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MULTIVARIATE ANALYSIS OF MORPHOLOGICAL CHARACTERISTICS OF AWASSI SHEEP IN THE WEST BANK, PALESTINE

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ABSTRACT

A field surveywasconducted to characterizelocal Awassi sheep in the West Bank, Palestine. A total of 130 sheep flocks were sampled over thirteen districts in the Southern, Central and Northern geographical regions. Body characteristics (qualitative and quantitative traits) were recorded on 130 rams aged 1 to 4 years and 520 ewes (first through fourth parities). Significant differences were found among regions in qualitative and quantitative traits. The multivariate analyses on quantitative traits identified five traits for rams and ten traits for ewes which were significant in discriminating Awassi sheep populations of the three regions. The largest squared Mahalanobis distances were found between the Southern and Northern regions (31.83 for rams and 49.51 for ewes) and the smallest distances were found between the Central and Northern regions (4.28 for rams and 5.23 for ewes) consistent with geographical distances. Discriminant analysis showed that 85.4% of rams and 89.4% of ewes were correctly classified into their geographic areas with highest rates found for the Southern region (97.5% of rams and 100% of ewes were correctly classified). These results form the basis for the development of future characterization and conservation plans of Awassi sheep.

Keywords: Awassi sheep, Palestine, morphological characteristics, multivariate, discriminant analysis.

INTRODUCTION

Awassi sheep is a fat-tailed breed which is well adapted to harsh arid areas (Said *et al*., 1999) and is widespread in the Middle East(Epstein, 1985; Hailat, 2005; Tabbaa *et al*., 2001; Zarkawi *et al*., 1999). Besides Awassi, Assaf and Awassi x Assaf sheep are also raised in Palestine. Awassi sheep are characterized by their large fat-tail. Assaf breed has long thin tail and was developed by crossing Awassi with East Friesian sheep with original gene proportions of 5/8 Awassi and 3/8 East Friesian (Goot, 1986). Awassi x Assaf sheep are locally named "half-tailed" because they have distinctively smaller tail than Awassi. The Awassi population in the West Bank has been decreasing over recent years. In 2007, Awassi represented the major sheep breed (68%), while Assaf and Awassi x Assaf represented 32% (PCBS, 2007). In 2010, Awassi represented 54.5% of the total West Bank sheep population while Assaf and Awassi x Assaf accounted for 45%, (PCBS, 2011). Amore recent investigation by the Ministry of Agriculture(MoA, 2013, unpublished) found that Awassi only comprised about 20% of the total sheep population in the West Bank.This alarming trend emphasizes the need for an urgent conservation plan.

Characterization of indigenous livestock genetic resources are essential for planning national domestic animal diversity and conservation plans (FAO, 2012). Morphological characterization is the first step before performing molecular genetic characterization. Severalauthors studied performance and morphological characteristics of Awassisheep in neighbor countries (Abdullah *et al*., 2015; Abdullah and Tabbaa, 2011; Alnimer *et al*., 2005; Al-Tarayrah and Tabbaa, 1999; Eliya and Juma, 1970; El-Sabeh and El-Najar, 1988; Galal *et al*., 2008; Gootwine and Pollot, 2000; Hailat, 2005; Kridli *et al*., 2009; Tabbaa, 1998; Tabaa, 2003; Tabbaa *et al*., 2001; Talafha and Ababneh, 2011). In Palestine, although some authors attempted to described milk production and reproductive performance of Awassi sheep (e.g., Abdallah, 1996 and Ahmad and Abdallah,2013),there is still a lack of information on morphological characteristics (both qualitative and quantitative) of this important breed. The main objectives of this study were to describe the qualitative and quantitative morphological characteristics of Awassi sheep of the West Bank and investigate if differences exist among geographical areas.

MATERIALS AND METHODS

Study Location: Palestine is composed of two provinces: the West Bank and Gaza Strip. The West Banks islocated 32 00 N, 35 15 E and has a total area ofabout 5900 km^2. The altitude varies from – 408m to 1022m. It has warm to hot summers and mild to cold winters. It is composed of thirteen districts geographically grouped into three regions:the Southern region includes Yatta, Dora, Hebron and Betlehem; the Central region includes Jerusalem, Ramallah, Jericho, and Salfit; the Northern region includes Qalqilia, Nablus, Tulkarm, Jenin, and Tubas.

Sampling Procedure: Within each district, 10 flocks raising Awassi sheep were randomly selected (a total of 130 flocks were sampled). Five adult animals (four ewes and one ram) were selected from each flock for a total of 520 ewes and 130 rams (40 ewes and 10 rams from each district). Selected rams were more than one year old while ewes were selected if they have given at least one birth.Sampling of ewes in each herd was such that the four selected ewes in the same flock were of different parities.

Data Collection: The data were collected in late summerof 2015 by animal husbandry technicians and filled using questionnaires prepared for this purpose. Two on-farm training sessions were held for technicians before starting data collection. Information were obtained on flock size and composition (no of breeding and replacement animals), different breeds raised and proportion of Awassi in the flock, % of horned males and females at the flock level. Flock characteristics were obtained through observation of the flocks on site and questioning of farmers.The morphological characteristics studied and measurement methods were according to the FAO Animal Production Health Guidelines (FAO, 2012). Qualitative characteristics included body color, coat color pattern, presence of horns, horn shape and orientation, ear shape and orientation, head (facial) profile, and backline profile.Quantitative morphometric characteristics included body length, chest girth, chest depth, height at withers, pelvic width, ear length, ear width,horn length, tail length, head length, headwidth,teat length, and scrotal circumference. Quantitative characteristics were measured using regular and flexible tapes calibrated in centimeters. Animals were measured while held in upright position on a flat floor.

