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Morphological Characterization of the Libyan Barbary Sheep.

A. E. Ahtash[1*], F. M. Abousaq[1], M. M. Edahmani[2], N. A. Aboubareeq[2], O. K. Alsibae[3] , M. H. Abounouwarah[2] , S. A. Shaykh[3] , E. Zaatot[2] , A. Eltashani[3] , H. Agoob[2], A. Mahmod[2], M.A. Ashteba[2], H. A. Alfaleedni[2], A. A. Tarhuni[2], A. M. Targy[2], K. M. Abdulkarim[2], A. Shiba[2] and I. Ibrahim[2]

[1] Department of Animal Production-Faculty of Agriculture - University of Tripoli/ Libya.

[2] Agriculture Research Center-Ministry of Agriculture and Animal Wealth/ Libya.

***Corresponding author:** E-mail: a.ahtash@uot.edu.ly Department of Animal Production-Faculty of Agriculture - University of Tripoli/ Libya.

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Abstract: This study aimed to morphometrically characterize Libyan Barbary sheep across four distinct geographical regions (eastern, western, central, and southern) to determine if they constitute a single population. Data were collected on ten qualitative and eleven quantitative traits from 853 rams and 3008 ewes. Libyan Barbary sheep are characterized by a white coat, a brown or black head, a straight nose, and the absence of a beard and wattles, females are hornless, while males have curved or spiral horns. Ears are mostly pendulous. The results show highly significant differences between regions and between males and females within the same region. The average for quantitative traits, including head length, horn length, wither height, chest girth, canon circumference and body length, ear length, staple length, tail length, teat length and scrotum circumference were 11.9, 56.52, 72.65, 92.14, 8.33, 72.06, 13.92, 8.29, 42.55, 2.63 and 29.8 cm., respectively. Analysis of variance revealed significant effects of both region and sex on the measured traits. Variance component analysis indicated high within-region variability for all traits. Head length, body length, wither height, and chest girth exhibited greater discriminatory power between subpopulations. All pairwise comparisons between regions were statistically significant ($P < 0.001$), with distances ranging from 0.8 to 3.62. Canonical discriminant analysis confirmed significant differences between the groups based on linear combinations of the measured variables. Despite their geographical dispersion, these sheep populations demonstrate remarkable phenotypic similarities. While the current findings suggest they may belong to a single population, further molecular genetic analysis is necessary to de-finitively confirm this.

Key words: Barbary, regions, morphometric, discriminant..

*عبدالكريم امحمد أحتاش، قسم الانتاج الحيواني، كلية الزراعة، جامعة طرابلس، طرابلس، ليبيا.
، فتحي مصطفى أبوساق قسم الانتاج الحيواني، كلية الزراعة، جامعة طرابلس، طرابلس، ليبيا.
امصطفى الدهماني[2]، ناصر أبوبريق[2]، أسامة الأصيبعي[2]، محمود أبونوارة[2]، سالم الشيخ[2]، عصام زعطوط[2]، عبدالحفيظ الطشاني[2]، حسن عقوب[2]، عبدالكريم محمود[2]، محمد شطيبة[2]، حسن الفليدني[2] ، أبوعجيلة الترهوني[2]، عبدالقادر محمد التارقي[2] ، خالد محمد عبدالكريم[2] ، عبدالكريم شيبة[2]، اسماعيل ابرهيم[2].
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التوصيف المورفولوجي للضأن البربري الليبي

المستخلص: تهدف هذه الدراسة إلى التوصيف الشكلي للضأن البربري الليبية في أربع مناطق جغرافية (الشرق والغرب والوسط والجنوب) لتحديد أن هذه السلالة تنتمي إلى عشيرة واحدة. جمعت بيانات لعشرة صفات نوعية وأحد عشر صفة كمية من 853 كبشا و 3008 نعجة. الضأن البربري الليبية يتصف بغطاء خارجي لونه أبيض والرأس بلون بني أو أسود والأنف مستقيم وغياب اللحية والدواليات، والإناث بدون قرون أما الذكور بقرون مقوسة أو حلزونية، والأذن متدلية. أظهرت النتائج فروقات عالية المعنوية بين المناطق وبين الذكور والإناث داخل المنطقة. كان متوسط الصفات الكمية، التي تشمل طول الرأس، وطول القرن، والارتفاع عند الحارك، ومحيط الصدر، ومحيط الساق، وطول الجسم، وطول الأذن، وطول خصلة الصوف، وطول الذيل، وطول الحلمة، ومحيط الخصية 11.9 و 56.52 و 72.65 و 92.14 و 8.33 و 72.06 و 13.92 و 8.29 و 42.55 و 2.63 و 29.8 سم على التوالي. تحليل التباين أكد وجود تأثيرات معنوية لكل من المنطقة والجنس على الصفات المدروسة. تحليل مكونات التباين تشير إلى أختلافات داخل المنطقة لكل الصفات. طول الرأس وطول الجسم وارتفاع الكاهل ومحيط الصدر أظهرقوة تمييزية أكبر بين الفئات الفرعية. أظهرت المقارنات الزوجية بين المناطق اختلافات عالية المعنوية ($p<0.001$) وتراوحت المسافات الثنائية ما بين 0.8 و 3.62. تحليل التمايز الكنسي أكد الاختلافات النعنوية بين المجموعات بناء على توليفات خطية للمتغيرات المقاسة. على الرغم من الانتشارالجغرافي، تظهر هذه الأغنام تشابهات ظاهرية ملحوظة. في حين النتائج الحالية تقترح أنها قد تنتمي إلى عشيرة واحدة، يلزم إجراء مزيد من التحليل الجيني الجزيئي لتأكيد ذلك بشكل قاطع.

