

# Phenotypic characterization of indigenous Cyprus Native Hair Goat breed using quantitative and qualitative trait analysis

## Caracterización fenotípica de la raza caprina indígena de pelo nativa de Chipre mediante análisis de rasgos cuantitativos y cualitativos en condición de pastoreo

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### ABSTRACT

The loss of genetic diversity in farm animal genetic resources is a growing concern, with many local breeds facing possible extinction. This study on Goat production in Cyprus was carried out to establish the morpho-biometric profile of indigenous Cyprus Native Hair Goats, for which there is no scientific information necessary for their proper classification and identification, for that purpose 60 animals were measured on 17 morphobiometric traits. A two-way analysis of variance with the interaction of the effects of age and gender was performed. White, chamoise, light buckskin, brown-white, white-grey, grey, pinto, and bay colors were the common coat colors recorded with proportions of 28.6; 14.29; 14.29; 14.29; 7.14; 7.14; 7.14 and 7.14%, respectively. All the Cyprus Hair Goats had horns with an arc shape. Wattles, beard, topknot, and feathered feet traits were seen in proportions of 14.3, 57.14, 50 and 21.43%, respectively. Gender factor showed a significant ( $P<0.05$ ) effect on ear length, head length, wither height, heart girth, chest width, body length, hip height, cannon circumference, and body weight, as well as on morphological indices such as foreleg length, compact index, and area index. However, female Cyprus Hair Goats recorded greater proportionality index values than males. This revealed that females had a brevilinear profile with dairy-type breed characteristics and males were mesolinear with a meat-type profile. Further studies are needed to highlight and expose the potential genetic material of Cyprus Native Hair Goats.

**Key words:** Body indexes; animal biodiversity; food security

### RESUMEN

La pérdida de diversidad genética en los recursos genéticos de los animales de granja es una preocupación creciente, y muchas razas locales se enfrentan a una posible extinción. Se llevó a cabo este estudio en las granjas caprinas en Chipre con el objetivo de establecer el perfil morfo-biométrico de las cabras autóctonas de pelo indígenas de Chipre, para las cuales no existe información científica necesaria para su adecuada clasificación e identificación, para ello se midieron características morfométricas en 60 animales, se realizó un análisis de varianza a dos vías de clasificación con interacción con los factores edad y género. El color blanco, chamois, buckskin claro, marrón-blanco, blanco grisáceo, gris, pinto y bayo fueron los colores de pelo predominantes de esta raza en proporciones del 28,6; 14,29; 14,29; 14,29; 7,14; 7,14; 7,14 y 7,14 % respectivamente. Todas las cabras de pelo indígenas de Chipre tenían cuernos en forma de arco. Los rasgos de mamellas, barba y pies emplumados se observaron en proporciones de 14,3; 57,14; 50 y 21,43 %, respectivamente. El factor género mostró un efecto significativo ( $P<0,05$ ) en la longitud de las orejas, la longitud de la cabeza, la altura de la cruz, el perímetro torácico, la anchura del pecho, la longitud corporal, la alzada a la grupa, el perímetro de la caña y el peso vivo, así como en índices zoométricos como el índice de la longitud de patas delanteras, el índice compactidad e índice de área. Sin embargo, las cabras registraron valores de índice de proporcionalidad mayores que los machos. Esto reveló que las hembras tenían un perfil brevilineo, características de raza lechera y los machos eran mesolineales con un perfil de tipo carne. Se necesitan más estudios para resaltar y exponer el potencial genético de las cabras de pelo indígenas de Chipre.

**Palabras clave:** Índices zoométricos; biodiversidad animal; seguridad alimentaria

## INTRODUCTION

Sustainable development represents a comprehensive approach that seeks to balance environmental preservation, economic advancement, and social equity to ensure the well-being of present and future generations [1]. Within the context of animal breeding, the genetic diversity of Goat (*Capra hircus*) breeds assumes a pivotal role in facilitating climate adaptation and considering geographical factors [2]. Indigenous Goat breeds, specifically those local to a particular Region, are of utmost importance as they possess unique adaptability to local climates, contribute to sustainable land management practices, safeguard cultural heritage, foster research and genetic enhancement, and bolster resilience against the impacts of climate change. The preservation of a diverse array of Goat breeds is therefore indispensable for ensuring the long-term sustainability and rural livelihoods of agriculture and the overall equilibrium of ecosystems [3].

In Cyprus, Goat and Sheep (*Ovis aries*) farming have been of significant historical importance, exerting a positive impact on the socio-economic development of the population. Particularly noteworthy is the substantial role played by Goat milk and meat in traditional Cypriot nutrition, such as in the production of "Halloumi" cheese (Χαλλούμι, Halloumi, Hellim) and oven kebab (Kleftico, Thief Kebab, Hırsız Kebab), which hold vital culinary and cultural significance in the Region. Notably, the production of Halloumi, a cheese with historical mention dating back to a Venetian manuscript from 1554 as "Calumi," thrives on the island due to its compatibility with the local climate conditions [4].