Statistical Analyses: Qualitative variables were subjected to analysis in SPSS statistical package (SPSS, 2007). Frequencies were calculated by region and sex and Fisher's Exact test was used to test for differences in the distribution of qualitative characteristics among regions and between males and females. Statistical analyses on quantitative characteristics were carried out using the SAS/STAT package (SAS, 2002). Preliminary analyses showed significant differences between males and females and thus the data were analyzed separately by sex. Descriptive statistics for quantitative traits(means and coefficients of variation) were obtained using the MEANS procedure. The effects of region on measured traits were assessed using the GLM procedure fitting a model with region and age for rams (two classes: 1-2yr, and $\geq$ 3yr) or parity (1 to 4) for ewes.Initially, a stepwise discriminant analysis was performed using the STEPDISC procedure to identify variables which are important in discrimination among regions. These variables were then used in the SCANDISC and DISCRIM procedures to derive the canonical functions and compute the percentage of correct assignment of each animal to its sampling region.In the canonical analysis, squared Mahalanobis distances were obtained to test differentiation among regions.

RESULTS

Flock Characteristics: Characteristics of sampled sheep flocks are in Table 1. Overall average flock size was 127.8 heads (ranged from 17 to 596 heads). Average flock size was lowest for the Central districts (89.1 heads) and highest for the Northern districts (150.6 heads). Female to male ratio was about 20 ewes per ram and percent of replacements was about 18% in accordance with the worldwide breeding practices. Average percentage of horned animals at the flock level was about 70% for males and about 20% for females. All sampled flocks in the Southern region and 98% in the Northern region kept only Awassi breed, while 75% of sampled flocks in the Central districts raised Awassi x Assaf and 7.5% raised Assaf in their flocks besidesthe Awassi breed.

Qualitative Characteristics: Qualitative characteristics of Awassi sheep are presented by sex (Table 2) and by region (Table 3). Fisher's Exact test showed highly significant differences ($P < 0.001$) between males and females for presence of horns, horn shape, and horn orientation, but no differences were found ($P > 0.05$) for body color, coat color pattern, ear shape, and ear orientation. Highly significant differences were found among regions ($P < 0.001$) for all qualitative characteristics except coat color pattern ($P > 0.05$). Most of Awassi sheep sampled (71.95%) were of white body with brown heads (69.5 of ewes and 81.4% of rams) with plain coat color pattern (about 90%). However, the Northern region had lower percentage of white body and brown head sheep (62.2%) than the Southern and Central regions (79.4 and 76.4%, respectively). About 80% of rams were horned compared to about 25% of ewes. The percentage horned was highest for the Southern region (61.3%) and lowest in the central region (19.9%). The percentages of horned males and females found at the individual level are in agreement with those found at the flock level.Horns of males were mostly spiral (52.0%) or curved (26.5%) in shape with backward orientation (88.1%). About two-thirds of males and females had semi-pendulous and pendulous ears. About half of ewes and rams had straight head profile and about one third had a convex head. However, 47.2% ofsheep in the Southern region had concave heads while these were nearly absent in the Central and Northern regions.About two-thirds of sampled Awassi sheep hada straight backline (64% of ewes and 74% of rams).

Quantitative Characteristics:Raw means and significance of region and age class (or parity) of quantitative characteristicsare in Table 4. Body measurements indicate that Awassi sheep are generally of medium size. As expected, rams had larger size than ewes (averages of body length, wither height, chest circumference, chest depth, and pelvic width were respectively 87.83, 90.12, 108.05, 54.58, 28.77 cm for rams and 78.39, 79.17, 99.87, 50.23, and 25.74 cm for ewes) and particularly longer horns (43.81 cm vs. 9.52 cm). Head length and head width were 28.72 cm and 11.89 cm for rams and 27.31 and 10.50 cm for ewes. Ear length and ear width were very similar in both sexes (20.45 and 10.88 cm for rams; 20.59 and 10.81 cm for ewes). Tail length averaged 28.52 cm for rams and 26.42 cm for ewes.Teat length averaged 4.38 cm and scrotal circumference averaged 33.18 cm. Highly significant differences ($P < 0.0001$) were found among regions for all measured characteristicsof ewes except horn length ($P > 0.05$). For rams, differences among regions were highly significantin pelvic width, head length, headwidth, ear length, ear width, and tail length ($P < 0.0001$) and in chest girth and scrotal circumference ($P < 0.01$) but not in body length, wither height, and horn length ($P > 0.05$). No significant differences were found by age class (for rams) and parity was only significant for chest girth ($P < 0.001$), head length ($P < 0.01$) and ear length ($P < 0.05$). Least squares means of quantitative traits by region are in Table 5. The Southern region had higher means of head length, headwidth, ear length, ear width, and tail length than the Central and Northern regions for both rams and ewes but had the lowest means for chest girth, chest depth, pelvic width and scrotal circumference.

The stepwise discriminant analysis identified five traits for rams and ten traits for ewes (Table 6) which were significant discriminant traits among Awassi animals in different regions. These traits were then used in the canonical and discriminant analyses. Tail length, headwidth, and pelvic width had the highest discriminating power for both sexes as indicated by their high partial R^2 and F values. This was also confirmed by the bi-dimensional plots constructed with the standardized canonical discriminant coefficients (Figures 1 and 2).