الكلمات المفتاحية: البربري، مناطق، المورفولوجية، التمييز.

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INTRODUCTION

Sheep production is a key agricultural activity in most pastoral regions of Libya, and natural pastures represent an important part of the sources of fodder and feed for these animals. The spread of natural pastures on most of the plains in Libya makes sheep one of the most important priorities for raising small ruminants in Libya, in order to benefit from its productivity of meat and wool. The number of sheep varies over the years, depending on the environmental conditions such as rainfall and availability of pasture. Statistics show that the number of sheep in Libya is estimated at about 2.950.000 million (Animal Genetic Resources committee, 2020).

The Libyan Barbary sheep breed represents about 95% of the sheep population in Libya (Magid et al., 1992), which is characterized by their ability to survive in challenging conditions like prolonged drought and extreme heat, and this also enables them to achieve much higher productivity in high-resource environments.The Barbary sheep breed, prevalent in Libya's Jafara Plain, exhibits good growth rates when adequate pastures are available. This breed has also demonstrated its ability to withstand the challenges of foraging in less abundant grazing areas, which have often become scarce and shorter in recent years due to climate change (Ihtash & Magid 1999).

Barbary sheep are generally characterized as having a white body, the head and legs are brown, black or sometimes white; however, the head may be speckled in black or brown, especially around the eyes and snout. Magid & Mursy (1992) conducted a survey of several herds of Libyan Barbary sheep, noted that the sheep with black facial coloration tended to weigh more than those that are brown or white and they confirmed that there are significant differences in weight after weaning associated with different face color. Ahtash et al., (2010) confirmed that the color of the face had a significant effect on the weight at weaning of the Libyan Barbary sheep, and recommended the possibility of relying on the characteristic of the color of the face in the early selection of newborn lambs according to the color of the face. Libyan sheep breeder values morphological differences, recognizing their socio-cultural and economic importance; some breeders have specific consideration for sheep face colors followed by body weight. Characterizing morphological trait variations allows for the classification or identification of livestock breeds, thereby facilitating the effective use of available animal genetic resources (Delgado et al., 2001 and Lanari et al., 2003). To understand the relationships within and between regions, the immediate characterization and identification of sheep is necessary. According to Food and Agriculture Organization of the United Nations (FAO) (Please provide the full form of the abbreviation at its first mentioning in the manuscript) (1999), the rapid transformation of agricultural systems in developing countries is eroding animal genetic resources. The primary cause of this erosion is the indiscriminate introduction of exotic breeds before proper characterization, utilization, and conservation of indigenous breeds. Multivariate analyses of variance are used to determine which of the many measured traits is necessary to distinguish within and/or between Sub-populations, and to identify the morphological characteristics crucial for classifying individuals into groups based on their overall resemblance (FAO, 2012). The aims of this study are to morphometric characterize the Libyan Barbary sheep population in the four regions of Libya and to contribute to the international data base.

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MATERIALS AND METHODS

Main Eco-agriculture in which the Sheep produce : Libya is one of the North African countries, located between 18° and 33° North latitude and 9° and 25° East longitude. Its total area is about 1,759,540 km^2, of which more than 90% is desert (FAO, 2006). According to official statistics, there are 3.6 million hectares of agricultural land and 13 million hectares of range land represented 2% and 7.5% of total areas of Libya, respectively (Pasture development project, 2020). Libya experiences a climatic gradient, transitioning from Mediterranean climates along the coast to arid and semi-arid conditions in the south. The arid and semi-arid regions, with their limited and variable feed resources, present significant challenges for livestock production (Figure1).