In Northern Cyprus, the main native Goat breeds reported are Damascus, Native Hair Goat breeds, and some crossbreeds [4]. Concurrently, the production of traditional Halloumi cheese, a significant dairy product with substantial economic importance in contemporary Cyprus, relies primarily on the milk obtained from Cyprus Sheep (Fat-tailed Cyprus Sheep, Awassi, Chios) and Goat breeds. The substantial importance of Halloumi has prompted an application for the registration of its names 'Χαλλούμι' (Halloumi)/'Hellim' as a Protected Designation of Origin (PDO) under the Quality Regulation (EU) No 1151/2012. This registration application underscores various critical factors, including the specific geographic origin, the presence of Sheep and Goats, breed characteristics, feed, geographical Region, the quality of vegetation impacting milk production, and the milk's overall quality, which collectively contribute to the unique characteristics of Halloumi cheese. As a result, the PDO stipulates the utilization of local Sheep and Goat breeds and regionally sourced feed resources for Halloumi cheese production, further accentuating the significance of preserving indigenous breeds. This registration process has had profound implications for livestock production in the Region.

The production of Native-Hair Goats has held a significant role for smallholder farmers in Cyprus, as it sustains their economic well-being by providing a reliable source of income till now [5, 6]. Besides of this, the Cyprus Native Hair Goat breed bears historical significance and requires stringent protection due to its critical role in the Country's Goat flock composition. Nonetheless, the breed faces the peril of extinction primarily because of uncontrolled crossbreeding practices today. The preservation of genetic diversity assumes paramount importance for ensuring the viability of breeding programs in the future and safeguarding the existence of the Cyprus Hair Goat breed [7].

Notably, Cyprus Native Hair Goats are found in the mountainous Regions of the island and some nearby farms, where they roam freely amidst high temperatures and severe scarcity of pasture and water

in the Bes Parmak / Trados mountain. In light of 'climatic changes' adverse effects on production parameters, many Cypriot farmers are integrating these Native Hair Goats into their herds to counter these challenges effectively. Due to their disease resistance, high milk fat content, and ease of breeding, Cyprus Native Hair Goats are specifically sought for breeding purposes or to solely obtain Hair Goat progeny. The morphological characterization of indigenous breeds, including the Cyprus native Hair Goat, holds utmost significance in the establishment of conservation programs for zoo-genetic resources [8, 9, 10, 11, 12, 13]. Accurate identification and comprehensive understanding of the breed requires the quantification and expression of morpho-structural characteristics through precise body measurements. Morphometrics provides a robust toolkit for analyzing morphological variation, thus contributing invaluable insights to comparative studies and developmental research in this context.

This study aims to scientifically identify the physical and morphological traits of the Cyprus Native Hair Goat breed for the first time, thus supporting its genetic conservation and PDO application process.

## MATERIALS AND METHODS

### Study area

The study was conducted on the region of Kyrenia, Northern Cyprus; where there are goat production farms. The farm where the study was performed, was located in the Beş Parmak mountain range. Goats were in a free extensive rearing system in this area with harsh weather conditions (FIGS. 1A, 1B, 1C and 1D). The stockowner has a small open barn for milking the goats. Only at milking time we were able to have access to the animals and take their body measurements. Finding and keeping animals was quite difficult. Therefore, the number of animals used in this study was small. There are Hair Goats on some farms, but most of them are crossbred. For this reason, hair Goats that have owners but roam free in the mountains and mate only among themselves were selected. The research was approved by the Near East University Animal Ethics Committee, (2019/04, 17.04.2019/73).

Northern 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.

### Data collection

The animals had ear tags for identification. There were 7 qualitative traits: presence of horn, horn shape, presence of wattle, beard, and topknot (FIGS. 1A, 1B and 1D), coat color, and presence of feathered feet, and 10 quantitative morphological traits: body weight, ear length, head length, withers height, heart girth, chest depth, chest width, body length, hip height, and cannon circumference (TABLE I), which were recorded according to procedures described by FAO and ICAR [12, 13]. In this research, there were a total of 60 Cyprus Native Hair Goats, all the measurements on the animals were performed by the same group of people in order to minimize errors during the data collection phase of the research.