The canonical analysis on the data for ramsidentified two statistically significant ($P < 0.001$) canonical variables, CAN1 and CAN2. These functions respectively accounted for 95.5% and 4.5% of the total variation.The pair-wise squared Mahalanobis distances between areas(Table 7) were all highly significant ($P < 0.0001$).The squared distances found between the Southern region and each of the Central and Northern regions(16.44 and 31.83, respectively) were larger than that found between the Central and the Northern region (4.28). For ewes, twosignificant canonical functions were also identified ($P < 0.001$) accounting respectively for 96.9% and 3.1% of the total variation.Pair-wise squared Mahalanobis distances between areas (Table 7) were all highly significant ($P < 0.0001$).The same trends found for rams were also found for ewes, i.e., higher distances between the Southern and Central region (27.06) and between the Southern and Northern regions (49.51) than between the Central and Northern regions (5.23). These results for males and females were confirmed by the Bi-dimensional plots constructed from CAN1 and CAN2 to illustrate the differentiation between regions (Figures 3 and 4).These plots show that the first canonical function (CAN1) separated well the sheep populations in the three areas. The multivariate statistics testing differences among sampling areas (Wilks' lambda, Pillai's trace, Hotelling–Lawley trace and Roy's greatest root) were all highly significant ($P < 0.0001$) for both sexes.

The correct assignment of rams to their geographic area(Table 8) ranged from 70% (for the Central region) to 97.5% (for the Southern region) with 85.4% of the total sample correctly assigned (overall error count estimate of 14.6%). For ewes, the correct classification rate ranged from 74.4% for the Central region to 100%for the Southern region (Table 9). The overall percentage of the female sample correctly classified was 89.4% (overall error count rate of 10.6%).Most misclassifications were between the Central and Northern regions (only one ram from the Southern region was incorrectly classified in the Central region and three ewes from the Central region were incorrectly classified in the Southern region).

Table 1. Main characteristics of sampled flocks[1] raising Awassi sheep in the West Bank, Palestine.

Characteristic	Region [1]			All (n = 130)
	Southern (n = 40)	Central (n = 40)	Northern (n = 50)	
	mean ± SD			
Flock size [2]	143.0±68.3	89.1± 48.2	150.6±115.4	127.8±90.8
Female to male ratio [3]	19.1±7.0	20.8±9.4	21.9±9.8	20.9±9.1
% Replacement animals, [4]	14.5±3.6	16.2±6.0	20.5±8.4	17.6±7.2
% Horned males	96.9±3.4	68.0±32.6	53.8±38.1	68.6±35.4

% Horned females	51.6±23.0	8.4±18.4	8.8±15.8	18.6±25.5
	% of flocks			
proportion of Awassi breed in the flock				
<50%	0	30.0	0.0	10.3
50-80%	0	45.0	2.0	16.2
100%	100	25.0	98.0	73.5
% of flocks raising also Assaf breed	0	7.5	2.0	3.4
% of flocks raising also Awassi x Assaf breed	0	75	0	25.6

[1] The Southern region included Hebron, Yatta, Dora, and Betlehem; the Central region included Jerusalem, Ramallah, Jericho, and Salfit; the Northern region included Qalqilia, Nablus, Tulkarm, Jenin, and Tubas.
[2] Total no of breeding and replacement males and females
[3] Number of breeding and replacement males/ no of breeding and replacement females.
[4] % of replacement males and females in the flock

Table 2. Frequency of class levels of qualitative characteristics of Awassi sheep by sex.

Characteristic	P value[1]		Ewes (n = 520)	Rams (n = 130)	Total (n = 650)
				% (Number)	
Body color	0.057	White body, brown head	69.5 (357)	81.4(105)	71.95(462)
		White body, black head	6.6 (34)	3.1(4)	5.9 (38)
		White body and head	8.8(45)	7.8(10)	8.6(55)
		Black or black and white body, black or black and white head	10.1(52)	3.9(5)	8.9(57)
		Brown or brown and white body, brown head	5.1(26)	3.9(5)	4.8(31)
Coat color pattern	0.119	Plain	88.4(456)	94.6(122)	89.6(578)
		Patchy	8.3(43)	3.9(5)	7.4(48)
		Spotted	3.3(17)	1.6(2)	2.9(19)
Presence of horns	< 0.001	Horned	24.9(126)	79.1(102)	35.9(228)
		Polled	75.1(380)	20.9(27)	64.1(407)
Horn shape	< 0.001	Scurs	26.2 (33)	5.9(6)	17.1(39)
		Straight	34.9(44)	15.7(16)	26.3(60)
		Curved	24.6(31)	26.5(27)	25.4(58)
		Spiral	14.3(18)	52.0(53)	31.1(71)
Horn orientation	< 0.001	Lateral	16.0(20)	7.9(8)	12.4(28)
		Upward	42.4(53)	4.0(4)	25.2(57)
		Backward	41.6(52)	88.1(89)	62.4(141)
Ear shape	0.911	Rounded	61.5(308)	62.0(80)	61.6(388)
		Straight	38.5(193)	38.0(49)	38.4(242)
Ear orientation	0.833	Erect	1.2(6)	0.8(1)	1.1(7)
		Semi-pendulous	33.3(171)	32.0(41)	33.0(212)
		Pendulous	32.7(168)	36.7(47)	33.5(215)
		Carried horizontally	32.9(169)	30.5(39)	32.4(208)
Head profile	0.05	Straight	54.7(281)	51.2(66)	54.0(347)
		Concave	16.5(85)	11.6(15)	15.6(100)
		Convex	28.8(148)	36.4(47)	30.3(195)
		Ultra convex	0.0(0)	0.8(1)	0.2(1)
Backline profile	0.023	Straight	64.0(329)	74.0(94)	66.0(423)
		Slopes up towards rump	22.6(116)	14.2(18)	20.9(134)
		Slopes down from withers	7.6(39)	10.2(13)	8.1(52)
		Dipped or curved	5.8(30)	1.6(2)	5.0(32)