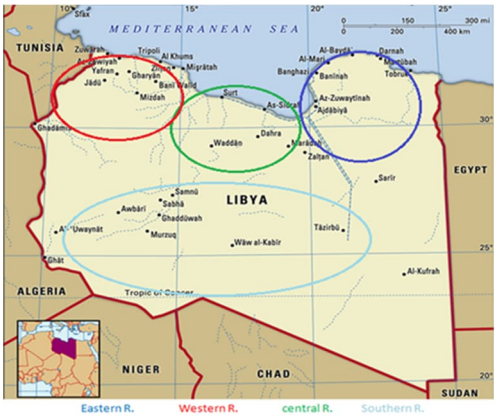

Figure: (1). Libyan Map Showing Different Regions.

Indigenous sheep populations: In terms of numbers, sheep were consistently the most important type in the three regions of Libya (western, eastern, southern), followed by goats, cattle and camels (FAO, 2006). Four environmental areas described below, which are habitats of the sheep populations concerned with this work; include eastern, western, central, and southern area. Targeted municipalities were randomly selected to collect morphological data from the respective sheep populations. The agricultural development experts who were involved in the actual field survey were trained on characterization of the indigenous sheep populations at morphological levels using the manual prepared by (ARC/ICARDA, 2008). Barbary sheep in this study were raised by smallholder farmers under extensive management systems, sheep were sampled from those farmers. To maximize the capture of existing genetic diversity, we sampled relatively unrelated animals from multiple flocks within each population for morphological characterization of the sheep breed; however the rams are not exchanged for breeding between regions. Veterinary health care, appropriate feeding, and controlled mating were largely absent in these flocks. Furthermore, no performance recording system was in place. The spatial distribution of breeders in the municipalities and the number of animals targeted for study was determined based on the number of sheep in the municipalities and agricultural areas.

Characteristics studied: A standardized form was used to record morphological traits. Random samples of 3-5 mature, unrelated animals were selected from each herd for measurement, allowing for the assessment of morphological characteristics within each population. Ten qualitative and eleven quantitative characteristics were measured in this study from four sheep sub-populations obtained for morphological characterization of Libyan Barbary sheep at the following areas, in eastern (N= 467), western (N= 2125), central (N=1160) and southern (N=109); the measurements ac-

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cording to the sex were used (♂♂= 853) and (♀♀= 3008). The qualitative characteristics were coat color, head color, eye color, nose profile, beard presence, wattle presence, body condition score, horn shape, horn orientation and ear orientation, while quantitative characteristics were head length, horn length, height at withers, chest girth, canon circumference, body length, ear length, staple length, tail length, teat length and scrotum circumference were measured using a measuring tape. Figure (2) Showing Libyan Barbary sheep..

Figure: (2). Libyan Barbary sheep

Statistical analysis:The statistical analysis was performed using various procedures of the statistical program SAS-PC (SAS, 2002). Basic statistics for the measurements were obtained using Proc Univariate and Proc Frequency, respectively. Quantitative and qualitative data were analyzed using the General Linear Model (GLM) procedure according the following model:

$$y_{ijk} = \mu + R_i + S(R)_j + e_{ijk}$$

Where y_{ijk} an observation, μ is the overall mean, R_i is fixed effect of the *i* region, $S(R)_j$ is effect of the sex within region and e_{ijk} is the random error attributed to the observation. Stepwise discriminant procedure was applied using (PROC STEPDISC) to determine which morphological traits have more discriminant power than others. The (CANDISC) procedure was used to perform canonical analysis to derive canonical functions, linear combinations of the quantitative variables that summarize variation between areas and to compute the Mahalanobis distance matrix between regions.

RESULTS

The Qualitative traits: The use of qualitative morphological characteristics to study the similarity or diversity in the Libyan Barbary sheep breed across four regions is shown in Table (1), (2) and (3).The results relating to the qualitative characters in all sheep raised in the four regions are presented in Table 1. Significant differences (P <0.0001) exist between regions and between sexes within region for all studied traits (Table 2). Although coat color and absence of Wattle did not differ significantly between the sexes within the region, the other traits differed significantly.