FIGURE 1. A: White Cyprus Native Hair B: Light Buckskin Cyprus Native Hair. C: Goats in extensive system. D: Topknot and beard in Cyprus Native Hair

**TABLE I**  
**Morphological body measurement**

Traits	Description
Body length (BL)	Measured as the diagonal distance from the tip of the sternum to the base of the tail
Chest girth (CG)	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)	It was the distance from the backbone at the shoulder to the brisket between the front legs (cm)
Rump height (RH)	Height from the ground to the spina iliac (cm)
Rump length (RL)	Distance from the anterior point to the posterior extremity of the pin bone (cm)
Wither height (WH)	Measured from the bottom of the front foot to the highest point of the shoulder between the withers
Pelvic width (PW)	Measured as the distance between pelvic bones across the dorsum
Horn length (HL)	Measured as the length of the horn on its exterior side from its root at the poll of the tip

Morphological indices and body weight were calculated according to the procedures described by Chacon *et al.* and Salako [14, 15] as follows:

- $Body\ Weight = \frac{body\ length \times heart\ girth \times heart\ girth}{10838}$
- $Body\ index = \frac{Body\ length}{Heart\ girth} \times 100$
- $Length\ index = \frac{Body\ length}{Wither\ height}$
- $Depth\ index = \frac{Chest\ depth}{wither\ height}$
- $Foreleg\ length = Wither\ height - Chest\ depth$
- $Compact\ index = \frac{Body\ weight}{Wither\ height} \times 100$
- $Relative\ Cannon\ Thickness\ Index = \frac{Cannon\ circumference}{Wither\ height} \times 100$
- $Area\ index = Wither\ height \times Body\ length$
- $Proportionality\ index = \frac{Wither\ height}{Body\ length} \times 100$

### Statistical analyses

Data obtained from body measurements of females of distinct ages were subjected to descriptive statistics using IBM SPSS Statistics 20 for Windows [16]. A two-way ANOVA test was used to evaluate the

interaction of age and gender factors on morphological body traits and indices. The significance level was set to  $\alpha=0.05$ , so that ( $P \leq 0.05$ ).

The model used in the present study was:

$$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + \epsilon_{ij}$$

$\mu$  = the common mean

$A_i$  = the gender effect (males, ..., females)

$B_j$  = the age effect (j = 6 months old, 2 years old, ..., 7 years old)

$AB_{ij}$  = the interaction effect between the  $i^{\text{th}}$  gender and  $j^{\text{th}}$  age group

$\epsilon_{ijk}$  = 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 DISCUSSIONS

In order to maintain and improve sustainability, it is crucial to have an effective knowledge of transfer strategy and cultural awareness achievement and appreciation of biodiversity [17]. Physical traits, structural indices, and morphometric measurements are useful to determine the type and function of the animal and to estimate animal performance due to their relation to productivity parameters [18, 19]. In the current study, the morphometric and physical traits of the indigenous Cyprus Native Hair Goat breed in a Goat production farm located in Kyrenia, Northern Cyprus were evaluated.

### Qualitative traits in Cyprus Native Hair Goats

The qualitative trait results are presented as percentages for the number of Goats evaluated (TABLE II). The 100 percent of the Cyprus Native Hair Goats had horns with an arc horn shape. The majority (85.7%) of the Goats did not present wattles. The beard trait (FIG. 1D) was seen frequently on 57.14% of occasions. White coat color (FIG. 1A) was seen frequently on 28.6% of the number of Goats evaluated in the research, which was followed by chamoise, light buckskin (FIG. 1B), and brown-white coat with the same frequency of 14.29%. Around 80% (TABLE II) of the Goats in this study did not present feathered feet trait patterns. In the study, it was found that the indigenous Cyprus Native Hair Goats had a wide range of coat colors, dominated by white and followed by chamoisee and light buckskin coat colors. The presence of a wide range of coat colors might be due to a lack of systematic selective crossbreeding programs in the flock.

Horns help to regulate body temperature and are a desirable physical trait for livestock owners, who consider polled Goats unable to reproduce. All the evaluated Cyprus Native Hair Goats had horns with an arc shape. The non-appearance of polled Goats in the flock may be due to a lack of interest from livestock owners.

According to Gatew *et al.* [20], the wattle and beard issues can be used as selection criteria to improve animal performance. Wattle and beard play a role in thermoregulation and are related to higher prolificity, higher fertility, a higher conception rate, and a higher milk yield [21]. In the Cyprus Native Hair Goats, the beard trait was seen frequently on 57.14% of occasions, however, the wattle trait was only seen in 14.3% of the flock. Similarly, in different indigenous Goat populations, researchers have obtained lower values for the wattle trait [21, 22].