[1] Fisher's Exact Test

Table 3. Frequency of class levels of qualitative characteristics of Awassi sheep by region.

Characteristic	P value[1]		Southern	Central	Northern
				% (Number)	
Body color	**< 0.001**	White body, brown head	79.4(158)	76.4(149)	62.2(155)
		White body, black head	5.5(11)	2.6(5)	8.8(22)
		White body and head	3.5(7)	6.2(12)	14.5(36)
		Black or black and white body, black head	6.5(13)	9.2(18)	10.4(26)
		Brown or brown and white body, brown head	5.0(10)	5.6(11)	4.0(10)
Coat color pattern	**0.316**	Plain	88.4(176)	91.9(181)	88.8(221)
		Patchy	7.0(14)	5.6(11)	9.2(23)
		Spotted	4.5(9)	2.5(5)	2.0(5)
Presence of horns	**< 0.001**		61.3	19.6	27.9
Horn shape	**< 0.001**	Scurs	5.7	13.5	39.7
		Straight	48.0	0	1.5
		Curved	33.3	16.2	16.2
		Spiral	13.0	70.3	42.6
Horn orientation	**< 0.001**	Lateral	18.7 (23)	5.7(2)	4.4(3)
		Upward	36.6 (45)	2.9(1)	16.2
		Backward	44.7(55)	91.4(32)	79.4
Ear shape	**< 0.001**	Rounded	98.0(193)	19.6(38)	65.7(157)
		Straight	2.0 (4)	80.4(156)	34.3(82)
Ear orientation	**< 0.001**	Erect	3.5(7)	0.0(0)	0.0(0)
		Semi-pendulous	91.0(181)	4.1(8)	9.3(23)
		Pendulous	5.5(11)	19.4(38)	67.2(166)
		Carried horizontally	0.0(0)	76.5(150)	23.5(58)
Head profile	**< 0.001**	Straight	44.7(89)	44.9(88)	68.5(170)
		Concave	47.2(94)	0.5(1)	2.0(5)
		Convex	8.0(16)	54.1(106)	29.4(73)
		Ultra convex	0.0(0)	0.5(1)	0.0(0)
Backline profile	**< 0.001**	Straight	52.0(103)	65.0(128)	78.0(192)
		Slopes up towards rump	48.0(95)	11.7(23)	6.5(16)
		Slopes down from withers	0.0(0)	17.3(34)	7.3(18)
		Dipped or curved	0.0(0)	6.1(12)	8.1(20)

[1] Fisher's Exact Test

Table 4. Raw means, coefficient of variation (CV), and significance (P values) of region and age class (or parity) for quantitativecharacteristics of rams and ewes of Awassi sheep.

Trait[1], cm	Rams				Ewes				
	Statistics		Significance of fixed effects (P value)		Statistics		Significance of Fixed effects (P value)		Sexual dimorphism (m/f)
	Mean	CV	Region	Age class	Mean	CV	Region	Parity	
BL	87.83	7.03	0.18	0.64	78.39	6.17	<0.0001	0.09	1.12
WH	90.12	7.40	0.70	0.55	79.17	8.83	0.0002	0.89	1.14
CG	108.05	5.78	0.009	0.36	99.87	7.42	<0.0001	<0.0001	1.08
CD	54.58	6.30	0.03	058	50.23	10.08	0.0008	0.09	1.09
PW	28.77	14.78	<0.0001	0.52	25.74	13.15	<0.0001	0.39	1.12
HL	28.72	10.92	<0.0001	0.59	27.31	11.91	<0.0001	0.001	1.05
HW	11.89	13.11	<0.0001	0.63	10.50	16.10	<0.0001	0.24	1.09
EL	20.45	11.23	<0.0001	0.68	20.59	11.83	<0.0001	0.02	0.99
EW	10.88	14.53	<0.0001	0.08	10.81	17.61	<0.0001	0.21	1.01

TL	28.52	23.78	<0.0001	0.45	26.42	26.73	<0.0001	0.85	1.08
HNL	43.81	46.14	0.08	0.82	9.52	68.69	0.21	0.55	4.60
SC	33.18	7.11	0.009	0.64					
TTL					4.38	29.11	<0.0001	<0.0001	

[1] BL = body length, WH = wither height, CG = chest girth, CD= chest depth, PW = pelvic width, HL = head length, HW = head width, EL= ear length, EW = ear width, TL = tail length, HNL = horn length, SC = scrotal circumference, TTL = teat length.

Table 5. Least square means of quantitative morphological traits of Awassi rams and ewes by region.