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Variations in coat color were observed between different regions, the predominant color of the coat is white 91%, 89% and 96.8% in Eastern, Western and Central regions respectively, while the southern region characterized by the predominant coat color speckled (46.5%). In the western, eastern and central region the predominant color of the head is black, followed by brown, while in the southern region the predominant color is speckled followed by brown. The eye color of Libyan sheep was brown constituting the maximum proportion in all regions, 15% of the sheep of the eastern region have olive-colored eyes. The average values of some qualitative characters observed in rams and ewes are presented in table (2). There were no differences between rams and ewes in the characteristics of the nose pattern, as the percentage of straight head was 97% and 66% for the central and southern sheep, respectively; whereas males in the western and eastern regions tend to have a nose with a convex profile and females tend to have a straight shape. Beard was mostly absent in all regions except those in eastern region, where it was present in 18% of males and 6% of females. 18% and 6% for males and females, respectively. Large proportions of males and females (over 80 percent) were devoid of wattle except those in males and females of southern region were 40% and 46%, respectively. Horns were present in most of the males across all regions with variable proportions ranged from 85 % to 99 %. About 60% to 89 % of the males had spiral shape; while, about 36% to 94% were lateral orientation. However, about 15 % of male sheep in southern region were polled. These subpopulations have pendulous ears in 81% of individuals, while 18% of the animals have horizontal ears. The statistical results indicate highly significant differences ($P<0.0001$) among sheep in the four studied regions based on the qualitative traits. However, visual field observations suggest a noticeable similarity in the general appearance of the sheep. Therefore, despite the presence of statistically significant differences, these differences may not be visually apparent or have a major biological impact. Statistical analysis is highly sensitive and can detect small, but statistically significant, differences due to the large sample size, whereas visual observation relies on general assessment and often does not reveal the subtle differences that analyses do. Therefore, it was necessary to perform multivariate analysis to determine whether the sheep in these regions were similar or not.

Table:(1). Percentage values (frequency in brackets) of some qualitative morphological traits of Libyan Barbary sheep according to regions.

Traits	classes	Overall mean	Eastern	Western	Central	Southern	Pr > F
Coat color (CC)	White	90 (3470)	91(424)	89(1893)	96.8(1122)	24(31)	<0.0001
	Black	3 (120)	2.7(13)	3.8(80)	10(12)	11.6(15)	
	Brown	3 (105)	<1(4)	3.5(75)	<1(3)	17.8(23)	
	speckled	5 (180)	5(24)	3.5(74)	1.9(22)	46.5(60)	
Head Color (HC)	White	9 (338)	6.6(31)	8(171)	9.5(107)	22.5(29)	<0.0001
	Black	47 (1813)	54(253)	41.6(881)	58.5(661)	14(18)	
	Brown	30 (1134)	35(164)	28(593)	30(341)	27.9(36)	
	speckled	14 (557)	4(19)	22(472)	1.8(20)	35.7(46)	
Eye color (EC)	White	0(10)	1.5(7)	<1(3)	0	0	<0.0001
	Blue	0(7)	1(5)	<1(2)	0	0	
	Olive	2(74)	15.6(72)	<1(1)	<1(1)	0	
	brown	98(3783)	82(376)	99.7(2119)	99.9(1159)	100(129)	
Nose profile (NP)	Convex	14(529)	30(142)	15(323)	2(21)	33.3(43)	<0.0001
	Straight	86(3330)	67(312)	85(1793)	98(1139)	67(86)	
	Concave	0(18)	2.8(13)	<1(5)	0	0	
Beard (B)	Present	1(46)	9(42)	<1(3)	<1(1)	0	<0.0001
	Absence	99(3835)	91(425)	99.9(2122)	99.9(1159)	100(129)	
Wattle (W)	Present	12(459)	17(80)	10(223)	8.5(99)	44.2(57)	<0.0001
	Absence	88(3421)	83(387)	89.5(1902)	91.5(1060)	55.8(72)	

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Body condition score(BCS)	Good	76(2929)	16.7(78)	93(1976)	70(814)	48.4(61)	<0.0001
	Middle	24(923)	83(386)	6.3(134)	29.4(339)	50.8(64)	
	Bad	0(16)	<1(2)	<1(11)	<1(2)	<1(1)	
Horn shape (HS)	straight	0(15)	2(11)	0	<1(1)	2.3(3)	<0.0001
	curved	24(1151)	1.3(6)	4.9(104)	2.7(31)	7.8(10)	
	spiral	15(723)	27(128)	15.5(330)	20.8(241)	8.6(24)	
	absence	61(2988)	69(321)	79.6(1690)	76(885)	71(92)	
Horn orientation (HO)	backwards	14(122)	21(31)	17(73)	6.6(18)	0	<0.0001
	Upward	10(93)	11(16)	3.2(14)	21(58)	13.5(5)	
	Lateral	53(472)	57(83)	58(250)	39(106)	86(32)	
	Forward	22(199)	10(15)	22(95)	32.8(89)	0	
Ear orientation (EO)	Erect	1(39)	4(21)	<1(8)	0	7.8(10)	<0.0001
	horizontally	18(685)	26(121)	23(492)	2(19)	41(53)	
	pendulous	81(3154)	70(325)	76.4(1622)	98(1141)	51(66)	