**TABLE II**  
Frequency of qualitative traits status in Cyprus Native Hair Goat

Qualitative traits	Trait status	% of the flock
Horns	Present	100.00
Horn shape	Arc	100.00
Wattles	Present	14.30
	Absent	85.70
Beard	Present	57.14
	Absent	42.86
Topknot	Present	50.00
	Absent	50.00
Coat color	White	28.60
	Chamoise	14.29
	Light Buckskin	14.29
	Brown-white	14.29
	White-grey	7.14
	Grey	7.14
Feathered feet	Pinto	7.14
	Bay	7.14
	Present	21.43
	Absent	78.57

### Cyprus Native Hair Goats body measurements

The results of the descriptive statistics of body measurement of female Cyprus Mountain Goats are shown in TABLE III.

The average ear length, head length, wither height, heart girth, chest width, body length, hip height, and body weight of a 6-month-old Cyprus Native Hair Goat were 7.5; 18.16; 56; 75; 14.66; 59.33; 58.66 cm, and 30.81 kg, respectively. The ear length, head length, and wither height at 6 months of age reported by Singh *et al.* [23] in female Gohilwadi kids were higher than those found in the present study. However, the heart girth value in Cyprus Native Hair Goats was much higher. In addition, during the same period when Gohilwadi female kid Goats reached barely 20 kg of body weight, Cyprus Native Hair kid Goats reached a mean of 30.80 kg. For Gohilwadi female kid Goats to reach this body weight, they need another 6 months. These results demonstrate how good the growth performance of Cyprus Native Hair Goats can be.

At 2 years old, the average ear length, head length, wither height, heart girth, chest width, body length, hip height, and body weight were 11.2, 22, 71.4, 91, 19, 69, 75.9, cm, and 52.90 kg, respectively.

At 3 years old, Cyprus Native Hair Goats averaged 12.37, 22.5, 76.87, 89.75, 19, 72.75, 80.5 cm, and 54.3 kg of ear length, head length, height at withers, heart girth, chest width, body length, hip height, and body weight, respectively. Body weight ranged from 41.4 to 65.11 kg.

Then the average ear length, head length, wither height, heart girth, chest width, body length, hip height, and body weight of a 4 years old Cyprus Native Hair Goat were 10.11, 22.88, 77.88, 93.88, 19.88, 75.11, 81.55 cm, and 62.7 kg, respectively. According to the results reported by Tatar *et al.* [24] for the Turkish Damascus Goat breed in Diyarbakir Province, the results found in this study for wither height, body length, chest depth, chest width, and heart girth in Cyprus Native Hair Goats seem to be higher, particularly in males of 4 years of age. So logically, the body weight of this breed was much

**TABLE III**  
**Descriptive Statistics of Cyprus Native Hair Goats Body Measurements in Females**

Age		EL	HL	WH	HG	CW	BL	HH	BW
6 months old	Mean	7.50	18.16	56.00	75.00	14.66	59.33	58.66	30.81
	Std.Dev.	1.04	1.32	1.26	2.00	1.03	0.52	1.63	1.65
	Min	6	16	54	72	13	59	57	28.22
	Max	79	20	58	78	16	60	61	33.12
2 years old	Mean	11.20	22.00	71.40	91.00	19.00	69.00	75.90	52.90
	Std.Dev.	2.9	1.82	3.06	3.80	4.10	3.91	3.81	6.28
	Min	7	20	67	83	12	63	70	40.04
	Max	15	25	78	95	24	75	79	60.79
3 years old	Mean	12.37	22.50	76.87	89.75	19.00	72.75	80.50	54.30
	Std.Dev.	1.92	1.77	3.72	6.11	4.00	3.15	3.66	7.77
	Min	10	20	69	79	13	70	73	41.4
	Max	15	25	81	97	25	78	85	65.11
4 years old	Mean	10.11	22.88	77.88	93.88	19.88	75.11	81.55	62.70
	Std.Dev.	4.28	2.61	6.29	8.07	5.66	11.38	6.85	20.83
	Min	5	20	70	84	13	63	72	41.02
	Max	16	28	88	110	30	97	90	100.48
5 years old	Mean	12.46	23.46	77.90	94.61	19.30	75.46	79.38	63.39
	Std.Dev.	3.38	2.14	5.60	6.53	4.92	9.41	5.89	16.86
	Min	8	20	71	88	13	68.00	71	48.59
	Max	19	28	88	110	30	97	90	100.8
6 years old	Mean	12.50	24.83	78.33	91.16	15.33	83.00	87.33	63.70
	Std.Dev.	2.58	2.48	3.93	3.60	1.75	6.29	4.13	7.03
	Min	9	21	71	88	12	71	79	57.88
	Max	16	28	83	96	17	88	90	74.83
7 years old	Mean	13.75	24.12	81.50	98.75	20.75	74.25	80.75	66.98
	Std.Dev.	3.28	1.12	2.56	3.37	3.80	4.33	2.60	7.30
	Min	7	23	77	95	16	69	78	58.29
	Max	18	26	84	105	27	80	85	77.31

EL: Ear Length; HL: Head Length; WH: Wither Height; HG: Heart Girth; CW: Chest Width; BL: Body Length; HH: Hip Height; BW: Body Weight

higher compared to Damascus Goats. These results must receive widespread attention from livestock owners in order to offset the current low productivity of small ruminants.