Trait[1], cm	Rams			Ewes		
	Southern	Central	Northern	Southern	Central	Northern
BL	$87.05^{a,2}$	87.21^{a}	89.26^{a}	79.71^{a}	76.89^{b}	78.68^{a}
WH	89.92^{a}	89.95^{a}	91.00^{a}	80.25^{a}	76.97^{b}	80.04^{a}
CG	106.95^{b}	110.75^{a}	107.28^{b}	104.2^{a}	98.35^{b}	97.23^{b}
CD	53.59^{b}	55.59^{a}	$54.79^{a, b}$	51.34^{a}	49.92^{b}	49.34^{b}
PW	24.84^{b}	30.29^{a}	31.12^{a}	23.48^{c}	25.06^{b}	28.25^{a}
HL	31.60^{a}	28.66^{b}	26.76^{c}	31.20^{a}	26.14^{b}	25.10^{c}
HW	14.36^{a}	11.16^{b}	10.58^{b}	13.53^{a}	9.36^{b}	9.13^{b}
EL	22.16^{a}	19.64^{b}	19.58^{b}	22.30^{a}	19.53^{b}	20.02^{b}
EW	12.44^{a}	10.60^{b}	9.96^{c}	12.55_{a}	10.25^{b}	9.84^{b}
TL	35.52^{a}	29.54^{b}	22.21^{c}	35.17^{a}	24.77^{b}	20.39^{c}
HNL	47.35^{a}	47.72^{a}	37.21^{a}	8.86^{a}	13.72^{a}	10.33^{a}
SC	32.25^{b}	33.79^{a}	33.43a			
TTL				5.51^{a}	3.90^{b}	3.79^{b}

[1] BL = body length, WH = wither height, CG = chest girth, CD= chest depth, PW = pelvic width, HL = head length, HW = head width, EL= ear length, EW = ear width, TL = tail length, HNL = horn length, SC = scrotal circumference, TTL = teat length.

[2] Means with different superscripts in the same row are significantly different ($P < 0.05$) using Tukey's adjustment for multiple comparisons.

Table 6. Summary of stepwise selection of important quantitative morphological traits to discriminate Awassi rams and ewes among different regions.

Step	Variables entered[1]	Partial R^2	F value	P > F	Wilks' Lambda	P < Lambda	ASCC [2]	P > ASCC
				Rams				
1	TL	0.6785	103.41	< 0.0001	0.3215	< 0.0001	0.3393	< 0.0001
2	PW	0.3872	30.65	< 0.0001	0.1970	< 0.0001	0.4174	< 0.0001
3	HW	0.3868	30.28	< 0.0001	0.1208	< 0.0001	0.4884	< 0.0001
4	CG	0.0825	4.27	0.0167	0.1108	< 0.0001	0.5191	< 0.0001
5	BL	0.0721	3.54	0.0328	0.1031	< 0.0001	0.5473	< 0.0001
				Ewes				
1	TL	0.7502	746.25	< 0.0001	0.2498	< 0.0001	0.3751	< 0.0001
2	HW	0.4214	180.61	< 0.0001	0.1445	< 0.0001	0.4681	< 0.0001
3	PW	0.3263	119.89	< 0.0001	0.0974	< 0.0001	0.5219	< 0.0001
4	HL	0.0950	25.94	< 0.0001	0.0881	< 0.0001	0.5274	< 0.0001
5	TTL	0.0264	6.70	0.0014	0.0858	< 0.0001	0.5331	< 0.0001
6	CG	0.0194	4.88	0.0080	0.0841	< 0.0001	0.5397	< 0.0001
7	BL	0.0275	6.93	0.0011	0.0818	< 0.0001	0.5509	< 0.0001
8	EW	0.0132	3.29	0.0382	0.0807	< 0.0001	0.5517	< 0.0001
9	EL	0.0104	2.57	0.0773	0.0799	< 0.0001	0.5557	< 0.0001
10	CD	0.0102	2.51	0.0822	0.0791	< 0.0001	0.5584	< 0.0001

[1]BL = body length, CD= chest depth, CG = chest girth, EL= ear length, EW = ear width, HL = head length, HW = head width, PW = pelvic width, TL = tail length, TTL = teat length.

[2] ASCC = Average Squared Canonical Correlation.

Table 7. Squared Mahalanobis distances between regions for rams (above diagonal) and ewes (below diagonal).

Region	Southern	Central	Northern
		Analysis including all flocks	
Southern	-----------	16.44^{***}	31.83^{***}
Central	27.06^{***}	-----------	4.28^{***}
Northern	49.51^{***}	5.23^{***}	----------
		Analysis excluding flocks raising Assaf or Awassi x Assaf sheep	
Southern	-----------	52.49^{***}	48.92^{***}
Central	75.32^{***}	-----------	1.58^{*}
Northern	80.40^{***}	2.01^{***}	----------

* P < 0.05
*** P < 0.0001

Table 8. Percentage and number of observations classified in different regions for the male sample.

Region	Southern	Central	Northern	Total
			% (Number)	
Southern	97.5 (39)	2.5(1)	0	100.0 (40)
Central	2.5 (1)	70.0 (28)	27.5(11)	100.0 (40)
Northern	0	12.0(6)	88.0(44)	100.0 (50)

Table 9. Percentage and number of observations classified in different regions for the female sample.

