat-tailed had horns with arc shape, wattles, bear and convex head shape. However, we found no females with horns, but they do have wattles, bear, and convex head shape. This finding is in line with Bebek and Keskin [21] who have reported that the South Karaman sheep are generally black or blackish ash color. Males of this breed are usually horned and females are hornless. These sheep were mainly distributed in Antalya, Mersin, Hatay, and Gaziantep Provinces. In the present study, 75 % of evaluated females were white and the remaining were in white-black and brown coat colors in the same proportion of 12.5%. Similarly, Yılmaz *et al.* [22] reported a wide range of coat colors in South Karaman sheep. Cyprus fat-tailed sheep breed has its origin mainly from Turkish fat-tailed sheep and the close resemblance in its physical traits with South and White Karaman sheep and the geographical and historical proximity to Cyprus may indicate that the provenance of Cyprus fat-tailed sheep is either from Middle Anatolia or South Anatolia. Furthermore, Kizilaslan *et al.* [23] revealed Akkaraman sheep to be clustered with Moghani, Karakas, Tibetan and Cyprus Fat Tail sheep. There are many different types of Akkaraman breed such as Kangal, Karakas, and Norduz. Akkaraman sheep is a combined, productive, large-bodied and well-built breed that is well adapted to adverse breeding conditions [24, 25]. It is resistant to harsh environmental conditions and diseases. It can be raised on inadequate feeding system, different and variable climatic conditions.

Wattle and beard traits can be used as selection criteria to improve animal performance [12], in thermoregulation and are related to higher prolificity, higher fertility, higher conception rate, and higher milk yield [26]. In the present study all females and males had wattle and bear.

Morphometric traits (Body measurements) of Cyprus fat-tailed sheep breed

Morphological indices are the combined results of two or more morphometric body measurements, expressed in percentage in order to indicate type and function of the animal [20]. Indices obtained from body measurements such as foreleg length, height slope and length index are closely related to bone growth [11].

Mean and standard deviation of each morphometric trait of Cyprus fat-tailed sheep breed are presented in TABLE III.

There was no interaction between gender and age factors on Cyprus fat-tailed sheep breed morphometric traits. However, there was gender impact for wither height, chest width and hip height. The male Cyprus fat-tailed sheep breed had higher wither height, chest width and hip height than female (P<0.05; TABLE III). On the other hand, even though there were no significant differences between male and female for ear length, head length, chest depth, body length, tail length (FIG. 3) and tail width, males tend to have higher values.

Age factor impacted all the evaluated morphometric traits except ear length, tail length, and tail width. In general, Cyprus fat-tailed males showed higher values than female sheep for these traits and these morphometric traits increase as animal age increases. However, for the tail width got decreased over the years. These findings agree with those reported by Yilmaz *et al.* [22] and Yilmaz *et al.* [27] who reported higher values of these traits for males in Turkish fat-tailed sheep. In this study, the tail length found in Cyprus fat-tailed sheep was much longer than that reported by Deribe *et al.* [28] in Ethiopian fat-tailed sheep breeds (Tumele, SSFT and Afar), and Zom sheep, a variety of Turkish White Karaman (Akkaraman) reported by Koncagül *et al.* [14].

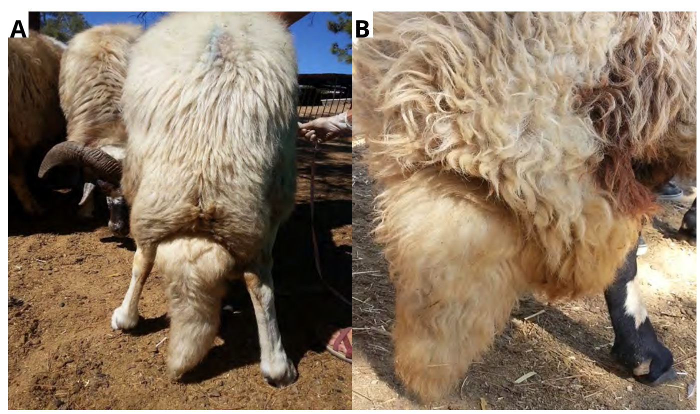

FIGURE 3. Length of tail in Cyprus fat-tailed sheep. A- Sheep with white coat, B- Sheep with white-black coat (Photo courtesy: Prof.Dr.Dilek Arsoy).