At 5 years old, the average ear length, head length, height at withers, heart girth, chest width, body length, hip height, and body weight were 12.46, 23.46, 77.9, 94.61, 19.3, 75.46, 79.38 cm, and 63.39 kg, respectively. The body weight ranged from 48.59 kg to 100.8 kg.

For a 6-years old Cyprus Native Hair Goat, the average ear length, head length, height at withers, heart girth, chest width, body length, hip height, and body weight were 12.50, 24.83, 78.33, 91.16, 15.33, 83, 87.33 cm, and 63.7 kg, respectively. The body weight ranged from 57.88 to 74.83 kg.

And the average ear length, head length, height at withers, heart girth, chest width, body length, hip height, and body weight of the Cyprus Native Hair Goat at 7 years of age were 13.75, 24.12, 81.5, 98.75, 20.75, 74.25, 80.75 cm, and 66.98 kg, respectively.

### Effect of gender, age and their interaction on body weight and body measurements

TABLE IV shows the interaction between sex and age on the body traits of Cyprus Native Hair Goats. In the present study, it was found no significant interaction ( $P>0.05$ ) of gender and age factors on all of the body measurements. This means that the main effect of gender and age on body traits of Cyprus Native Hair can be fully accepted. The ear length, head length, wither height, heart girth, chest with, body length hip height, and body weight of both genders were significantly higher in older age groups than in younger age groups. Additionally, males exhibited significantly higher values for these body traits compared to females ( $P<0.05$ ). For chest depth, although statistically no significant difference was found between both genders, there was a tendency for a higher value in females. However, for the cannon circumference, although no statistically significant difference was found, males showed a tendency for a higher value. Kurnianta *et al.* [25] have reported that the effect of gender on live weight and morphological traits in Goats is principally due to hormonal mechanisms leading to different growth rates. Results from the current research are in