Region	Southern	Central	Northern	Total
			% (Number)	
Southern	100.0 (159)	0.0 (0)	0.0 (0)	100.0(159)
Central	1.9 (3)	74.4(116)	23.7(37)	100.0(156)
Northern	0.0(0)	7.0(13)	93.0(173)	100.0(186)

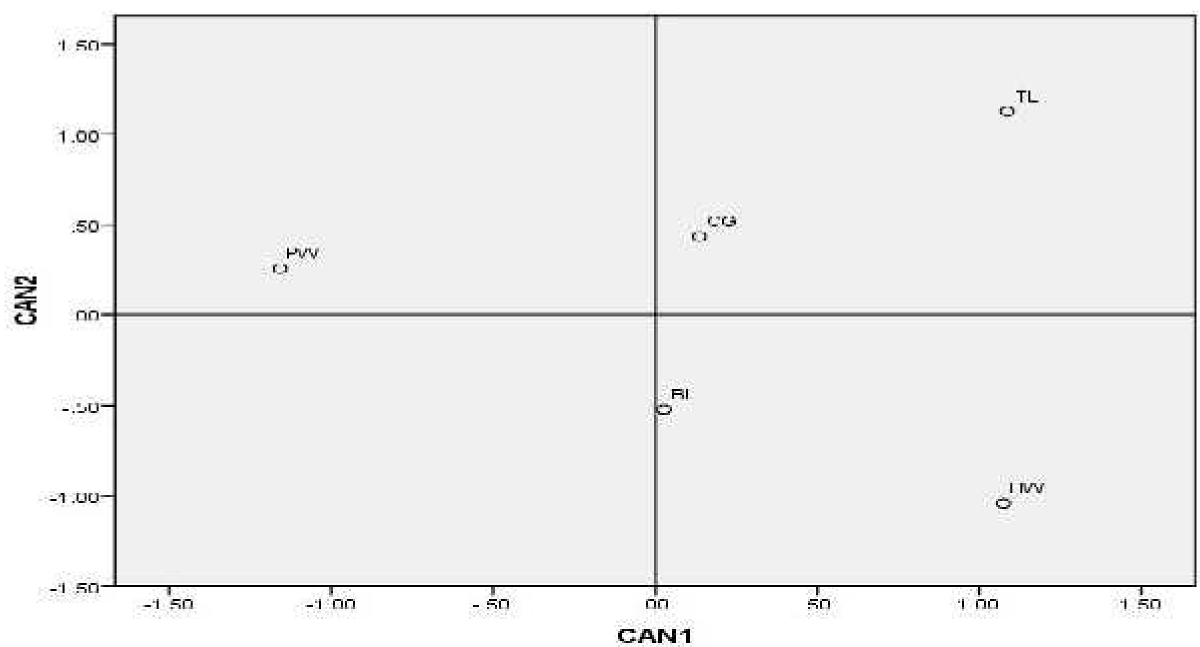

Fig 1. Bi-dimensional plot illustrating the association between body measures of Awassi rams assessed via canonical analysis. Traits: BL = body length, CG = chest girth, HW = head width, PW = pelvic width, TL = tail length

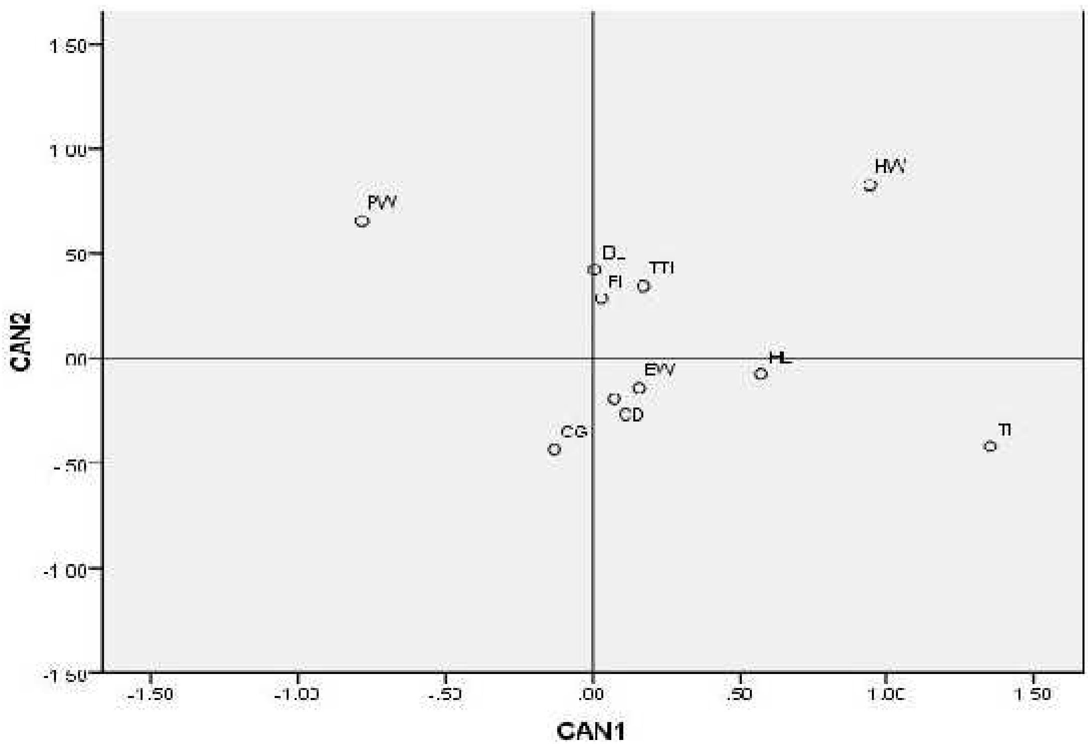

Fig 2. Bi-dimensional plot illustrating the association between body measures of Awassi ewes assessed via canonical analysis. Traits: BL = body length, CD= chest depth, CG = chest girth, EL = ear length, EW = ear width, HL= head length, HW = head width, PW = pelvic width, TL = tail length, TTL= teat length.