Morphological indices of Cyprus fat-tailed sheep

The morphological indices and body weight of Cyprus fat-tailed sheep breed are shown in TABLE IV. No interaction between gender and age factors on Cyprus fat-tailed sheep breed morphological indices and body weight. There was a gender effect for foreleg length (FL), compact index (CI), area index (AI) and body weight (BW); Cyprus fat-tailed sheep breed males had higher values than females (P<0.05; TABLE IV). However, females had higher body index, length index, and depth index. These findings are in line with those reported by

TABLE III

Impact of gender and age on morphometric traits in Cyprus fat–tailed sheep breed

Groups	EL	HL	WH	HG	CD	CW	BL	HH	TL	TW
Gender										
Female	14.87+0.44	28.37+0.81	86.69+0.95	105.17+1.07	44.36+0.81	27.81+1.22	80.32+1.43	86.84+1.362	77.5+2.43	53.46+1.46
Male	15.25+0.75	30.00+ 1.39	93.75+1.62	111.62+1.83	46.50+1.39	33.75+2.08	85.25+2.43	94.12+2.33	84.5+4.15	54.37+2.49
Age (year old)										
1 y	15.25+0.89	24.12+1.66^{a}	83.50+1.94^{a}	100.63+2.19^{a}	35.25+1.66^{a}	30.12+2.49	66.00+2.91^{a}	82.12+2.78^{a}	69.25+4.96	58.37+2.98
2 y	14.50+0.67	29.00+1.24^{ab}	90.50+1.45^{ab}	109.35+1.64^{ab}	47.10+1.24^{b}	29.00+1.86	83.90+2.18^{b}	89.55+2.08^{ab}	79.50+3.71	54.55+2.23
3 y	14.50+0.89	33.40+1.66^{b}	92.37+1.94^{b}	109.12+2.19^{ab}	47.87+1.66^{b}	30.00+2.49	87.50+2.91^{b}	92.50+2.78^{ab}	88.00+4.96	52.50+2.298
4 y	16.00+0.98	30.25+1.82^{ab}	94.50+2.13^{b}	114.50+2.40^{b}	51.50+1.82^{b}	34.00+2.73	93.75+3.19^{b}	97.75+3.05^{b}	87.25+5.4	50.25+3.26
Age × Gender										
1 y × Female	14.50+0.8	23.25+1.48^{a}	82.00+1.74^{a}	98.25+1.96^{a}	35.50+1.49^{a}	31.25+2.23	68.00+2.60^{a}	81.25+2.49^{a}	67.50+4.43	54.75+2.66
1 y × Male	16.00+1.60	25.00+2.97^{a}	85.00+3.47^{a}	103.00+3.92^{a}	35.00+2.98^{a}	29.00+4.46	64.00+5.20^{a}	83.00+4.97^{a}	71.00+8.87	62.00+5.33
2 y × Female	14.00+0.72	27.00+1.32^{ab}	86.00+1.55^{ab}	103.20+1.75^{ab}	45.20+1.33^{b}	25.00+1.99	80.80+2.33^{b}	85.60+2.22^{ab}	73.00+3.96	51.60+2.38
2 y × Male	15.00+1.14	31.00+2.10^{ab}	95.00+2.45^{ab}	115.50+2.77^{ab}	49.00+2.11^{b}	33.00+3.15	87.00+3.68^{b}	93.50+3.52^{ab}	86.00+6.27	57.50+3.77
3 y × Female	15.00+0.80	32.75+1.48^{b}	87.75+1.74^{b}	106.25+1.96^{ab}	46.75+1.49^{b}	28.00+2.23	87.00+2.49^{b}	87.00+2.49^{ab}	83.00+4.43	56.00+2.66
3 y × Male	14.00+1.61	34.00+2.97^{b}	97.00+3.47^{b}	112.00+3.92^{ab}	49.00+2.98^{b}	32.00+4.46	93.00+5.20^{b}	98.00+4.97^{ab}	93+8.87	49.00+5.33
4 y × Female	16.00+1.14	30.50+2.10^{ab}	91.00+2.45^{b}	113.00+2.77^{b}	50.00+2.11^{b}	27.00+3.15	90.50+3.68^{b}	93.50+3.52^{b}	86.50+6.27	51.50+3.77
4 y × Male	16.00+1.61	30.00+2.97^{ab}	98.00+3.47^{b}	116.00+3.92^{b}	53.00+2.98^{b}	41.00+4.46	97.00+5.20^{b}	102+4.97^{b}	88.00+8.87	49.00+5.33
***P*–value**										
Age	0.599	**0.014**	**0.011**	**0.007**	**0.001**	0.528	**0.001**	**0.017**	**0.072**	0.330
Gender	0.674	0.333	0.003	0.010	0.210	0.030	0.106	0.019	0.171	0.760
Age × Gender	0.753	0.762	0.623	0.355	0.778	0.205	0.353	0.690	0.788	0.280

EL: Ear Length, HL: Head Length, WH: Wither Height, HG: Heart Girth, CD: Chest Depth, CW: Chest Width, BL: Body Length, HH: Hip Height, TL: Tail length, TW: Tail Width. Means with different superscripts (^{a,b}) within the same column are statistically different (P<0.05)