**TABLE IV**  
**Effect of gender and age and their interaction on the body traits of Cyprus Native Hair Goats**

Traits	EL (N=60)	HL (N=60)	WH (N=60)	HG (N=60)	CD (N=60)	CW (N=60)	BL (N=60)	HH (N=60)	CC (N=60)	BW (N=60)
	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM
<b>Gender</b>										
Female	10.69±0.47	22.05±0.29	73.37±0.67	88.98±0.80	38.39±0.85	17.17±0.58	71.24±0.96	76.80±0.71	11.46±0.16	53.00±1.72
Male	13.19±0.75	23.76±0.44	76.47±1.04	94.52±1.23	37.44±1.35	21.05±0.90	76.67±1.49	80.14±1.1	11.97±0.26	65.35±2.67
<b>Age</b>										
6 months old	7.75±1.28	18.37±0.78	56.25±1.82	75.50±2.16	-	14.75±1.58	59.37±2.62	58.88±1.92	-	31.25±4.67
2 years old	12.00±1.02	22.57±0.62	71.38±1.45	91.86±1.72	35.91±1.77	20.05±1.26	69.67±2.08	76.21±1.53	10.38±0.34	54.44±3.72
3 years old	12.50±1.08	22.87±0.65	77.50±1.54	90.73±1.82	32.70±1.87	19.80±1.33	73.07±2.21	80.93±1.62	11.73±0.36	55.74±3.94
4 years old	10.25±1.18	22.93±0.72	78.46±1.69	95.00±2.00	38.86±2.05	20.46±1.46	75.61±2.42	81.89±1.78	12.32±0.40	65.64±4.32
5 years old	13.12±0.97	24.35±0.59	79.70±1.39	96.85±1.64	39.10±1.68	21.53±1.20	80.55±1.99	81.82±1.46	11.82±0.33	71.24±3.55
6 years old	13.12±1.28	25.00±0.78	79.00±1.82	92.00±2.16	40.38±2.22	15.50±1.58	84.25±2.62	87.75±1.92	12.13±0.43	65.92±4.67
7 years old	14.83±1.20	24.25±0.78	82.16±1.72	100.33±2.16	40.58±2.09	21.67±1.49	75.17±2.47	81.83±1.81	11.92±0.40	70.02±4.40
<b>Gender × Age</b>										
F*6 months old	7.00±1.47	17.75±0.90	55.50±2.11	74.00±2.49	-	14.50±1.83	59.25±3.02	58.25±2.22	-	29.95±5.39
M*6 months old	8.50±2.08	19.00±1.27	57.00±2.98	77.00±3.53	-	15.00±2.58	59.50±4.27	59.50±3.14	-	32.55±7.62
F*2 years old	10.00±1.12	21.14±0.68	71.43±1.59	89.71±1.89	36.14±1.93	17.43±1.38	68.00±2.28	75.43±1.68	10.43±0.37	50.64±4.07
M*2 years old	14.00±1.70	24.00±1.04	71.33±2.43	94.00±2.88	35.67±2.95	22.67±2.11	71.33±3.49	77.00±2.56	10.33±0.57	58.23±6.22
F*3 years old	12.00±1.32	21.40±0.80	75.00±1.88	86.80±2.23	37.40±2.29	16.60±1.63	71.80±2.70	79.20±1.99	10.80±0.44	49.97±4.82
M*3 years old	13.00±1.70	24.33±1.04	80.00±2.43	94.67±2.88	28.00±2.95	23.00±2.11	74.33±3.49	82.67±2.56	12.67±0.57	61.52±6.22
F*4 years old	10.00±1.12	22.86±0.68	77.43±1.59	93.00±1.89	38.71±1.93	19.43±1.38	74.71±2.28	81.29±1.68	12.14±0.37	60.52±4.07
M*4 years old	10.50±2.08	23.00±1.27	86.50±2.98	101.50±3.53	39.00±3.62	21.50±2.58	93.50±3.50	82.50±3.14	12.50±0.70	87.75±7.62
F*5 years old	11.90±0.93	22.70±0.57	76.40±1.33	92.70±1.58	38.20±1.62	17.40±1.16	71.10±1.91	77.30±1.41	11.30±0.31	56.67±3.41
M*5 years old	14.33±1.70	26.00±1.04	83.00±2.43	101.00±2.88	40.00±2.95	25.67±2.11	90.00±3.49	86.33±2.56	12.33±0.57	85.82±6.22
F*6 years old	11.25±1.47	24.50±0.90	77.00±2.11	89.50±2.50	39.75±2.56	15.00±1.83	80.50±3.02	86.50±2.22	12.75±0.49	59.31±5.39
M*6 years old	15.00±2.08	25.50±1.27	81.00±2.98	94.50±3.53	41.00±3.62	16.00±2.58	88.00±4.27	89.00±3.14	11.50±0.70	72.53±7.62
F*7 years old	12.67±1.20	24.00±0.73	80.83±1.72	97.17±2.04	40.17±2.09	19.83±1.49	73.33±2.47	79.67±1.81	11.33±0.40	63.95±4.40
M*7 years old	17.00±2.09	24.50±1.27	83.50±2.98	103.50±3.53	41.00±3.62	23.50±2.58	77.00±4.27	84.00±3.14	12.50±0.70	76.09±7.62
<b>P-values</b>										
Age	0.006*	0.001*	0.001*	0.001*	0.044*	0.006*	0.001*	0.001*	0.007*	0.001*
Gender	0.006*	0.002*	0.016*	0.001*	0.554	0.001*	0.004*	0.014*	0.104	0.001*
Age × Gender	0.840	0.489	0.738	0.936	0.298	0.374	0.055	0.571	0.104	0.333

\*:The significance level was determined at  $P \leq 0.05$ , EL: Ear Length, HL: Head Length, WH: Withers Height, HG: Heart Girth, CD: Chest Depth, CW: Chest Width, BL: Body Length, HH: Hip Height, CC: Cannon Circumference, BW: Body Weight

agreement with those of Tsegaye *et al.* [22], Kurnianto *et al.* [25], and Gatew *et al.* [20] except for ear length and chest depth traits, suggesting that sex had a very significant effect on ear length, head length, withers height, heart girth, chest width, body length, hip height, cannon circumference, and body weight. Although statistically no significant difference was found for chest depth, there was a tendency for a higher value in males.

Some morphological body measurements obtained from hair goat studies conducted in Türkiye are compared in TABLE V [26, 27, 28]. In all the studied Regions included in TABLE V, the Cyprus domestic Goats are larger than these Goats in both sexes. The closest average values belong to The Hair Goats of the Burdur–Antalya Region in the Mediterranean Region.

### Effect of gender, age and their interaction on morphological body traits indices

Although morphological measurements are used to indicate the type and function of the animal, for accurate animal conformation estimation and animal type, weight, and function assessment, morphological indices have been reported to perform better [29].