Quantitative traits: The analysis of variance for body measurements of adult animals by regions and sex within region are presented in Table (3). All the studied traits were affected ($p<0.0001$) by agro-ecological regions. Among ewes, teat length was the only trait affected ($P<0.0001$) by region, while among rams, scrotum circumference was significantly affected. The overall mean were 11.9, 56.52, 72.65, 92.4, 8.33, 72.06, 13.92, 8.29, 42.55, 2.63 and 29.08 cm for Head length, Horn length, high at wither, Chest girth, Canon circumference, Body length, Ear length, staple length, Tail length, Teat length and Scrotum circumference, respectively.

In this study a relatively high coefficient of variation was found for staple length and teat length which reached (41.82%) and (34.25%), respectively. While, the moderate coefficients of variance were ranged between (8.79%) and (20.55%) for other traits. The variance component was used in the current study to divide the variance of the traits related to the size and dimensions of the body or body parts of the Libyan Barbary sheep into inter-locality and intra-locality (residual) components. The results of VARCOMP procedure in table (4) showed that between regions variance for all studied traits was higher than within region (the residual) variance; the ratio of variance between regions ranged from 0.004 to 0.278 for all traits.

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Table:(2). Percentage values (frequency in brackets) of some qualitative morphological traits of Libyan Barbary sheep according to sex within region.

Traits	classes	*Pr > F*	Eastern		Western		Central		Southern	
			Male	Female	Male	Female	Male	Female	Male	Female
Coat color (CC)	White	0.102	92(119)	91(305)	87.5(378)	89.6(1515)	99.3(269)	96(853)	15(6)	28(25)
	Black		3(4)	2.7(9)	4.6(20)	3.6(60)	0	1.4(12)	10(4)	12.4(11)
	Brown		0	1.2(4)	4.6(20)	3.3(55)	<1(1)	<1(2)	25(10)	14.6(13)
	speckled		4.7(6)	5.4(18)	3.2(14)	3.6(60)	<1(1)	2.4(21)	50(20)	44.9(40)
Head Color (HC)	White	0.014	4.7(6)	7.4(25)	7.9(34)	8.1(137)	4.9(13)	10.9(94)	10(4)	28(25)
	Black		50(64)	56(189)	48.8(209)	39.8(672)	65(174)	56.4(487)	15(6)	13.5(12)
	Brown		35(45)	35(119)	22.8(98)	29(495)	28.2(75)	30.8(266)	45(18)	20.2(18)
	speckled		11(14)	1.4(5)	20.5(88)	22.7(384)	1.5(4)	1.9(16)	30(12)	38(34)
Eye color (EC)	White	0.0002	2.3(3)	1.2(4)	<1(1)	<1(2)	0	0	0	0
	Blue		<1(1)	1.2(4)	<1(1)	<1(1)	0	0	0	0
	Olive		21(27)	13.6(45)	0	<1(1)	0	<1(1)	0	0
	brown		76(97)	84(279)	99.5(430)	99.8(1689)	100(272)	99.9(887)	100(40)	100(89)
Nose profile (NP)	Convex	0.0001	57(73)	20(69)	47(203)	7(120)	4.4(12)	1(9)	35(14)	32.6(29)
	Straight		41(53)	77(259)	52.4(226)	92.7(1567)	95.6(260)	99(879)	65(26)	67(60)
	Concave		2(3)	3(10)	<1(2)	<1(3)	0	0	0	0
Bear (B)	Present	0.0001	18(23)	5.6(19)	<1(1)	<1(2)	0	0	0	0
	Absence		82(106)	94(319)	99.8(431)	99.9(1691)	100(272)	100(887)	100(40)	100(89)
Wattle (W)	Present	0.6198	20(26)	16(54)	10(43)	10.6(180)	7.7(21)	8.8(78)	40(16)	46.1(41)
	Absence		80(103)	84(284)	90(389)	89(1513)	92.3(251)	91(810)	60(24)	54(48)
Body condition score (BCS)	Good	0.0001	23(30)	14(48)	99.5(429)	91.5(1547)	70(190)	70.5(624)	65(26)	40.7(35)
	Middle		77(99)	85(287)	<1(2)	7.8(132)	29.6(80)	29(259)	35(14)	58(50)
	Bad		0	<1(2)	0	<1(11)	0	<1(2)	0	1.2(1)
Horn shape (HS)	straight	<0.0001	8(10)	<1(1)	0	0	0	<1(1)	0	3.4(3)
	curved		1.5(2)	1.2(4)	22.5(97)	<1(7)	10.7(29)	<1(2)	25(10)	0
	spiral		89(115)	3.9(13)	75(323)	<1(7)	88.9(241)	0	60(24)	0
	absence		1.6(2)	95(319)	2.6(11)	99.2(1679)	<1(1)	99.7(884)	15(6)	96.6(86)
Horn orientation (HO)	back-wards	<0.0001	20(26)	27.8(5)	16.3(68)	35.7(5)	6.6(18)	0	0	0
	Upward		12.6(16)	0	3(13)	7(1)	21.4(58)	0	5.9(2)	100(3)
	Lateral		57(72)	61(11)	59(245)	35.7(5)	39(106)	0	94(32)	0
	Forward		10(13)	11(2)	22(92)	21(3)	32.8(89)	0	0	0
Ear orientation (EO)	Erect	<0.0001	8(10)	3 (11)	1.2(5)	<1(3)	0	0	5(2)	9(8)
	horizon-tally		20(26)	28(95)	11.6(50)	26(442)	<1(1)	2(18)	40(16)	41.6(37)
	pendulous		72(93)	69(232)	87(377)	73.7(1245)	99.6(271)	98(870)	55(22)	49(44)