TABLE IV

Effect of sex on morphological indices in Cyprus fat-tailed sheep breed

Groups	BI	LI	DI	FL	CI	AI	PI	BW
Gender								
Female	76.28+1.65	0.92+0.01	0.51+0.01	42.32+1.14	9.52+0.2	6990+160	109+2,25	82.99+1.88
Male	76.05+2.83	0.90+0.03	0.49+0.02	47.25+1.95	10.75+0.34	8060+274	112+3.85	101.5+3.22
Age (year old)								
1 y	65.77+3.38^{a}	0.79+0.03^{a}	0.42+0.02^{a}	48.25+2.33	7.80+0.41^{a}	5508+327^{a}	127+4.60^{a}	65.24+3.85^{a}
2 y	76.83+2.53^{ab}	0.93+0.03^{b}	0.52+0.01^{b}	43.40+1.74	10.27+0.30^{b}	7615+245^{b}	108+3.44^{b}	93.37+2.88^{b}
3 y	80.19+3.38^{ab}	0.95+0.04^{ab}	0.52+0.02^{b}	44.50+2.33	10.43+0.41^{bc}	8107+327^{bc}	106+4.60^{b}	96.68+3.85^{b}
4 y	81.86+3.70^{b}	0.99+0.04^{b}	0.54+0.02^{b}	43.00+2.55	12.03+0.45^{c}	8870+358^{c}	101+5.03^{b}	113.70+4.21^{c}
Age × Gender								
1 y × Female	69.41+3.02^{a}	0.83+0.03^{a}	0.43+0.02^{a}	46.50+2.08	7.32+0.36^{a}	5577+292^{a}	121+4.11^{a}	59.97+3.44^{a}
1 y × Male	62.13+6.05^{a}	0.75+0.07^{a}	0.41+0.04^{a}	50.00+4.16	8.29+0.73^{a}	5440+585^{a}	133+8.22^{a}	70.51+6.88^{a}
2 y × Female	78.28+2.71^{ab}	0.94+0.03^{b}	0.53+0.02^{b}	40.80+1.86	9.27+0.33^{b}	6955+262^{b}	107+3.68^{b}	79.63+3.08^{b}
2 y × Male	75.39+4.28^{ab}	0.91+0.05^{b}	0.52+0.03^{b}	46.00+2.94	11.27+0.52^{b}	8275+414^{b}	109+5.81^{b}	107.10+4.87^{b}
3 y × Female	77.34+3.02^{ab}	0.94+0.03^{ab}	0.53+0.02^{b}	41.00+2.08	9.74+0.36^{bc}	7192+292^{bc}	107+4.11^{b}	85.56+3.44^{b}
3 y × Male	83.03+6.05^{ab}	0.96+0.07^{ab}	0.50+0.04^{b}	48.00+4.16	11.11+0.73^{bc}	9021+585^{bc}	104+8.22^{b}	107.80+6.88^{b}
4 y × Female	80.09+4.28^{b}	0.99+0.05^{b}	0.55+0.03^{b}	41.00+2.94	11.75+0.52^{c}	8234+414^{c}	100.6+5.81^{b}	106.80+4.87^{c}
4 y × Male	83.62+6.02^{b}	0.99+0.07^{b}	0.54+0.04^{b}	45.00+4.16	12.31+0.73^{c}	9506+585^{c}	101+8.22^{b}	120.60+6.88^{c}
***P*–value**								
Age	**0.026**	**0.015**	**0.006**	0.383	**0.001**	**0.001**	**0.010**	**0.001**
Gender	0.944	0.565	0.413	**0.049**	**0.009**	**0.005**	0.520	**0.001**
Age × Gender	0.526	0.811	0.985	0.953	0.565	0.222	0.719	0.328

BI: Body Index, LI: Length Index,DI: Depth Index,FL: Foreleg length, CI: Compact Index, AI: Area Index, PI: Proportionality Index, BW: Body weight. Means with different superscripts (^{a,b}) within the same column are statistically different (P<0.05)

Yilmaz *et al.* [22] and Yilmaz *et al.* [27] in Turkish fat-tailed sheep. The higher values found in males could be attributed to the effects of sex hormones which lead to a differential growth rate [29]. The obtained results in this study were much higher than those reported in South Karaman sheep by [27, 30].

For the proportionality index, although there was no statistical significance, male Cyprus fat-tailed sheep had a higher proportionality index than females. Both genders had a proportionality value greater-than 100, which indicates that the Cyprus fat-tailed sheep animal has a greater proportion of muscle relative to the bone, which is generally considered desirable for meat production. Based on the body index, Cyprus fat-tailed sheep is classified as mediolineous with a body index less-than 85. These results show how large are Cyprus fat-tailed sheep and high growth performance could be expected.