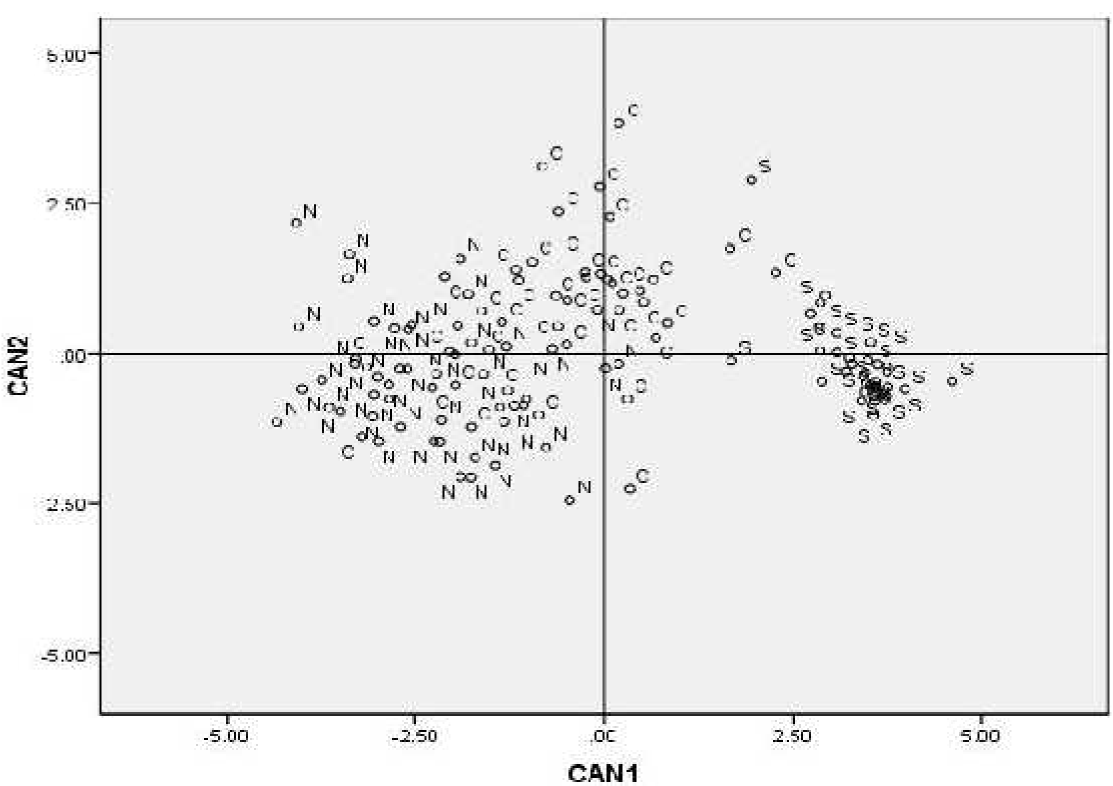

Fig 3. Bi-dimensional plot of canonical variables associated with Awassi rams sampled in three different regions (S = Southern, C = Central, N = Northern).

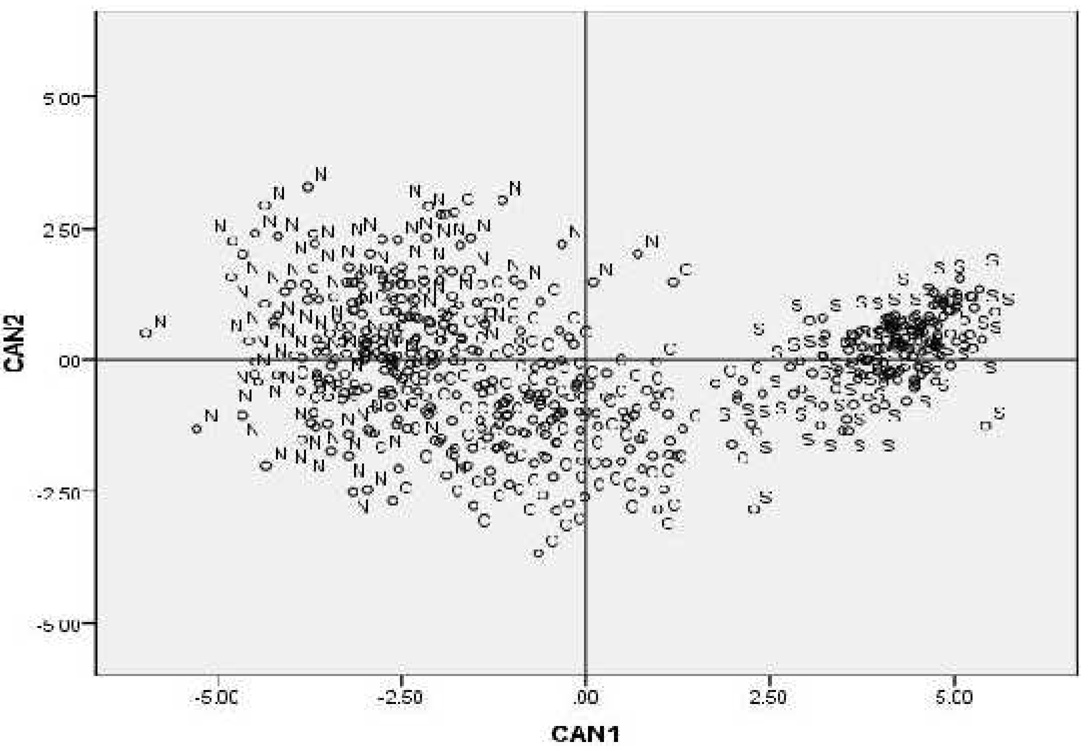

Fig 4. Bi-dimensional plot of canonical variables associated with Awassi ewes sampled in three different regions (S = Southern, C = Central, N = Northern).