significance of eight out of eleven traits ($P < 0.0001$). Head Length followed by Body length, High at wither and Chest girth have more discriminant power than the others as shown by their and F-value, this attribute that takes these four traits would be more important in differentiating Libyan sheep sub-population. The other traits (Tail length, Ear length, staple length and Horn length) were removed from the final model due to their lowest discriminant power.

The raw canonical coefficients for the first canonical variable (Can1), showed that the classes differ on the linear combination of the centered variables:

All pairwise Mahalanobis distances, presented in Table 6, were statistically significant ($P < 0.001$) and ranged from 0.8 to 3.62. The Mahalanobis distances revealed substantial differentiation, with the greatest distances observed between the southern region and both the eastern (3.62) and western regions (3.38). In contrast, the distance between the southern and central regions was relatively small (0.8).

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Table:(3). The quantitative morphological characteristics of Libyan Barbary sheep.

Source of variations	Head length (cm)	Horn length(cm)	High at wither (cm)	Chest girth (cm)	Canon circumfer-ence (cm)	Body length (cm)
The region	P< 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P< 0.0001
Eastern	13.51±2.28(467) [a]	47.99±13.26(143)[b]	75.65±7.11(467)[a]	94.33±13.96(464)[a]	9.43±2.37(465)[a]	70.23±8.49(464)[c]
Western	11.79±1.63(2123) [b]	59.74±10.27(427)[a]	72.35±6.54(2124)[c]	95.79±11.45(2121)[a]	8.18±1.12(2118)[b]	73.55±7.54(2120)[a]
Central	11.48±0.65(1160) [c]	58.00±6.74(272)[a]	71.74±5.17(1159)[c]	85.70±10.25(1160)[b]	8.28±1.01(1157)[b]	70.09±5.37(1159)[c]
southern	11.65±0.98(109)[bc]	28.80±13.00(20)[c]	73.72±7.17(109)[b]	81.12±8.11(109)[c]	7.39±0.81(109)[c]	71.41±5.49(108)[b]
The gender	P< 0.0001	P < 0.0001	P< 0.0001	P < 0.0001	P < 0.0001	P < 0.0001
Male	12.82±1.86(853)	57.74±9.32(832)	80.17±5.67(851)	105.37±10.58(851)	9.68±1.68(848)	78.39±7.84(849)
Female	11.63±1.44(3006)	22.63±16.90(30)	70.46±4.70(3008)	88.42±10.05(3008)	7.96±0.98(3001)	70.25±5.92(3002)
Overall mean	11.90	56.52	72.65	92.14	8.33	72.06
Min.	8.00	6.00	35.00	43.00	5.00	47.00
Max.	23.00	96.00	99.00	143.00	19.00	115.00
Std. devia-tion	1.62	11.62	6.39	12.36	1.36	7.23
C.V%	13.58	20.55	8.79	13.40	16.43	10.03