Morphological indices in Cyprus Native Hair Goats are given in TABLE VI. There was no significant interaction ( $P > 0.05$ ) of gender and age factors on all morphological body trait indices, except in body index trait ( $P = 0.42$ ). The effect of gender on body index differs between ages. There were significant effects of age on length index, depth index, foreleg length, compact index, relative cannon thickness index (RCTI), area index, and proportionality index. The effect of gender was significant in foreleg length, compact index and area index with higher

**TABLE V**  
Comparison of some body measurements of Hair Goats in different studies in Türkiye

Body measurements	Sex	Cyprus Native Hair Goat	Hair Goat, Antalya Province, Türkiye (Gezer 2018)	Turkish Hair Goat, Antalya, Burdur Province, Türkiye (Elmaz <i>et al.</i> 2016)	Hair Goat, Kütahya Province, Türkiye (Altay 2022)
Live weight (kg)	female	60.52±4.07	39.52±4.10	51.20±0.33	36.15±0.95
	male	87.75±7.62	54.86±6.08	82.80±2.16	48.40±1.76
Withers height (cm)	female	77.43±1.59	75.40±3.48	74.80±0.18	68.70±0.94
	male	86.50±2.98	83.51±4.04	86.60±0.74	70.63±1.20
Chest / hearth girth (cm)	female	93.00±1.89	83.41±3.62	86.80±0.20	81.50±0.98
	male	101.50±3.53	93.55±6.54	100.70±0.91	86.64±1.05
Body length (cm)	female	74.71±2.08	74.47±4.09	80.60±0.20	68.30±0.83
	male	93.50±3.50	81.92±4.88	93.70±0.86	74.63±1.12

**TABLE VI**  
Effect of gender and age and their interaction on morphological body traits indices

Indices	Body Index (N=60)	Length Index (N=60)	Depth Index (N=60)	Foreleg length (N=60)	Compact Index (N=60)	RCTI (N=60)	Area Index (N=60)	Proportionality Index (N=60)
	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM
<b>Gender</b>								
Female	80.22±0.86	0.98±0.01	0.43±0.01	40.46±0.89	7.15±0.19	12.80±0.02	5273.90±111.50	103.22±1.22
Male	81.01±1.33	1.00±0.017	0.40±0.02	44.38±1.37	8.35±0.29	12.90±0.05	5954.69±172.57	98.24±1.30
<b>Age</b>								
6 months old	78.69±2.33	1.06±0.03	–	56.25±2.41	5.55±0.51	–	3339.75±302.01	94.75±3.29
2 years old	75.86±1.85	0.98±0.02	0.50±0.02	35.48±1.92	7.64±0.40	14.60±0.03	4974.02±240.64	102.71±2.62
3 years old	80.83±1.96	0.94±0.03	0.43±0.02	44.80±2.03	7.17±0.43	15.10±0.04	5665.33±254.67	106.21±2.78
4 years old	79.25±2.15	0.96±0.03	0.50±0.02	39.61±2.23	8.19±0.47	15.60±0.04	6004.75±279.60	104.99±3.05
5 years old	83.06±1.77	1.01±0.02	0.49±0.02	40.60±1.83	8.84±0.38	14.90±0.03	6464.22±229.56	100.00±2.50
6 years old	91.67±2.33	1.07±0.03	0.51±0.03	38.63±2.41	8.33±0.51	15.40±0.04	6672.75±302.01	93.94±3.29
7 years old	74.94±2.19	0.92±0.03	0.49±0.02	41.58±2.27	8.52±0.48	14.50±0.04	6179.25±284.73	109.52±3.10
<b>Gender × Age</b>								
F*6 months old	80.09±2.69	1.07±0.04	–	55.50±2.78	5.40±0.58	–	3288.50±348.73	93.67±3.80
M*6 months old	77.29±3.80	1.04±0.05	–	57.00±3.93	5.71±0.82	–	3391.00±493.17	95.82±5.38
F*2 years old	75.86±2.03	0.95±0.03	0.51±0.02	35.29±2.10	7.11±0.44	14.60±0.04	4855.71±263.61	105.39±2.87
M*2 years old	75.87±3.10	1.00±0.04	0.50±0.03	35.67±3.21	8.16±0.67	14.50±0.06	5092.33±402.67	100.03±4.39
F*3 years old	83.14±2.40	0.96±0.03	0.50±0.03	37.60±2.49	6.65±0.52	14.40±0.05	5385.00±311.91	104.56±3.40
M*3 years old	78.52±3.10	0.93±0.04	0.35±0.03	52.00±3.21	7.69±0.67	15.80±0.06	5945.67±402.67	107.86±4.39
F*4 years old	80.08±2.03	0.96±0.03	0.50±0.02	38.71±2.10	7.78±0.44	15.70±0.04	5813.00±263.61	104.75±2.87
M*4 years old	78.41±3.80	0.96±0.05	0.49±0.04	40.50±3.93	8.60±0.82	17.00±0.07	6196.50±493.17	105.24±5.38
F*5 years old	76.71±1.70	0.93±0.02	0.50±0.02	38.20±1.76	7.45±0.37	14.80±0.03	5428.10±220.55	107.80±2.40
M*5 years old	89.41±3.10	1.09±0.04	0.48±0.03	43.00±3.21	10.24±0.67	14.90±0.06	7500.33±402.67	92.21±4.39
F*6 years old	90.19±2.69	1.04±0.04	0.52±0.03	37.25±2.78	7.71±0.58	16.60±0.05	6217.50±348.73	95.83±3.80
M*6 years old	93.15±3.80	1.09±0.05	0.51±0.04	40.00±3.93	8.95±0.82	14.20±0.07	7128.00±493.17	92.05±5.38
F*7 years old	75.46±2.19	0.91±0.03	0.50±0.02	40.67±2.27	7.92±0.48	14.10±0.04	5929.50±284.73	110.57±3.10
M*7 years old	74.43±3.80	0.92±0.05	0.49±0.04	42.50±3.93	9.11±0.82	15.00±0.07	6429.00±493.17	108.47±5.38
<b>P-values</b>								
Age	0.001*	0.003*	0.001*	0.001*	0.001*	0.001*	0.001*	0.007*
Gender	0.619	0.184	0.111	0.021*	0.001*	0.947	0.002*	0.189
Age × Gender	0.042*	0.149	0.234	0.241	0.524	0.070	0.101	0.219