DISCUSSION

The current study provided information on qualitative and quantitativecharacteristics of Awassi ewes and rams which would help characterize the breed in Palestine. In particular, body dimensions (e.g.; body length, wither height, chest girth, pelvic width, chest depth), areimportant to study the morphological structure of a breed (Tabbaa, 2003) and to discriminate among different breeds (Herera *et al*., 1996). Furthermore,they provide information on meat productivity (Al-Tarayrah and Tabbaa, 1999) because they have high positivecorrelations with body weight of the animal (Eliya and Juma, 1970;Gajbhiye and Johar, 1985)and carcass conformation and weight of lambs (Al-Jalili *et al*., 1987). Therefore, body dimensions can be used in designing breeding programs to improve meat production of Awassi sheep.

The estimates of body length found in the current studyfor Awassi sheep in Palestine were higher than those found for Awassi sheep in Jordan (Tabbaa, 1998) and Iraq (Eliya and Juma, 1970) but less than those found for Syrian Awassi (El-Sabeh and El-Najar, 1988). Estimates of wither height were higher than those found in Jordan and Syria (Tabbaa, 1998; El-Sabeh and El-Najar, 1988). Our estimates of chest girth were similar to those found for Awassi sheep in Jordan (Tabbaa, 1998) but larger than those found in other countries (Eliya and Juma, 1970 and El-Sabeh and El-Najar, 1988). Tabbaa (1998) reported similar estimates of pelvic width to those found in our study.

Awassi is a fat-tailed breed. Tabba(1998) studied fat-tail dimensions of Awassi sheep and found higher average values of tail length for ewes (31.2 cm) compared to rams (24.4 cm), contrary to the results of our study where rams had higher average tail length (28.5 cm) than ewes (26.4). According to Tabbaa (1998), the differences in tail dimensions in his study could be due to the selection ofa smaller fat-tail in rams and probably due to reserving fat during pregnancy for ewes. There is no indication that such selection is practiced in Palestine. Furthermore, the measures in our study were taken in late summer which corresponds to late breeding season and early pregnancy, while in the study of Tabbaa (1998) the measures were taken at lambing for ewes and during breeding season for rams.

The stepwise analysis identified five significant discriminatory traits (to discriminate among regions) for rams (tail length, pelvic width, head width, chest girth, and body length) and ten for ewes (tail length, headwidth, pelvic width, head length, teat length, chest girth, body length, ear width, ear length, and chest depth) with tail length, headwidth, and pelvic width showing the highest discriminating power for both sexes. Most of these traits were also significant contributors to discrimination among geographical regions in Spanish Assaf (Legaz *et* *al.*, 2011) and Bengal (Banerjee, 2015) and Ethiopian (Melesse *et al.*, 2013) indigenous sheep breeds.

The results of the multivariate analyses found in this study indicated adaptive morphological divergence between Awassi sheep populations raised in different geographical areas of the West Bank. Awassi rams and ewes kept in the Southern region have more distinct characteristics from those in the Central and Northern areas which are less different.Geographic proximity may have facilitated genetic exchange between the Northern and Central regions and to lesser extent between the Southern and Central regions.Very similar trends of geographic divergence were reported by Dekhili *et al.* (2013) for Algerian goat population of Sétif.

Keeping mixed breeds in Awassi- raising flocks results in uncontrolled crossbreeding and may be the main reason for decreasing numbers of Awassi sheep over the past few years in Palestine. This is very alarming and emphasizes the urgent need for conservation and genetic improvement programs. By examining the characteristics of sampled flocks in Table 1, we see that 75% of flocks in the Central region and one flock in the Northern region keep also Assaf and Awassi x Assaf sheep while none of the sampled flocks in the Southern regionkeep any of these breeds. It is possible that this may have contributed to the divergence between the Central region and each of the Southern and Northern regions. To test this hypothesis, the data were reanalyzed excluding all flocks which raise Assaf and Awassi x Assaf sheep. The results showed that the distance between the Central and the Northern regions decreased but the distance between the Southern and Central regions increased (Table 7). After excluding flocks raising other breeds from the data, all remaining flocks in the central region were from the district of Salfit which is geographically the closest district to the Northern region and farthest from the Southern region. This confirms that the geographical distance is the main reason for divergence of Awassi populations among different regions.

Conclusions: The current study presented qualitative and quantitative characteristics of local Awassi sheep in the West Bank, Palestine and described flockcharacteristics. These identified characteristics could be used as references and utilized to develop future conservation and breeding strategies for these breeds. The differences found among regions in these characteristics increases the necessity for genetic analysis to differentiate between subpopulations and link genetic differences to morphological differences.

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