Continue…

Source of variations	Ear length (cm)	Staple length (cm)	Tail length(cm)	Teat length(cm)	Scrotum circumfer-ence (cm)
The region	P < 0.0001	P< 0.0001	P < 0.0001	P < 0.0001	P < 0.0001
Eastern	13.19±1.51(467)[b]	7.30±3.11(462)[b]	41.93±8.02(466)[b]	3.30±0.97(335)[a]	25.69±5.38(126)[c]
Western	13.95±1.78(2121)[a]	8.55±3.47(2096)[a]	41.79±6.53(2120)[b]	2.57±1.02(1687)[c]	29.01±4.37(424)[b]
Central	14.14±1.45(1160)[a]	8.46±4.11(100)[a]	44.41±6.11(1154)[a]	2.47±0.45(887)[c]	30.54±2.12(271)[a]
Southern	13.92±1.80(109)[a]	6.28±2.79(47)[c]	40.46±8.18(109)[c]	2.79±0.43(89)[b]	30.60±4.83(20)[a]
The gender	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001
Male	13.71±1.63(852)	9.89±4.34(613)	47.32±6.62(851)	----	29.04±4.29(841)
Female	13.97±1.69(3005)	7.83±3.01(2092)	41.20±6.18(2998)	2.63±0.90(2998)	------
Overall mean	13.92	8.29	42.55	2.63	29.08
Min.	7.00	3.00	23.00	1.00	14.00
Max.	19.00	24.00	93.00	2.9	78.00
Std. deviation	1.68	3.46	6.78	0.9	4.30
C.V%	12.81	41.82	15.92	34.25	14.80

Table:(4). Variance components according regions for quantitative traits

Character	Variance Component		
	Inter-location	Proportion of Inter-location variability	Intra-location
Head Length	0.861	0.277	2.242
Horn Length	2.325	0.004	584.116
Wither high	3.437	0.080	39.308
Chest girth	42.829	0.249	129.000
Canon circumference	0.652	0.278	1.691
Body length	2.648	0.051	49.464
Ear length	0.183	0.062	2.750
Staple length	1.089	0.085	11.703
Tail Length	2.320	0.050	44.439
Teat Length	0.137	0.154	0.751
Scrotum Circumference	5.130	0.242	16.102

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Multivariate

Table:(5). summarizes the results of the stepwise discriminant analysis, demonstrating the

Table (5): summary of stepwise selection of traits

Step	Variable Entered	Partial R^2	F-value	$p>F$	Wilk's lambda	P>Lambda	ASCC	p>ASCC
1	Head Length	0.1228	124.1	<0.0001	0.877	<0.0001	0.041	<0.0001
2	Body length	0.0665	63.15	<0.0001	0.819	<0.0001	0.061	<0.0001
3	Wither high	0.0566	53.18	<0.0001	0.772	<0.0001	0.077	<0.0001
4	Chest girth	0.0433	40.02	<0.0001	0.739	<0.0001	0.091	<0.0001
5	Tail Length	0.0133	11.92	<0.0001	0.729	<0.0001	0.095	<0.0001
6	Ear length	0.0055	4.86	0.0023	0.725	<0.0001	0.096	<0.0001
7	Staple length	0.0041	3.68	0.0116	0.722	<0.0001	0.098	<0.0001
8	Horn Length	0.0052	4.61	0.0032	0.718	<0.0001	0.099	<0.0001

ASCC= Average squared canonical correlation

Table:(6). Mahalanobis distance between sub-populations in each environmental region

Region	East	Central	south
Central	2.42***		
south	3.62***	0.80***	
west	2.57***	1.14***	3.38***

DISCUSSION

Morphological description is based on quantitative and qualitative traits and essential for defining Libyan Barbary Sheep in the present study, since all traits showed significant differences between sub-populations. This may be due to two reasons, the 1st: was the large sample size taken; the 2nd: the influence of environmental factors (such as climate and feed availability), management practices, and genetic variation on the physiological adaptation of sheep sub-populations.

Qualitative traits: The main morphological features which are traditionally used to characterize breeds of sheep are concerned with the outside appearance of the animal. Large variations were not observed among the other qualitative characteristics of population; however, the sheep in the southern region are more distinct than the sheep in other regions. All studied traits were significantly affected by environmental regions and sex; as expected that all sheep sub-populations have certain variability between regions due to specific feeding and vegetation of each region in the present study, a relative high variability was observed; the coefficient of variation was (41.82%) and (34.25%) for staple length and teat length respectively. The moderate CVs ranged between (8.79%) and (20.55%) for other traits.

Like most sheep breeds of north Africa, Libyan Barbary Sheep belongs to the fat - tailed and carpet wool type characterized by the body, legs and tail which are mostly white in color, while the head is brown or reddish brown, or black. Sometimes, the color extends from the head to the neck. In many animals, nozzle, tips of the ears and a ring around each eye are black; however, entirely white heads are not common. The ears are long, flat and pendulous. Rams nearly carry large horns that are strongly striated and spiral to curve backward with tips directed outward. The Nose of the Libyan Barbary sheep is usually straight in profile, though it may be slightly convex. This is in agreement

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with (Magid & Mursy, 1992) for the same breed and (ACSAD, 2018) for most breeds of North Africa. Rams have heavy horns, curved around the ears while ewes are polled, and rarely have small horns, which is associated with a single genomic region on chromosome 10 that controls the presence or absence of horns in domestic breeds, and that the horn absence is now common among many modern breeds (Kijas, et al., 2021). However, large variations were not observed among other qualitative characteristics of sheep in western, eastern and central regions which were in agreement with most breeds of North Africa (ACSAD, 2018).The white coat is the predominant and distinctive for sheep sub-populations, seems to be an adaptation to the hot environment where white coat enhances heat tolerance by minimizing the absorption of solar radiation, with the southern sheep being distinguished in speckled color. The animal owners prefer the white wool because of its importance in industrial processing and accepting different dyes.