In the same TABLE IV, age factor also had a significant impact on all the evaluated morphological indices, except for foreleg length index. In general, the traits increased as the animal aged, except for proportionality index, which decreased over time.

Correlations between the morphometric trait of Cyprus fat-tailed sheep breed

The relationships between the morphometric trait of Cyprus fat-tailed sheep breed are presented in TABLE V. Head length, wither height, heart girth, chest depth, body length, and hip height morphometric traits showed very high significant positive correlation with body weight ($P<0.01$). The highest correlation coefficient found was between body weight and heart girth ($r= 0.930$). It also found a medium positive correlation between body weight and tail length. The obtained positive correlations between weight and other body measurements are in line with those reported by Melesse *et al.* [31] and Taye *et al.* [32].

Additionally, there were strong positive correlations between body index and length index, and between compact index and area index in TABLE VI.

On the other hand, the study found strong negative correlations between body index and proportionality index, length index and proportionality index, and between depth index and foreleg length. These correlations could be used to estimate the body index and proportionality index of the animal by only using its length index.

TABLE V
Pearson's correlation coefficients between body measurements

	BW	EL	HL	WH	HG	CD	CW	BL	HH	TL	TW
BW		0.084	0.729**	0.869**	0.930**	0.823**	0.302	0.893**	0.820**	0.590**	-0.066
EL	0.084		0.020	0.107	0.095	-0.013	0.129	-0.028	0.088	0.006	0.007
HL	0.729**	0.020		0.720**	0.728**	0.771**	0.081	0.630**	0.676**	0.653**	-0.034
WH	0.869**	0.107	0.720**		0.817**	0.727**	0.335	0.739**	0.884**	0.593**	-0.036
HG	0.930**	0.095	0.728**	0.817**		0.770**	0.356	0.697**	0.819**	0.491*	0.102
CD	0.823**	-0.013	0.771**	0.727**	0.770**		0.048	0.780**	0.740**	0.597**	-0.169
CW	0.302	0.129	0.081	0.335	0.356	0.048		0.114	0.164	0.110	0.135
BL	0.893**	-0.028	0.630**	0.739**	0.697**	0.780**	0.114		0.655**	0.558**	-0.262
HH	0.820**	0.088	0.676**	0.884**	0.819**	0.740**	0.164	0.655**		0.572**	0.009
TL	0.590**	0.006	0.653**	0.593**	0.491*	0.597**	0.110	0.558**	0.572**		-0.169
TW	-0.066	0.007	-0.034	-0.036	0.102	-0.169	0.135	-0.262	0.009	-0.169	

BW: Body Weight, EL: Ear Length, HL: Head Length, WH: Wither Height, HG: Heart Girth, CD: Chest Depth, CW: Chest Width, BL: Body Length, HH: Hip Height, TL: Tail length, TW: Tail Width

TABLE VI
Pearson's correlation coefficients between morphological indices

	BI	LI	DI	FL	CI	AI	PI
BI		0.911**	0.486*	-0.230	0.574**	0.753**	-0.914**
LI	0.911**		0.624**	-0.441*	0.716**	0.723**	-0.995**
DI	0.486*	0.624**		-0.827**	0.638**	0.555**	-0.652**
FL	-0.230	-0.441*	-0.827**		-0.214	-0.041	0.454*
CI	0.574**	0.716**	0.638**	-0.214		0.899**	-0.719**
AI	0.753**	0.723**	0.555**	-0.041	0.899**		-0.740**
P	-0.914**	-0.995**	-0.652**	0.454*	-0.719**	-0.740**	

BI: Body Index, LI: Length Index, DI: Depth Index, FL: Foreleg length, CI: Compact Index, AI: Area Index, PI: Proportionality Index, BW: Body weight

CONCLUSIONS

The current study revealed the first physical and morphological results of a local Cyprus fat-tailed sheep necessary for their accurate classification and identification.

The results showed that male Cyprus fat-tailed sheep had higher wither height, chest width, hip height, foreleg length, compact index, area index, and body weight than females. However, females had higher body index, length index, depth index, and proportionality index than males.

The study found that the morphometric traits increase as animal age increases, except for the tail width, which decreases over time.

It was found strong positive correlations between body weight and wither height, heart girth, chest depth, body length, and hip height. The highest correlation coefficient was between body weight and heart girth.

These findings provide important information for the conservation and breeding programs of the Cyprus fat-tailed sheep breed. It is crucial to preserve the breed's genetic diversity and maintain its unique traits to ensure the sustainability of the sheep production industry in Cyprus.

Genetic and growth performance studies on Cyprus fat-tailed sheep should be performed as well.

Availability of data and materials

The data supporting the findings of the current study are available from the authors upon reasonable request.

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Conflict of interest

The authors declared that there is no conflict of interest.

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