\*: The significance level was determined at  $P \leq 0.05$

values in males than in females. Although there was no significant effect of gender on depth index and proportionality index, female Cyprus Native Hair Goats tended to have higher values for these traits. These findings were in agreement with those of Hilal *et al.* [30], suggesting that sex must be an important factor of variation in body weight and morphological indices in indigenous Goat breeds. According to Silva-Jarquín *et al.* [31], body index is used to classify Goats into brevilinear (body index  $\leq 85$ ), mesolinear (body index  $> 86$  and  $< 88$ ), or longilinear (body index  $\geq 90$ ). From the study results, this indicates that female Cyprus Native Hair Goats at 4 years old have a brevilinear profile (body index 76), whereas males are mesolinear (body index 88). This indicates that male and female Cyprus Native Goats have a good deep chest capacity which is desired for long-distance grazing and undulating area [14]. However, these values were lower than those reported by Hankamo *et al.* [32] for their local Goat breed.

The proportionality index relates the body height to body length to indicate the animal's shape. Proportionality index  $< 100$  shows that the animal body tends to have a rectangular shape, which is a meat-type breed characteristic. However, an index  $> 100$  indicates that the shape of the animal tends to have a dairy breed characteristic, a square shape [8, 33]. In this study, female Cyprus Native Hair Goats had a proportionality index higher than 100, which characterized them as a dairy Goat-type breed. Male Cyprus Native Hair Goats had a proportionality index of 98.24, indicating their meat-type characteristic.

The relative cannon thickness index (RCTI) is a good indicator in the determination of breed type. It shows the correlation between the perimeter of the cannon bone and the animal's height. This index is higher in meat-type Goat breeds than in dairy types.

As expected, the results from the current study showed Cyprus Native Hair bucks to be more suitable for Goat meat production. Getaneh *et al.* [8] also reported a higher relative cannon thickness index in Ethiopian indigenous bucks. The highest value found in Cyprus Native hair bucks of 4 years old indicates their superiority over Ethiopian bucks.

The length index values of the current study were slightly lower than those found in Assam Hill goats [34]. However, it seemed that the depth index values of Cyprus Native Hair Goats in both sexes of 4 years old are equal to the Assam Hill Goats breed. The depth index revealed Cyprus Native Hair Goats to have a deep chest.

The compact index shows how compact the animal is. The meat-type Goats have values above 3.15. A value close to 2.75 indicates the animal has a dual purpose, and a value close to 2.60 indicates the animal is more suitable for milk production [14]. The compact index values of Cyprus Native Hair Goats of 4 years old from this study were higher than those reported by Chacón [14] in Cuban Creole Goats ( $5.20 \pm 0.32$ ). This result indicates the suitability of Cyprus Native Hair Goats for meat production.

The area index value of this study in Cyprus Native Hair Goats was greater than that found in Assam Hill Goats ( $3355.13 \pm 48.84$ ) by Khargharia *et al.* [34].

## CONCLUSIONS

The current study presented the first morpho-biometric results of indigenous Cyprus Native Hair Goats necessary for their proper classification and identification.

Analysis of the morphological body measurements, and indices indicated that the females had a brevilinear profile with dairy type

breed characteristics and the males were mesolinear with a meat-type profile.

Based on known information, productive and reproductive performance studies have not been yet studied.

It is expected that the current study will be considered as a starting point for further studies to highlight and expose the potential genetic material of Cyprus Native Hair Goats.

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## Conflict of interest statement

The authors declare no conflict of interest.

## Data availability statement

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

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