Quantitative traits: In accordance with (ARC/ICARDA, 2008), the assessment of body conformation should include at least these linear measurements: body length, height at withers, heart girth, ear length, and horn length. As for sex-related characteristics, teat length is the only characteristic among ewes, and scrotal circumference among rams, both of which are affected by regions, the CV% values for staple length and teat length were 41.82 % and 34.25%, respectively, which were the highest in comparison with other traits; it may be due to the difference between animals in the period of shearing wool to take measurements, and the difference in the stages of lactation and suckling effect among ewes. In many cases qualitative traits are related to quantitative traits, Magid and Mursy (1992) observed significant differences in fleece weight and post-weaning weights between black, brown and white faces of Libyan Barbary sheep, while no significant differences in fertility, birth weight, survival of lambs to weaning and weaning weights.

In comparison with the Libyan Barbary Sheep with breeds located in North African states to highlight differences and similarities with those related breeds, the overall mean of height at withers (72.65cm), chest girth (92.14 cm), body length (72.06 cm), presented in this study as traits related to body mass were lower than the values reported by (Dekhili, 2014) for Sétif area ewes in Algeria, while greater than the values reported by ACSAD (2018) for Barbary sheep located around the Algerian-Tunisian border area. The results of this study correspond to some extent to the characteristics of Rembi and Beni Guil sheep in Algeria and Morocco (ACSAD, 2018).

The tail is relatively short (42.55 cm), wide, pendulous without sigmoid flexure, mostly ending above the hocks. The fat content reflects animal's condition which is affected by the availability of feeds (Magid & Mursy 1992).

As expected that all sheep sub-populations have certain variability between regions, these differences could be attributed to the specific feeding and vegetation cover of each region. Although body measurements of sheep in the four regions show a relatively moderate degree of variance in traits related to body mass, but there are wide variation between male and female in these traits, this might be related to the differences in growth rate and reproductive activities, since the observed higher measurements in males compared to females can be attributed to the influence of androgens, which stimulate muscle and skeletal development in males, whereas estrogen may have an inhibitory effect on growth in females (Baneh & Hafezian, 2009 and Hailu et al., 2020).

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Multivariate analysis : The restricted maximum likelihood method was used to estimate the components of variance showed that all traits had high degree of Intra-locality (residual) variation; this residual variance component can be attributed to random environmental or genetic factors. This was a preliminary indicator to similarity in Libyan sheep population.

While all pairwise Mahalanobis distances were significant (table, 6), these differences were not sufficient to statistically distinguish the populations as separate genetic groups or breeds; these results support the hypothesis of homogeneity in the Barbary sheep common in Libya. Differences in agroclimatic conditions and management practices may contribute to the observed morphological divergence between sub-populations. The canonical discriminant analysis demonstrated a high degree of efficacy in distinguishing between individuals from the four studied regions; this analysis provided a comprehensive understanding of the distribution of the studied sheep population, revealing four distinct zones.

CONCLUSION

It was concluded that Libyan Barbary Sheep are medium in size, belongs to the carpet wool, fat-tailed type which varies greatly in staple length between flock. The coat is mostly white in color. Despite their geographical separation, the four populations in this study exhibit limited morphological diversity. Analysis revealed that head length, body length, wither height, and chest girth were significant discriminatory variables between sheep subpopulations in the different Libyan regions. The combination of Univariate and multivariate analyses facilitated the successful discrimination between Libyan Barbary Sheep sub-populations based on their morphometric characteristics. The incorporation of molecular genetic analysis utilizing diagnostic marker loci is recommended for future investigations.

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ETHICS

Scientific Research Ethics Committee at the University of Tripoli, based on the Scientific Research Ethics Document issued by the University of Tripoli

Duality of interest: The authors declare that they have no duality of interest associated with this manuscript.

Author contributions: Example, A.B. developed the theoretical formalism, performed the analytic calculations and performed the numerical simulations. Both A.B and B.C. authors contributed to the final version of the manuscript. B.C. supervised the project.

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